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Thursday, March 15, 2018

Ms. Melanie Humphrey
Michigan Department of Environmental Quality
1504 W. Washington St.
Marquette, MI 49855

Subject: Annual Mining and Reclamation Report, Eagle Mine, LLC
Nonferrous Metallic Mineral Mining Permit (MP 01 2010), Humboldt Mill

Dear Ms. Humphrey:

Eagle Mine, LLC has an approved Mining Permit (MP 01 2010) dated February 9, 2010. General Permit Condition F-2 states, "The permittee shall file with the MMU supervisor a Mining and Reclamation Report on or before March 15 of each year, both during milling operations and post closure monitoring as required by Section 324.63213 and R 425.501. The report shall include a description of the status of mining and reclamation operations, an update of the contingency plan, monitoring results from the preceding calendar year, tonnage totals of material mined, and amount of metallic product by weight."

Please find enclosed, the 2017 Annual Mining and Reclamation Report for the Humboldt Mill.

Should you have any questions about this report, please do not hesitate to contact me at 906-339-7022.

Sincerely,

David Tornberg
Environmental Advisor

Cc: Humboldt Township

enclosure

2017 Annual Mining and Reclamation Report
Humboldt Mill
Mine Permit MP 01 2010

March 15, 2018

Contents

Appendices

Acronyms and Abbreviations

AEM	Advanced Ecological Management
BMPs	best management practices
CN	Canadian National
DO	dissolved oxygen
Eagle	Eagle Mine LLC.
EMT	Emergency Medical Technician
gpm	gallons per minute
HDPE	high-density polyethylene
HTDF	Humboldt Tailings Disposal Facility
KME	King and MacGregor Environmental
MER	Middle Branch Escanaba River
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MG	million gallons
MRR	Mining and Reclamation Report
µg/L	micrograms per liter
mg/L	milligrams per liter
MNFI	Michigan Natural Features Inventory
MSL	mean sea level
NPDES	National Pollution Discharge Elimination System
NREPA	Natural Resources & Environmental Protection Act
NTU	Nephelometric Turbidity Units
ORP	Oxidation Reduction Potential
PEC	Probable Effects Concentration
Q1	Quarter 1
QAL	quaternary unconsolidated formation
SESC	Soil Erosion and Sedimentation Control
SU	standard units
SWPPP	Storm water Pollution Prevention Plan
t	metric ton (tonne)
TDS	total dissolved solids
TEC	Threshold Effects Concentration
UFB	upper fractured bedrock
WBR	Black River
WTP	Water Treatment Plant

1. Document Preparers and Qualifications

This Mining and Reclamation Report (MRR) was prepared by the Eagle Mine-Humboldt Mill Environmental Department and incorporates information prepared by other qualified professionals. Table 1 provides a listing of the individuals and organizations who were responsible for the preparation of this MRR as well as those who contributed information for inclusion in the report.

Table 1. Document Preparation – List of Contributors

Organization	Name	Title
Individuals responsible for the preparation of the report		
Eagle Mine LLC	David Tornberg	Environmental Advisor
Eagle Mine LLC	Amanda Zeidler	HSE & Permitting Manager
Report contributors		
Advanced Ecological Management, LLC.	Doug Workman	Aquatic Scientist
Eagle Mine LLC	Jason Evans	Land & Information Management Specialist
Eagle Mine LLC	Travis Hansen	Senior Metallurgist
Eagle Mine LLC	Mark Ketchem	Operations Supervisor
Eagle Mine LLC	Jennifer Nutini	Senior Environmental Engineer
Eagle Mine LLC	Roger Olson	Water Systems Superintendent
Eagle Mine LLC	Joe Petrocik	Transportation Advisor
Eagle Mine LLC	Alexxa Young	HSE Data Analyst
Eagle Mine LLC	Mackenzy Shega-Fox	Environmental Analyst
Eagle Mine LLC	Bill Scarffe	Mill Superintendent
Eagle Mine LLC	Darby Stacey	Mill Manager
Eagle Mine LLC	Hugo Stanton	Chief Metallurgist
TriMedia Environmental & Engineering	Ryan Whaley	Senior Engineer
King & MacGregor Environmental, Inc.	Matt MacGregor	Wetland Scientist/Biologist

2. Introduction

Eagle Mine officially began the remediation and reconstruction of the Humboldt Mill located in Humboldt Township in October 2008. Processing of ore from the Eagle Mine commenced in September 2014. Due to the commencement of milling operations, Eagle Mine is required per Part 632 to submit an annual Mining and Reclamation Report (MMR) as detailed in R 425.501.

The MRR is required to provide a description of mining and reclamation activities, updated contingency plan, monitoring results, tonnage of material processed, and a list of incident reports that created, or may create a threat to the environment, natural resources, or public health and safety at the Eagle Mine Site. In addition, this MRR will also memorialize the decisions and/or modifications that have been approved throughout the process.

3. Site Modifications and Amendments

One permit amendment was submitted to the Department in 2017. In August, a request for amendment to Condition F4 of MP 01 2010 was submitted to the Department for review. Table 3. below summarizes the submittals that were provided to the Department in 2017 as required under the Part 632 Mining Permit. A copy of the current site map is provided in Appendix A.

Table 3. Submittals Required Under Part 632

Date	Description	Approval
3/14/17	Submitted 2016 Annual Mining and Reclamation Report	N/A
4/28/17	Submitted Q1 groundwater and surface water monitoring data	N/A
8/2/17	Application for amendment to Part 632	
8/7/17	Submitted Q2 groundwater and surface water monitoring data	N/A
9/22/17	Notification of construction of WTP Facilities (i.e. oxidation reactor)	N/A
11/14/17	Submitted Q3 groundwater and surface water monitoring data	N/A
2/8/18	Submitted Q4 groundwater and surface water monitoring data	N/A

4. Processing Activities and Data Report

As of September 23, 2014, the mill was officially operating and producing concentrate. The commencement of milling activities initiated all monitoring programs per the Part 632 Mining Permit. A description of the 2017 monitoring activities can be found in Section 7 of this report.

4.1. Processing Report

In 2017, 754,564 dry metric tonnes (t) of ore was transported from the Eagle Mine to the Humboldt Mill by over the road haul trucks. Table 4.1 below summarizes the dry tonnes of ore crushed and milled and the total volume of nickel and copper concentrate produced in 2017.

Haul Truck on Triple A Road Enroute to the Humboldt Mill

Table 4.1 Volume of Ore Crushed, Milled, and Concentrate Produced in 2017

Month	Ore Crushed (dry tonnes)	Ore Milled (dry tonnes)	Copper Concentrate Produced (dry tonnes)	Nickel Concentrate Produced (dry tonnes)
January	61,800	61,600	5,800	15,800
February	58,600	59,300	6,700	12,800
March	66,200	66,500	4,400	14,800
April	67,100	66,900	4,500	16,700
May	65,000	65,400	6,500	15,000
June	56,700	57,100	3,800	9,500
July	67,700	65,700	4,600	16,000
August	60,200	61,000	3,600	11,300
September	63,000	63,900	4,000	12,500
October	59,100	59,500	3,600	8,300
November	62,100	60,400	3,600	9,300
December	66,500	66,800	3,700	11,600
2017 Annual Total	**753,900**	**754,100**	**54,700**	**153,700**

Source: Mill Operations Year End Reconciled Report - Numbers have been rounded to the nearest hundred tonnes as there are small tonnage adjustments that occur after the final assays and weights come in from the smelter. The final results may not be received for 8-10 months after delivery of the product to the smelter.

In 2017, approximately 54,700 dry tonnes of copper and 153,400 dry tonnes of nickel were shipped offsite via rail. Mineral Range manages rail shipments from the Humboldt Mill to the Ishpeming Rail Yard. From that point Canadian National (CN), and to a lesser extent, Quebec Gatineau Railway transports the material to its final destination.

4.1.1. Tailings

Tailings are the waste material that is generated when processing ore. At the Humboldt Mill, tailings are subaqueously disposed in the Humboldt Tailings Disposal Facility (HTDF) which is an industry best practice to minimize the risk of oxidation of sulfide bearing material. The tailings slurry is comprised of finely ground waste rock, water, and process effluents and is deposited in the HTDF via a double-walled high density polyethylene (HDPE) pipeline. At the shoreline of the HTDF, the pipeline splits and the tailings can be routed to one of the subaqueous outfalls located within the HTDF. In 2017, the middle, northern, and eastern lines (spigot system installed in 2016) were utilized for the sub-aqueous disposal of approximately 285,000,000 gallons of tailings slurry at an average rate of 542 gallons per minute. The use of multiple outfalls allows for better control of the depth of tailings in an area and optimizes the storage volume that is available.

During the winter months, tailings were deposited at the bottom, near the center of the HTDF and from midway along the eastern wall using the spigot system during the summer and fall months. As previously reported, the angle of repose of the settled tailings was higher than anticipated and a small number of peaks are near or will likely be greater than the currently permitted limit of 1420 MSL due to the settling characteristics of the tailings. However, the overall volume of tailings is well below 1420 MSL. Due to the settling characteristics of the tailings, the spigot system was installed in order to better utilize the full capacity of the HTDF and currently discharges tailings approximately 100' below the water surface near the eastern wall of the HTDF. 2017 marked the first full season of use of the spigot system and a large enough volume of tailings was deposited to enable analysis of the pile consolidation and slope angles. This data will be used to fine tune the deposition design in 2018.

Installation of the "Spigot System" for Tailings Disposal

In accordance with permit condition, F-7, an annual bathymetry survey is required to be conducted in order to accurately monitor tailings placement and calculate changes in HTDF water storage. However, in order to better understand the settling characteristics of the tailings, two surveys were completed in 2017. The surveys were conducted in May and September and focused on the entire HTDF as tailings were dispersed to multiple areas in 2017. During the September survey, particular focus was placed on the eastern lines to monitor their performance. Copies of the bathymetry surveys are available in Appendix B.

As stated above, Eagle is currently permitted to subaqueously dispose of tailings in the HTDF to an elevation of 1420 MSL (Condition F-4 of MP 01 2010). On August 2, 2017, an amendment request was submitted to the Department to increase the tailings volume to an elevation of 1515 MSL in order to accommodate the additional ore reserves from the Eagle deposit as well as the Eagle East deposit.

The Metallic Minerals Lease (No. M-00602) requires the lessee to furnish a mill waste reject report on an annual basis. In 2017, 3,285 dry metric tonnes of nickel and 433 dry metric tonnes of copper were deposited in the HTDF as tailings.

5. Site Water Usage, Treatment and Discharge

Three separate water sources supply the facility with either potable or process water which is necessary for operational activities to occur. The site water balance is comprised of process water, precipitation, groundwater infiltration, and storm water runoff all of which is captured in the HTDF and treated by the water treatment plant (WTP) before discharging to a nearby wetland.

5.1. Supply Water Sources and Use

Three separate sources supply water to the mill site to support various operational activities. These sources include the potable well, industrial well, and reclaim water from the HTDF. Utilizing the detailed water use logs maintained on site, the following summary of average water use from each source has been compiled.

The potable well is mainly used to supply potable water to the facility, but may also be utilized to replenish the fire water tank and supplement process water requirements if necessary. In 2017, approximately 0.75 million gallons (MG) of water was drawn from the potable water well which is a decrease from 2016 when 0.84 MG of water was withdrawn. Potable well water usage has decreased by approximately 32% since 2015 when 1.1 MG of water was used.

The industrial well is primarily used to replenish the fire water tank and to supplement process water requirements. In 2017, approximately 4.2 MG of water was utilized from the industrial well. This is an improvement in terms of water use because it was a decrease from the 7.3 MG that was withdrawn in 2016. During the month of August, the industrial well usage dropped to zero as modifications were made to correct the high water usage in centrifugal pump seals, and reclaim water usage in other areas of the mill was reduced, increasing the availability for use in the seal water system. As a result of these changes, the industrial well water was not required to be utilized from September onwards.

The third source of water at the mill site is the reclaim water which is pumped from the HTDF. This water is used throughout the process with the volume that is not consumed being recycled back to the HTDF via tailings. Reclaim water consumption was reduced in mid-2017 in an effort to better manage the HTDF. Where possible, reclaim water usage in the mill has been replaced with internally recycled process water and the volume of water sent to the HTDF has been reduced to match the reduction in reclaim water brought into the mill. In 2017, approximately 237 MG of reclaim water was pumped from the HTDF for use in processing ore. With the exception of approximately 5.7 MG of water that was contained in the concentrate and shipped offsite, the remainder of the water was recycled back to the HTDF for eventual reuse or treatment by the WTP.

5.2. Storm Water Control

A site grading plan was developed with the purpose of keeping all storm water onsite and directing run-off to one of two locations; the HTDF or storm water retention basin. The majority of site grading, paving, and curbing was previously completed to direct water to the series of catch basins that were installed along the length of the main facility from the rail spur to the security building. These catch basins direct storm water from the main mill facility to the HTDF. Water which falls south of the main site access road, is directed to the storm water retention basin via a drainage ditch or series of catch basins in the administrative building parking lot. A copy of the Humboldt Mill Storm Water Drainage map is included in Appendix C.

Storm water control at the Humboldt Mill is managed under a National Pollutant Discharge Elimination System (NPDES) permit (MI00058649) and in accordance with Part I.B of the permit a storm water pollution prevention plan (SWPPP) has been developed. The SWPPP describes the Humboldt Mill site and its operations, identifies potential sources of storm water pollution at the facility, recommends appropriate best management practices (BMPs) or pollution control measures to reduce the discharge of pollutants in storm water runoff, and provides for periodic inspections of pollution control measures. The plan must be reviewed, and updated if necessary, on an annual basis and a written report of the review must be maintained and submitted to the Michigan Department of Environmental Quality (MDEQ) on or before January 10th of each year. The 2017 SWPPP annual review was completed and submitted to the Department on January 8th, 2018. A copy of the plan is available upon request.

5.3. Water Treatment Plant Operations and Discharge

Effluent discharges to the wetland are regulated under the NPDES permit MI0058649 with analytical results and discharge volume reported to the MDEQ monthly through the MiWaters electronic reporting system.

Water Treatment Plant, Ultrafiltration Units

In 2017, approximately 327 million gallons of water was treated and discharged from the water treatment plant to the adjacent wetland. Table 6.3 below summarizes the monthly flow rate from each WTP outfall to the wetland in 2017. The outfall selected for discharge is based on wetland demand and is adjusted as required to maintain pre-operational conditions. This is further explained in Section 5.4 below.

Table 5.3 Volume of Water Discharged from the WTP in 2016

Month	Outfall 001 Volume of Water Discharged (MG)	Outfall 002 Volume of Water Discharged (MG)	Outfall 003 Volume of Water Discharged (MG)
January	0.60	24.3	0
February	0.81	24.7	0
March	0.12	30.0	0
April	0.033	24.8	0
May	0.13	8.4	0
June	0.08	14.7	14.8
July	0	23.6	13.7
August	0	18.4	17.5
September	0	15.2	17.1
October	0	11.8	14.4
November	0	9.9	17.7
December	0	5.8	18.2
Total	**1.7**	**211.6**	**113.4**

Source = WTP Operators log

From August 2014 until the present time, the HTDF was managed by decanting water from the upper layer for both WTP influent and mill process water requirements, while tailings and WTP backwash water were discharged to the deep-water layer of the HTDF. Operating in this manner allowed the deep-water layer and associated transitional boundary (i.e. chemocline) to rise over time. To stabilize and lower the elevation of the chemocline, operational modifications were made in late 2017 and early 2018, which allow for utilization of the deep-water layer as both the mill process water supply and WTP influent. Due to the water chemistry within the deep-water layer, an oxidation reactor (i.e. Fenton's Reaction) is necessary as the initial step of the WTP process. The purpose of the oxidation reactor is for pretreatment of the water prior to membrane treatment. This is accomplished by oxidizing trace levels of hydrogen sulfide and elevated levels of thiosulfate. Thiosulfate forms transition metal complexes making organo-sulfide and hydroxide precipitation difficult. Construction began in Q4 2017 and commissioning and routine use of the reactor is expected in early Q2 2018.

The water treatment process generates one waste stream which derives from the filter press. The filter press waste stream is dewatered solids from the clarifier and is primarily comprised of aluminum, iron, and calcium. Waste characterization samples are required by the landfill prior to acceptance of the material. Samples from the filter press waste stream were sent to ALS Laboratory for analysis and results indicate the waste stream is non-hazardous. In 2017, approximately 148.6 tonnes of filter press waste was disposed at the Marquette County Landfill.

5.4. Water Balance

The main components of the water balance are process water, well water, precipitation, groundwater infiltration, and storm water runoff all of which is captured in the HTDF and treated by the WTP before discharging to a nearby wetland. Permit condition F-2 requires that the site water balance is updated on a quarterly basis to ensure the water level of the HTDF is managed in a manner that minimizes risk to the environment. The target operating water elevation of the HTDF is between 1529.5 and 1530.5 MSL which is significantly lower than originally planned during the permitting process. The lower operating level mitigates risks associated with overflow situations and provides excess capacity to manage various operational situations.

The HTDF water elevation did rise above the target operating level mid-year due to the decision to suspend water treatment discharge while conducting a source investigation related to toxicity results for Ceriodaphnia dubia that were outside of permitted limits. Upon completion of the investigation, the discharge was re-started and the HTDF water level returned to target levels by late summer and remained near target levels throughout the remainder of the year. As stated above, operating at a lower water level than originally planned allows the flexibility to stop discharge when needed to perform maintenance, conduct studies, or investigations when necessary. It is estimated that under current operating conditions, there is sufficient capacity in the HTDF to suspend WTP discharge for approximately eleven months before full capacity would be reached. This is subject to change based on operating conditions or extreme weather events.

Higher levels of industrial well water use seen in 2016 continued until July 2017 when modifications were made to the seal water feeding the centrifugal pumps to reduce the water consumption. From September onwards, the industrial well was no longer required to provide make up water to the fresh water tank as the demand was met by the reclaim water system. In addition to the changes to the seal water system, reclaim water usage throughout the mill was reduced starting in July in an effort to lower the consumption of water from the HTDF and reduce the total volume of tailings produced.

In 2017, Eagle commissioned Barr Engineering to develop an integrated groundwater, surface water, and water balance model to improve estimations of the water balance based on several years of operational data collection. The model strives to estimate the water balance for the HTDF and surrounding watershed for both current watershed conditions and those consistent with pre-existing conditions prior to redevelopment of the Humboldt Mill. One of the outcomes of the effort was the development of a water discharge tool in the modeling program, GoldSim. The GoldSim tool simulates the natural hydrologic cycle that occurred prior to Humboldt Mill operations and installation of the cut-off wall. The tool considers mill processes, current discharge from the WTP, precipitation, snowfall, and other weather factors such as evapotranspiration, temperature, and wind. When updated with current operational and weather information, the model provides a flow rate that the WTP should be discharging to the adjacent wetland system in order to maintain the natural (pre-existing) hydrologic balance as closely as possible. The response of the wetland will be monitored over time to determine if the discharge quantities are appropriate to use as a basis of design for a passively controlled closure discharge structure.

Eagle Mine began utilizing the GoldSim discharge tool in September, and the model and tool will be continually refined as more data and wetland response observations become available. A copy of the Groundwater, Surface Water, and Water Balance Model Development Report is included in Appendix D**.** Copies of the 2017 quarterly water balance diagrams and HTDF water elevation data are included in Appendix E.

Aerial view of WTP and HTDF

6. Materials Handling

6.1. Fuel Handling

The mobile diesel fuel truck, which Eagle began using in 2015, was the only bulk fuel storage source onsite in 2017. The truck is used to fuel mobile equipment and has a storage capacity of approximately 4,000 gallons. The truck is refueled as necessary by an offsite fuel provider.

6.2. Bulk Chemical Handling and Storage

It is the goal of Eagle Mine to create a culture of environmental awareness throughout the workforce. Therefore, all employees and subcontractors are trained to immediately respond and report any spills that occur. In 2017, the Humboldt Mill had zero reportable spills under the Part 5 Rules of Part 31, Water Resources Protection of NREPA, 1994 PA 451 as amended (Spillage of Oil and Polluting Materials).

The Michigan SARA Title III Program requires reporting of onsite chemicals being stored above certain threshold quantities. Due to the volume of chemicals stored/used at the site for processing and water treatment, a Tier II Report was submitted in February 2017 via the online Tier II Reporting System to the State Emergency Response Commission (SERC). Copies of the report were also mailed to the Marquette County Local Emergency Planning Committee (LEPC) and Humboldt Township Fire Department.

7. Monitoring Activities

7.1. Water Quality Monitoring

A significant amount of surface water and groundwater quality monitoring is required both on and surrounding the mill site. The following is a summary of the water quality monitoring activities.

7.1.1. Quarterly Groundwater Quality Monitoring

Groundwater quality is monitored through a network of monitoring wells located inside the perimeter fence line of the mill site. The monitoring wells are classified as either compliance, leachate, facility or monitoring. Compliance wells are located on the north-side of the cut-off wall, outside of the influence of the HTDF; leachate wells are located on south-side of the cut-off wall and generally represent HTDF water quality; facility monitoring wells are located downgradient of each operating facility; the remaining monitoring wells are located north of the cut-off wall, but are not used to confirm effectiveness of the cut-off wall as the compliance and leachate wells are. A map of the well locations can be found in Appendix F. Four rounds of quarterly sampling were completed in February, May, August, and November/December 2017. The Eagle Mine Permit prescribes both a long parameter list for annual monitoring events (conducted in Q3 2017) and a short list to be used quarterly (Q1, Q2, Q4 2017). Samples were collected in accordance with the Eagle Project Quality Assurance Project Plan and Standard Operating Procedures (North Jackson, 2004a and 2004b) and the results are summarized and compared to benchmarks in the tables found in Appendix G.

Two sets of benchmarks were calculated for all mine permit groundwater monitoring locations based on the guidance provided by the Mine Permit and Part 632. It should be noted that due to the required statistical nature of these benchmark values, the accuracy will improve over time as the quantity of data that becomes available increases. In addition, now that three years of data has been collected, the benchmark values will be updated in 2018.

Sampling at Monitoring Location HW-2, February 2017

Monitoring Results

Twenty-four monitoring well samples were collected by TriMedia Environmental & Engineering (TriMedia) during each of the four quarterly sampling events. Samples were collected using low-flow sampling techniques, and field parameters (dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, specific conductivity, temperature, turbidity) are collected and analyzed using a flow-through cell and YSI probe. All samples are shipped overnight to Pace Analytical Services in Grand Rapids, Michigan, for analysis.

The following is a summary of field observations that occurred in 2017:

- Due to turbidity levels that exceeded 3 NTU, twelve of the twenty-four monitoring locations required field filtering for at least one quarter in 2017 and therefore the values are reported as dissolved concentrations. The remaining locations/quarters reported turbidity below 3 NTU and are reported as total concentrations. The sample summary denotes whether the sample values are total or dissolved.
- Four of the monitoring locations (i.e. MW-702 UFB, MW-703 UFB, HW-1L, and HW-1U LLA) are very slow to recharge and are pumped down in advance of sampling in order to ensure that the samples collected are representative of the groundwater at the monitoring location. Locations MW-702, MW-703, and HW-1L take approximately one month to recover while HW-1U takes approximately four months to fully recover due to the tight formation in which it is located. The presence of bentonite has also been observed in close proximity to the screened interval of the monitoring well and may also contribute to the slow recharge rate at HW-1U. Samples from these locations are taken immediately and do not follow low-flow sampling procedures due to the limited volume of water available and slow re-charge rates.

The majority of the metals and anion parameters analyzed reported values below the analytical reporting limit and calculated benchmark, and are listed as non-detect. The cation parameters analyzed were detected at all locations with the majority of the detections below the calculated benchmarks. A summary of wells that have had one or more parameters exceed a benchmark value can be found in Appendix G.

In accordance with Part 632, R426.406 (6) when a result is greater than a benchmark for two consecutive sampling events, at a compliance monitoring location, the permittee is required to notify the MDEQ and determine the potential source or cause resulting in the deviation from the benchmark. Locations classified as monitoring or facility specific have also been included in the summary of 2017 events in addition to compliance locations required to be summarized per Part 632.

- Per the Part 632 Regulation (Rule 7(b)), an action level was reached for pH at locations HW-1L and MW-703 QAL as the pH was lower than the average long-term average by 0.5 units for at least two consecutive sampling events. Table 7.1.1 below lists the benchmarks and 2017 results for locations in which the action level was met. As required, a source investigation was completed to determine the potential source of the deviations. Many of the findings in 2017 were similar to 2016. Results of the investigation are summarized below.

Table 7.1.1 Result Summary of Locations Meeting the pH Action Level

Location	pH Benchmark Range	2017 pH Results (SU)			
		Q1	Q2	Q3	Q4
HW-1L	9.0-10.0	8.4	8.6	8.4	7.7
MW-703 QAL	7.2-8.2	6.3	6.1	6.1	6.1

  - Although the pH results at HW-1L and MW-703 QAL, were outside of their respective benchmark ranges, the results are still generally within the neutral range of the pH scale. Results within this range generally do not pose a threat to the environment.
  - After review of the historic pH results at HW-1L and MW-703 QAL, it was found that the pH values have been consistently lower than the established benchmark value since the first results were reported in 2014.

- Benchmarks for HW-1L and MW-703 QAL are based on only four sample results collected in the months immediately following well installation and therefore may not fully characterize the water quality of the monitoring locations. In addition, the pH readings are within ranges observed at other monitoring locations within the adjacent area.
- No operational activities or changes have occurred within the vicinity of monitoring locations HW-1L and MW-703 QAL. The area in which these wells are located is isolated from operational activities and rarely accessed by site personnel.
- HW-1L is very slow to recharge and take approximately one month to recover. As such, low-flow sampling techniques cannot be utilized and therefore the pH value is based on a single reading that may not accurately characterize the groundwater chemistry at this monitoring location.
- HW-1L is classified as a monitoring well location that is located outside of the cut-off wall and therefore outside the influence of the HTDF. With the exception of sulfate and pH, all other results were found to be within the established benchmarks for the location.
- Monitoring location MW-703 QAL is a compliance monitoring well located outside of the cut-off wall and therefore outside of the influence of the HTDF. With the exception of nitrogen, nitrate and pH all other results were found to be within the established benchmarks for the location. The results from MW-703 QAL were compared to leachate monitoring location MW-702 QAL to determine if there were any correlations. The review found that the pH at leachate location MW-702 QAL tends to be more basic and the major anion and cation results were consistently higher than those reported at MW-703 QAL. The water chemistry between the locations does not indicate that the water quality at MW-703 QAL is being influenced by the HTDF.

Results from the investigation do not clearly indicate a source of the pH deviations at locations HW-1L and MW 703 QAL. During 2017, the pH values at HW-1L were consistent with results reported in 2016 with the exception of the Q4 result which was slightly lower. pH results at MW 703 QAL remained consistent throughout the year. The locations will continue to be closely monitored during quarterly sampling events and results reviewed to determine if a source can be determined.

- HYG-1, located on the north side of the cut-off wall, reported several parameters above calculated benchmarks for at least two consecutive sampling quarters (i.e. manganese, mercury, alkalinity bicarbonate, ammonia, sulfate, calcium, potassium, and sodium and hardness), however to date no parameters have exceeded an action level. HYG-1 is a very shallow well with a total depth of 25 feet and depth to water of approximately 12-14 feet depending on the season. A comparison of monitoring results from leachate wells, MW-701 QAL and MW-702 QAL, to HYG-1 does not indicate a correlation as all results detected at HYG-1 were greater than results detected at the leachate monitoring wells. This indicates that HYG-1 is not being influenced by the HTDF and since no other mining or milling activities are occurring within a close proximity of HYG-1 the elevated results are most likely related to the well being compromised in some way due its age. Results at HYG-1 for all the parameters listed increased in Q4 from levels previously reported in 2017. The location will continue to be closely monitored in 2018.

- Iron, lead, manganese, mercury, and cation concentrations at location HW-1U LLA all decreased during 2017, while anion concentrations, with the exception of alkalinity bicarbonate, fluoride, nitrite, and sulfide showed an increase over the year. As previously stated, HW-1U takes approximately four months to fully recover due to the tight formation in which it is located therefore low-flow sampling techniques cannot be used and results may not accurately characterize the true water quality of the location.

- Manganese, calcium, magnesium, and hardness were outside of benchmark values during all four quarters at monitoring location MW-704 UFB. Manganese trended down throughout the year, magnesium trended up slightly over the year, and calcium and hardness results fluctuated but Q4 results were greater than results reported in Q1. Results from this compliance monitoring location were compared to the leachate monitoring location MW-701 UFB and a distinct difference was found between the monitoring locations. This indicates that the location is not being influenced by the HTDF.

- The majority of the rest of the monitoring locations reported results that were just outside of the calculated benchmark values. The benchmarks are based on a small sample set of three to five results, most of which were collected in 2014 during monthly sampling events that occurred after well construction was completed. As such, the majority of the benchmarks do not currently take into account seasonal variation or natural variability that may occur after well installation. In many cases, the benchmark is set at the default of four times the reporting limit due to all non-detect results. As previously stated, benchmark values will be updated during 2018. All locations will continue to be closely monitored and benchmarks updated as more data becomes available.

A Mann-Kendall trend analysis was conducted for all groundwater locations. A parameter was considered to be trending if analysis determined a minimum confidence of 95%. Possible trends, either positive or negative, were identified for one or more parameters at seven compliance locations, three leachate monitoring wells, and twelve monitoring locations (includes facility monitoring locations), using data collected from baseline sampling events (i.e. 2014) through December 2017. Sulfate, pH, chloride, and hardness were the most frequently noted as possibly trending. Results for trending parameters from locations near the cut-off wall classified as either monitoring or compliance were compared to leachate locations to determine if any apparent correlations existed that would indicate the locations were being influenced by the HTDF. Locations HW-1L, HW-1U LLA, MW-704 QAL, MW-704 UFB, MW-705 UFB, and HW-8U were compared to leachate monitoring wells MW-701 QAL and UFB. Although the results for a couple of the parameters (i.e. sulfate and magnesium) were similar between leachate and compliance/monitoring wells there was not a correlation between all trending parameters at each specific location indicating that the locations are likely not being influenced by the HTDF.

Monitoring location MW-706 QAL reported a positive trend for chloride. This location is located just southeast of the COSA and the chloride results are likely the result of the sand/salt mixture that is applied to the asphalt near the COSA exit for ice melt and traction for the over the road haul trucks exiting the building. MW-706 QAL is located directly downgradient of this activity and although caution is taken in the management of snow and water in this area, it is highly possible that the location is still be influenced by the sand/salt mixture that is being applied to the area. It should be noted that due to the small sample size, the current trending results should all be considered preliminary.

A trend analysis will continue to be conducted after each quarterly monitoring event in 2018 and results reviewed to determine if the trends are attributable to milling operations. A table summarizing the potential groundwater trends can be found in Appendix H. For compliance and monitoring locations in which results were outside of established benchmarks for at least two consecutive quarters and a potential trend was identified, the trend charts are also provided in Appendix H.

7.1.2. Quarterly Surface Water Quality Monitoring

Surface water sampling was conducted on a quarterly basis in 2017 at eight surface water locations by TriMedia. Four locations are associated with surface water resources in the subwatershed containing the HTDF and four are associated with the subwatershed of the milling facility. The samples collected represent winter base flow, spring snowmelt/runoff, summer base flow, and the fall rain season. Samples were collected in February (Q1), May (Q2), August (Q3), and November/December (Q4) in 2017. A map of the surface water sampling locations is found in Appendix I. Samples are collected in accordance with the Eagle Project Quality Assurance Project Plan and Standard Operating Procedures (North Jackson, 2004a and 2004b) and the results are summarized and compared to benchmarks (i.e. upper prediction limit) and are located in the tables found in Appendix J.

Similar to the groundwater benchmarks discussed in section 7.1.1, two sets of benchmarks were calculated for all mine permit surface water monitoring locations based on the guidance provided by the Mine Permit and Part 632. MP 01 2010 L2 also requires that seasonal variation be accounted for when calculating surface water benchmarks. To date, a large enough sample set has not been collected during each of the four seasons and therefore are not incorporated into the current benchmarks. Similar to the groundwater benchmark values, now that three years of data has been collected, the surface water benchmarks will be recalculated in 2018 and will take into account seasonal variation as required by MP 01 2010 L2. Until the update is complete, the benchmarks are based on baseline data collected in February, May, July, and October 2008, and May, July, and September 2014.

Escanaba River Monitoring Location MER-002

Monitoring Results

Grab samples were collected from designated surface water monitoring locations during the quarterly sampling events completed in February, May, August, and November/December in 2017. Samples were unable to be collected from monitoring location HMP-009 in Q1 and Q2 due to the lack of water, and due to a sampling error was missed in Q3. Similarly, HMWQ-004 also was unable to be sampled during any of the 2017 quarterly sampling events due to lack of water.

- HMP-009 is located within the wetland just north of the WTP that is strongly influenced by WTP discharge. As explained above, water samples were unable to be collected in Q1 and Q2 due to a lack of water. The WTP did not utilize this discharge location during the winter and early spring seasons as it is not necessary to sustain the wetland. Water was present in Q4, but due to freezing conditions was very limited and exhibited higher than normal suspended solids. Due to these factors, the data likely does not represent the true water quality of that location.
- HMWQ-004 is located in an area in which the only contributions are related to precipitation and storm water run-off from the adjacent roadway, therefore sampling from this location is dependent upon precipitation. There was insufficient water to collect samples from this location in 2017.

The Humboldt Mill Surface Water and Sediment Monitoring Plan prescribes a long parameter list that is collected annually and a short list to be used quarterly In addition to the grab samples, field measurements (DO, pH, specific conductivity, temperature) were collected and determined through the use of an YSI probe. Flow measurements were obtained, where conditions allowed, using a wading rod and current meter. Flow rates for location MER-002 were recorded from the USGS website for the station located adjacent to the monitoring location (i.e. 04057800 Middle Branch Escanaba River Humboldt Mill location). Water quality samples were shipped overnight to Pace Analytical Services in Grand Rapids, Michigan, for analysis. Parameters requiring low-level analysis were sent to the White Water Associates Laboratory in Amasa, MI.

Following is a summary of the 2017 events that occurred.

- At HMP-009, twenty-one parameters were found to be outside of their respective benchmark values during the annual sampling event completed in Q4. As stated above, the data does not likely represent the water quality of the area because the sample was collected during freezing conditions when there was very little water in the area to sample. pH, chloride, sulfate, and sodium all increased slightly compared to the previous year, and the remainder of the parameters increased dramatically. This indicates that the dissolved and suspended solids present in the sample markedly effected the results.
- Monitoring location WBR-002 reported results for lead and nickel that were greater than established benchmarks for at least two consecutive sampling quarters. Results for lead trended up but were still significantly lower than lead levels reported at the Black River reference monitoring location, WBR-001, indicating lead is present throughout the river system. Nickel trended down in Q3 and Q4 and was also present at the reference location though at lower concentrations.

- pH was reported to be outside of the calculated benchmarks at compliance locations WBR-002, and WBR-003 for at least two consecutive sampling quarters in 2017. pH results at these locations, as well as all other river monitoring locations, experienced a slight rise in pH in Q3 and returned to benchmark or near benchmark levels in Q4. The Black River reference location (WBR-001) historically has experienced pH results within, or close to the benchmark value of 5.0-6.0 SU. The downstream compliance locations showed similar results of approximately 6.0 SU during the Q4 sampling event.

It is very likely that a number of the benchmark deviations that were reported in 2017 are not actually deviations from natural conditions. As reported above, the benchmarks were calculated using all baseline data available and do not take into account seasonal variation at this time. A large enough sample set was not available to complete the statistical analysis for each of the four seasons and therefore the benchmarks should be considered estimated values. Similar to the groundwater benchmark values, now that three years of data has been collected, the surface water benchmarks will be recalculated in 2018 and will take into account seasonal variation as required by MP 01 2010 L2.

See Appendix J for a complete summary of surface water results and applicable benchmarks.

A Mann-Kendall trend analysis was also conducted for the surface water monitoring locations in 2017. The trend analysis does not currently take into account seasonal variations, but will be modified once sufficient data has been collected to complete the analysis. Possible trends, positive or negative, were identified for one or more parameters at one compliance and one reference monitoring location using data collected from baseline sampling events (May 2014) through December 2017 and are summarized in Appendix K. A parameter was considered to be trending if analysis determined a minimum confidence of 95%. Based on this premise, nickel was identified as trending at WBR-002 and calcium, chloride, magnesium, and sodium at reference monitoring location WBR-001. The nickel results at compliance location WBR-002 appear to contain some seasonal variation with the lowest results historically reported during the late summer base flow and highest readings during fall rain runoff periods. Once more results are obtained and seasonal variation is able to be included in the trend analysis a more accurate picture of the potential trends at this location will be available.

A trend analysis will continue to be conducted after each quarterly monitoring event in 2018 and results reviewed to determine if the trends are attributable to milling operations. For compliance monitoring locations in which results were outside of established benchmarks for at least two consecutive quarters and a potential trend was identified, the 2017 trend charts are also provided in Appendix K.

7.2. Sediment Sampling

Sediment sampling was not conducted in 2017. The next sediment sampling event will occur in 2018 as required.

7.3. Regional Hydrologic Monitoring

7.3.1. Continuous Groundwater Elevations

Monitoring wells MW-701, MW-702, MW-703, MW-704, MW-705, HYG-1, HW-2, HW-1U, HW-1L, HW-8U are instrumented with continuous water level meters and downloaded quarterly by TriMedia field technicians. Permit condition F-9 requires that water levels are continuously monitored in Wetland EE and the HTDF. HTDF water level readings were recorded using a stilling well containing a pressure transducer which was installed in the HTDF to collect continuous water level measurements. To ensure accurate readings in the winter, an "ice eater" was installed to prevent the water surrounding the stilling well from freezing. A map of monitoring locations can be found in Appendix F.

Special Condition F-9a requires continuous monitoring of water levels on each side of the cutoff wall and a comparison of the gradient changes actually measured versus earlier predictions. As previously reported, the operating level of the HTDF was lowered from what was originally planned resulting in the HTDF water elevation being lower than the wetland elevation located outside of the cut-off wall. Therefore, the predicted gradient measurements originally calculated with a high HTDF elevation can no longer be used as measurement of effectiveness of the cutoff wall. In addition, the water elevation cannot be compared in the reverse direction due to outside influences on the water levels in the wetland. If at any time during operations the water level rises to levels above the elevation of the downstream wetland, gradient changes will again be measured and discussed.

Continuous groundwater elevation results are reported by water year (October 1 – September 30). Water year is the preferred approach for reporting water levels, because the hydrographs demonstrate the effect of late fall and winter precipitation, which melts and drains in spring, in one 12-month hydrologic cycle. Copies of groundwater hydrographs are located in Appendix L. A review of the hydrographs found the following:

- The hydrographs clearly illustrate when the wells are pumped down in advance of, or during, sampling and the rate in which they recharge.
- Equipment malfunctions which resulted in data gaps of continuous water level data occurred at several locations over the course of the year. All water level meters were replaced as soon as possible after discovery of the malfunction. Table 7.3.1 summarizes the locations, duration, and potential cause of equipment malfunctions:

Table 7.3.1 Summary of Continuous Monitoring Equipment Malfunctions

Location(s)	Date Equipment Malfunction Occurred	Reason for Malfunction
HW-1U LLA, HW-2, MW-701 UFB, MW-704 LLA	Oct. 2016	Water entered the unit causing circuitry damage
MW-702 UFB	Sept. 2017 -Nov. 2017	Unknown
MW-703 QAL	1/17/17 – 3/13/17	Internal clock failure
MW-704 DBA	Mid-April 2017 to Q1 2018	Unknown

- HW-1L, HW-1U LLA, MW-702 UFB, and MW-703 UFB are located in a tight formation and are very slow to recharge. MW-702 UFB, and MW-703 UFB took approximately one month to recharge and HW-1L and HW-1U LLA took almost four months to fully recharge. The slow recharge rates are an indication that the integrity of the cut-off wall is intact. If the cut-off wall was compromised one would expect to see the wells recharge more quickly.
- As expected, HTDF surface water elevations were consistently lower than water elevations for monitoring wells located on the opposite side of the cut-off wall. The exceptions are HW-1L, HW-1U LLA and HW-1U UFB. These wells are located in a tight formation and HW-1L and HW-1U LLA are very slow to recharge.
- Similar to previous years, most of the shallower, quaternary aquifer wells displayed signs of seasonal influence as groundwater elevations decreased during the winter months and increased again in during the onset of spring melt.

7.3.2. Continuous Surface Water Monitoring

In accordance with permit condition F-9, Wetland EE is required to be instrumented with a meter to continuously monitor water levels. However, due to the construction of the cut-off wall, recharge is now primarily based on WTP discharge and precipitation (i.e. rain and snow melt). With the onset of WTP discharge into Wetland EE in the fall of 2015, the water levels in Wetland EE are a function of operational decisions and only minimally impacted by natural conditions (i.e. precipitation). The purpose of the continuous water level measurements is to monitor the effectiveness of the cut-off wall and record seasonal variations. Due to the operational influence of the WTP discharge, the monitoring objective can no longer be met and therefore continuous readings are not being collected. However, surface water grab samples and field parameters will be collected quarterly when possible although results will be strongly influenced by effluent discharge water quality.

7.4. Cut-Off Wall Water Quality Review

In accordance with permit condition F-9, Eagle is required to monitor the effectiveness of the cut-off wall in terms of hydraulic containment. This is best accomplished by review of water levels and chemical signatures between the leachate (i.e. MW-701 and MW-702) and compliance monitoring wells (MW-703, MW-704). Focus of the review is on water levels in the quaternary unconsolidated formation (QAL) and chemical signature in the upper fractured bedrock zone (UFB).

Leachate wells are located on the south side of the containment wall (HTDF side) and should show similar water levels and chemical signatures of the HTDF. The compliance wells are downgradient of the leachate wells and are located on the north side of the containment wall and should be outside the influence of the HTDF. Results from leachate monitoring location MW-701 are compared to compliance location MW-704 and results from leachate monitoring location MW-702 are compared to compliance location MW-703.

Chemical Signature Review

- The majority of the metals and anion parameters were consistently non-detect at both the compliance and leachate monitoring locations, therefore, chemical signature comparisons were focused on iron, manganese, mercury, chloride, sulfate, and cation parameters as these were the most frequently detected.

- In the quaternary unconsolidated formation, the iron, manganese, and mercury results were all significantly higher at compliance location MW-704 than were reported at leachate well MW-701. Iron was also higher in MW-704 in the upper fracture bedrock zone, while manganese was more than two times greater in MW-701 than MW-704. Sulfate, chloride and most cations were also found to be higher in MW-704 than leachate well MW-701. pH results at all of the locations were consistent with their respective benchmark values; each of which is distinctly different from the other. These results indicate there is a distinct difference between the leachate and compliance locations. If the containment wall was compromised, the results at the MW-701 and MW-704 would be similar.
- At leachate location MW-702 QAL pH, mercury, alkalinity bicarbonate, calcium, sodium, sulfate, and hardness were greater than results reported at compliance location MW-703 QAL. These results indicate that the containment wall is functioning as expected as the results would otherwise be closer in comparison.
- Similar to 2016, iron, manganese, and sulfate were greater at compliance location MW-703 UFB than compared to leachate monitoring location MW-702 UFB. Again, the differences between the leachate and compliance wells show that the containment wall has not been compromised as results would be similar if it was not functioning properly.

<u>Water Level Review</u>

- There is a distinct difference in groundwater elevations between MW-702 QAL and MW-703 QAL. As expected, due to the operating level of the HTDF, compliance monitoring location MW-703 QAL, has an average groundwater elevation that is approximately five feet higher in elevation than leachate well MW-702 QAL. The groundwater elevation at MW-702 QAL continues to closely mimic the groundwater elevation of the HTDF.
- As predicted due to the operating level of the HTDF, compliance monitoring location MW-703 UFB has a groundwater elevation that is slightly greater than leachate well MW-702 UFB. Groundwater elevations at MW-702 UFB continue to trend closely with HTDF water levels.
- The groundwater elevations at compliance monitoring locations MW-704 QAL and UFB are approximately three feet higher than those reported at leachate monitoring locations MW-701 QAL and UFB. As expected, the water elevations recorded at MW-701 are closer to elevations reported in the HTDF. The distinct separation between the leachate and compliance monitoring wells show that the containment wall has not been compromised as groundwater elevations would be similar if it was not functioning properly.

Based on the review of the chemical signature and groundwater elevations of the leachate and compliance monitoring wells there is sufficient evidence to show that the cut-off wall is functioning as expected. The variability in the detected parameters, difference in reported results, and groundwater elevations all demonstrate that the effectiveness and integrity of the containment wall are intact.

7.5. Biological Monitoring

Biological monitoring events conducted in 2017 included surveys of birds, large and small mammals, frogs, toads, fish and macro invertebrates. Results from each survey have been compiled into annual reports which are available upon request. A brief summary of each survey is provided below.

7.5.1. Flora and Fauna Report

The 2017 flora, fauna, and wetland vegetation surveys were conducted by King & MacGregor Environmental, Inc. (KME). Table 7.5.1 below outlines the type and duration of the surveys that were conducted in 2017. A map of the survey locations can be found in Appendix M.

Table 7.5.1 Type and Duration of 2015 Ecological Investigation

Survey Type	Survey Date
Birds	June 7-8, September 18-19
Small Mammals	September 27-29
Large Mammals	May - September
Toads/Frogs	May 3, June 6 & 26
Threatened and Endangered Species	May - September

The wildlife and plant species identified during the 2017 surveys within the Study Area are similar to those identified during previous KME surveys. Following is a summary of the survey results:

- A combined total of 688 birds representing 54 species were observed during the 2017 (June and September) surveys. In June, the Canada Goose, American Robin and white-throated sparrow were the most abundant birds observed, while the Canada goose, American crow and Black-capped Chickadee was the most abundant species observed during the September 2016 survey. There was approximately twice as many Canada geese observed in 2017 than the previous year as it had the highest relative abundance out of any species (19.9%)., There was an overall increase in count by 210 individuals from the 2016 survey to 2017. This is due to the increased numbers of most species observed compare to the previous year, with Canada Geese, American Robin and American crows having the highest increase in total individuals. The number of birds observed can be influenced by weather conditions including temperature, wind speed, etc., and therefore variations are expected to occur between survey events. The bird species identified are similar to those bird species identified in previous surveys conducted within the Study Area and are consistent with the bird species expected to be found in the habitats present.
- Thirty-two small mammals representing nine species were collected during the September survey period. The total number of individuals captured in 2017 was the same as 2016, although total species richness increased by 1with the most common small mammal identified during the survey being the southern redback vole. No threatened, endangered, or special concern small mammals were observed during any of the surveys. The small mammals encountered within the Study Areas during the 2017 surveys are typical of those expected in the habitats present and are consistent with previous survey results.
- Whitetail deer tracks were observed throughout the study area and the scat of coyote, American black bear, and grey wolf was also observed in September 2017. The large mammal

species detected during the 2017 surveys are regionally common large mammal species and are expected to utilize the habitats present.

- Four frog species were observed during the survey; none of which are threatened or endangered. Breeding frog calls were observed at all five sampling points with the exception of Survey Point 2 in the spring and Survey Point 1 in the summer. The most frequently heard species during the surveys in 2017 was the northern spring peeper. Similar to last year's study, elevated noise levels related to operations were noted at survey points 2 and 3, potentially diminishing the observer's ability to hear and distinguish calls. All of the frog species identified are typical of those expected in the habitats present in the Study Area.

7.5.2. Threatened and Endangered Species

The Michigan Natural Features Inventory (MNFI) maintains a database of rare plants and animals in Michigan. KME requested a Rare Species Review to determine if any protected species had been found within 1.5 miles of the Study Area. Table 8.5.2 lists the species identified during the MNFI review process.

Table 7.5.2 MNFI Review Results of Study Area

Species	Classification
Canada rice grass	State threatened species
American bittern	State special concern species
Bald eagle	State special concern species
osprey	State special concern species
Great blue heron rookery	Rare natural feature

In accordance with Michigan Department of Natural Resources (MDNR) guidelines (MDNR 2001), KME surveyed for any MNFI listed species and their habitats during the appropriate season. Following are the results of the threatened and endangered species survey:

- Canada grass was not observed in 2017 and is not expected to occur in the study area due to the lack of suitable habitat.
- American bittern was observed near Survey Point 5 in 2017.
- In June 2017, the bald eagle nest on the north shore of Lake Lory was occupied by two adults and at least one juvenile.
- Although suitable habitat for osprey is present in the study area, no birds were directly observed in 2014, 2015, 2016, or 2017.
- In May and June 2017, 16 of 17 nests were identified as active in the heron rookery. The great blue heron rookery appears to be robust and unaffected by the presence of the mill.

A copy of the 2017 Humboldt Mill flora and fauna report is available upon request.

7.5.3. Fisheries and Macro Invertebrate Report

The 2017 Fisheries and Macro-Invertebrate annual surveys were conducted by Advanced Ecological Management (AEM). A total of six stations were surveyed in June 2016, including two stations on the

Middle Branch of the Escanaba River (MBER), one station on a tributary of the Middle Branch of the Escanaba, one station on an unnamed tributary of the Black River (WBR), one station in Wetland Complex EE located northeast of the HTDF, and Lake Lory. A map of the survey locations can be found in Appendix N.

Stream Stations

A total of 61 fish representing 13 species were collected in 2017 from all stream stations, up from 51 fish in 2016. Station 1 and MBER 1 are located upstream of the mill and outside of potential impact from operations and Station 5 and MBER 2 are located downstream of milling operations. The most notable change observed in 2017 was that only one slimy sculpin (Cottus cognatus) was captured whereas thirteen were observed in 2016. The Central mudminnow was the most frequently collected species (16) followed by the pearl dace (15). No threatened, endangered, or special concern fish species were observed at any of the stream stations in 2017. The following is a summary of the findings:

- The community composition of fish species was generally consistent over the past four years.
- A beaver dam located near Station 1 that has been observed since 2014, continues to influence the hydrology and potentially the number of fish collected during the surveys at that location.
- Historically, very few fish are observed at Station 5, however, the number has risen over the past three years. Fourteen fish were collected in 2017 which included twelve Central mudminnows and two brook trout. Six Central mudminnows and zero brook trout were collected in 2016.
- Twenty fish were collected between MBER1 & 2. Fish totals between these locations are typically 20 fish or less with the exception of 2007 when 50 fish were collected. Similar to 2016, Northern pike was the most frequently observed species at MBER1 while the Common shiner was the most noted at MBER2. The surveys conducted to date have determined that the segments of stream associated with these locations are not productive fisheries.

Using the P-51 protocol, a total of 697 macro-invertebrates, representing 38 taxa, were collected from all four stream stations investigated in 2017. The total number of macro-invertebrates collected in 2017 decreased by only 14 specimens compared to the total number collected in 2016. The largest deviation was at Station 5 where 76 fewer specimens were collected in 2017 compared to 2016. Although fewer macroinvertebrates were collected from the stream stations in 2017, the community composition has remained generally consistent between years. No threatened, endangered, or special concern macroinvertebrate species were observed at any of the stream stations in 2017.

A summary of the fish, macroinvertebrate, and habitat ratings for the four stream stations are displayed in Table 7.5.3 below. Stream habitat was considered “excellent” in stations MBER1 and MBER2 and “good” at station 1 and 5. Because the fish community of Station 5 was comprised of trout greater than a total of 1% of the fish community composition, as indicated in the P-51 protocol, the P-51 fish community scores were not applicable and were not determined for this station. The fish community was rated as “poor” at this location in 2016. The macroinvertebrate community rating at Station 1 changed from “acceptable” in 2016 to “poor” in 2017 due to the reduction in the total number of taxa collected during the aquatic survey. Station 1 has exhibited annual variations in macroinvertebrates in both number and taxa since the study began.

Table 7.5.3 2017 Habitat Ratings

	Station 1	Station 5	Station MBER1	Station MBER2
Fish Community	Poor	N/A	Poor	Poor
Macroinvertebrate Community	Poor	Acceptable	Acceptable	Acceptable
Stream Habitat	Good	Good	Excellent	Excellent

Lake Lory

A total of 152 fish representing thirteen taxa were collected from Lake Lory in 2017 which is less than the 169 fish that were captured in 2016. Historically, the community composition has been generally consistent at this location. In 2017, Bluegills (Lepomis macrochirus) and largemouth bass (Micropterus salmoides) were the most frequently collected species followed by yellow perch (Perca flavescens). Many of the fish observed in Lake Lory appear to be in good condition, however black spot which is caused by a natural parasite (larval trematode) that burrows into the skin of the fish was observed in several species. Review of the Michigan Department of Natural Resources website found that black spot is a common disease in earthen bottom ponds and lakes.

Aquatic macroinvertebrate sampling was conducted on June 22, 2017 within Lake Lory where a total of 174 macroinvertebrates were collected which is 38 fewer than the total 212 macroinvertebrates that were collected in 2016. Snails, true flies, and dragonflies were the most abundant macroinvertebrates within Lake Lory, and the 2017 community composition was generally consistent with the 2015 and 2016 macroinvertebrate communities. No threatened, endangered, or special concern macroinvertebrate species were observed in Lake Lory.

Wetland EE

Zero fish were collected from Wetland EE during the 2017 aquatic survey. In 2016, one juvenile brook stickleback (Culaea inconstans) was collected from this location and no fish were collected during the 2015 aquatic survey.

Aquatic macroinvertebrate sampling was conducted on June 23, 2017, where a total of 96 macroinvertebrates were collected. A total of 68 macroinvertebrates were Chironomids (true flies known as midges) and 10 aquatic snails comprised most of the species collected. Predaceous diving beetles (Dytiscidae) and true bugs were also collected during the 2017 aquatic survey. A total of 38 macroinvertebrates were collected during the 2016 aquatic survey, where predaceous diving beetles and true flies were the most frequently observed macroinvertebrates. No threatened, endangered, or special concern macroinvertebrate species were observed in Wetland Complex EE. The 2017 aquatic vegetation density appeared to be greater than has been observed by AEM in previous surveys. Cattails have grown in most of the areas of Wetland Complex EE that were previously open water. A copy of the 2017 Humboldt Mill Aquatic Survey Report is available upon request.


Aquatic Survey, Electroshocking on Escanaba River

7.5.4. Fish Tissue Survey

Similar to the baseline fish tissue survey completed in 2014, two lakes were selected for the 2017 survey; Lake Lory which is located within the vicinity of the Humboldt Mill and Squaw Lake which was selected as the reference lake outside of the influence of the Mill. Smallmouth bass collections for metals analyses were conducted in accordance with the MDEQ Nonferrous Metallic Mineral Mining Permit Number: MP O1 2007, following the GLEAS *Procedure #31 Fish Collection and Processing Procedure* (MDEQ, 1997).

Ten smallmouth bass were collected from both Lake Lory and Squaw Lake for metals analyses on June 20, 2017. Five out of ten smallmouth bass in Lake Lory were males and nine out of ten smallmouth bass in Squaw Lake were males. Both the fish fillets and livers were analyzed for metal content. Among all metal parameters measured in smallmouth bass fillets, the average metals content for arsenic, iron, manganese, selenium, strontium, and zinc were slightly higher in the Lake Lory fish than the ones observed in Squaw Lake. Average nickel content of smallmouth bass livers from Lake Lory were lower than was observed in Squaw Lake smallmouth bass, and all other metals were higher in Lake Lory than were observed in Squaw Lake smallmouth bass.

Overall, metals concentrations increased from 2014 to 2017 at both Lake Lory (located within project influence) and reference lake Squaw Lake (located outside project influence), indicating a regional increase in metals concentration and not the result of Eagle operational activities.

A table summarizing the metal results can be found in the 2017 Humboldt Mill Smallmouth Bass Metals Report which is available upon request. The next survey will be conducted in 2020.

7.6. Miscellaneous Monitoring

7.6.1. Soil Erosion Control Measures

Soil erosion and sedimentation control (SESC) measures related to the construction of mining facilities now falls under the purview of Part 632. No new SESC measures were required to be implemented in 2017, however, although no work is currently being conducted, silt fence remains along the HTDF where additional work on the cut-off wall is scheduled to occur in the future. The Department will be notified in the event that any construction activities occur in which soil erosion measures are necessary and all inspections will be completed as required.

7.6.2. Impermeable Surface Inspections

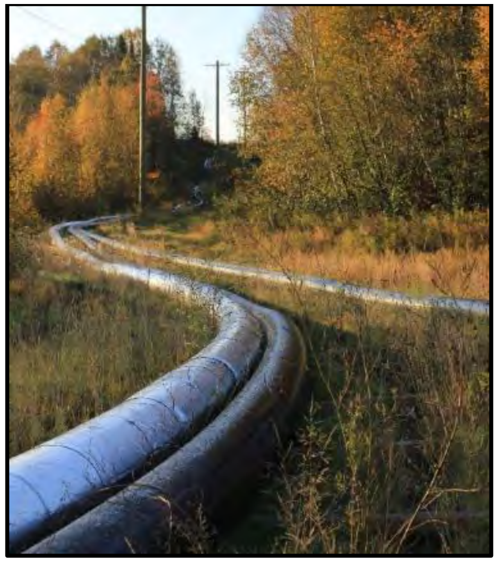
The Impermeable Surface Inspection and Surface Repair Plan outlines the requirements of integrity monitoring of surfaces exposed to site storm water and areas of ore, concentrate and chemical handling/storage. Areas inspected in 2017 included sumps and floors of the coarse ore storage area, concentrator building, concentrate load out facility, and WTP. Monitoring was conducted monthly as required by the plan.

Floors are inspected for cracks and overall general condition and the sumps are evaluated for any areas of cracking, pitting, or other surface deficiencies, and accumulation of material. All inspection results are recorded on the impermeable surface inspection form by Environmental Department staff and stored in the compliance binder at the Mill Services Building. Any issues identified during the inspections are immediately reported and fixed by onsite staff. Follow-up inspections are completed to ensure the repairs were made. Other than minor, superficial cracks within the Concentrator building, no notable issues were identified in 2017

7.6.3. Tailings Line Inspection

In accordance with Mining Permit Condition E-12, the double-walled HDPE pipeline is monitored by mill operators and Environmental Department staff. Any concerns identified during the inspections would be immediately reported to the Mill operations and maintenance departments who would complete any necessary repairs. The following items were identified in 2017:

- Weekly inspections of the tailings lines found that in cold weather months minor amounts of water was introduced into the sump located in the shore vault building. This likely results from condensation which builds up within the outer pipe and not the result of a leak in the tailings lines.
- On June 16, 2017 a leak on the inner tailings line occurred due to a plug at the discharge end of the pipe. Tailings slurry backed up in the line and pressure built up causing a seam on the welded HDPE pipe to open. The system functioned as designed as the outer pipe contained the slurry which then gravity drained to the shore vault building. The operating crew on shift during the incident closely monitored the pressure of the line and witnessed the slurry drain to the shore vault via a security camera mounted in the structure. The plugged line was taken out of commission and an alternate line was used while maintenance of the other line commenced. The tailings which were deposited into the shore vault building was removed using a vacuum truck and reintroduced into the milling/tailings disposal process.



Tailings lines, extending from Mill to HTDF

7.6.4. Geochemistry Program

In accordance with Permit Condition F-1, Eagle continued implementation of the comprehensive HTDF geochemistry monitoring program which was prepared by Hatch Associates in 2015. In 2017, the monitoring program was used to further understand the relationship between surface water quality and deep-water (tailings slurry-related) chemistry, as well as changes in layer properties such as thickness, density, temperature, salinity, and conductivity. Results from monitoring programs, studies, and observations were used to update and further refine the geochemical model of the HTDF.

The following HTDF monitoring events occurred in 2017:

Sample Date	Profile of Physiochemical Parameters	Profile of Water Chemistry
February 20, 2017	X	
April 26, 2017	X	
May 11, 2017	X	
July 20, 2017	X	X
September 28, 2017	CTD	
October 6, 2017	CTD	
October 12, 2017	CTD	
October 18, 2017	CTD	
October 25, 2017	CTD	

Profiling of physiochemical parameters provides finer detail about the dynamics of layers within the HTDF including movement of the chemocline and potential seasonal mixing of the upper water column. Until September 2017, *in situ* physiochemical profiles were collected using a multiparameter probe lowered over the side of a boat to multiple depths. Measured parameters included temperature (°C), pH, electrical conductivity (µS/cm), dissolved oxygen (mg/L), and oxidation-reduction potential (mV). Beginning in September 2017, a YSI Castaway conductivity-temperature-depth (CTD) probe was used to measure high-resolution temperature (°C), electrical conductivity (µS/cm), and water density (kg/m^3) profiles. This device free-falls through the water column and samples at 5 times per second, to produce continuous profiles of the entire water column.

Water chemistry profile samples were collected on July 20, 2017 from one location within the HTDF at multiple depths. All water samples collected were sent to a certified lab for analysis.

HTDF sampling, July 2017

Additional monitoring included the inputs and outputs of the HTDF water balance (e.g. precipitation, tailings, process water, WTP discharge, etc.), ambient temperature, wind speed, groundwater monitoring, influent/effluent WTP chemistry, and HTDF bathymetry. In addition, sulfur speciation, biomass, and tailings composition studies were also conducted and are described in further detail below.

During the summer of 2017, a specially-designed sampling program was conducted to understand the sulfur species present in the HTDF. The concentration and mass of dissolved solids and thiosulfate were studied to determine the potential for entrainment of these species within the treated water influent stream, and what the required water treatment upgrades should be to manage these species during operations and closure. As a result of these studies, Eagle designed and began installation of an oxidation reactor to remove thiosulfate and oxygen demand, and planned for upgrades to its reverse osmosis capacity to manage dissolved solids loading to ensure compliance with the NPDES permit conditions. This work was done in conjunction with a request for a modified NPDES permit with an allowance to discharge water to the nearby Middle Branch of the Escanaba River.

Late in 2017, Eagle commissioned a specialty laboratory to conduct biomass sampling of the HTDF for characterization of the microbiological communities in various layers of the HTDF. The laboratory was selected for their specialty in conducting DNA sequencing of these bacteria to determine the speciation, abundance, and biochemical reactions that the microbiota may contribute based on the layer chemistry. Results of this laboratory work will be complete in the first half of 2018, with the eventual goal of understanding how to best activate or otherwise manipulate existing bacterial communities to produce reactions that may be helpful for in situ water treatment.

Eagle continued to monitor the tailings composition as has been done previously. Tailings slurry water is quite variable based on ore blend. Geochemical models were updated to further refine the predicted changes in water quality during operations and in closure, which was used to facilitate planning for near- and long-term water treatment solutions. The geochemical modeling in 2017 focused extra attention on refining the model to match the layer dynamics which were being observed through physiochemical profiling. In short, the current conceptual model that represents the actual limnological and geochemical behavior of the HTDF shows that the layers are not fixed and the chemocline would migrate upward due to tailings slurry injection simultaneous with surface water decanting. This model was described in a report previously submitted to MDEQ in a response to questions on Eagle's Part 632 amendment request to condition F.4. of MP 01 2010.

Further modeling attention was placed on using the updated conceptual model to determine likely closure scenarios for water treatment, so that long-term water treatment decisions could be made in appropriate timeframes. In summary, the model now more accurately predicts geochemical conditions that are occurring in the HTDF. Therefore, the model can be relied upon to predict and/or test future conditions, allowing for conservative assumptions and timeframes. The pertinent outcomes of the model are that the observed changes in shallow water chemistry are not driven by leakage from the chemocline or deep layer due to strong density contrasts preventing this from occurring. This means that a chemocline can be created at a desired elevation, and incorporated with strategic placement of tailings bathymetry, to produce a long term stable environment.

Throughout 2017, the HTDF continued to be stratified, even during strong wind events in November. As previously experienced, in the spring and fall there were thermodynamically driven shallow turnover events within the mixolimnion with some partial erosion of the upper layer of the chemocline, but complete mixing of the entire water body did not occur. For this report and in the future, seasonal turnover will be defined as occurring within the mixolimnion only, while "mixing" will refer to complete mixing of the entire water column including the monimolimnion. Metal concentrations of the WTP influent continue to oscillate seasonally in sync with these events and can be removed by the treatment processes in place at the WTP. During the spring 2017 turnover event, iron levels increased rapidly, causing nickel removal efficiencies to decline, which in turn, resulted in chronic toxicity to test organisms. This issue was rectified by a minor pH adjustment within the treatment process. As anticipated, the dissolved solids load within the HTDF continued to rise and approach limits of the site's NPDES permit. As such, reverse osmosis has been used regularly, with reject concentrate being placed below the chemocline. This has a stabilization effect on the HTDF, by increasing the density contrast between the deep-water layer and the shallower fresh water cap.

8. Reclamation Activities

No reclamation activities occurred in 2017 and there are currently no plans to conduct any reclamation activities in 2018. The Department will be notified, in advance, if any activities do commence in 2018. Eagle retained a closure consultant late in 2017 to begin detailed work-planning for activities and technical studies needed to support closure planning for the facility. This process was initiated in 2017 due of the Lundin corporate requirement to have a written closure plan in place five years in advance of anticipated closure. The closure plan will remain flexible to support change or growth within the business.

9. Contingency Plan Update

One element of the contingency plan is to test the effectiveness on an annual basis. Testing is comprised of two components. The first component is participation in adequate training programs for individuals involved in responding to emergencies and the second component is a mock field test.

In 2015, the Humboldt Mill Emergency Response Team (ERT) was formed to assist in emergency response situations should they arise. This team is not required by the Mine Safety Health Administration (MSHA) but was established to help ensure the safety of employees while at work. The team is comprised of 17 individuals that are divided into four teams each of which includes at least one licensed emergency medical technician (EMT) and one National Fire Protection Association (NFPA) certified firefighter. Training occurs on a monthly basis and in 2017 included first aid, rapid trauma assessments, assisting with fire drills, extrication from various facilities and equipment, triaging multiple patients and completion of a 40-hour high angle rescue and confined space rescue technician training. The monthly trainings have at minimum two scenarios that facilitate response from the Emergency Response Team. The Humboldt Mill Emergency Response Team now has one of the largest professionally trained high angle rescue teams in the Midwest.

Confined Space Rescue Training, August 2017

In addition to the (ERT), security personnel are EMTs and paramedics who are trained in accordance with state and federal regulations. This allows for immediate response to medical emergency situations.

A mock field test was conducted in September 2017 and was a desktop exercise which tested the emergency response measures of the contingency plan and crisis management plan in place at Eagle Mine. With the assistance of Eagle Mine employees, a third-party consultant developed an emergency scenario. The scenario generally involves a situation in which both safety and environmental risks are considered and in 2017 the emergency was related to fires in both the concentrator building at the mill and underground at the mine. The crisis management team was aware that a test would occur, but were unaware of the nature of the emergency. Two rooms were utilized during the exercise, the first contained the crisis management team and the second contained the “actors” playing roles of employees, regulators, local politicians, media outlets, and concerned citizens and family members. The actors had a loose script developed by the consultant which ensured that certain elements were included and that the scenario progressed at a pre-determined pace. During the crisis management exercise, the third-party consultant observed the activity to identify strengths, weaknesses and opportunities for improvement. Once the exercise was complete, the consultant and crisis management team held a debrief session to capture feedback from each participant. Following this session, the consultant captured the overall feedback and prepared a report with actions for improvement. Throughout the following 12-month period, the crisis management team meets on a quarterly basis to review and update the status on those actions in preparation for the annual exercise.

An updated contingency plan can be found in Appendix O. This plan will also be submitted to the Local Emergency Management Coordinator.

10. Financial Assurance Update

Updated reclamation costs can be found in Appendix P. It is understood that the MDEQ will notify Eagle if these updated costs require re-negotiation of the current bond for financial assurance.

11. Organizational Information

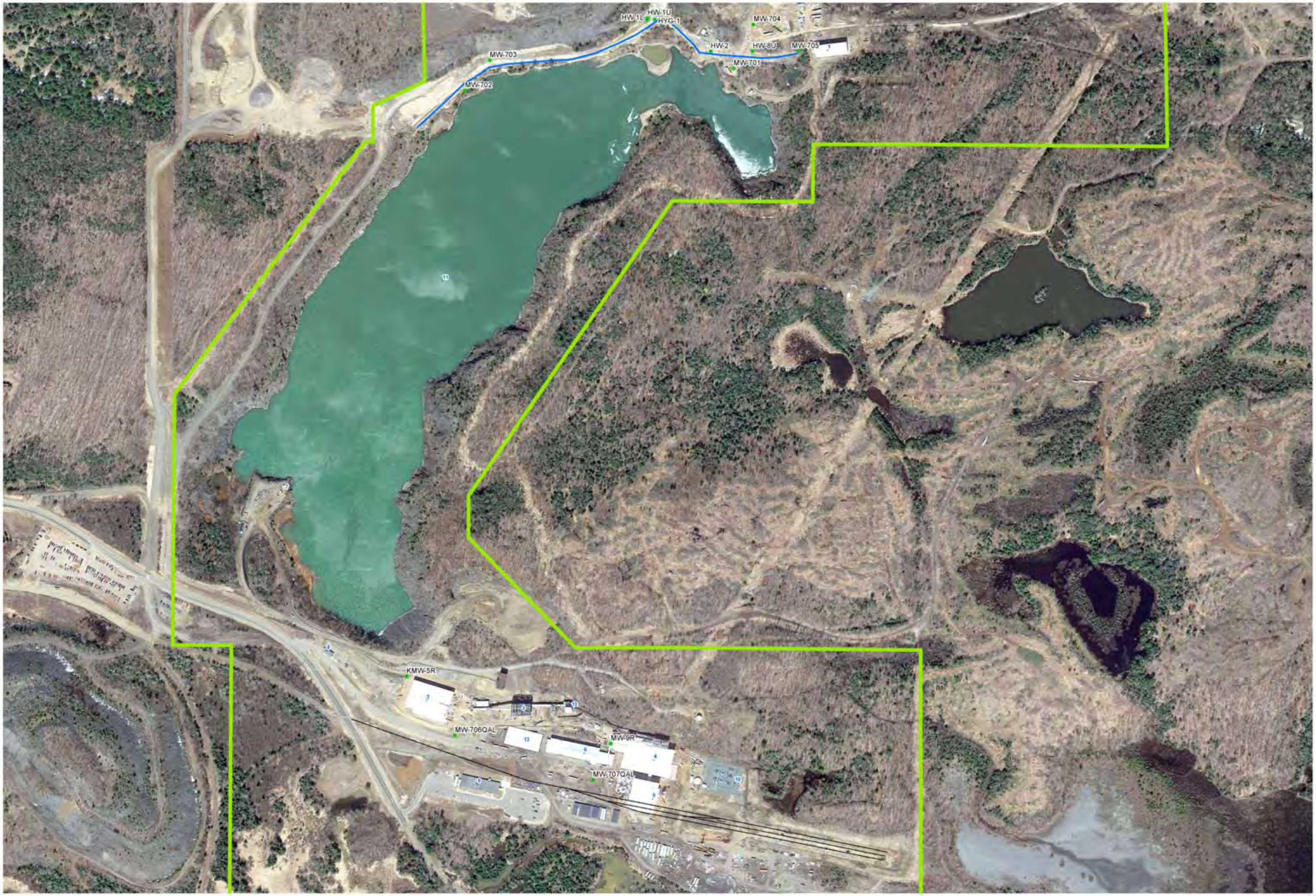
An updated organization report can be found in Appendix Q.

Appendix A

Humboldt Mill

Site Map

Eagle Mine LLC Humboldt Mill Monitoring Map



Legend

- Rail Spur
- Cut Off Wall
- Eagle Mine LLC Ownership
- Humboldt Mill Part 632 Wells

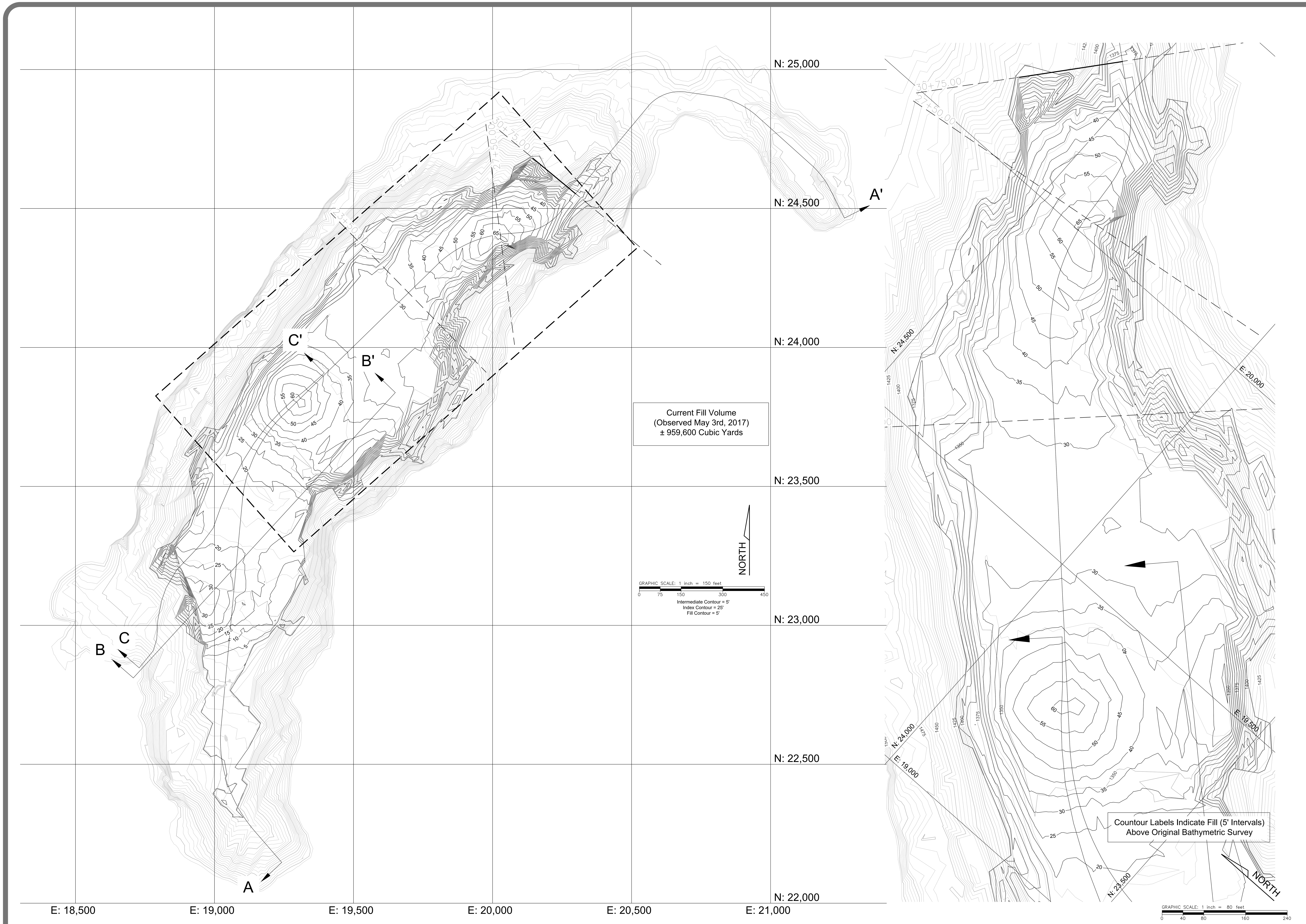
1 - Water Treatment Plant
2 - Coarse Ore Storage Building
3 - Secondary Crusher
4 - Concentrator
5 - Concentrate Loadout Facility
6 - Mill Services Building
7 - Tailings Pump House
8 - Guardhouse
9 - Administration Building
10 - UPPCO Powerstation
11 - Humboldt Tailings Disposal Facility
12 - Transfer Building
13 - Cold Storage Building

0 0.05 0.1 0.2 0.3 0.4 0.5 Miles

Appendix B

Humboldt Mill

Bathymetry Maps



TRIMEDIA
ENVIRONMENTAL & ENGINEERING

Eagle Mine - Humboldt Mill
May 3rd, 2017 Bathymetric Survey
Champion, MI

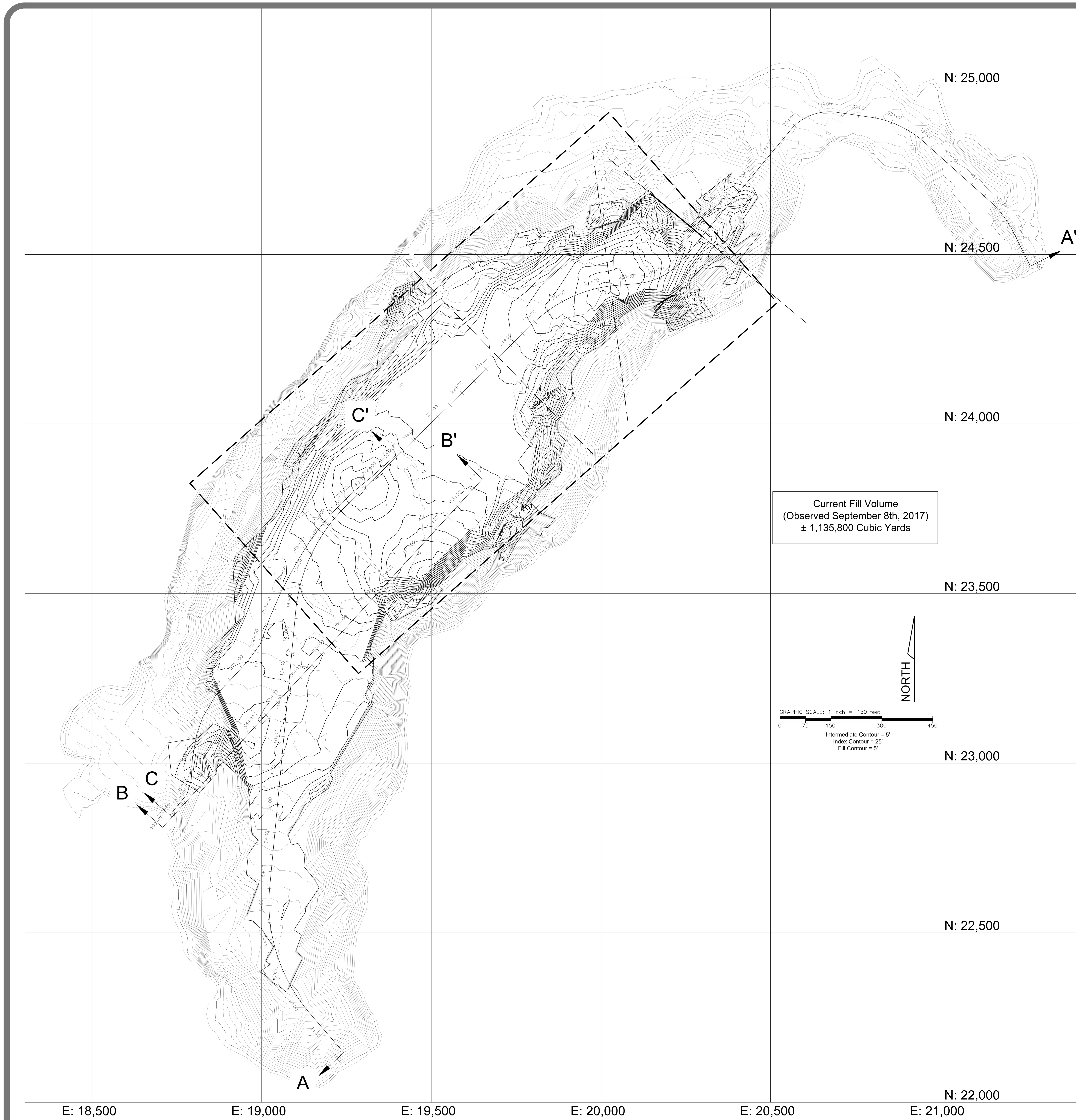
DATE	DESCRIPTION	ISSUED

DESIGNED:
DRAWN: JWM
CHECKED: PGC
APPROVED: GWM

TRIMEDIA
JOB NUMBER:
2014-100

SHEET TITLE:
Tailings Basin
Product Fill Map

SHEET NUMBER:
1.0



TRIMEDIA
ENVIRONMENTAL & ENGINEERING

Eagle Mine - Humboldt Mill
September 8th, 2017 Bathymetric Survey
Champion, MI

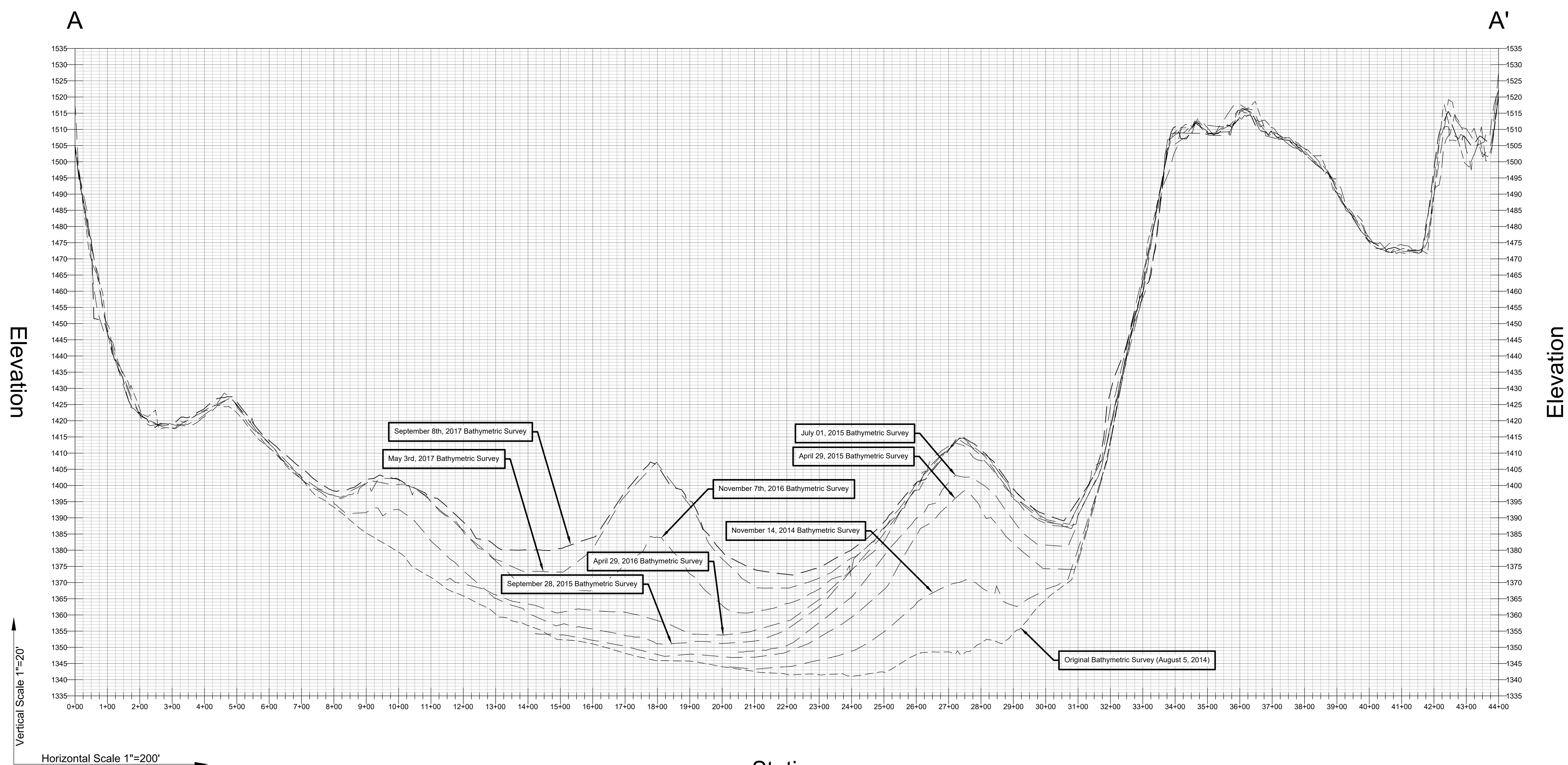
DATE	DESCRIPTION	ISSUED

DESIGNED:
DRAWN: JWM
CHECKED: PGC
APPROVED: GWM

TRIMEDIA
JOB NUMBER:
2014-100

SHEET TITLE:
Tailings Basin
Product Fill Map

SHEET NUMBER:
1.0



TRIMEDIA
ENVIRONMENTAL & ENGINEERING

Eagle Mine - Humboldt Mill
September 8th, 2017 Bathymetric Survey
Champion, MI

DATE	DESCRIPTION	ISSUED

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DRAWN: JWM
CHECKED: PGC
APPROVED: GWM

TRIMEDIA
JOB NUMBER:
2014-100

SHEET TITLE:
Tailings Basin 2017 Profile (Cross Section A)

SHEET NUMBER:
2.0

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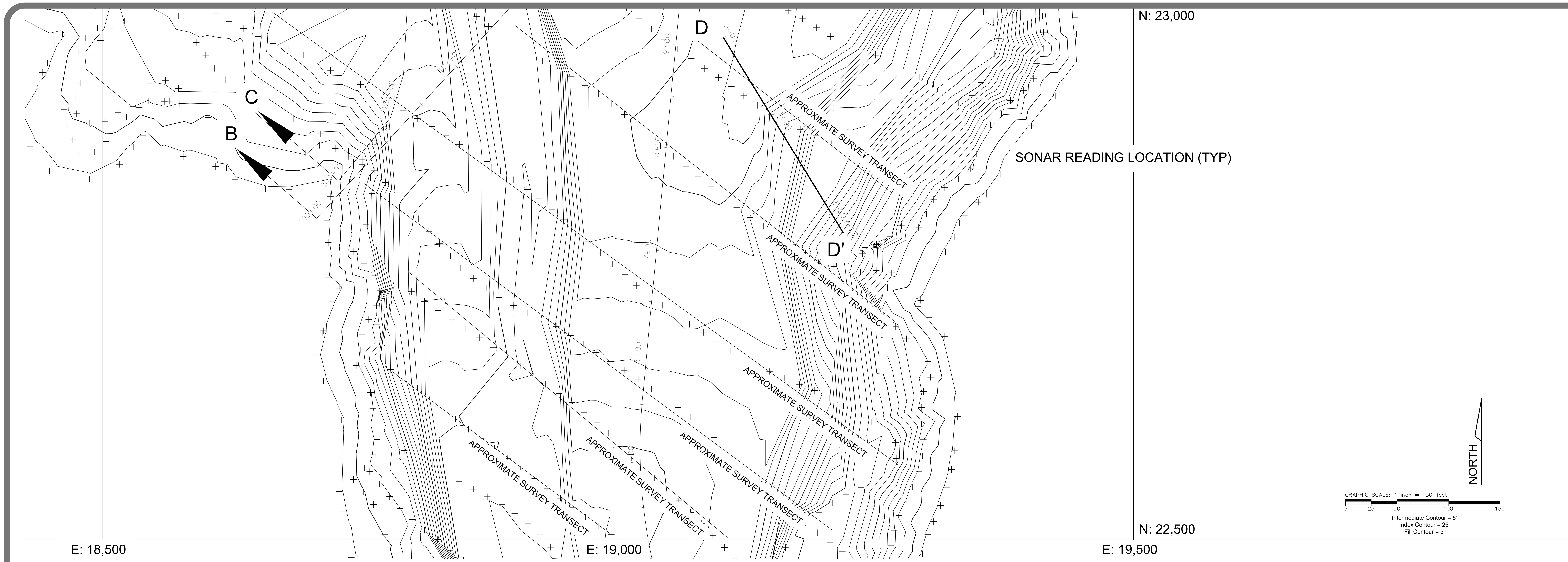

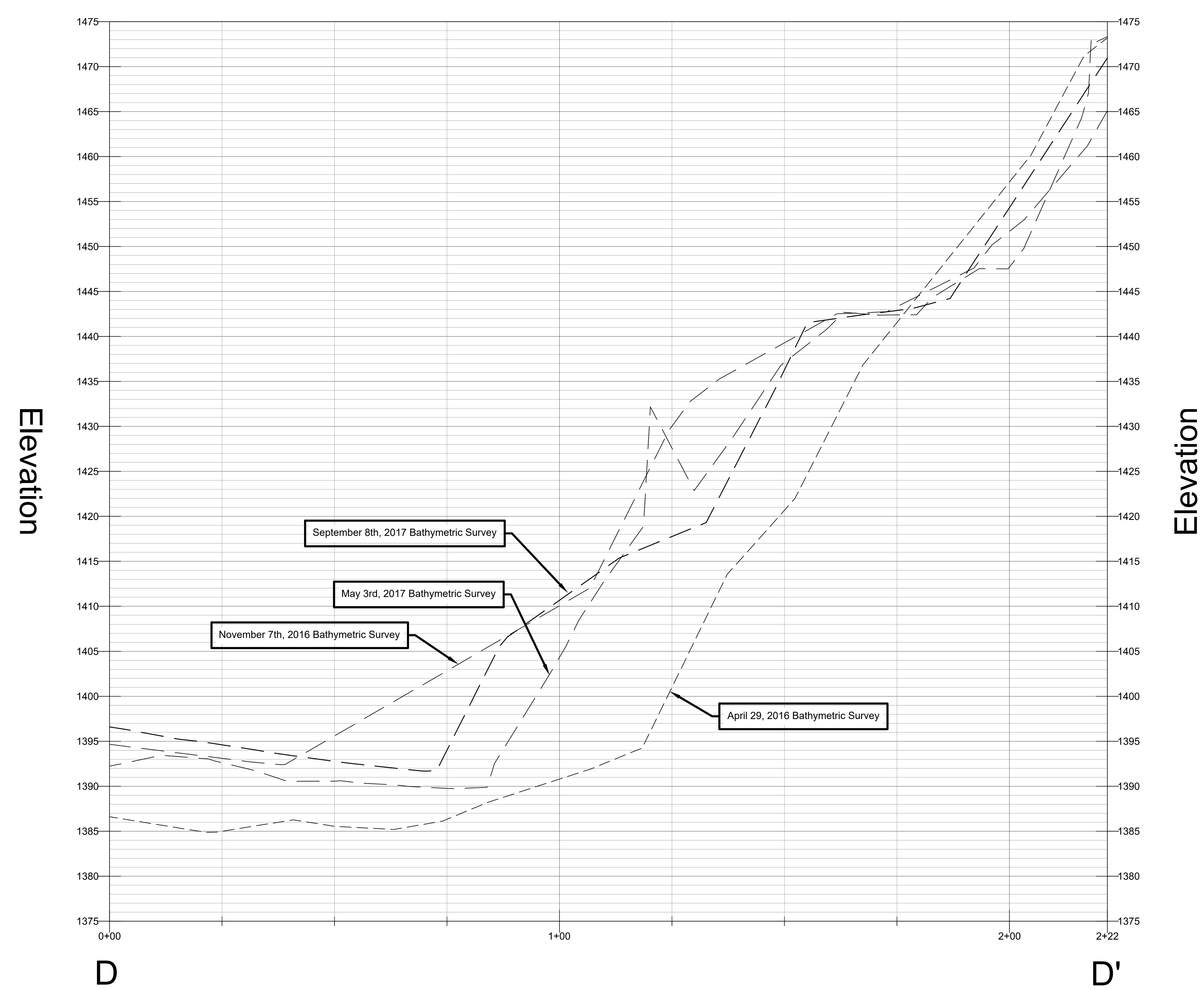

Vertical Scale 1"=12.5'

Horizontal Scale 1"=25'

TRIMEDIA
ENVIRONMENTAL & ENGINEERING

Eagle Mine - Humboldt Mill
September 8th, 2017 Bathymetric Survey
Champion, MI

DATE	DESCRIPTION	ISSUED
01/10/2017		

DESIGNED:
DRAWN: JWM
CHECKED: PGC
APPROVED: GWM

TRIMEDIA
JOB NUMBER:
2014-100

SHEET TITLE:
Tailings Basin
2017
Cross Section D

SHEET NUMBER:
5.0

Appendix C

Humboldt Mill

Storm Water Drainage Map

Humboldt Mill Storm Water Drainage Map

Legend

- Cut Off Wall
- Eagle Mine Property Boundary
- Catch Basins
- Berm
- Stormwater Conduit
- Surface Water Flow
- Contours 10ft
- Humboldt Facilities
- Humboldt Tailings Disposal Facility
- Main Roads
- World Imagery
- Low Resolution 15m Imagery
- High Resolution 60cm Imagery
- High Resolution 30cm Imagery
- Citations

Humboldt Mill Site Map	
Figure 1	
Edited on December 15, 2017 Created on October 9, 2015	Locations and Coordinates based on UTM Zone 16N NAD83

Eagle Mine

Author: JRE

Appendix D

Humboldt Mill

Groundwater, Surface Water, and Water Balance Model Development Report

Groundwater, Surface Water, and Water Balance Model Development Report

Humboldt Tailings Disposal Facility, Humboldt Mill
4547 County Road 601
Humboldt Township, Marquette County, Michigan

Prepared for:
Eagle Mine, LLC

March 2018

Groundwater, Surface Water, and Water Balance Model Development Report

Humboldt Tailings Disposal Facility, Humboldt Mill
4547 County Road 601
Humboldt Township, Marquette County, Michigan

Prepared for
Eagle Mine, LLC

March 2018

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Groundwater, Surface Water, and Water Balance Model Development Report

March 2018

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Acronyms

Acronym	Description
amsl	Above mean sea level
DEM	Digital elevation model
FAO	Food and Agriculture Organization
gpm	Gallons per minute
HTDF	Humboldt Tailings Disposal Facility
HWMB	Humboldt Wetland Mitigation Bank
NWS	National Weather Service
PET	Potential evapotranspiration
WSEL	Water surface elevation
WTP	Water Treatment Plant

1.0 Introduction and background

Eagle Mine, LLC (Eagle) operates a beneficiation facility at 4547 County Road 601 in Humboldt Township, Marquette County, Michigan, referred to as the Humboldt Mill facility (see Large Figure 1). The Humboldt Mill facility was historically used for processing of iron ore from the adjacent Humboldt Mine, an open pit mine, as well as for processing of gold ore from the Ropes Gold Mine. The facility was redeveloped by Eagle to process copper and nickel ore from Eagle Mine.

The Humboldt Mill facility produces copper and nickel concentrates from ore mined at its Eagle Mine facility. Tailings from Eagle's beneficiation operations are placed in the Humboldt Tailings Disposal Facility (HTDF), the flooded pit which was formerly the Humboldt Mine. As part of Eagle's redevelopment of the Humboldt Mill facility, a groundwater flow barrier was constructed in unconsolidated soils north of the HTDF to reduce hydraulic communication between the water in the HTDF and groundwater underlying wetlands north of the HTDF.

Integrated groundwater, surface water, and water balance models of the HTDF were developed by Barr Engineering Co. (Barr) on behalf of Eagle. The models were developed to provide an understanding of groundwater and surface water flow conditions for current operational use and to support future post-closure outfall design. The models estimate water flows to/from the HTDF for: 1) the HTDF and surrounding watersheds as they exist today; and 2) the HTDF and surrounding watersheds under conditions that are consistent with those prior to Eagle's redevelopment of the Humboldt Mill facility and construction of the cut-off wall. This report provides a summary of information used in development of these models, modeling methods, model calibration, and modeling results.

As noted above, the HTDF is a former open pit iron mine which has filled with water and is now used for subaqueous disposal of tailings. Surface water discharge from the HTDF, including precipitation/snowmelt and water displaced as a result of placement of tailings in the HTDF, is treated in a water treatment facility and discharged to surface water via one or more of three outfalls (designated outfalls 001, 002 and 003).

For operational use, groundwater, surface water, and water balance modeling were completed to establish and implement a water discharge protocol whereby treated water from the HTDF will be discharged in a manner that is representative of anticipated water discharge under post-closure conditions at the Humboldt Mill facility (i.e., subsequent to the conclusion of Eagle's operations and at such a time as water in the HTDF is of adequate quality that water treatment is not necessary). Post-closure conditions are proposed to be established based on replication of estimated groundwater and surface water flow conditions prior to Eagle's redevelopment of the Humboldt Mill facility.[1] Future use of model estimates may include design for discharge of water from the HTDF in an analogous manner subsequent to closure of the Humboldt Mill facility.

[1] Conditions at the facility prior to Eagle's redevelopment are reflective of site conditions subsequent to respective use of the Humboldt Mill facility and the HTDF by Callahan Mining Company for beneficiation of gold ore from Callahan's Ropes Gold Mine and subaqueous disposal of the resultant tailings.

2.0 Groundwater modeling

The groundwater model was developed using geologic, hydrogeologic, and cut-off wall information to estimate groundwater flows to and from the HTDF. If the model is used for purposes other than those outlined in Section 1.0 of this report, the validity of the model for that purpose should be carefully evaluated. The model should not be applied to problems, settings, or scales other than those explicitly modeled in this project.

2.1 Model software selection

MODFLOW (McDonald and Harbaugh 1988) (Harbaugh 2005) was selected for simulation of three-dimensional, steady-state groundwater flow. MODFLOW was developed by the U.S. Geological Survey and is widely used and accepted. MODFLOW-NWT (Niswonger and Ibaraki 2011) was used to overcome potential issues with model instability caused by "dry" model cells. Where model layers are thin or where topography is steep, the hydraulic head may fall below the bottom elevation of some model cells. When this occurs in a model cell, the cell is considered "dry" by MODFLOW. If model cells become dry and then re-wet during an iterative solution, problems with model convergence and stability may result. MODFLOW-NWT is an alternate formulation of MODFLOW-2005 (Harbaugh 2005) specifically intended for solving problems involving drying and rewetting nonlinearities of the unconfined groundwater-flow equation.

The graphical user interface Groundwater Vistas, Version 6 (Environmental Solutions, Inc. 2011) was used to support the development of the MODFLOW model.

2.2 Model domain, grid, and layers

The HTDF is the area of interest for this modeling work. The model domain covers approximately 4 square miles centered on the HTDF as presented on Large Figure 2. Where possible, the "active area" of the model – the area where groundwater flow is simulated – extends to significant surface water features beyond the HTDF area, which are simulated as hydraulic boundaries in the groundwater flow system. For example, the active area of the model extends to the Escanaba River as well as tributaries to the Black River at the northern and southern boundaries and to wetlands at the eastern and western boundaries.

The horizontal model grid is also shown on Large Figure 2. An irregular grid spacing was used for increased discretization in the vicinity of the HTDF. Grid cell spacing ranges from 16.4 feet (5 meters) by 16.4 feet at the HTDF to 164 feet (50 meters) by 164 feet at the edges of the model domain, with the cell size increasing by a maximum factor of 1.5 between adjacent cells.

The model was divided vertically into six layers. Layer 1 represents regions with surface elevations above 1608 feet (480 meters) above mean sea level (amsl) based on a digital elevation model (DEM) of topography provided by Eagle. Layer 1 through Layer 4 represent areas of unconsolidated deposits and bedrock, and Layers 5 and 6 represent bedrock only. Elevations for Layers 2 through 4 were assigned based on the lithology of unconsolidated deposits, which is described in more detail in Section 2.5. A DEM of the top of bedrock surface was generated from data provided by Eagle and was used to define the contact between unconsolidated deposits and bedrock.

2.3 Modeled flow conditions

Three time periods were modeled. The first time period represents site conditions prior to redevelopment of the Humboldt Mill facility and Eagle's initiation of operations. During this period, the cut-off wall was not yet installed, the water in the HTDF was at a higher elevation, and there was no pumping from wells at the Humboldt Mill. The second and third modeled time periods represent site conditions after initiation of the Eagle Mine operations. During these periods, the cut-off wall was in place, the water in the HTDF was maintained at a lower elevation and there was active pumping from wells at the Humboldt Mill. A summary of the conditions for each modeled time period is presented Table 2-1. The following sub-sections of this report provide additional detail on model inputs.

Table 2-1 Model time periods

Model Time Period	Cut-off wall present	HTDF Water Surface Elevation (feet amsl)	Date of HTDF Water Surface Elevation
2008 conditions	No	1537.4	July 15, 2008
2014 conditions	Yes	1531.1	October 8, 2014
2017 conditions	Yes	1530.5	August 22, 2017

2.4 Boundary conditions

Groundwater model boundary conditions are shown by layer on Large Figure 3 to Large Figure 5, and additional detail is provided in the following subsections of this report.

2.4.1 Rivers

The Escanaba River and tributaries to the Black River were represented in Layer 2 with head-dependent flux cells as shown on Large Figure 4 using the MODFLOW River Package (RIV Package) (McDonald and Harbaugh 1988). Groundwater flow to and from river cells is proportional to the head difference between the model-estimated head in the aquifer and the specified head of the river and a conductance term. The locations of river cells were based on publically available data from the National Hydrography Dataset (U.S. Geological Survey and U.S. Environmental Protection Agency 2012). Heads were specified for each river cell using elevations from the same DEM used to specify the top elevation of Layer 1. Small adjustments were made to the heads assigned from topographic data in areas where the heads increased or did not change from upstream to downstream along each river.

The conductance term for the river boundary cells was calculated using Equation 2-1.

$$C_{RIV} = \frac{KLW}{M} \quad \text{Equation 2-1}$$

where:

> C_{RIV} is the riverbed conductance [L^2T^{-1}],
> K is the vertical hydraulic conductivity of the riverbed material [LT^{-1}],
> L is the length of the river crossing the model cell [L],
> W is the width of the river [L], and
> M is the thickness of the riverbed material [L].

A "baseline" conductance value was calculated for each river cell as the area (L x W) of the model cell intersected by the river divided by an assumed thickness of riverbed sediments (M) 1.6 feet (0.5 meters). All rivers were assumed to have a width of 3.3 feet (1 meter). The conductance parameter (K) was varied during calibration and represents an estimate of the vertical hydraulic conductivity of the riverbed sediments, given the assumptions described above. This value was multiplied by the baseline conductance value to calculate the conductance for each river cell during each model run.

2.4.2 Wetlands

Similar to rivers, wetlands were represented in the uppermost active layer (Layer 1 or Layer 2) with head-dependent flux cells using the RIV Package (McDonald and Harbaugh 1988). To the north of the HTDF, locations of the wetlands commonly referred to as Wetland EE and the Phase 1 South bank of the Humboldt Wetland Mitigation Bank (HWMB) were set based on site-specific data provided by Eagle. The Phase 1 North wetland location of the HWMB was set based on a desktop delineation completed by Barr. The locations of remaining wetland cells were based on publically available data (Michigan Center for Geographic Information 2014) (U.S. Geological Survey and U.S. Environmental Protection Agency 2012). The spatial distribution of the wetlands in the groundwater model is shown on Large Figure 3 and Large Figure 4. Where data were available, measured stages were used to assign specified heads to the wetland cells. Measured stage data were available to the north of the HTDF at 16 wetland staff gauges and at 4 staff gauges to the south of the HTDF. For the 2008 conditions, measured wetland stages from 2006 through 2008 were averaged to assign wetland heads. For 2014 and 2017 conditions, measured wetland stages from 2015 were averaged to assign wetland heads. Wetlands without measured stage data were assigned heads based on topographical elevations from DEM data provided by Eagle.

As with rivers, wetland cells were also defined with a "baseline" conductance value calculated as the area (L x W) of the model cell intersected by wetlands divided by an assumed thickness of wetland sediments of (M) of 1.6 feet (0.5 meters). The parameter varied during calibration conceptually represents the vertical hydraulic conductivity of the wetland bed sediments. This value was multiplied by the baseline conductance value to calculate the conductance for each wetland cell during each model run.

2.4.3 HTDF

The HTDF was represented in Layers 2 through 6 with specified-head cells using the MODFLOW Constant Head Package (CHD Package) (Harbaugh, Banta, et al. 2000). The location of the HTDF is presented in Large Figure 4. The specified heads were assigned from water level measurements at the HTDF. Water level data for the HTDF was available from staff gauge measurements taken at the HTDF between 2007 and 2017. The HTDF water levels used in the model are presented in Table 2-1.

2.4.4 Other surface water

Two surface water features present within the southern end of the model extent were represented with the CHD Package (Harbaugh, Banta, et al. 2000) in Layer 1 and Layer 2 as shown on Large Figure 3 and Large Figure 4. The locations of these surface water features were based on data provided by the National Hydrography Dataset (U.S. Geological Survey and U.S. Environmental Protection Agency 2012). The heads in the CHD cells used to define the two surface water features were assigned based on topographical elevations from the DEM provided by Eagle.

2.4.5 Recharge

Recharge to the aquifer system was simulated using the Recharge Package (RCH Package) (McDonald and Harbaugh 1988). Recharge was applied to the uppermost active layer of the model at two different rates based upon the material at the ground surface: bedrock or unconsolidated deposits. Recharge was not applied to model cells with specified-head boundary conditions, such as in the HTDF.

Precipitation data was taken from the Clarksburg, MI gauge (National Weather Service 2017). Recharge for unconsolidated sediments was estimated as one-quarter of the annual average precipitation (Twenter 1981). This resulted in recharge to unconsolidated deposits of 7.01 inches per year for the 2008 conditions, 8.13 inches per year for the 2014 conditions, and 9.05 inches per year for the 2017 conditions. Twenter (1981) reported actual local recharge is highly dependent on surficial geology and could vary by a factor of 50. Conceptually, less recharge is expected for areas where bedrock is at or near the ground surface (i.e., modeled as bedrock in the uppermost active model layer). Therefore, recharge was applied at one-tenth the rate applied to unconsolidated deposits where bedrock is present at the ground surface.

2.4.6 Cut-off wall

The cut-off wall, which was initially installed at the north end of the HTDF in 2012 and then grouted for further flow reduction in August 2014, was represented in the model with the Horizontal Flow Barrier Package (HFB Package) (Hsieh and Freckleton 1993). Information on the construction and properties of the cut-off wall were provided by Gannett Fleming (2014) (2015) (2017), Golder Associates (2014) and North Jackson Company (2014). HFBs were assigned to model layers based on the depth of the cut-off wall. Like the River Package, groundwater flow horizontally across an HFB is proportional to the difference between the model-estimated heads on either side of the HFB and a conductance term. The HFB conductance is a function of the proportion of the cell overlapped by the wall, an assumed constant thickness perpendicular to groundwater flow of 3 feet, and the hydraulic conductivity of the wall material (i.e., soil-bentonite or grout).

Model cells with multiple wall materials were assigned conductance values from an area-weighted average hydraulic conductivity based on the overlap of each material type with the model cell. The cut-off wall was present in Layer 2 through Layer 4 and the modeled extent of the cutoff wall is presented in Large Figure 5.

2.4.7 Wells

Four pumping wells were included in the model using the MODFLOW Well Package (WEL Package) (McDonald and Harbaugh 1988). Two site wells were active during 2014 and 2017 conditions (Large Figure 5), a domestic well and a water supply well for mill operations use (i.e., an 'industrial' well). For 2014 conditions, August and September pumping information was available, and the domestic and industrial well pumping rates were set using September 2014 pumping rates (87.4 gallons per minute (gpm) for the domestic well and 15.1 gpm for the industrial well). For 2017 conditions, the wells were set to the average of the most recent year of available data (October 2016 – October 2017). For 2017 conditions, the domestic well pumping rates was set to 1.45 gpm and the industrial well pumping rate was set to 15.9 gpm. Where information was available, pumping from regional wells was simulated as one-third of the pump capacity listed in the well installation logs for all three model time periods. This information was available for two regional wells, and simulated pumping rates were set to 3.33 gpm and 1.67 gpm (Large Figure 5).

2.5 Material properties

A zone-based approach was used to designate material property values in the model based on site geologic information. Eleven zones were defined based on the material types (i.e., "lithology categories") observed in site geologic information, and each unit in a boring log was fit into one of these categories. Nine categories were assigned for unconsolidated deposits, and two categories were assigned for bedrock. These lithology categories and the associated zone ID's are presented in Table 2-2.

At site and regional borings and wells, lithologic categories were assigned to the model domain by selecting the most prevalent lithologic category within each model layer. Lithologic categories were then interpolated horizontally between neighboring borings and wells. Where limited geologic data were available, lithologic categories were extrapolated as generalized zones to fully cover the area of the model. Model areas with limited geologic data included areas beyond the extent of site borings, between regional wells, and at depth, where fewer borings intersect each model layer. Overall, this process results in a model that is a simplification of the inherent heterogeneity of the hydrogeologic system, and the model is neither expected nor intended to represent all spatial details of the site hydrogeology.

The bedrock was modeled as two separate zones based on regional and site-specific aquifer test results that suggest that the upper 100 feet of bedrock has higher hydraulic conductivity than deeper bedrock (Foth Infrastructure & Environment, LLC 2008) (North Jackson Company 2008).

Table 2-2 Primary lithology categories and zone IDs

Zone ID	Primary Lithology
1	Tailings
2	Fine Fill
3	Coarse Fill
4	Peat
5	Clay
6	Fine Outwash with Clay
7	Fine Outwash
8	Coarse Outwash with Fines
9	Coarse Outwash
10	Upper Bedrock
11	Deeper Bedrock

Each hydraulic conductivity zone was assigned a horizontal and vertical hydraulic conductivity. Site-specific aquifer testing data was compiled and analyzed to provide initial values and expected ranges for horizontal hydraulic conductivity for each hydraulic conductivity zone. Vertical anisotropy, defined as the ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity was allowed to vary between 5 and 1,000 for all zones. The ranges of horizontal and vertical hydraulic conductivity values allowed during model calibration are presented in Large Table 1. The spatial distribution of the hydraulic conductivity zones within each layer are presented in Large Figure 6 to Large Figure 11.

2.6 Model calibration

Calibration was completed using a combination of manual calibration and the automated parameter optimization software PEST, Version 13.6 (Watermark Numerical Computing 2016). Through systematic adjustment of model inputs (parameters) within a user-specified range, PEST attempts to minimize the difference between observed and modeled values (residuals). A residual is defined as the difference between an observation (i.e., a measured value) and corresponding model value (ASTM 2014); therefore, a positive residual indicates that the modeled value is less than the measured value (i.e., the model is under-predicting the value), and a negative residual indicates that the model is over-predicting the value of a given observation. When using PEST, the difference between observed and modeled values is quantified as the sum of squared weighted residuals and is termed the objective function. Therefore, the goal of the calibration was to minimize the objective function. More specifically, the objectives of model calibration were:

- Have at least 90% of the head residuals within 10% of the observed range in heads on site (ASTM 2014).
- Minimize the bias in the residuals. Bias in model results is the predominance of positive or negative residuals either throughout the range of modeled values or within portions of the range.

- Reproduce the overall flow patterns from the site head data to the extent practicable.

To accomplish calibration, a total of 34 parameters were adjusted by PEST to optimize the fit between modeled and observed heads for 91 observations. Setup and results of the model calibration are described in the following subsections.

2.6.1 Calibration data sets

The following data sets were used to calibrate the model:

- Regional groundwater levels from well data available from Michigan Department of Environmental Quality (Wellogic 2017).
- Groundwater levels in site wells measured on July 15, 2008.
- Groundwater levels in site wells measured on October 10, 2014.
- Groundwater levels in site wells measured on August 22, 2017.

The observation periods above were selected because data available at these times provided the most complete datasets for calibration. Dates for regional water levels were variable based on the dates of well installations, but the water levels from the regional wells were applied to the 2008 calibration dataset as the most representative time period, because most of the regional water levels were measured before 2008.

2.6.2 Calibration parameters

A total of 34 parameters were adjusted during calibration to optimize the fit between modeled and observed values. The adjustable parameters, along with the range of values allowed for each parameter during calibration, are shown on Large Table 1 (parameters that are "Free"). In addition to "Free" parameters Large Table 1 also shows "Tied" parameters. Tied parameters maintain a constant ratio to the parent parameter to which they are tied. This helps maintain relationships between parameters that can be reasonably be expected to be related. Adjustable parameters included:

- Horizontal Hydraulic Conductivity
- Vertical Hydraulic Conductivity
- River Bed and Wetland Sediment Vertical Hydraulic Conductivity

Recharge parameters with fixed values, which were not adjusted during calibration, are shown on Large Table 2.

2.6.3 Prior information

Automated calibration using PEST may be guided with user-supplied information related to model parameter values, known as "prior information". Prior information does not impose hard constraints on the parameter values; rather, PEST will attempt to match the preferred parameter values to the extent practicable, and a contribution will be added to the objective function if the values deviate from the preferred values. Prior information generally consists of independent estimates based on measurements of parameter values made within the model domain, such as the pumping and slug tests conducted at the site. Site-specific data from various aquifer and laboratory testing was used to develop the following prior information:

- the horizontal hydraulic conductivity of the tailing lithology (Zone 1) should be 22.5 feet/day;
- the horizontal hydraulic conductivity of the coarse outwash with fines lithology (Zone 8) should be 46.8 feet/day;
- the horizontal hydraulic conductivity of the coarse outwash lithology (Zone 9) should be 211 feet/day;
- the horizontal hydraulic conductivity of the shallow bedrock lithology (Zone 10) should be 0.294 feet/day, the average hydraulic conductivity for bedrock based on site-specific aquifer testing and regional estimates based on specific capacity data from wells within the model domain; and
- the horizontal hydraulic conductivity of the deeper bedrock (Zone 11) should be one-tenth the shallower bedrock (Zone 10) hydraulic conductivity.

2.6.4 Calibration results

A scatter plot of simulated versus observed steady-state heads is shown on Large Figure 12. In general, an acceptable match to the head observations was achieved. At the site wells, 90% of the head residuals were within 10% of the observed range in heads, meeting the calibration objective indicated above, which is consistent with ASTM recommendations (ASTM 2014). The residual mean for site wells was -2.2 feet. Regional well observations were not matched as well, with 74% of the head residuals within 10% of the observed range in heads. Given the higher degree of uncertainty associated with the regional well water levels, the poorer fit is to be expected. The regional well observations were assigned a lower weight during calibration (i.e., there was less emphasis placed on matching these observations), because limited geologic and elevation information from the well logs and only a single water level measurement taken at the time of well installation were available. The full results of the calibration are presented in Large Table 3.

The spatial distribution of head residuals for the 2008 calibration dataset is shown on Large Figure 13 through Large Figure 18. The spatial distribution of head residuals for the 2014 calibration dataset is shown on Large Figure 19 through Large Figure 24. The spatial distribution of head residuals for the 2017 calibration dataset is shown on Large Figure 25 through Large Figure 30.

2.7 Model-estimated HTDF groundwater flow

The calibrated model was used to estimate the groundwater inflow to and groundwater outflow from the HTDF during 2008 conditions, 2014 conditions, and 2017 conditions at various stages (i.e., HTDF water elevations). Groundwater inflow and outflow were estimated based on HTDF water elevations representing conditions in the referenced time periods. Results are presented in Large Table 4 and Large Figure 31.

The results indicate that net groundwater flow is into the HTDF for the full range of modeled elevations for all conditions. Groundwater flow into and out of the HTDF was confirmed to vary with HTDF elevation. Groundwater flow rates developed by the model were used as an input to the surface water/water balance model discussed in subsequent sections of this report.

2.8 Sensitivity analysis

A sensitivity analysis was performed in order to assess the effects of parameter value changes on modeled groundwater flow to and from the HTDF. Model scenarios were run with each calibrated parameter individually increased to ten times the calibrated value and then decreased to one-tenth the calibrated value. If increasing or decreasing a parameter exceeded a minimum or maximum parameter bound, the minimum or maximum bound was used. In addition to calibration parameters, recharge was also decreased to 5.05 inches per year and increased to 11.73 inches per year to reflect historical minimum and maximum annual rainfall. The historical precipitation data was taken from the Champion, MI gauge (National Weather Service 2010), which is approximately 5 miles northwest of the site. The Champion gauge was used to estimate high and low precipitation because the Champion gauge has precipitation data for the period from 1950 through 2000, while data were only available for the Clarksburg gauge from 2005 through 2018. As with the base model, recharge for the unconsolidated sediments was estimated as one-quarter of the high and low annual precipitation and bedrock recharge was set as one-tenth the rate applied to unconsolidated deposits. The adjustment of all 34 calibration parameters, recharge, and a baseline run resulted in a total of 71 model runs for the sensitivity analysis. The input parameters for each sensitivity run are presented in Large Table 5, and the HTDF groundwater flows were calculated for each sensitivity model run.

The results of the sensitivity analysis are presented in Large Table 5. Modeled HTDF inflow and outflow was most sensitive to changes to the horizontal hydraulic conductivity value for coarse outwash with fines (Zone 8). Coarse outwash with fines is present adjacent to the southern portion of the HTDF in Layers 2, 3 and 4. Similar, though less dramatic relationships can be seen in the horizontal hydraulic conductivity value for coarse outwash (Zone 9) and the horizontal hydraulic conductivity value for upper bedrock (Zone 10). Adjustments to the vertical hydraulic conductivity of the wetland bed sediments (kz_riv_1) for the regional wetlands was also found to have a significant influence on modeled HTDF inflow and outflow. As expected, increasing vertical hydraulic conductivity of the wetland bed sediments led to an increase in inflow to the HTDF and a decrease in vertical hydraulic conductivity of the wetland bed sediments led to a decrease in inflow to the HTDF. Increasing recharge to 11.73 inches per year and decreasing to 5.05 inches per year were found to have little effect.

2.9 Model assumptions and limitations

Uncertainty is inherent to all groundwater flow models and many assumptions must be made during model design. The groundwater flow model that was constructed and calibrated for this study is a simplification of groundwater flow in the vicinity of the area studied. Several limitations to the model need to be acknowledged. These limitations are the result of assumptions and simplifications that are common and accepted practices in groundwater modeling. The model assumptions and limitations include:

- The model assumes that no changes in hydraulic stresses other than those explicitly simulated in a given scenario occur in the model domain that will significantly affect the boundary conditions.
- The bedrock units are assumed to act as an equivalent porous media at the scale simulated.
- Recharge is assumed to be an average value that is representative for the conditions to which the model was calibrated.
- The validity of the modeling results is based on the assumption that the conceptual model is a reasonable representation of the groundwater flow system. The conceptual model, in turn, is based on the data collected in the area and the interpretation of that data. Variations in subsurface material properties between locations where the data were collected may result in deviations between simulated and actual flow directions and rates. Future data collection at the site may alter the conceptual model, requiring changes to the numerical model.
- Although surface water features are incorporated into the model as they pertain to groundwater flow, the model does not solve for open channel flow.

3.0 Surface water and water balance modeling

A surface water and water balance model of the HTDF was developed to simulate the HTDF water surface elevation (WSEL) and outflow for multiple time periods. The model is referred to here as the "water balance" model, which includes surface water and other inflows to and outflows from the HTDF. This section describes the model objective and time periods, individual components of the combined model, and model calibration and results.

3.1 Model objectives and software selection

The water balance model of the HTDF was constructed in order to better-quantify the various aspects of the HTDF water balance as well as to serve as a tool for setting the discharge rate from the HTDF to the adjacent Wetland EE. The specific modeling objectives included:

- Simulation of surface-water flows into the HTDF for both current and "pre-Eagle" conditions;
- Using the results of the groundwater modeling to simulate the overall HTDF water balance for both current and pre-Eagle conditions;
- Prediction of HTDF WSEL under current conditions, as well as the hypothetical WSEL in the HTDF at the present time if conditions were unchanged from the pre-Eagle state; and
- Predict the total discharge from the HTDF to the adjacent Wetland EE at the present time if conditions were unchanged from the pre-Eagle conditions.

The software selected for the construction of the water balance model was GoldSim, Version 12.0 (GoldSim Technology Group 2017). GoldSim is a simulation engine that functions as a visual programming language, with objects linked graphically and equations written in a manner similar to Microsoft Excel.

GoldSim is used world-wide for simulation of mine water balances and numerous other applications. The software has the ability to perform static (unchanging) or dynamic (time-varying) simulations, and is also tailored to probabilistic uncertainty analysis through the use of Monte Carlo simulation. For the HTDF water balance application, GoldSim was run as a dynamic simulation without using the software's probabilistic functionality (i.e., the water balance model was run as a deterministic simulation).

3.2 Model time periods and conditions

The water balance model performs a continuous simulation with a daily time step. The simulation begins on May 31, 2007 (the earliest date of reliable HTDF WSEL data) and continues to the present. The model is designed to be updated on an ongoing basis by Eagle for use as a discharge planning tool. Because the model runs continuously between 2007 and the present, the simulation spans multiple time periods with varying site conditions during the development and operation of the Eagle project.

Two water balance models are simulated in parallel, designated "**with-Eagle"** and "**no-Eagle"**. Both models are identical during the pre-Eagle period prior to initial cut-off wall construction. The with-Eagle model includes the effects of cut-off wall construction, HTDF drawdown, the Humboldt Mill stormwater system, and Eagle's operations. The no-Eagle model simulates a hypothetical condition in which pre-Eagle conditions continue indefinitely, with no changes to the watershed or outlet of the HTDF. Key dates in the water balance modeling include:

- November 8, 2012: end of initial (partial) cut-off wall construction;
- April 30, 2013: beginning of pre-operations drawdown of water levels in the HTDF, assumed completion of Humboldt Mill stormwater system;
- August 21, 2013: completion of cut-off wall construction; and
- August 25, 2014: beginning of Eagle operations, Humboldt Mill and Water Treatment Plant (WTP) operational.

The effects of each of these changes in the site conditions will be discussed in more detail in the following sections.

3.3 Climate modeling

The water balance model of the HTDF relies on multiple data sources to represent observed climatic conditions as well as simulated or estimated parameters. The data sources used in the water balance modeling are shown in Large Figure 32 and include:

- On-site measurements by Eagle at the Humboldt Mill weather station;
- National Weather Service (NWS) data from Clarksburg, Michigan (National Weather Service 2017);
- Michigan State University (MSU) Enviro-Weather data from the experiment station at Chatham, Michigan (Michigan State University 2017);
- National Climatic Data Center data from the Sawyer International Airport (National Climatic Data Center 2017); and
- Precipitation, air temperature, and evaporation monthly climatic normal values (Foth Infrastructure & Environment, LLC 2007).

3.3.1 Precipitation

For surface water and water balance modeling, it is important that the precipitation data match as closely as possible the actual conditions within the study watershed. Because of the small size of the HTDF watershed, localized events may deliver precipitation to the watershed that is quite different from that observed at weather stations as close as several miles away. For this reason, the water balance model initially gave preference to the precipitation data collected by Eagle at the Humboldt Mill (within the current HTDF watershed, see Section 3.4) and used other data sources only when on-site data were unavailable or missing.

However, additional examination of the Humboldt Mill data showed a significant difference between the reported precipitation at the mill and at the NWS Clarksburg weather station, which is 2.9 miles east of the HTDF. As shown in Figure 3-1, for days with measurements reported at both locations from 2013-2017, the mill precipitation is cumulatively 18.5% (22.7 inches) less than that measured at Clarksburg. This significant difference, combined with periods of missing site data records due to equipment malfunction, caused us to preferentially use the NWS Clarksburg weather station as the default precipitation data source for the water balance model.

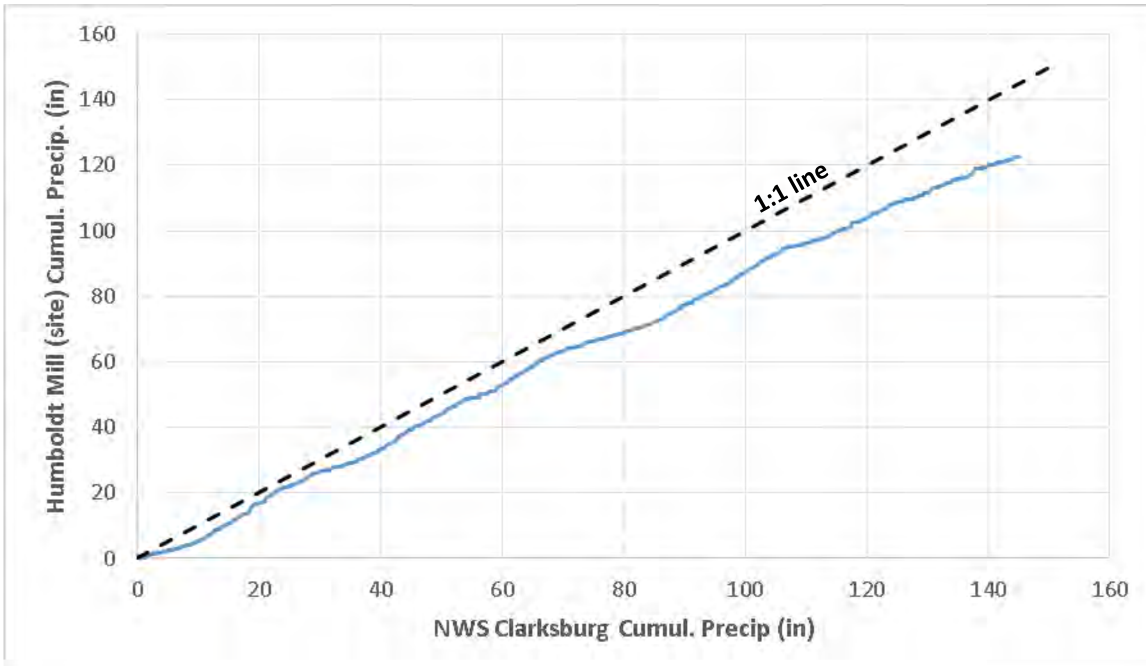

Figure 3-1 Comparison of site and National Weather Service precipitation data

In case of missing data from Clarksburg, the water balance model uses Humboldt Mill precipitation data, then data from the MSU station at Chatham, then the monthly normal precipitation to estimate daily precipitation.

3.3.2 Temperature

The water balance model uses daily average air temperature to inform the evaporation (Section 3.3.3) and snowfall/snowmelt modeling (Section 3.3.4). To be consistent with the precipitation data, the model gives preference to temperature data from the NWS Clarksburg weather station. If data at Clarksburg are unavailable, other stations are used in the following order: Humboldt Mill, Sawyer airport, MSU Chatham station, and the monthly normal air temperature.

3.3.3 Evapotranspiration and evaporation

The primary data source for evapotranspiration and evaporation modeling is the daily reference potential evapotranspiration (PET) reported by the Chatham weather station (Michigan State University 2017). Reference PET is a calculated value that represents the evapotranspiration expected from a well-watered reference crop (typically mown grass) as a function of the measured net radiation, air temperature, wind speed, and humidity at the weather station and is based on the Penman-Monteith equation (Food and Agriculture Organization of the United Nations 1998). Reference PET is intended to represent the varying climatic demand that drives evapotranspiration, independent of soil moisture or vegetative effects. Monthly normal PET is used when daily data from Chatham are not available.

Evapotranspiration from the upland watershed of the HTDF is simulated using a "crop coefficient" approach (Food and Agriculture Organization of the United Nations 1998). The daily reference PET is multiplied by a crop coefficient intended to represent the differences between the actual vegetation and soil characteristics and the well-watered grass reference crop used for PET calculations. The crop coefficient values used for the water balance model are based on Food and Agriculture Organization (FAO) guidance for the primarily deciduous trees in the watershed and vary by day of the year (Figure 3-2). Crop coefficient values were adjusted during model calibration (Section 3.6.2).

Open-water evaporation from the surface of the HTDF is also simulated using a crop coefficient approach, but one that is based on temperature of the HTDF surface water rather than by calendar month (Figure 3-2). FAO guidance for simulating open-water evaporation states that for deep water in temperate latitudes, "initial and peak period evaporation is low as radiation energy is absorbed into the deep water body. During fall and winter periods… heat is released from the water body that increases the evaporation above that for grass" (Food and Agriculture Organization of the United Nations 1998). Varying the evaporation factor by HTDF temperature rather than day of the year allows the model to account for different evaporative behavior in years with late-season warmth or early freeze. Open-water evaporation coefficient values were adjusted during model calibration (Section 3.6.2).

The HTDF temperature used for the evaporation calculation is the monthly running average temperature reported at the Eagle WTP intake or the monthly average air temperature, if WTP data are unavailable. The WTP intake is physically located below the surface of the HTDF. Review of multiple years' data has shown that HTDF surface waters are typically frozen when the observed WTP intake temperature is below 40°F. Therefore, no evaporation is simulated in the model when the monthly running average HTDF temperature is below 40°F. Detailed HTDF temperature profiles do not show a significant influence of the Humboldt Mill tailings discharge (which is at depth) on the surface water temperature (Golder Associates 2018), so no additional evaporation due to surface water warming from tailings discharge is simulated.

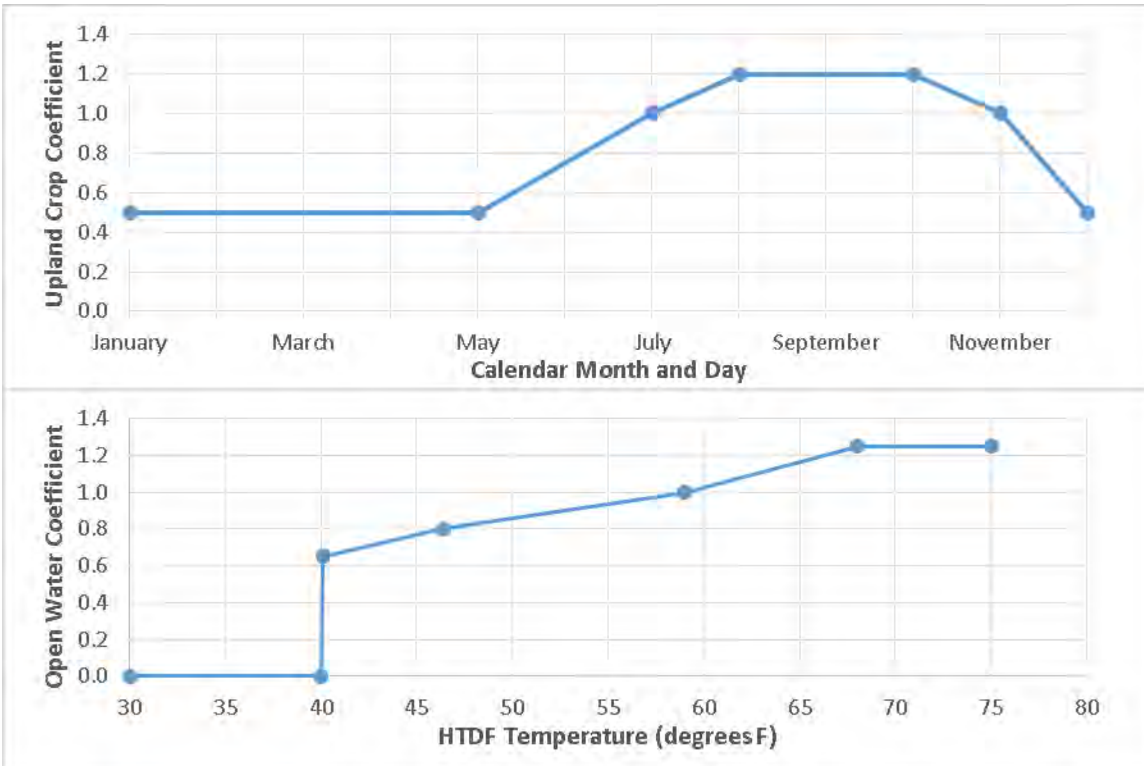

Figure 3-2 Upland evapotranspiration and open water evaporation coefficients

3.3.4 Snowfall and snowmelt

Snowfall and snowmelt are simulated using methods from the Natural Resources Conservation Service (2004) and U.S. Army Corps of Engineers (1998). Precipitation is assumed to fall as snow when the daily average air temperature is 34°F or lower. The albedo of the snowpack (*a*) is a function of the days since the last snowfall (*D*) (U.S. Army Corps of Engineers 1998) using Equation 3-1.

$$a = max\left(0.4, \frac{0.75}{D^{0.2}}\right) \quad \text{Equation 3-1}$$

For days with sufficient data available, the rate of snowmelt is calculated using the energy balance method for partially-forested areas (Natural Resources Conservation Service 2004) using Equation 3-2 for days without rain and Equation 3-3 for days with rain on snow.

$$M = C[0.002I_i(1-a) + (0.0011v + 0.0145)(T_a - T_F) + 0.0039v(T_d - T_F)] \quad \text{Equation 3-2}$$

$$M = C[0.09 + (0.029 + 0.00504v + 0.007P)(T_a - T_F)] \quad \text{Equation 3-3}$$

where:

M = snowmelt (inches snow-water equivalent/day)
I_i = incident solar radiation at Chatham (langleys/day)
v = wind speed 50 feet above the surface at Sawyer airport (miles per hour)
T_a = air temperature (°F)

T_F = freezing temperature (32°F)
T_d = dewpoint temperature at Sawyer airport (°F)
P = rainfall (inches/day)
C = calibration coefficient, value 2.0

For days without sufficient data available, snowmelt is calculated using the degree-day method (Natural Resources Conservation Service 2004) using Equation 3-4.

$$M = C_M(T_a - T_b) \quad \text{Equation 3-4}$$

where:

C_M = degree-day coefficient (inches/degree-day F), value 0.13
T_b = base temperature (taken as the freezing temperature of 32°F)

Coefficients C and C_M were adjusted during model calibration (Section 3.6.2).

The water balance model tracks the simulated snowpack for each day of the simulation, adding snow or removing snow melt as necessary. Note that all snowpack modeling is performed in units of snow-water equivalent (i.e., inches of water contained in the snowpack), not inches of snow. Sublimation losses from the snowpack are simulated as 20% of the 7-day rolling average reference PET.

3.4 Surface water modeling

The surface water component of the water balance model includes all contributions from the upland watersheds surrounding the HTDF and the Humboldt Mill to the HTDF. The surface water model uses the following outputs of the climate modeling discussed in Section 3.3: precipitation (as rain), upland evapotranspiration, and snowmelt.

3.4.1 Watersheds

The watershed of the HTDF was delineated from the DEM provided by Eagle, which is understood to represent current conditions. The area directly draining to the HTDF is 154.6 acres, excluding the 70.5 acres of the HTDF itself. Additional watershed areas for the Humboldt Mill stormwater system and related improvements to the grading to the south of the HTDF were delineated from the DEM and from drawings of the stormwater system (Fluor 2012). These areas total 63.5 acres. Both the direct HTDF watershed and the watershed of the stormwater system are shown on Large Figure 33, and the consideration of the watersheds in the various time periods of the water balance model are shown in Table 3-1.

Table 3-1 Surface water model watersheds

Watershed	With-Eagle model (before April 30, 2013)	With-Eagle model (after April 30, 2013)	No-Eagle model (all time periods)
HTDF footprint	70.5 acres	70.5 acres	70.5 acres
Direct drainage to HTDF	154.6 acres	154.6 acres	154.6 acres
Humboldt Mill stormwater	--	63.5 acres	--

The watershed area directly draining to the HTDF based on the current DEM (154.6 acres) is very similar to that estimated in the Eagle Mine Permit Application (Foth Infrastructure & Environment, LLC 2007), which was based on less detailed topographic data. A portion of the watershed to the northwest of the HTDF consists of a waste rock stockpile from previous mining operations at the site, but the remainder of the watershed has been relatively unchanged since 1939 (i.e., prior to development of the HTDF as an open-pit iron mine) (Environmental Data Resources, Inc. 2010).

The waste rock stockpile is assumed to contribute flow to the HTDF based on its surface topography (watershed divides delineated from the DEM). Although any infiltration through the fairly coarse stockpile material or shallow groundwater flow may follow other flow paths based on the pre-mining topography, there is no strong evidence to suggest that the effective watershed of the HTDF is significantly different than indicated by the surface topography.

3.4.2 Upland runoff

Runoff from upland areas to the HTDF is simulated using a catchment water balance model that represents a watershed with a series of surface stores or “buckets” as shown in Figure 3-3 (Boughton 2004). Conceptually, the surface stores represent portions of the watershed that have varying capacity to store soil moisture before generating runoff. The total surface area of the surface stores equals the total area of the watershed.

The model calculates the water balance of each surface store at a daily time step, adding rainfall or snowmelt and subtracting losses to upland evapotranspiration or groundwater recharge. The daily water balance equation for an individual surface store is shown in Equation 3-5. If a surface store becomes empty, it has no outflow. If a surface store becomes full, any additional inflow becomes rainfall excess (a.k.a. runoff). The use of multiple surface stores allows the model to generate runoff at a rate that varies depending on the soil moisture conditions and the magnitude of a given precipitation event.

$$V_{i,current} = V_{i,prev} + P + M - ET - R \qquad \text{Equation 3-5}$$

where:

V_i = soil moisture storage in a single surface store (inches)
P = rainfall (inches/day), see Section 3.3.1
M = snowmelt (inches snow-water equivalent/day), see Section 3.3.4

ET = upland evapotranspiration (inches/day), see Section 3.3.3

R = groundwater recharge, set at 6.0 inches/year, see below

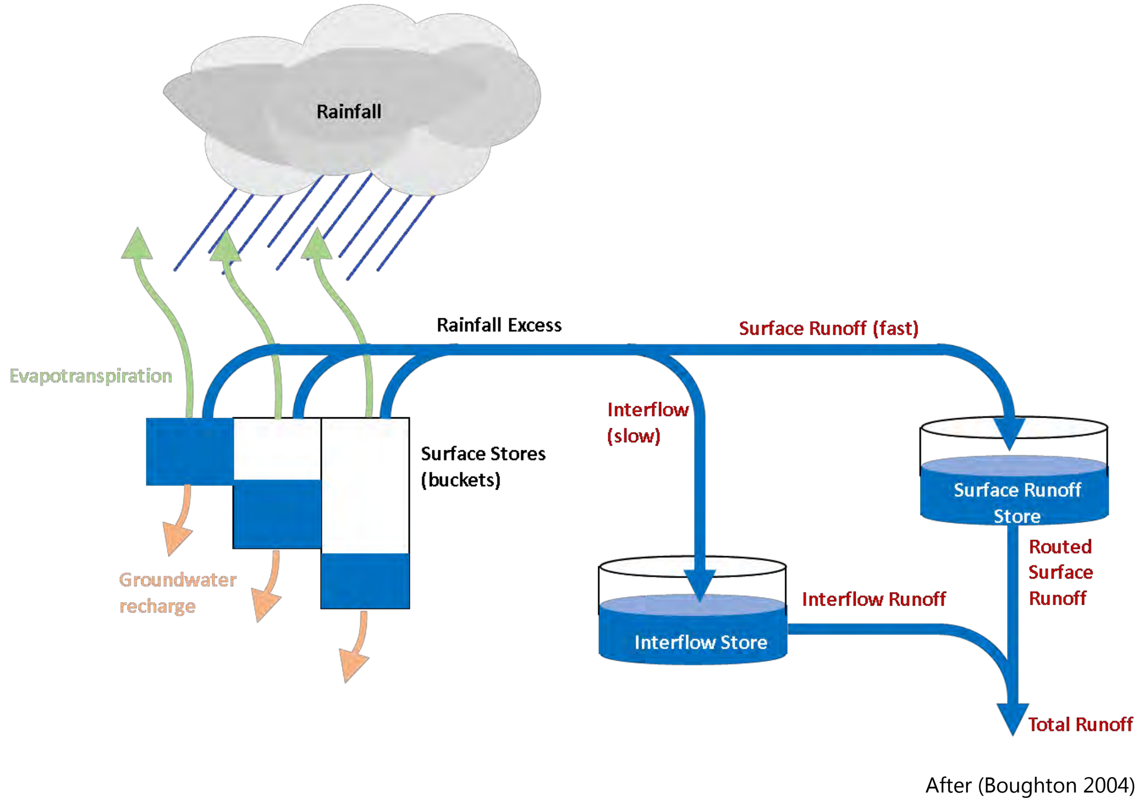

Figure 3-3 Upland runoff model schematic

When rainfall excess is generated from any surface store, part of the runoff is assumed to travel to the HTDF relatively slowly (interflow or shallow groundwater flow) and the remainder travels quickly (surface runoff). Both types of flow are routed through storage elements in the model, which are depleted at a user-specified rate (recession constant K_I and K_S) that is a function of the water remaining in the store as shown in Equation 3-6. This modeling method produces runoff curves that recede over time, with the rate of recession dependent on the partitioning of interflow versus surface runoff and the recession constants applied to each reservoir.

$$Interflow = (1 - K_I)V_{Interflow\ store}$$

$$Surface\ runoff = (1 - K_S)V_{Surface\ runoff\ store}$$

Equation 3-6

Runoff model parameters that were adjusted during model calibration (Section 3.6) are shown in Table 3-2. The average annual precipitation at Clarksburg for 2007-2016 is 29.4 inches; this corresponds to an estimated recharge rate of 7.4 inches per year for unconsolidated materials and 0.74 inches per year for bedrock based on Section 2.4.5. The recharge used in the surface water model represents the maximum demand on the surface soil stores and is not directly analogous to recharge applied in the groundwater flow model due to the difference in scale between the groundwater model and runoff model. The recharge value for the runoff model was adjusted during calibration and is within the range of variability suggested by the references in Section 2.4.5.

Table 3-2 Runoff model parameters

Parameter	Units	Direct HTDF watershed	Humboldt Mill stormwater
Surface store fractions[(1)]	% of watershed	15%, 45%, 40%	30%, 45%, 25%
Surface store capacity[(1)]	inch	0.75, 2.25, 3.5	0.75, 2.25, 3.5
Interflow fraction	% of rainfall excess	90%	75%
Interflow recession K_I	--	0.99	0.99
Surface runoff recession K_S	--	0.75	0.75
Groundwater recharge R	inch per year	6.0	6.0

Note
(1) Values listed are for the three surface stores (buckets) used in the runoff model.

3.5 Water balance modeling

The water balance model for the HTDF integrates the effects of climatic variability and changes in operations of the Humboldt Mill and the WTP. As noted in Section 3.2, the daily water balance computations are performed for the with-Eagle and no-Eagle conditions simultaneously. The following sections describe additional inputs to the water balance model.

3.5.1 HTDF stage-area and stage-storage

For both with-Eagle and no-Eagle conditions, the HTDF stage-area and stage-storage relationships are computed from information developed for the Mine Permit Application (Foth Infrastructure & Environment, LLC 2007), supplemented with data from the DEM provided by Eagle for higher HTDF water elevations (above 1538 feet amsl). The stage-storage curve represents the volume of the HTDF prior to placement of any Eagle tailings; the water balance model does not differentiate between the Eagle tailings and overlying water when computing changes in the storage volume in the HTDF.

3.5.2 Direct precipitation and evaporation

Daily direct precipitation on the HTDF surface is calculated as the sum of the daily rainfall and any snowmelt flow (inches per day), multiplied by the HTDF area at the rim elevation of 1542 feet amsl (70.5 acres). This calculation assumes 100% runoff from the small area of exposed walls of the HTDF below the rim elevation. The snowpack on the HTDF walls and on the frozen surface of the HTDF is assumed to behave identically to the remainder of the watershed (Section 3.3.4).

Evaporation from the HTDF surface is calculated using the weekly average PET (inches per day) multiplied by the open-water evaporation factor presented in Section 3.3.3. No evaporation is simulated for periods where the HTDF surface is understood to be frozen. The computed evaporation rate is multiplied by the current HTDF water surface area computed from the stage-area curve.

3.5.3 Water Treatment Plant

The WTP withdraws water from the HTDF near its surface, treats the water for discharge to one or more the three surface water outfalls north of the HTDF, and returns a portion of the water to the HTDF as reject concentrate. Eagle provided daily information on the WTP flow rates (gallons per day), including the intake rate, total discharge rate and discharge rates to the three outfalls, and the rate of return flow to the HTDF. A small volume of water (200 gallons per day) is assumed to be lost within the WTP for laboratory uses, based on water balance data provided to Barr by Eagle.

The water balance model uses the data from Eagle to set the WTP intake and discharge rates. If the reported daily total inflows and outflows from the WTP do not match (likely due to minor instrument errors), the balance in Equation 3-8 is adjusted by varying the reject return term. If the reported discharges to the individual outfalls do not match the reported total, the balance in Equation 3-9 is adjusted by varying the Outfall 002 term.

$$Intake = Lab + Discharge + \ Reject\ return \qquad \text{Equation 3-8}$$

$$Discharge = Outfall\ 001 + Outfall\ 002 + Outfall\ 003 \qquad \text{Equation 3-9}$$

For the purposes of the water balance model, all pumping of accumulated storm water out of the HTDF prior to the beginning of operations of the WTP (between April 30, 2013 and August 24, 2014) is handled in the same manner as the WTP flows.

3.5.4 Humboldt Mill

The Humboldt Mill discharges tailings slurry to the HTDF at depth, and withdraws make-up water from the HTDF for the processing operations. Eagle provided daily information on the mill flow rates (gallons per day), including the total discharge of tailings slurry (tailings plus water) and reclaim water. As noted in Section 3.5.1, the water balance model does not differentiate between the Eagle tailings and overlying water when computing changes in the storage volume in the HTDF. The total volume of slurry added to the HTDF (tailings plus water) is assumed to displace an equal volume of water.

3.5.5 Groundwater

Groundwater flows for the water balance were taken from the MODFLOW outputs discussed in Section 2.7 and shown in Large Figure 31. The water balance model uses lookup tables to define the groundwater inflow and outflow rates from the daily HTDF WSEL.

The MODFLOW results for conditions without the cut-off wall in place (2008 conditions in Large Figure 31) are used for the no-Eagle water balance (all time periods) and for the with-Eagle water balance prior to partial installation of the cut-off wall in November 2012. The MODFLOW results for conditions with the cut-off wall in place (2014 conditions in Large Figure 31) are used for the remainder of the with-Eagle water balance. Because the MODFLOW results for 2014 and 2017 conditions are nearly identical, only one set of results was used for the water balance modeling.

The MODFLOW results for the 2014 conditions are also used in the water balance model to estimate the portion of the groundwater inflow to the HTDF from the north. This flow rate does not change the water balance for the HTDF, but contributes to the discharge flow rate target.

3.5.6 Surface outflow (pre-Eagle and no-Eagle conditions)

Prior to installation of the cut-off wall and the subsequent pumpdown of the HTDF, the net excess of flow into the HTDF was observed to exit the HTDF to the wetlands to the north. Discharge was by surface flow, shallow subsurface flow through the porous rubble material in the area, and through several buried culverts that were later identified during the cut-off wall installation (Golder Associates 2014). Due to the complex and ambiguous nature of this outflow, the water balance model does not simulate flow through a specific shape of channel or weir. Rather, the general form of the weir equation is used to control surface outflow from the HTDF as shown in Equation 3-10.

$$Q = C(WSEL - D)^{\frac{3}{2}} \qquad \text{Equation 3-10}$$

where:

Q= total surface, shallow subsurface, and conduit outflow (gpm)
C = calibrated discharge coefficient, set at 100 gpm, see Section 3.6
WSEL = water surface elevation of the HTDF (feet amsl)
D = effective base elevation for surface outflow, set at 1535 feet amsl, see Section 3.6

Equation 3-10 was used for the no-Eagle water balance model for all time periods. For the with-Eagle model, Equation 3-10 was used prior to installation of the cut-off wall in November 2012. During the period when the cut-off wall was partially complete (November 8, 2012 to August 21, 2013), the outflow predicted by Equation 3-10 was reduced by 80% in the water balance model. Following completion of the cut-off wall in August 2013, no surface outflow is allowed in the with-Eagle model.

In addition to the surface outflow simulated with Equation 3-10, a HTDF rim elevation of 1543 feet amsl is defined in both no-Eagle and with-Eagle water balance models. If the predicted HTDF WSEL reaches this value, any additional inflow is assumed exit the HTDF in the same day. The highest observed WSEL in Eagle’s data is 1540.8 feet amsl.

3.6 Model calibration

The water balance model was manually calibrated through adjustment of a number of calibration parameters within user-specified ranges. The objectives of the calibration process were to:

- Match the long-term trends in the HTDF WSEL data provided by Eagle;

- Maintain predicted WSEL within ±2 feet of the observed WSEL for both with-Eagle and pre-Eagle conditions; and
- Match the WSEL response to individual storm events, winter water levels, and observed water levels during HTDF drawdown.

3.6.1 Calibration data sets

The primary data set used for calibration was the observed HTDF WSEL record provided by Eagle. Calibration focused on the time period during Eagle operations for which continuous HTDF water level measurement are available, specifically December 24, 2015 through February 5, 2018. This data set was used for calibration of the climate, surface water, and groundwater portions of the water balance models. The initial period of Eagle operations (August 25, 2014 through December 23, 2015) was not used for calibration.

The snowmelt model was calibrated to observed snow depth data from the NWS station at Clarksburg from 2007 to 2017 (National Weather Service 2017).

Additional calibration of the pre-Eagle model, specifically the surface outflow portion of the model, used a data set of six HTDF WSEL observations between May 2007 and October 2008.

Finally, transient model adjustments during the HTDF drawdown period were calibrated to the observed WSEL data between April 2013 and August 2014.

3.6.2 Calibration parameters

Parameters adjusted during calibration included:

- Upland evapotranspiration and open water evaporation coefficients (Section 3.3.3);
- Snowmelt coefficients for energy budget and degree-day methods (Section 3.3.4);
- Runoff model parameters, including surface store fractions and capacity, recharge, interflow fraction, and interflow and surface runoff recession constants (Section 3.4.2 and Table 3-2);
- Seasonal adjustments to groundwater inflows to the HTDF (discussed below); and
- Surface outflow base elevation, discharge coefficient, and reduction factor during partial cut-off wall construction (Section 3.5.6).

During the calibration process it was observed that water levels are stable or decreasing in the HTDF during winter periods, despite other factors in the water balance (groundwater inflows and pumping rates) that often suggest water levels should increase during winter. This observation led to the development of a seasonal groundwater reduction factor that was adjusted in the calibration process. Conceptually, the seasonal groundwater adjustment represents the reduction in groundwater flows to the HTDF due to reduced recharge and groundwater movement when the ground is frozen. This reduction was applied to both no-Eagle and with-Eagle conditions identically, with a final value of 100 gpm of reduced groundwater inflow applied whenever the HTDF is frozen.

3.6.3 Additional transient adjustments

In addition to the main calibration parameters discussed in Section 3.6.2, an additional transient groundwater inflow was included in the with-Eagle water balance model. The intent of the transient inflow was to represent additional groundwater flows into the HTDF as the groundwater cone of depression expanded (which are not represented in the steady-state MODFLOW models) during HTDF drawdown between April 2013 and August 2014. The transient flow was calibrated to match the observed change in the HTDF WSEL during this period, with a final value of 58 gpm.

3.6.4 Calibration results

The calibrated model results for the HTDF WSEL are shown in Figure 3-4 for the calibration period of December 24, 2015 through February 5, 2018. The calibration process was able to achieve the objectives of matching the long-term trends in the HTDF WSEL data and the WSEL response to individual events. For this period, observed and predicted HTDT WSEL are within ±0.5 feet of each other.

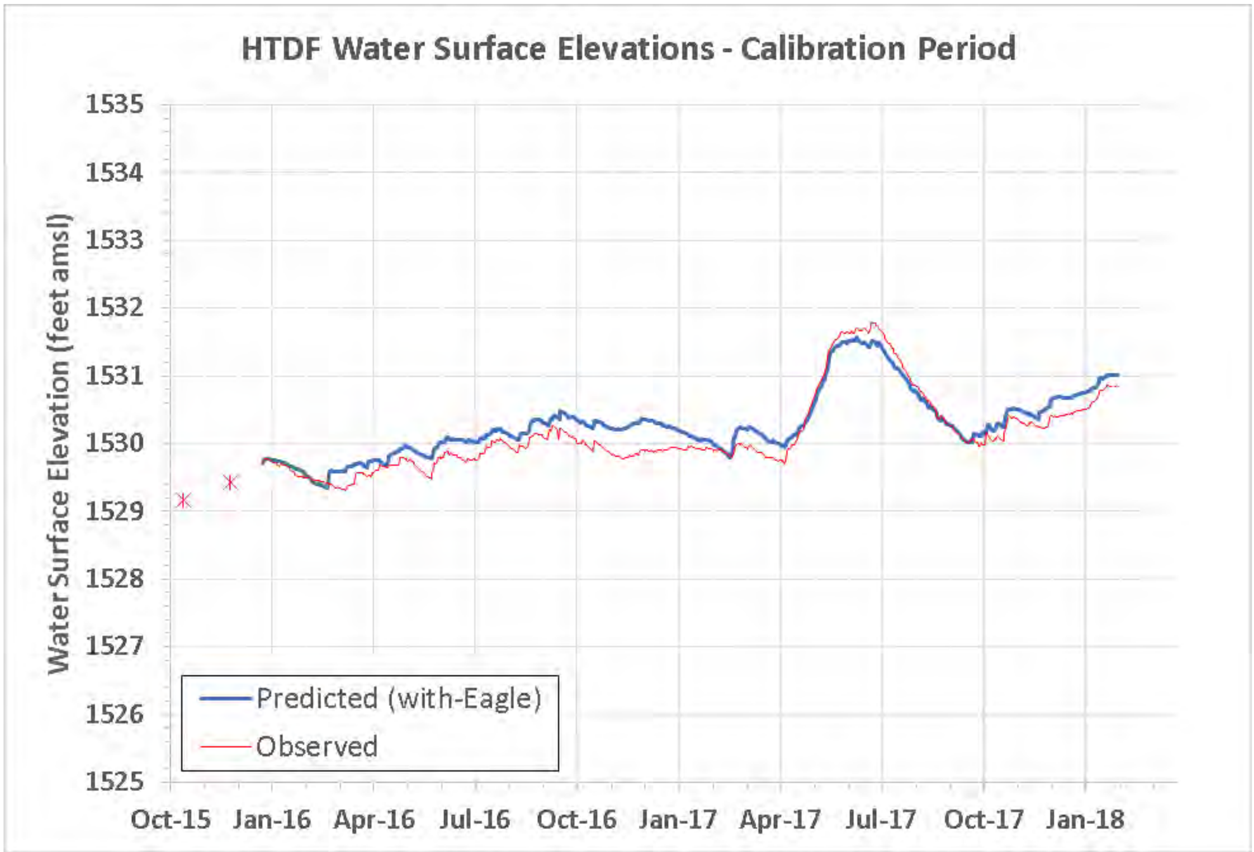

Figure 3-4 Modeled vs. observed HTDF water surface elevations, calibration period

3.7 Continuous model results

This section presents the results for the calibrated water balance models for both with-Eagle and no-Eagle conditions.

3.7.1 HTDF water surface elevation

The calibrated model results for the long-term simulation of HTDF WSEL are shown in Figure 3-5. Some separation between the observed and modeled WSEL occurs in the model during the initial period of Eagle operations (August 2014 through December 2015). This separation may be due to refinement of the water balance during this initial period of mill operation, specifically improvements made during the period to equipment and techniques used to measure the flow of tailings slurry and reclaim water to the mill. As shown for the model calibration period in Figure 3-4, the water balance model matches well with the observed pattern of WSEL changes following December 2015.

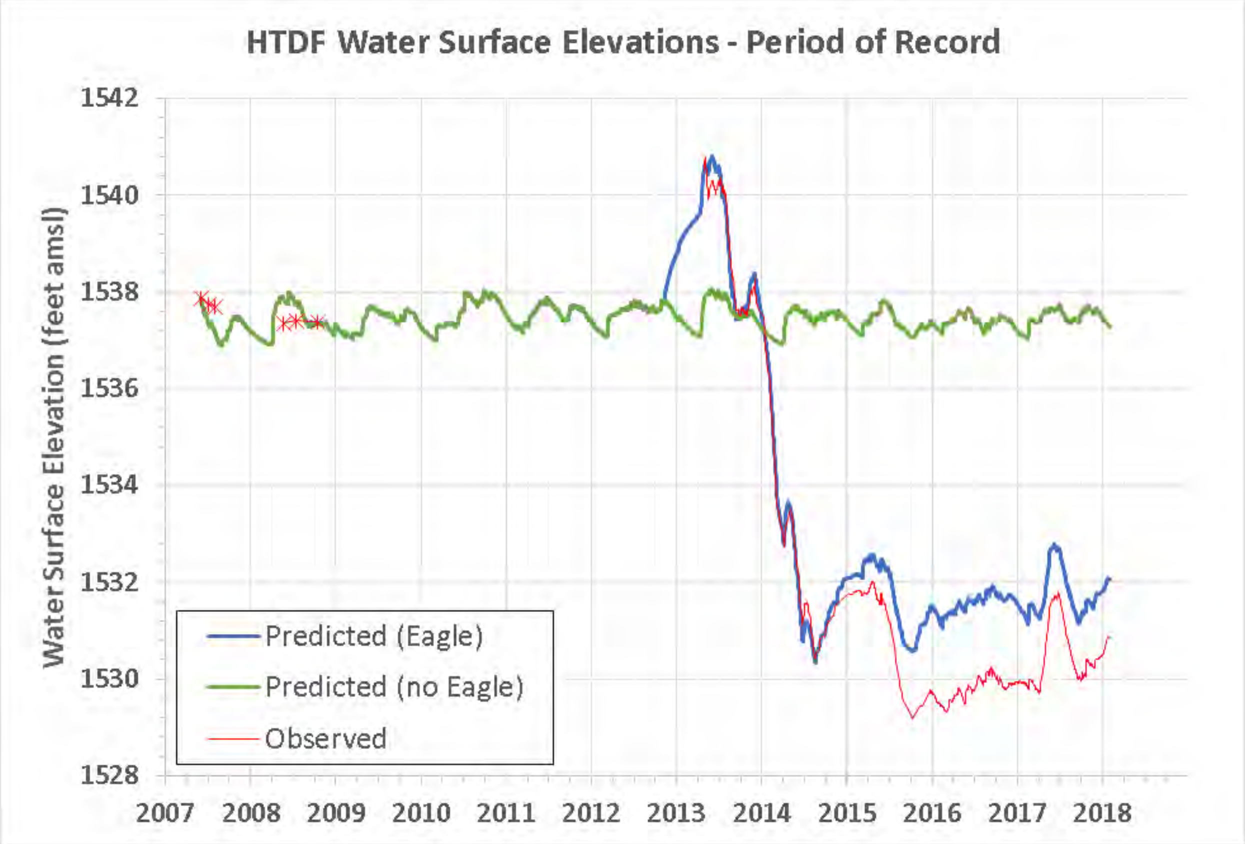

Figure 3-5 Modeled vs. observed HTDF water surface elevations, period of record

3.7.2 No-Eagle HTDF outflow

The calibrated model results for the total outflow from the HTDF under no-Eagle conditions are shown as the green line in Figure 3-6. The predicted two-week running average outflow, which combines both groundwater and surface water outflow, ranges from 320 to 590 gpm, with an average value of 440 gpm.

The predicted no-Eagle outflow is used to set the recommended target value for discharge to the wetlands north of the HTDF. The discharge target is simply the no-Eagle outflow plus the estimated amount of groundwater flow from the north to the HTDF under with-Eagle conditions.

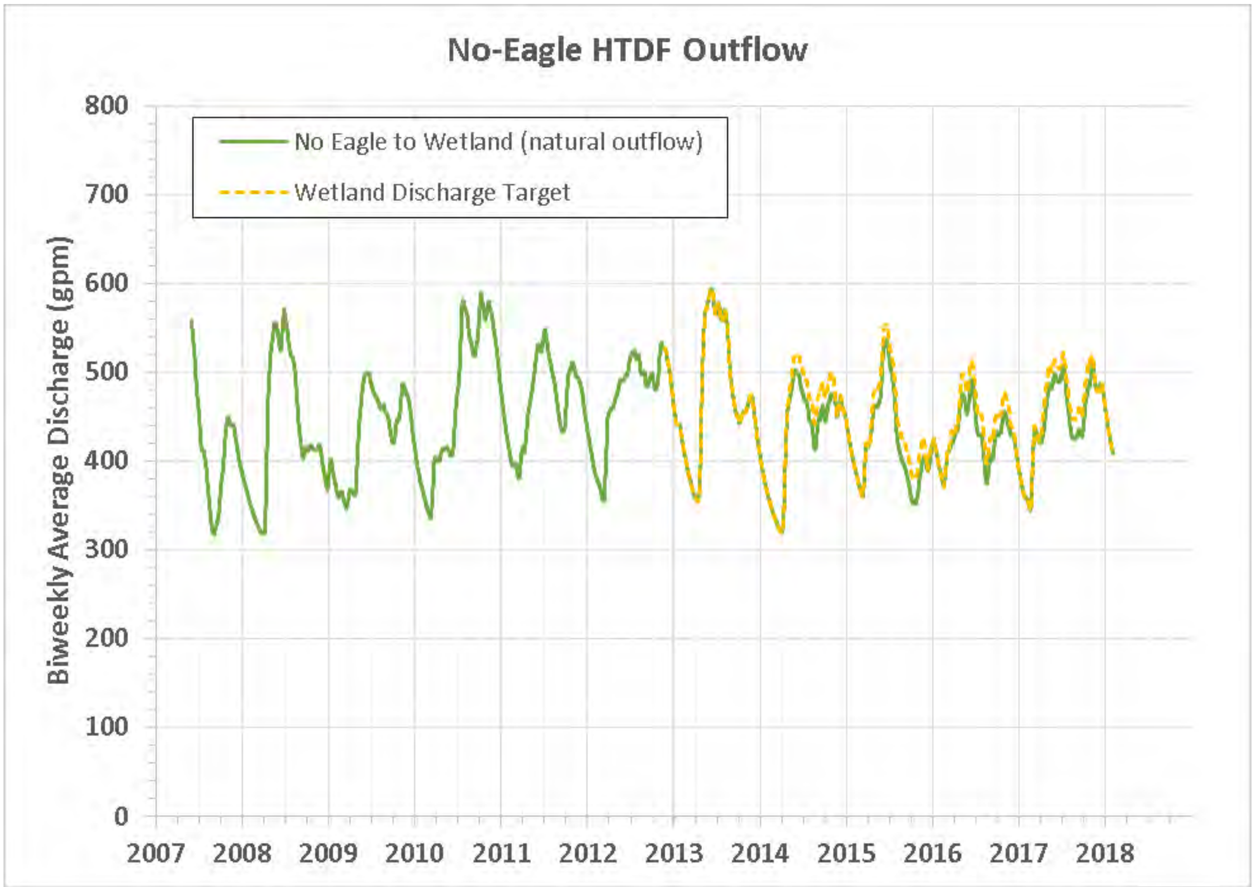

Figure 3-6 Modeled HTDF outflow (no-Eagle conditions) and wetland discharge target

3.7.3 Snowmelt

Results for the snowmelt portion of the water balance model are shown in Figure 3-7. The simulated snowpack closely approximates the observed snow depth at Clarksburg when increased by a factor of ten to convert snow-water equivalent into snow depth. The snowmelt model accurately represents the speed of snowpack decline, and captures most of the snowpack dynamics over ten years of data.

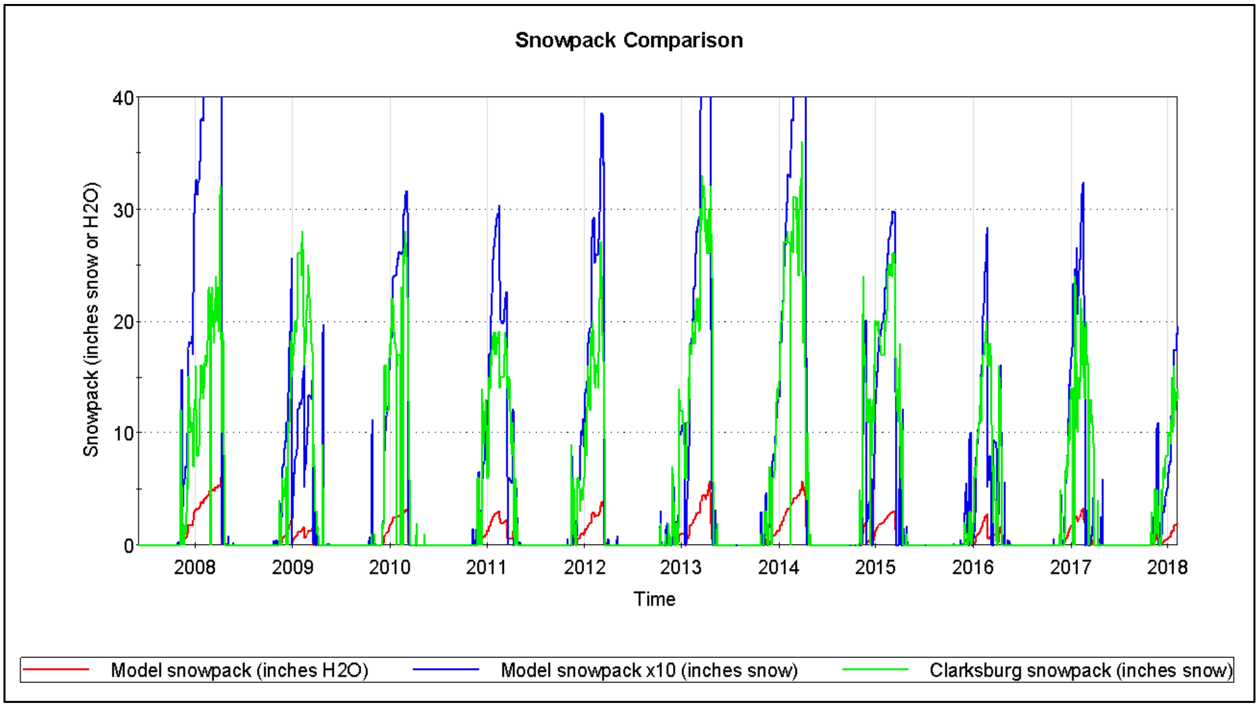

Figure 3-7 Modeled vs. observed snowpack

4.0 Summary and conclusions

Integrated groundwater, surface water, and water balance models of the HTDF were developed by Barr on behalf of Eagle. The models were developed to provide an understanding of groundwater and surface water flow conditions for current operational use and to support future post-closure outfall design. The models estimate water flows to/from the HTDF for: 1) the HTDF and surrounding watersheds as they exist today; and 2) the HTDF and surrounding watersheds under conditions that are consistent with those prior to Eagle's redevelopment of the Humboldt Mill facility and construction of the cut-off wall.

The groundwater, surface water, and water balance models are complete and have been calibrated to the extent practical. The calibrated models meet the objectives of the calibration and are within generally accepted industry norms in terms of accuracy for their intended purposes.

The integrated surface water and water balance model of the HTDF represents an appropriate tool for Eagle's use to prescribe water discharge rates to the wetlands north of the HTDF. The objective of the discharge protocol is to discharge treated water from the HTDF in a manner that replicates the estimated groundwater and surface water flow conditions prior to Eagle's redevelopment of the Humboldt Mill facility. This discharge protocol is also representative of anticipated water discharge under post-closure conditions at the Humboldt Mill facility (i.e., subsequent to the conclusion of Eagle's operations and at such a time as water in the HTDF is of adequate quality that water treatment is not necessary).

Additional adjustment, refinement, or re-calibration of the groundwater, surface water, and water balance models of the HTDF may be warranted as additional data becomes available or should Eagle desire to use the models for other purposes.

5.0 References

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Large Tables

Large Table 1
CALIBRATION PARAMETERS
Water Balance Modeling
Eagle Mine, LLC

Model Parameter	Units	Parameter Type	Parameter Description	Free/ Tied	Calibrated Value	Lower Bound	Upper Bound
kx1	ft/day	Horizontal Hydraulic Conductivity	Tailings	Free	3.55E+02	6.92E-02	1.73E+03
kx2	ft/day		Fine Fill	Free	1.64E+02	5.18E-05	1.73E+02
kx3	ft/day		Coarse Fill	Free	3.74E+02	1.73E-02	1.73E+03
kx4	ft/day		Peat	Free	2.14E+01	2.13E-02	1.08E+02
kx5	ft/day		Clay	Free	5.07E-02	1.93E-03	1.00E-01
kx6	ft/day		Fine Outwash with Clay	Free	1.21E-02	8.96E-03	2.80E+01
kx7	ft/day		Fine Outwash	Free	2.26E+02	6.04E-03	2.59E+02
kx8	ft/day		Coarse Outwash with Fines	Free	3.33E+01	6.04E-03	1.73E+02
kx9	ft/day		Coarse Outwash	Free	3.33E+01	6.04E-03	2.59E+03
kx10	ft/day		Upper Bedrock	Free	5.72E-01	8.63E-04	2.52E+00
kx11	ft/day		Deeper Bedrock	Free	5.69E-03	2.96E-05	2.52E+00
kz1	ft/day	Vertical Hydraulic Conductivity	Tailings	Free	7.10E-01	6.92E-05	3.46E+02
kz2	ft/day		Fine Fill	Free	2.05E-01	5.18E-08	3.46E+01
kz3	ft/day		Coarse Fill	Free	4.68E-01	1.73E-05	3.46E+02
kz4	ft/day		Peat	Free	2.18E+00	2.13E-05	2.16E+01
kz5	ft/day		Clay	Free	8.36E-03	1.93E-06	2.00E-02
kz6	ft/day		Fine Outwash with Clay	Free	1.18E-04	8.96E-06	5.60E+00
kz7	ft/day		Fine Outwash	Free	1.64E+01	6.04E-06	5.18E+01
kz8	ft/day		Coarse Outwash with Fines	Free	6.66E+00	6.04E-06	3.46E+01
kz9	ft/day		Coarse Outwash	Free	6.66E+00	6.04E-06	5.18E+02
kz10	ft/day		Upper Bedrock	Free	5.20E-02	8.63E-07	5.04E-01
kz11	ft/day		Deeper Bedrock	Free	6.70E-04	2.96E-08	5.04E-01
kz_riv_1	ft/day	Vertical Hydraulic Conductivity Component of Riverbed and Wetland Bed Conductance	Regional Wetlands	Free	4.74E-02	8.96E-07	2.59E+03
kz_riv_2	ft/day		Wetlands Surveyed by Eagle	Free	7.51E-01	8.96E-07	2.59E+03
kz_riv_3	ft/day		ALS Wetlands	Tied	7.51E-01	8.96E-07	2.59E+03
kz_riv_10	ft/day		Unnamed Creek	Free	3.30E+02	8.96E-07	2.59E+03
kz_riv_11	ft/day		Escanaba River	Tied	3.30E+02	8.96E-07	2.59E+03
kz_riv_12	ft/day		Middle Branch Escanaba River	Tied	3.30E+02	8.96E-07	2.59E+03
kz_riv_13	ft/day		Halfway Creek	Tied	3.30E+02	8.96E-07	2.59E+03
kz_riv_20	ft/day		Regional Wetlands near Mill	Free	9.51E-07	8.96E-07	2.59E+03
kz_riv_21	ft/day		Regional Wetlands near Mill	Free	9.51E-07	8.96E-07	2.59E+03
kz_riv_22	ft/day		Regional Wetlands near Mill	Free	9.51E-07	8.96E-07	2.59E+03
kz_riv_23	ft/day		Regional Wetlands near Mill	Free	9.51E-07	8.96E-07	2.59E+03
kz_riv_30	ft/day		Wetlands Surveyed by Eagle	Free	7.51E-02	8.96E-07	2.59E+03

Large Table 2
RECHARGE PARAMETERS
Water Balance Modeling
Eagle Mine, LLC

Model Parameter	Model Time Period	Units	Parameter Description		Value
rch_08_1	2008 Conditions	in/yr	Recharge	Unconsolidated Sediments Recharge	7.01
rch_08_2				Surficial Bedrock Recharge	0.70
rch_14_1	2014 Conditions			Unconsolidated Sediments Recharge	8.13
rch_14_2				Surficial Bedrock Recharge	0.81
rch_17_1	2017 Condition			Unconsolidated Sediments Recharge	9.05
rch_17_2				Surficial Bedrock Recharge	0.91

Large Table 3
CALIBRATION OBSERVATIONS AND RESIDUALS
Water Balance Modeling
Eagle Mine, LLC

Observation Name	Site Period	Observation Type	Observed Value	Simulated Value	Residual
HW-1	2008 Conditions (7/15/2008)	Head (ft)	1536.02	1535.50	0.53
HW-2_P			1536.65	1536.34	0.30
HW-3			1550.43	1560.22	-9.79
HW-4			1554.30	1562.21	-7.91
HW-5			1536.98	1536.91	0.07
HW-5A			1537.17	1537.08	0.10
HW-6_P			1533.83	1534.23	-0.41
HW-6A			1534.28	1534.19	0.09
KMW-1			1584.15	1573.74	10.42
KMW-2			1582.94	1579.95	2.99
KMW-3			1576.67	1574.43	2.24
KMW-5			1558.79	1565.91	-7.12
KMW-6A			1558.92	1567.36	-8.44
KMW-7			1559.61	1569.12	-9.51
KMW-9			1558.53	1567.85	-9.32
KMW-9P			1558.73	1567.74	-9.01
KMW-10			1589.37	1591.73	-2.36
MW-5			1582.74	1576.65	6.09
MW-6			1570.18	1576.30	-6.13
MW-7			1568.80	1575.13	-6.33
MW-9			1589.11	1579.52	9.58
MW-101			1596.03	1590.97	5.06
MW-601			1598.52	1605.08	-6.56
MW-602			1606.96	1612.01	-5.06
MW-603			1596.95	1609.14	-12.19
MW-604			1589.30	1588.90	0.41
MW-606			1604.63	1610.63	-6.01
P-602			1606.92	1611.85	-4.93
P-604			1588.85	1589.18	-0.33
P-605			1590.45	1595.59	-5.14
mi_2925			1525.98	1527.51	-1.53
mi_2926			1527.66	1534.81	-7.15
mi_2927			1512.01	1524.23	-12.22
mi_2929			1512.47	1524.55	-12.09
mi_2937			1578.67	1577.44	1.23
mi_2938			1584.22	1588.89	-4.68
mi_2939			1583.99	1575.14	8.85
mi_2941			1537.01	1543.14	-6.13
mi_2948			1567.16	1565.46	1.70
mi_2949			1568.04	1566.55	1.49
mi_2952			1578.58	1578.90	-0.33
mi_2953			1582.58	1575.14	7.44
mi_2954			1575.69	1572.73	2.96
mi_2956			1538.55	1544.80	-6.25
mi_2958			1555.77	1550.98	4.79
mi_2959			1581.99	1569.23	12.76
mi_2960			1556.86	1561.55	-4.69
mi_4197			1516.54	1539.85	-23.32
mi_4260			1590.09	1574.17	15.93

Large Table 3
CALIBRATION OBSERVATIONS AND RESIDUALS
Water Balance Modeling
Eagle Mine, LLC

Observation Name	Site Period	Observation Type	Observed Value	Simulated Value	Residual
MW-701-QAL	2014 Conditions (10/10/2014)	Head (ft)	1531.79	1531.25	0.54
MW-701-UFB			1531.99	1532.14	-0.15
MW-702-QAL			1530.81	1535.40	-4.59
MW-702-UFB			1531.82	1532.62	-0.80
MW-703-QAL			1535.53	1535.04	0.50
MW-703-UFB			1533.33	1533.07	0.27
MW-703-LLA			1533.23	1533.03	0.21
MW-703-DBA			1532.94	1532.89	0.05
MW-704-DBA			1533.60	1535.63	-2.04
MW-704-LLA			1533.40	1533.43	-0.03
MW-704-UFB			1533.23	1533.50	-0.26
MW-704-QAL			1533.01	1532.91	0.09
MW-705-QAL			1535.07	1533.60	1.48
MW-705-UFB			1534.94	1536.22	-1.28
HW-2_C			1531.46	1531.48	-0.02
HW-6_C			1532.25	1533.10	-0.85
HW-1U			1531.99	1532.48	-0.49
HW-1L			1528.58	1532.16	-3.58
HW-8U			1532.91	1533.58	-0.67
HWMB_1			1531.36	1532.39	-1.03
HWMB_REFC			1530.64	1530.92	-0.27
HWMB_REFD			1528.61	1530.60	-1.99
MW-701-QAL_2017	2017 Conditions (8/22/2017)	Head (ft)	1530.35	1530.75	-0.40
MW-701-UFB_2017			1530.54	1531.72	-1.18
MW-702-QAL_2017			1529.76	1535.42	-5.66
MW-702-UFB_2017			1533.04	1532.27	0.77
MW-703-QAL_2017			1532.87	1535.03	-2.16
MW-703-UFB_2017			1531.46	1532.79	-1.32
MW-703-LLA_2017			1531.33	1532.74	-1.41
MW-703-DBA_2017			1530.61	1532.52	-1.91
MW-704-DBA_2017			1531.07	1535.36	-4.29
MW-704-LLA_2017			1530.87	1533.29	-2.42
MW-704-UFB_2017			1530.74	1533.36	-2.62
MW-704-QAL_2017			1530.38	1532.91	-2.53
MW-705-QAL_2017			1533.46	1533.59	-0.12
MW-705-UFB_2017			1533.17	1536.08	-2.91
HW-2_2017			1531.10	1531.05	0.05
HW-1U_2017			1525.98	1532.24	-6.26
HW-8U_2017			1516.04	1533.34	-17.30
MW-706-QAL_2017			1561.15	1570.23	-9.08
MW-707-QAL_2017			1581.33	1577.89	3.44
H-N_2017			1528.94	1529.99	-1.05

Large Table 4
SIMULATED HTDF GROUNDWATER FLOW
Water Balance Modeling
Eagle Mine, LLC

	2008 Conditions	
HTDF Stage [ft amsl]	HTDF Inflows [GPM]	HTDF Outflows [GPM]
1528	516	0
1531.1	452	0
1532	433	0
1533	410	0
1537.4	359	56
1538	357	69
1538.5	354	80
1542	337	162

	2014 Conditions	
HTDF Stage [ft amsl]	HTDF Inflows [GPM]	HTDF Outflows [GPM]
1528	434	0
1531.1	408	0
1532	400	0
1533	391	0

	2017 Conditions	
HTDF Stage [ft amsl]	HTDF Inflows [GPM]	HTDF Outflows [GPM]
1528	441	0
1531.1	415	0
1532	407	0
1533	398	0

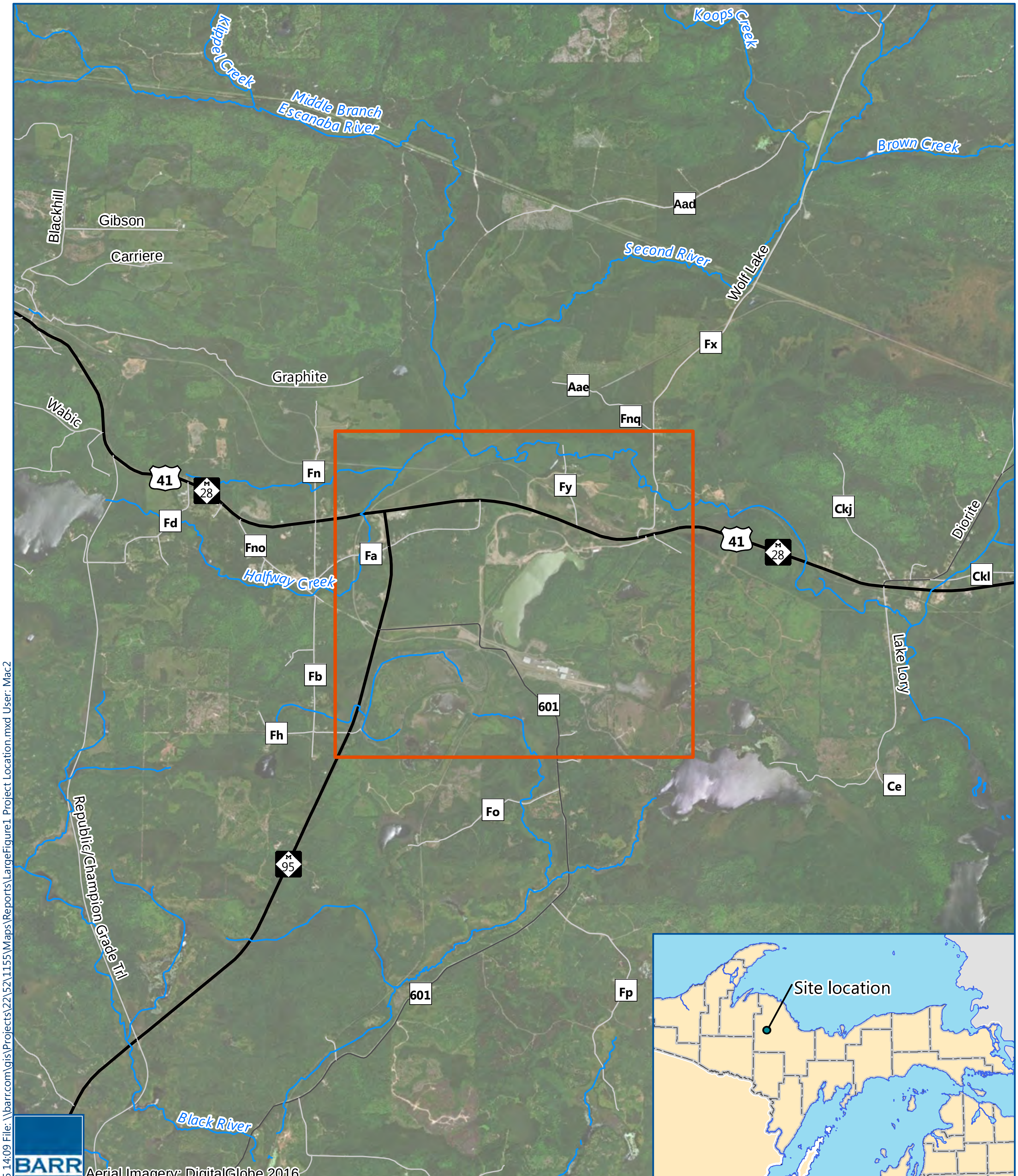
Large Table 5
SENSITIVITY ANALYSIS PARAMETERS AND RESULTS
Water Balance Modeling
Eagle Mine, LLC

			2008 CONDITIONS [Percent change from base]		2014 CONDITIONS [Percent change from base]		2017 CONDITIONS [Percent change from base]	
Parameter Type	**Parameter change from base**	**Parameter Value**	**HTDF Inflows**	**HTDF Outflows**	**HTDF Inflows**	**HTDF Outflows**	**HTDF Inflows**	**HTDF Outflows**
Horizontal Hydraulic Conductivity [ft/day]	kx1 increased	1.73E+03	0.7%	0.0%	0.5%	0.0%	0.6%	0.0%
	kx1 decreased	3.55E+01	-0.8%	0.0%	-0.7%	0.0%	-0.7%	0.0%
	kx2 increased	1.73E+02	0.1%	0.4%	0.1%	0.0%	0.1%	0.0%
	kx2 decreased	1.64E+01	-1.8%	-11.2%	-1.5%	0.0%	-1.7%	0.0%
	kx3 increased	1.73E+03	0.4%	0.0%	0.2%	0.0%	0.4%	0.0%
	kx3 decreased	3.74E+01	-0.5%	0.0%	-0.3%	0.0%	-0.5%	0.0%
	kx4 increased	1.08E+02	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%
	kx4 decreased	2.14E+00	0.0%	-4.4%	0.0%	0.0%	0.0%	0.0%
	kx5 increased	1.13E-01	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kx5 decreased	5.07E-03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kx6 increased	1.21E-01	0.1%	0.2%	0.1%	0.0%	0.1%	0.0%
	kx6 decreased	8.96E-03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kx7 increased	2.59E+02	-0.2%	0.0%	-0.1%	0.0%	-0.1%	0.0%
	kx7 decreased	2.26E+01	1.8%	0.2%	1.3%	0.0%	1.5%	0.0%
	kx8 increased	1.73E+02	88.1%	406.6%	93.6%	0.0%	92.7%	0.0%
	kx8 decreased	3.33E+00	-39.0%	-88.8%	-40.5%	0.0%	-40.2%	0.0%
	kx9 increased	3.33E+02	14.7%	27.8%	13.8%	0.0%	13.6%	0.0%
	kx9 decreased	3.33E+00	-7.7%	-14.3%	-7.5%	0.0%	-7.3%	0.0%
	kx10 increased	2.52E+00	62.0%	10.2%	61.8%	0.0%	61.3%	0.0%
	kx10 decreased	5.72E-02	-68.2%	-7.5%	-63.9%	0.0%	-63.4%	0.0%
	kx11 increased	5.69E-02	8.0%	-0.1%	7.9%	0.0%	7.8%	0.0%
	kx11 decreased	5.69E-04	-0.8%	0.0%	-0.8%	0.0%	-0.8%	0.0%
Vertical Hydraulic Conductivity [ft/day]	kz1 increased	1.00E+03	-0.2%	0.0%	-0.2%	0.0%	-0.2%	0.0%
	kz1 decreased	5.00E+01	0.3%	0.0%	0.3%	0.0%	0.3%	0.0%
	kz2 increased	1.00E+03	0.0%	-0.5%	0.0%	0.0%	0.0%	0.0%
	kz2 decreased	8.00E+01	0.6%	5.0%	0.5%	0.0%	0.5%	0.0%
	kz3 increased	1.00E+03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz3 decreased	8.00E+01	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%
	kz4 increased	9.80E+01	0.0%	-1.6%	0.0%	0.0%	0.0%	0.0%
	kz4 decreased	5.00E+00	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
	kz5 increased	6.06E+01	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz5 decreased	5.00E+00	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz6 increased	1.00E+03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz6 decreased	1.02E+01	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%
	kz7 increased	1.37E+02	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz7 decreased	5.00E+00	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz8 increased	5.00E+01	-6.4%	-29.9%	-6.6%	0.0%	-6.5%	0.0%
	kz8 decreased	5.00E+00	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz9 increased	5.00E+01	-0.4%	-5.9%	-0.3%	0.0%	-0.3%	0.0%
	kz9 decreased	5.00E+00	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz10 increased	1.10E+02	-9.0%	0.1%	-8.8%	0.0%	-8.7%	0.0%
	kz10 decreased	5.00E+00	1.9%	0.1%	2.1%	0.0%	2.1%	0.0%
	kz11 increased	8.49E+01	-0.4%	0.0%	-0.4%	0.0%	-0.4%	0.0%
	kz11 decreased	5.00E+00	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%

Large Table 5
SENSITIVITY ANALYSIS PARAMETERS AND RESULTS
Water Balance Modeling
Eagle Mine, LLC

Parameter Type	Parameter change from base	Parameter Value	2008 CONDITIONS [Percent change from base]		2014 CONDITIONS [Percent change from base]		2017 CONDITIONS [Percent change from base]	
			HTDF Inflows	HTDF Outflows	HTDF Inflows	HTDF Outflows	HTDF Inflows	HTDF Outflows
Vertical Hydraulic Conductivity Component of Riverbed and Wetland Bed Conductance [ft/day]	kz_riv_1 increased	4.74E-01	11.2%	-16.3%	10.8%	0.0%	10.0%	0.0%
	kz_riv_1 decreased	4.74E-03	-25.9%	11.8%	-24.0%	0.0%	-22.7%	0.0%
	kz_riv_2 increased	7.51E+00	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_2 decreased	7.51E-02	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_3 increased	8.20E+02	0.0%	3.8%	-0.1%	0.0%	-0.1%	0.0%
	kz_riv_3 decreased	8.20E+00	0.0%	-7.4%	0.3%	0.0%	0.3%	0.0%
	kz_riv_10 increased	2.59E+03	-0.1%	0.0%	-0.1%	0.0%	-0.1%	0.0%
	kz_riv_10 decreased	3.30E+01	0.5%	0.0%	0.4%	0.0%	0.4%	0.0%
	kz_riv_11 increased	2.59E+03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_11 decreased	3.30E+01	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_12 increased	2.59E+03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_12 decreased	3.30E+01	0.0%	-0.2%	0.0%	0.0%	0.0%	0.0%
	kz_riv_13 increased	2.59E+03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_13 decreased	3.30E+01	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_20 increased	3.28E-03	1.6%	0.0%	1.5%	0.0%	1.4%	0.0%
	kz_riv_20 decreased	3.28E-05	-0.2%	0.0%	-0.2%	0.0%	-0.1%	0.0%
	kz_riv_21 increased	3.28E-03	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%
	kz_riv_21 decreased	3.28E-05	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_22 increased	3.28E-03	0.3%	0.0%	0.3%	0.0%	0.3%	0.0%
	kz_riv_22 decreased	3.28E-05	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	kz_riv_23 increased	3.28E-03	1.2%	0.0%	1.1%	0.0%	1.1%	0.0%
	kz_riv_23 decreased	3.28E-05	-0.1%	0.0%	-0.1%	0.0%	-0.1%	0.0%
	kz_riv_30 increased	7.51E-01	0.3%	-16.8%	1.2%	0.0%	1.1%	0.0%
	kz_riv_30 decreased	7.51E-03	0.0%	-1.0%	-1.0%	0.0%	-0.9%	0.0%
Recharge [in/year]	2008 unconsolidated increase	11.74	6.2%	-12.7%	4.6%	0.0%	3.4%	0.0%
	2008 unconsolidated decrease	5.05	-2.6%	5.7%	-4.0%	0.0%	-5.1%	0.0%
	2008 bedrock increase	1.17	6.2%	-12.7%	4.6%	0.0%	3.4%	0.0%
	2008 bedrock decrease	0.50	-2.6%	5.7%	-4.0%	0.0%	-5.1%	0.0%
	2014 unconsolidated increase	11.74	6.2%	-12.7%	4.6%	0.0%	3.4%	0.0%
	2014 unconsolidated decrease	5.05	-2.6%	5.7%	-4.0%	0.0%	-5.1%	0.0%
	2014 bedrock increase	1.17	6.2%	-12.7%	4.6%	0.0%	3.4%	0.0%
	2014 bedrock decrease	0.50	-2.6%	5.7%	-4.0%	0.0%	-5.1%	0.0%
	2017 unconsolidated increase	11.74	6.2%	-12.7%	4.6%	0.0%	3.4%	0.0%
	2017 unconsolidated decrease	5.05	-2.6%	5.7%	-4.0%	0.0%	-5.1%	0.0%
	2017 bedrock increase	1.17	6.2%	-12.7%	4.6%	0.0%	3.4%	0.0%
	2017 bedrock decrease	0.50	-2.6%	5.7%	-4.0%	0.0%	-5.1%	0.0%

Large Figures



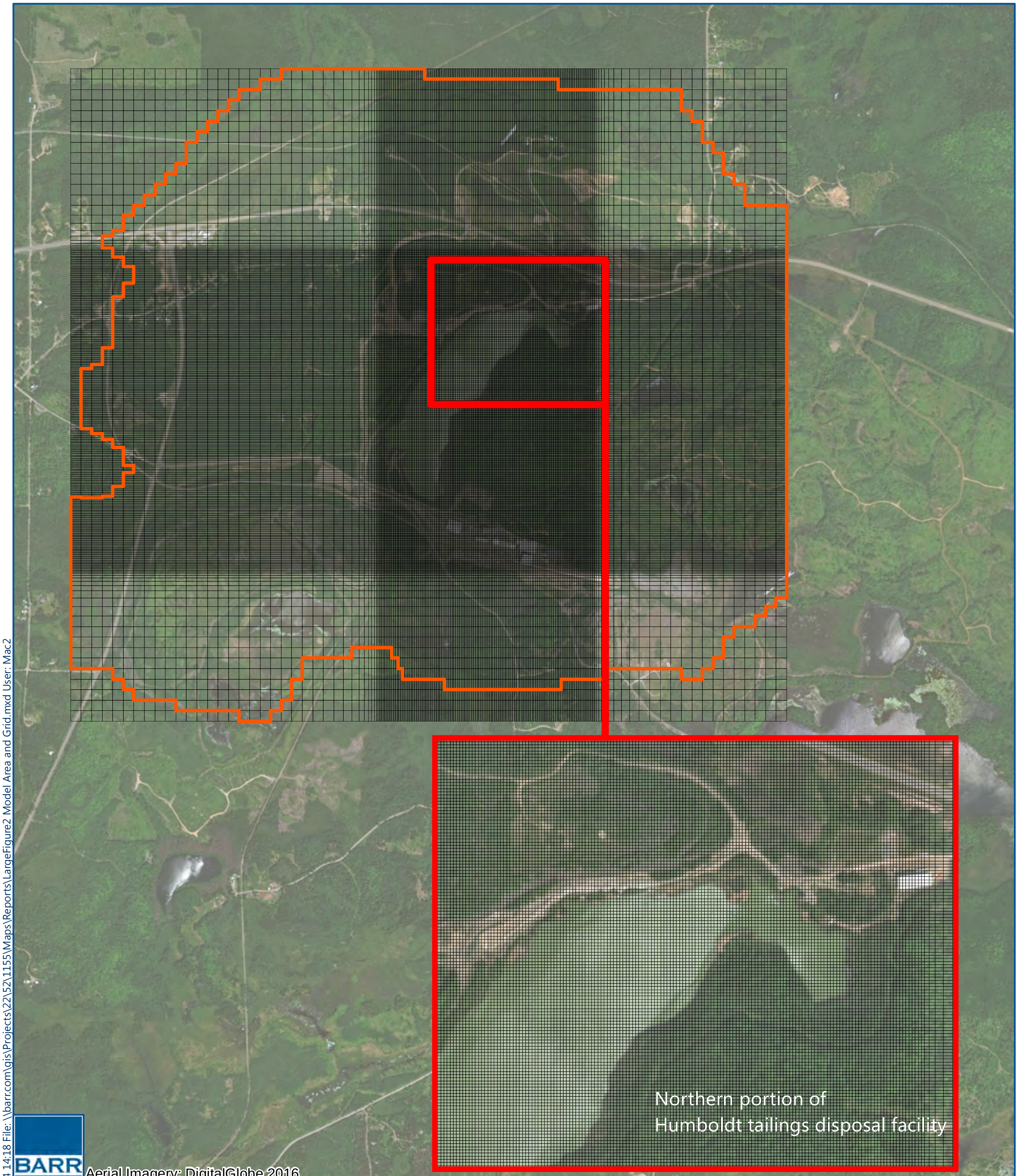
Groundwater model extent

N

0 2,000 4,000 6,000 8,000 Feet

SITE LOCATION
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 1



Groundwater Model Active Area

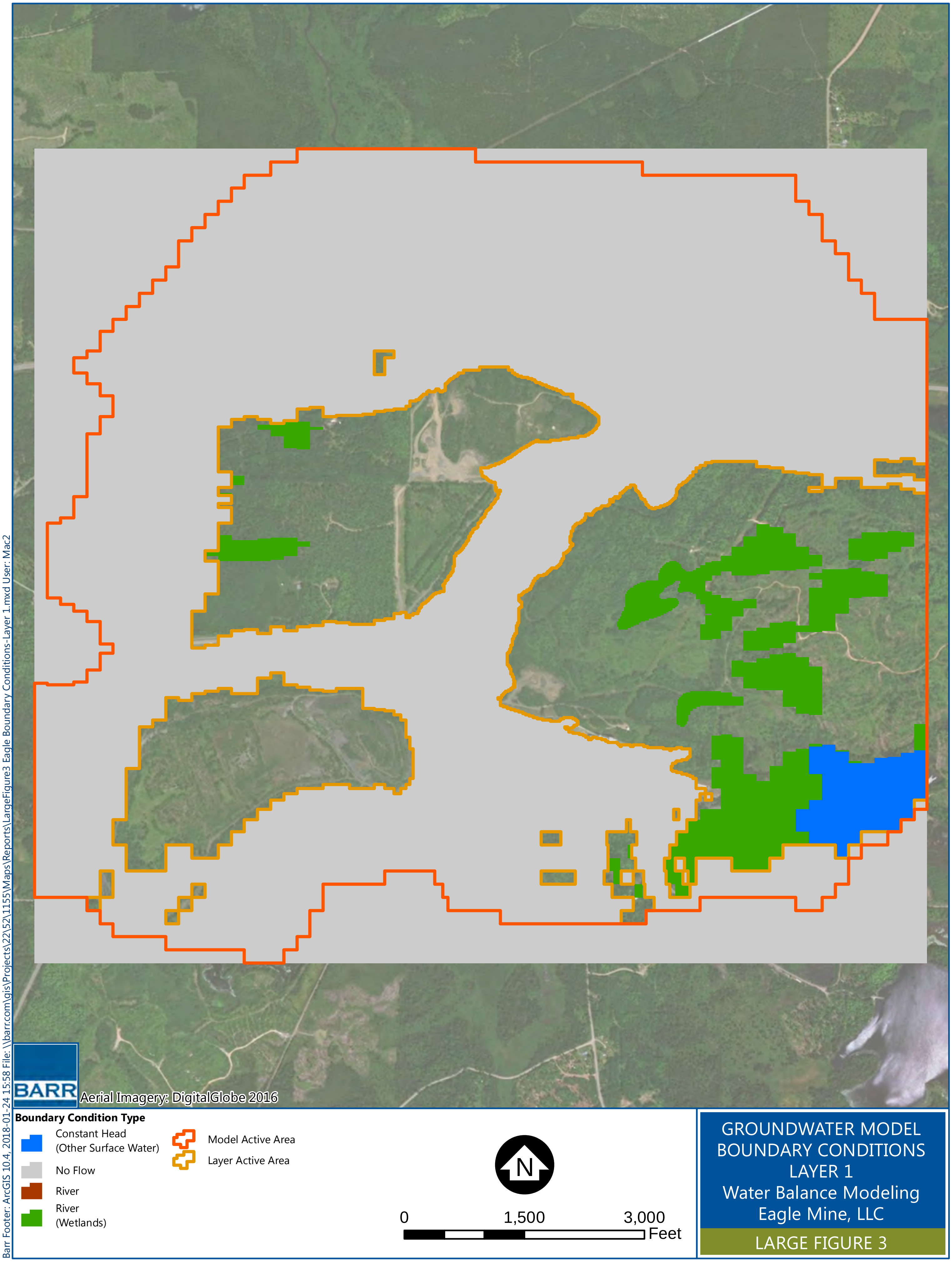
Groundwater Model Grid

N

0 2,000 4,000 Feet

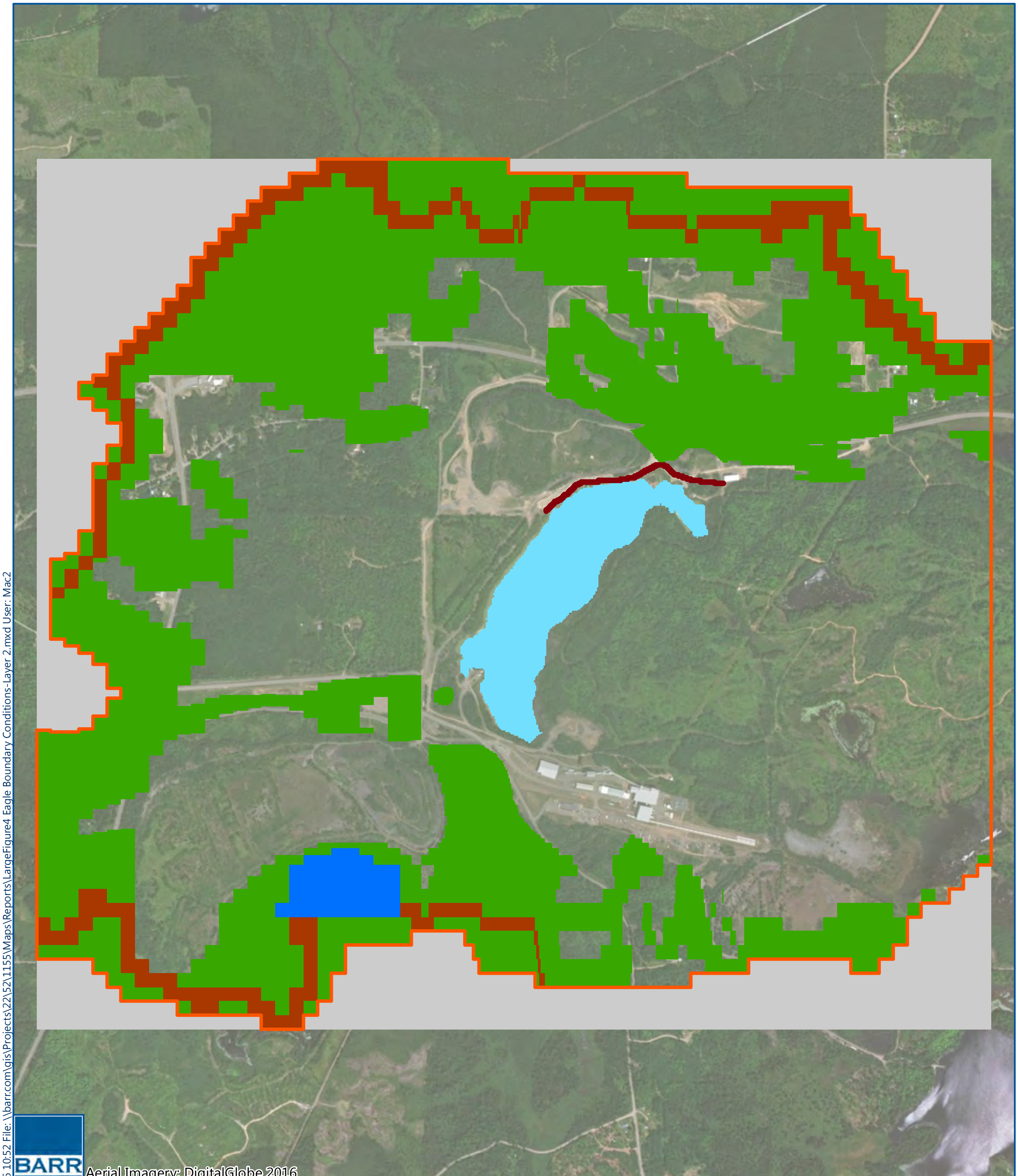
GROUNDWATER MODEL GRID
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 2



GROUNDWATER MODEL BOUNDARY CONDITIONS LAYER 1
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 3



Boundary Condition Type

- Constant Head (Other Surface Water)
- Constant Head (HTDF)
- No Flow
- River
- River (Wetlands)
- Model Active Area
- Horizontal Flow Barrier

Note:
-HTDF - Humboldt Tailings Disposal Facility

N

0 1,500 3,000
Feet

GROUNDWATER MODEL BOUNDARY CONDITIONS LAYER 2
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 4

Boundary Condition Type

- Constant Head (Other Surface Water)
- Constant Head (HTDF)
- No Flow
- River
- River (Wetlands)
- Model Active Area
- Horizontal Flow Barrier
- Pumping Well (Model Layer With Well)

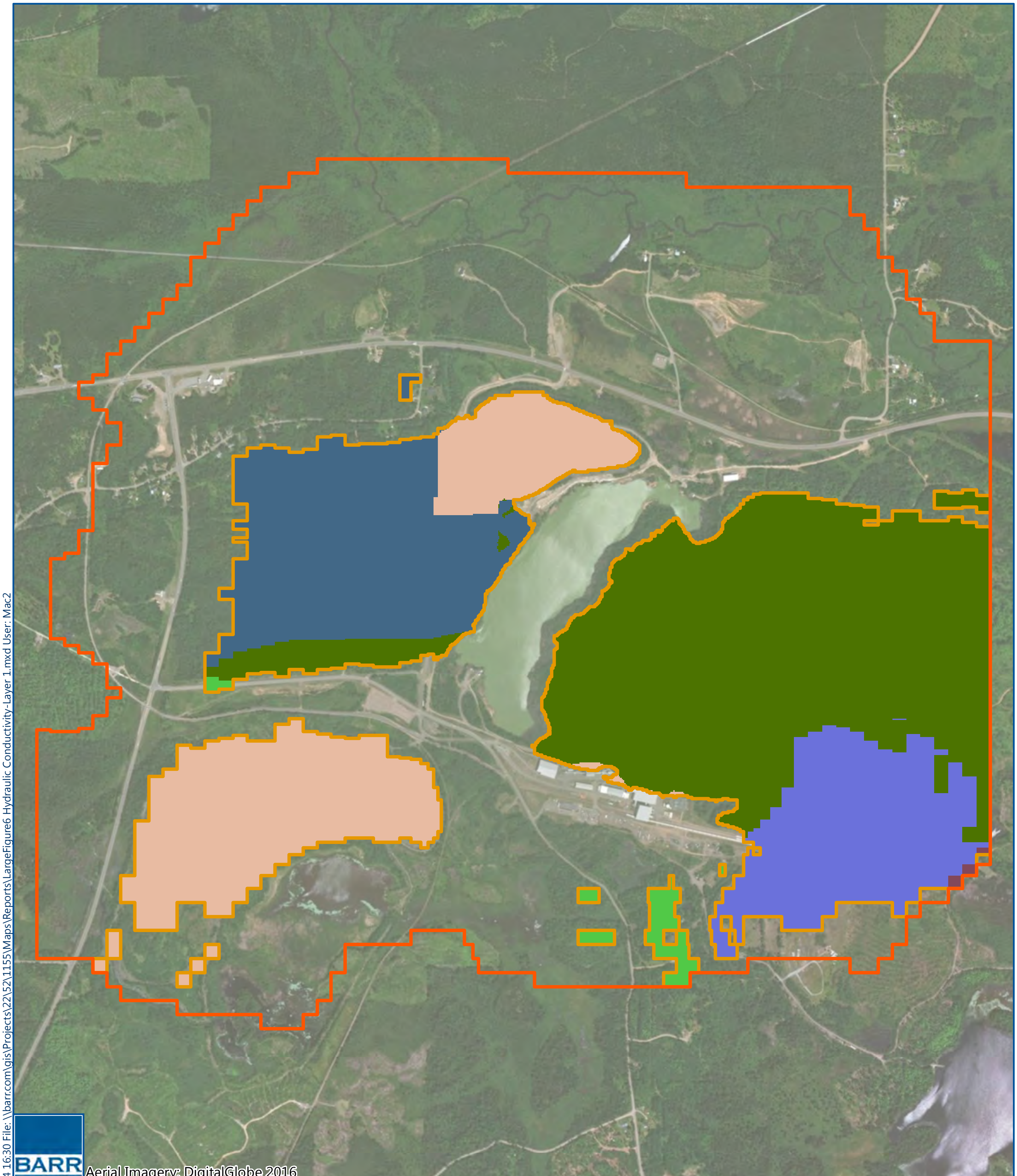
Notes:
-The Horizontal Flow Barrier present in Layer 2 through 4 and was used for 2014 and 2017 conditions.
-HTDF - Humboldt Tailings Disposal Facility
-Domestic and Industrial pumping well only used for 2014 and 2017 conditions

N

0 1,500 3,000
Feet

GROUNDWATER MODEL BOUNDARY CONDITIONS LAYER 3 THROUGH 6
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 5



Model Active Area
Layer Active Area

Hydraulic Conductivity Zone

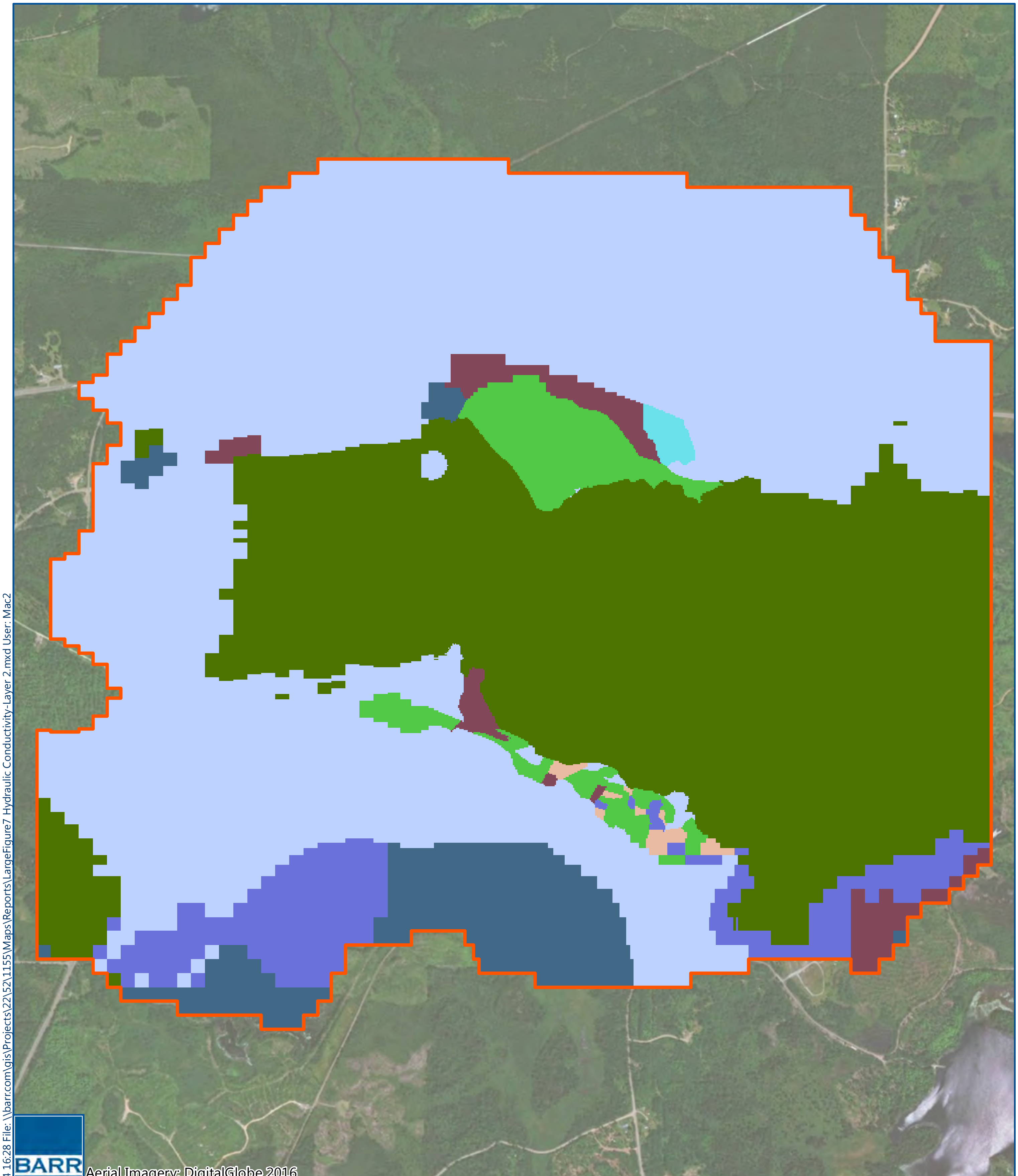
Zone 1: Tailings
Zone 2: Fine fill
Zone 3: Coarse fill
Zone 4: Peat
Zone 5: Clay
Zone 6: Fine-grained outwash with clay
Zone 7: Fine-grained outwash
Zone 8: Coarse-grained outwash with fines
Zone 9: Coarse-grained outwash
Zone 10: Upper bedrock
Zone 11: Deeper bedrock

N

0 1,500 3,000 Feet

GROUNDWATER MODEL HYDRAULIC CONDUCTIVITY ZONES - LAYER 1
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 6



Model Active Area

Hydraulic Conductivity Zone

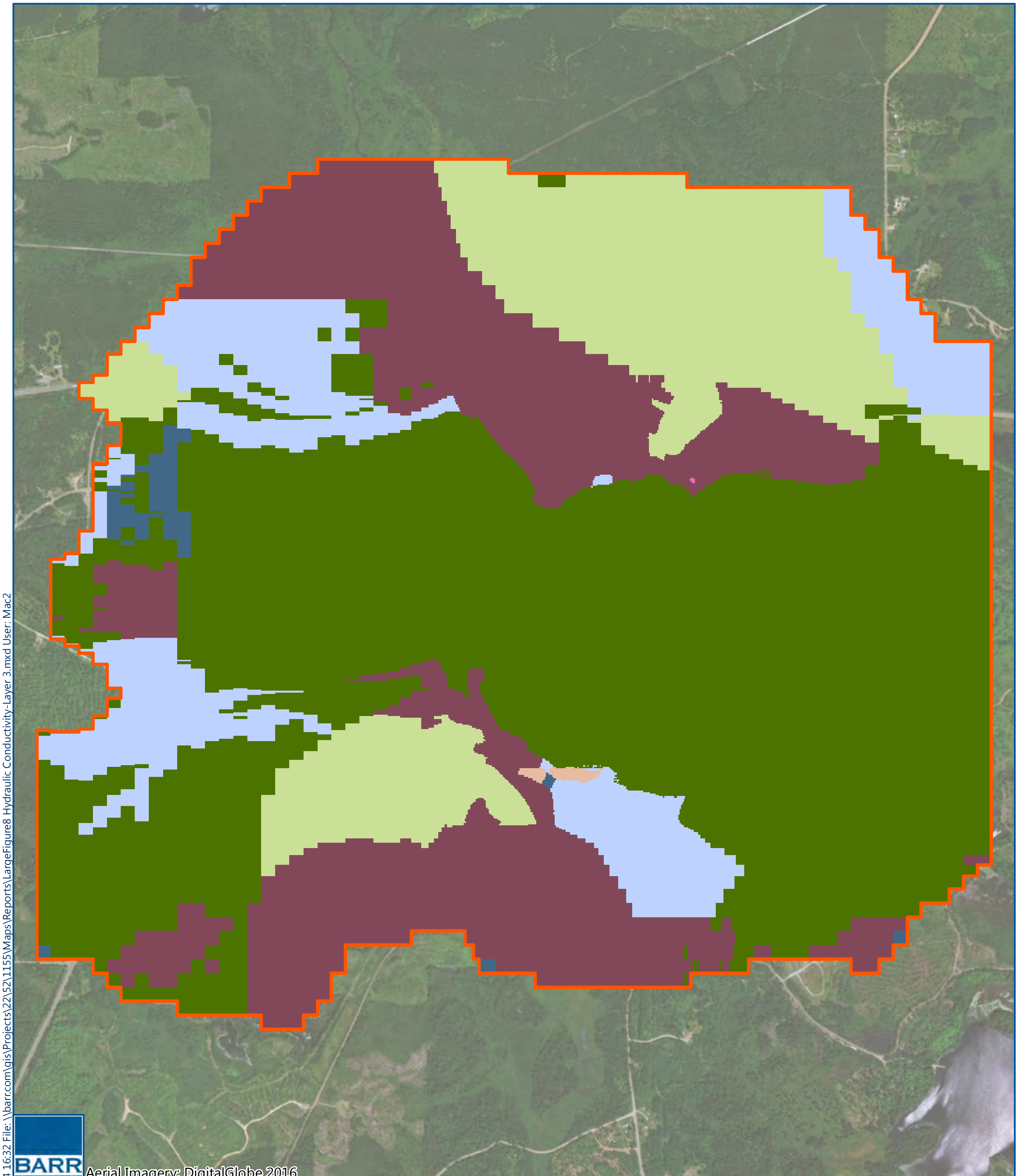
- Zone 1: Tailings
- Zone 2: Fine fill
- Zone 3: Coarse fill
- Zone 4: Peat
- Zone 5: Clay
- Zone 6: Fine-grained outwash with clay
- Zone 7: Fine-grained outwash
- Zone 8: Coarse-grained outwash with fines
- Zone 9: Coarse-grained outwash
- Zone 10: Upper bedrock
- Zone 11: Deeper bedrock

N

0 1,500 3,000 Feet

GROUNDWATER MODEL HYDRAULIC CONDUCTIVITY ZONES - LAYER 2
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 7



Model Active Area

Hydraulic Conductivity Zone

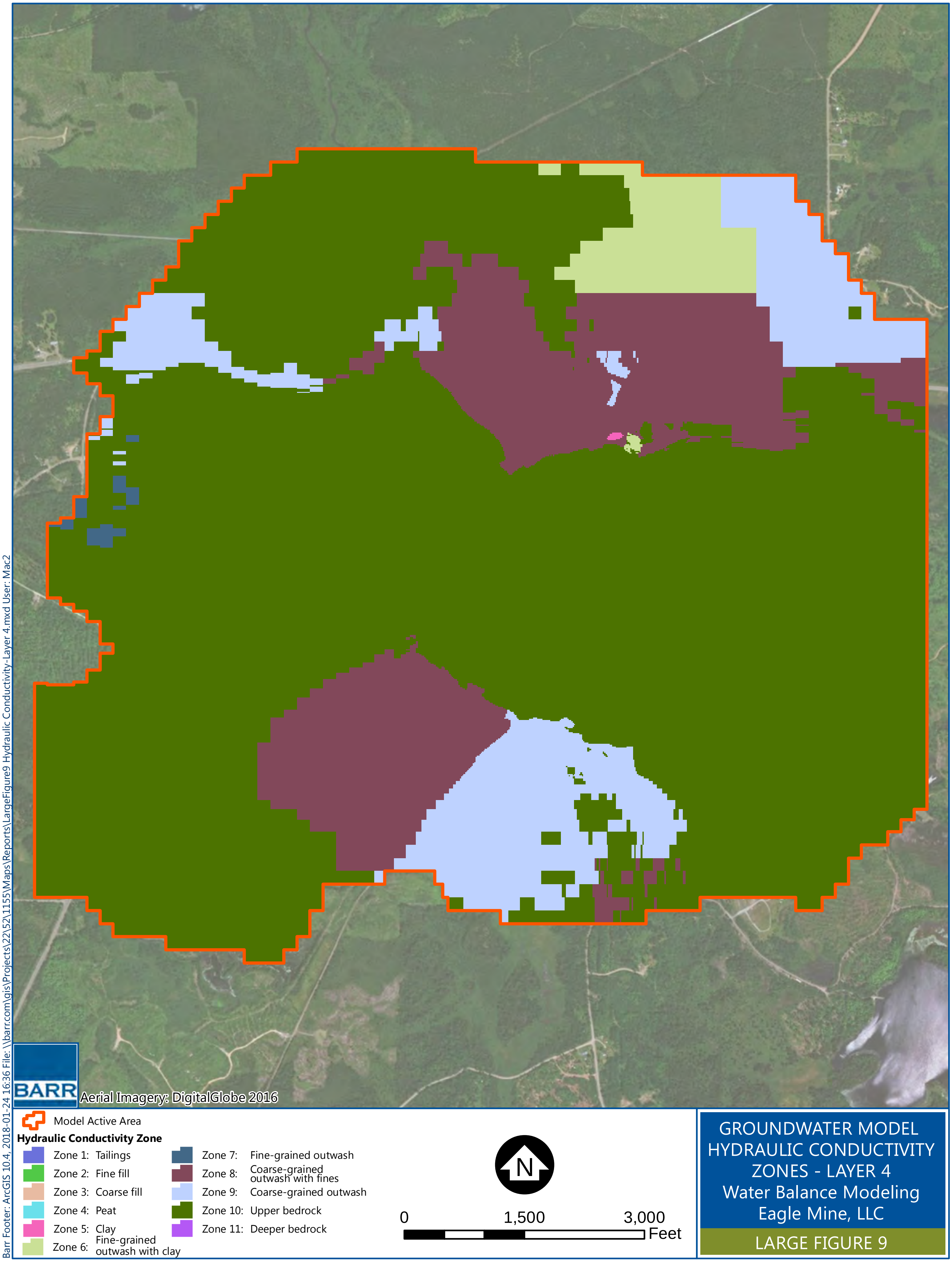
Zone 1:	Tailings	Zone 7:	Fine-grained outwash
Zone 2:	Fine fill	Zone 8:	Coarse-grained outwash with fines
Zone 3:	Coarse fill	Zone 9:	Coarse-grained outwash
Zone 4:	Peat	Zone 10:	Upper bedrock
Zone 5:	Clay	Zone 11:	Deeper bedrock
Zone 6:	Fine-grained outwash with clay		

N

0 1,500 3,000 Feet

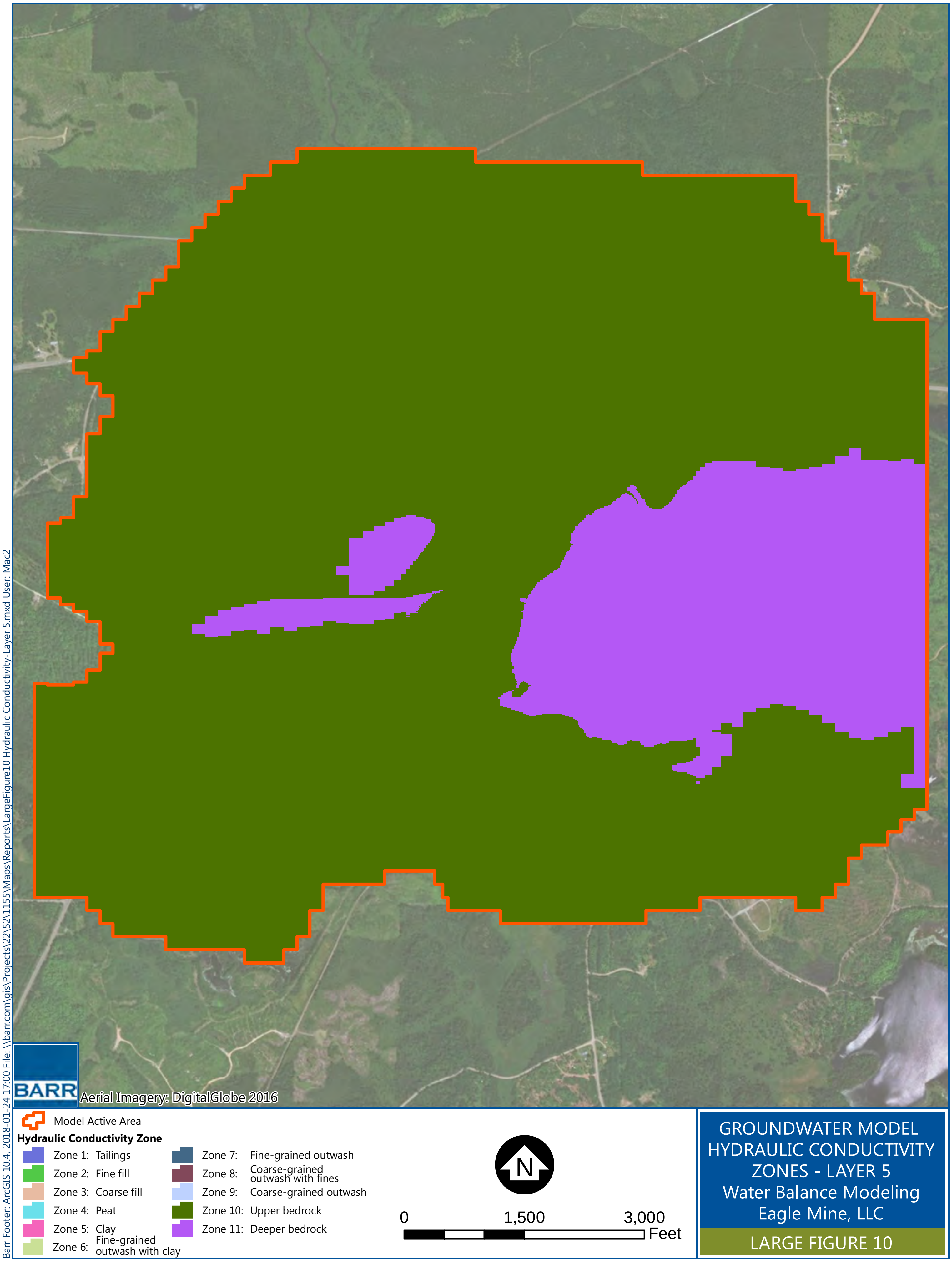
GROUNDWATER MODEL HYDRAULIC CONDUCTIVITY ZONES - LAYER 3
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 8



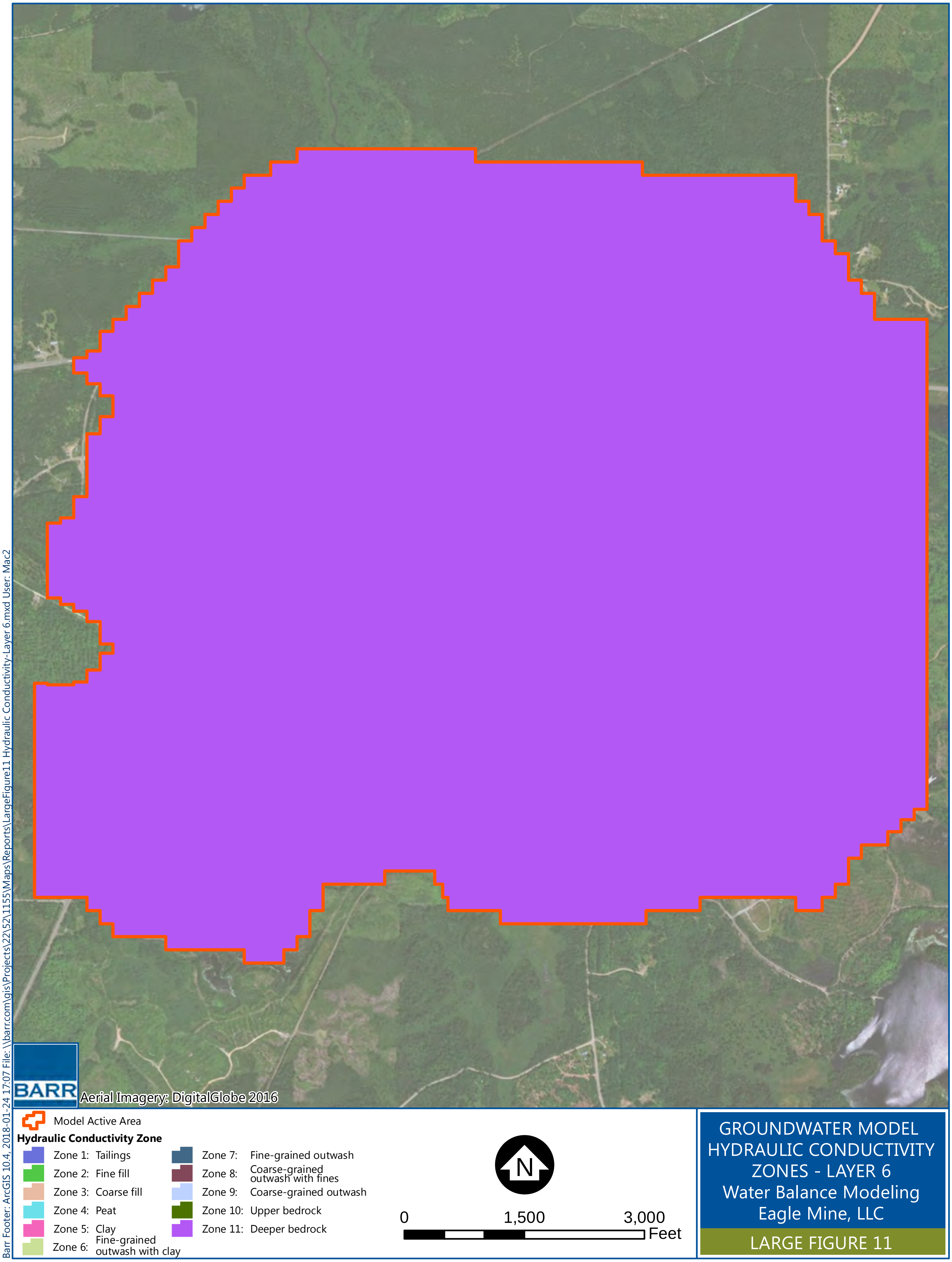
GROUNDWATER MODEL HYDRAULIC CONDUCTIVITY ZONES - LAYER 4
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 9



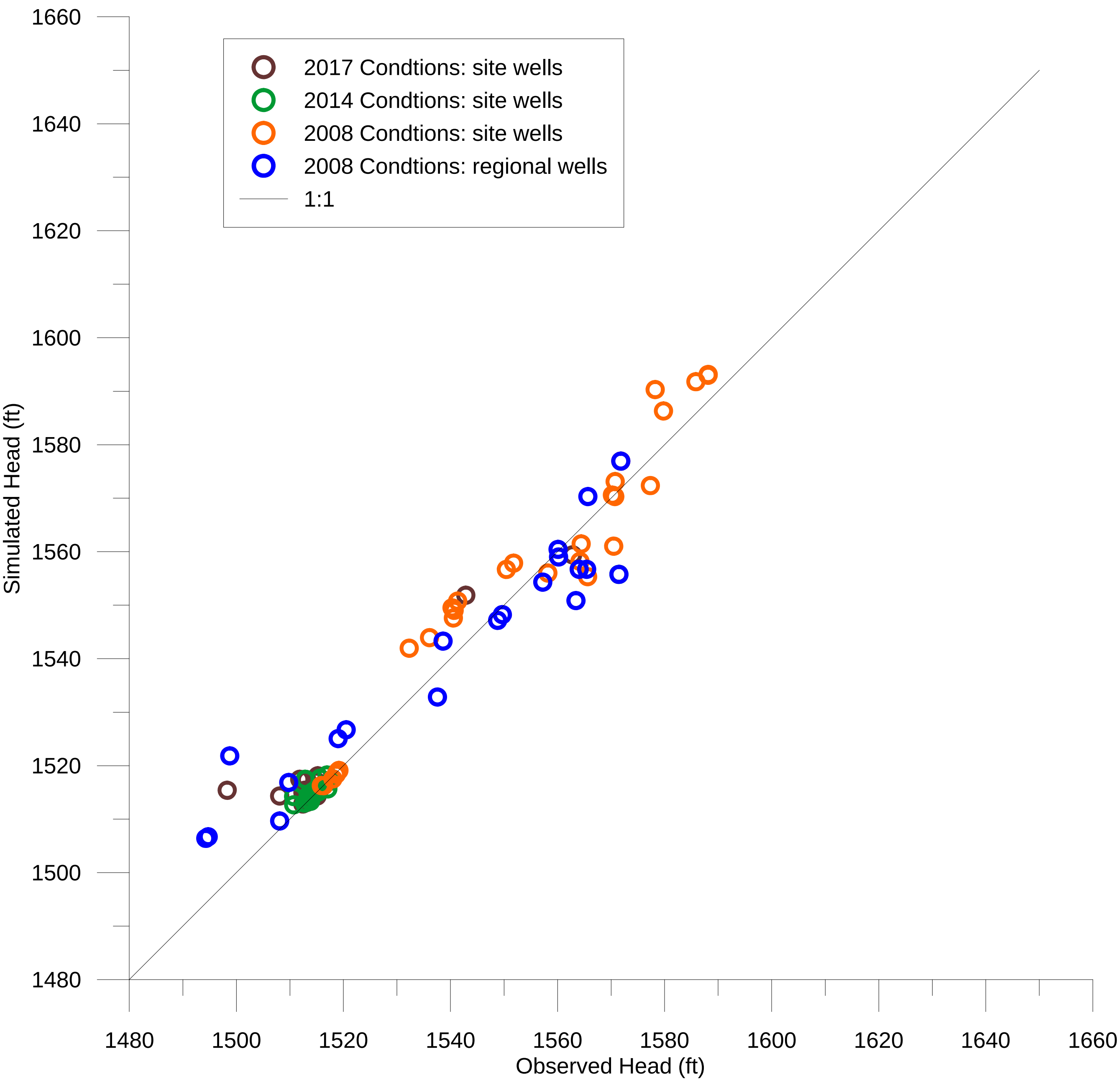
GROUNDWATER MODEL HYDRAULIC CONDUCTIVITY ZONES - LAYER 5
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 10



GROUNDWATER MODEL HYDRAULIC CONDUCTIVITY ZONES - LAYER 6
Water Balance Modeling
Eagle Mine, LLC

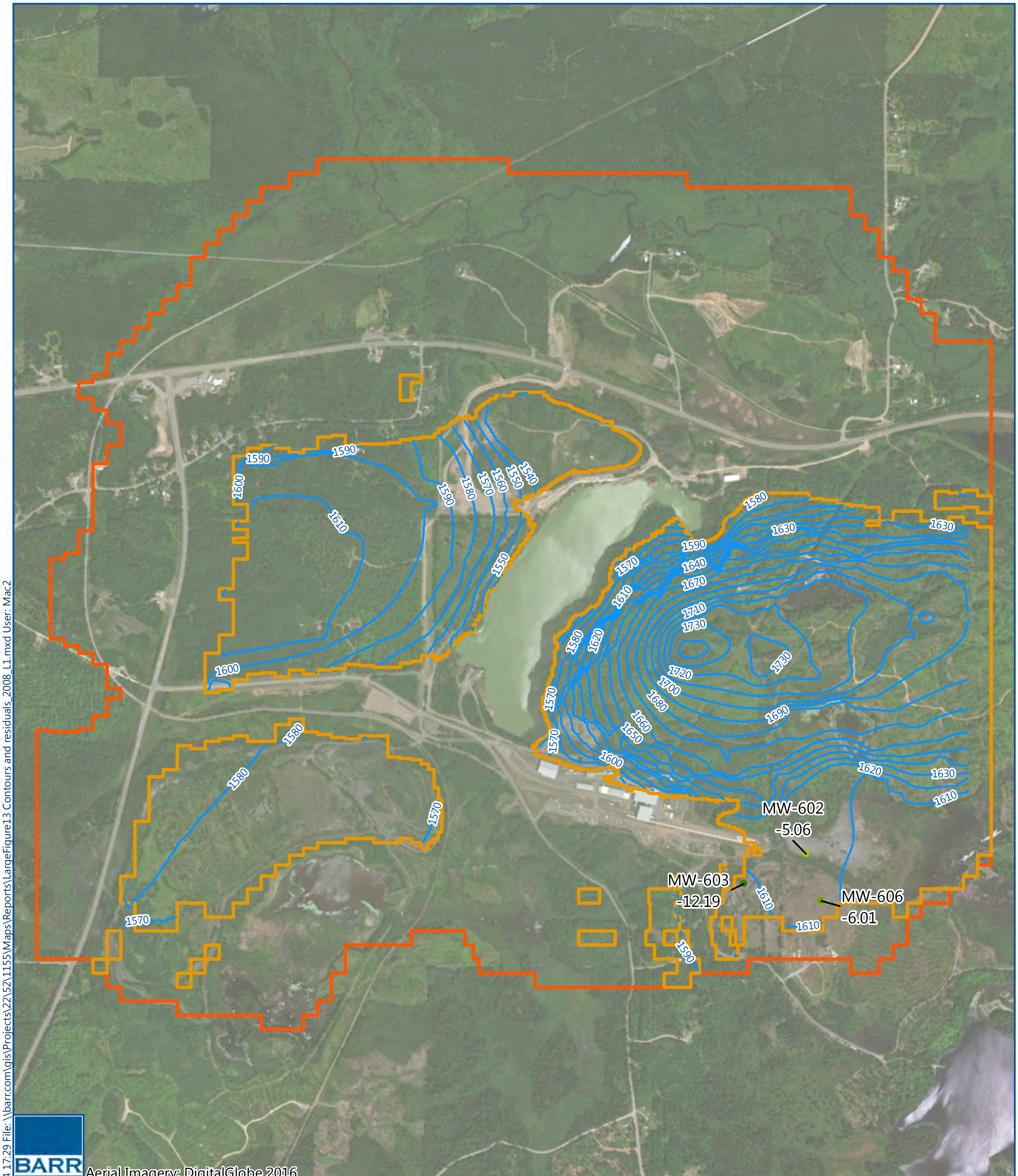
LARGE FIGURE 11



SIMULATED VS. OBSERVED
STEADY-STATE HEADS
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 12

BARR



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Layer Active Area

Simulated groundwater elevation [ft above mean sea level]

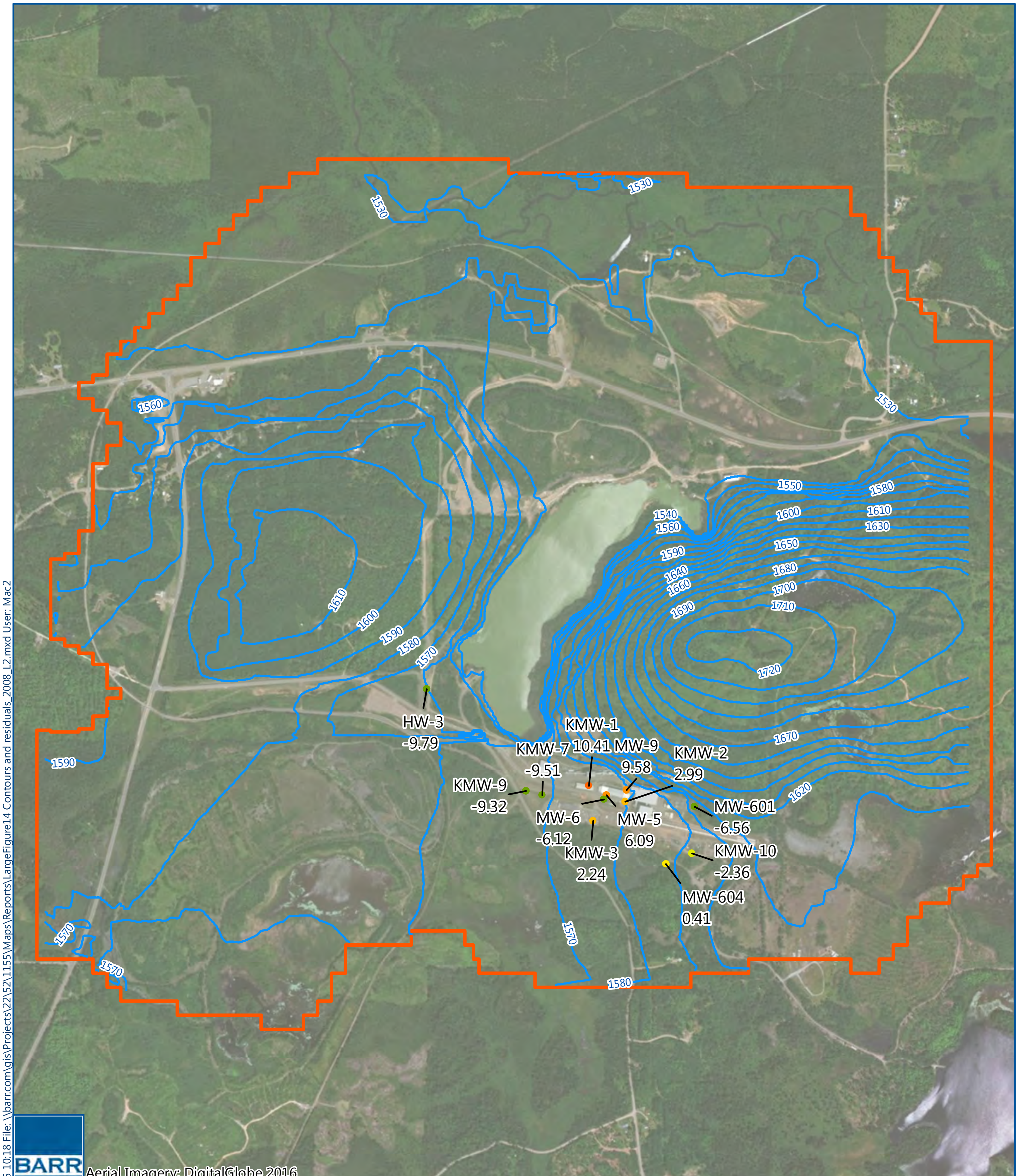
N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2008 CONDITIONS - LAYER 1

Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 13



Calibration residuals [ft] (observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

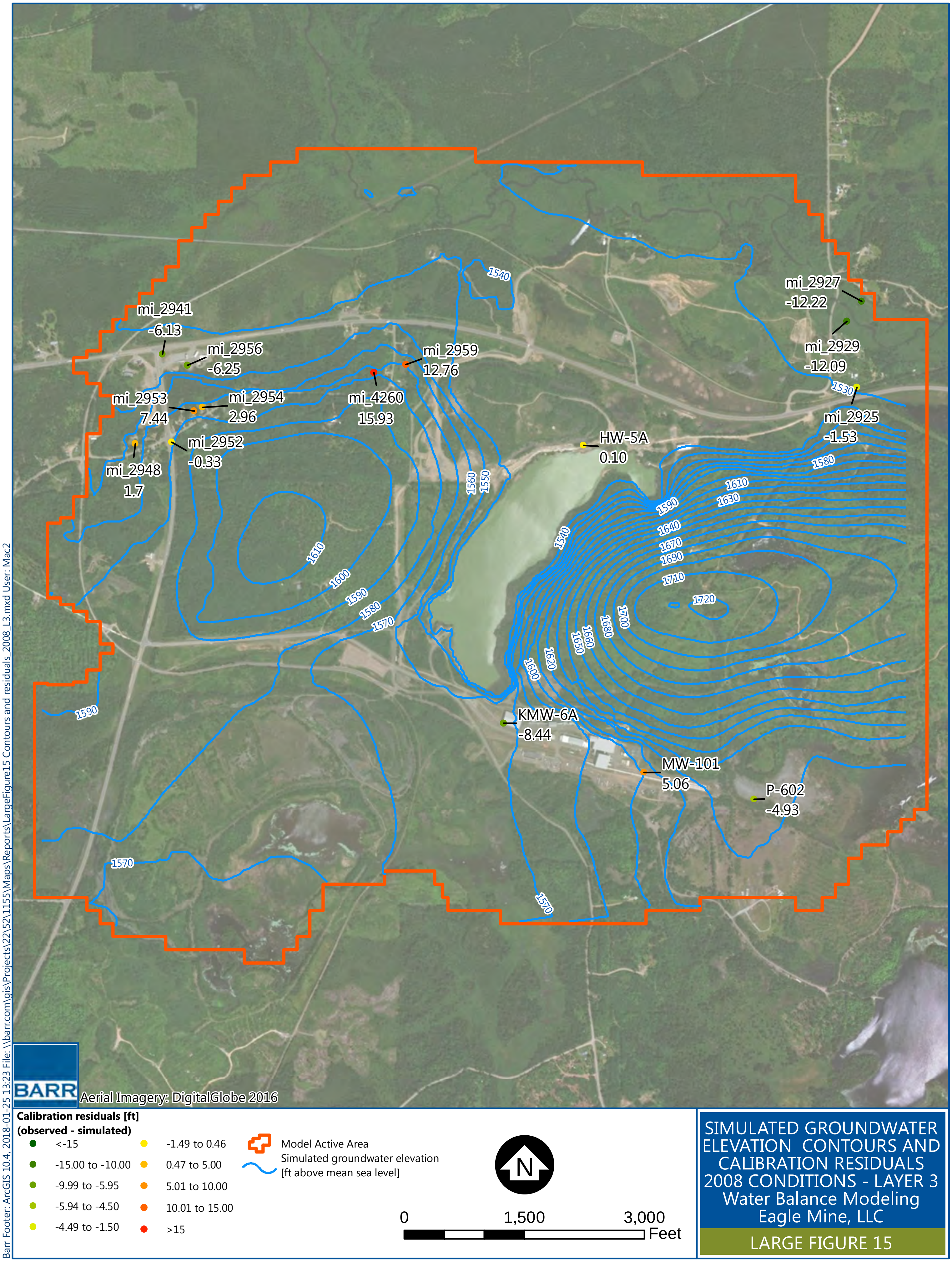
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

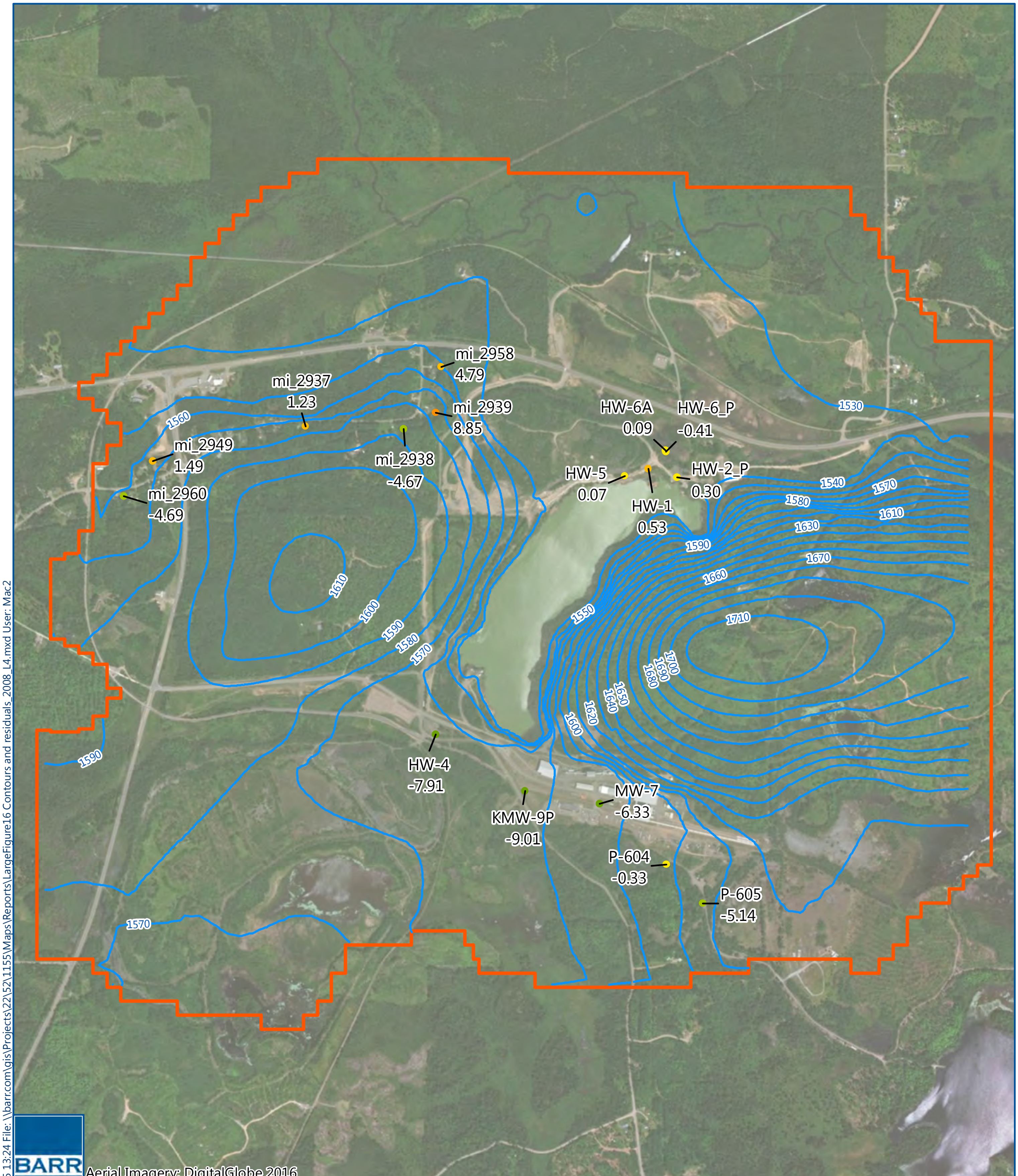
SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2008 CONDITIONS - LAYER 2
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 14



SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2008 CONDITIONS - LAYER 3
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 15



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

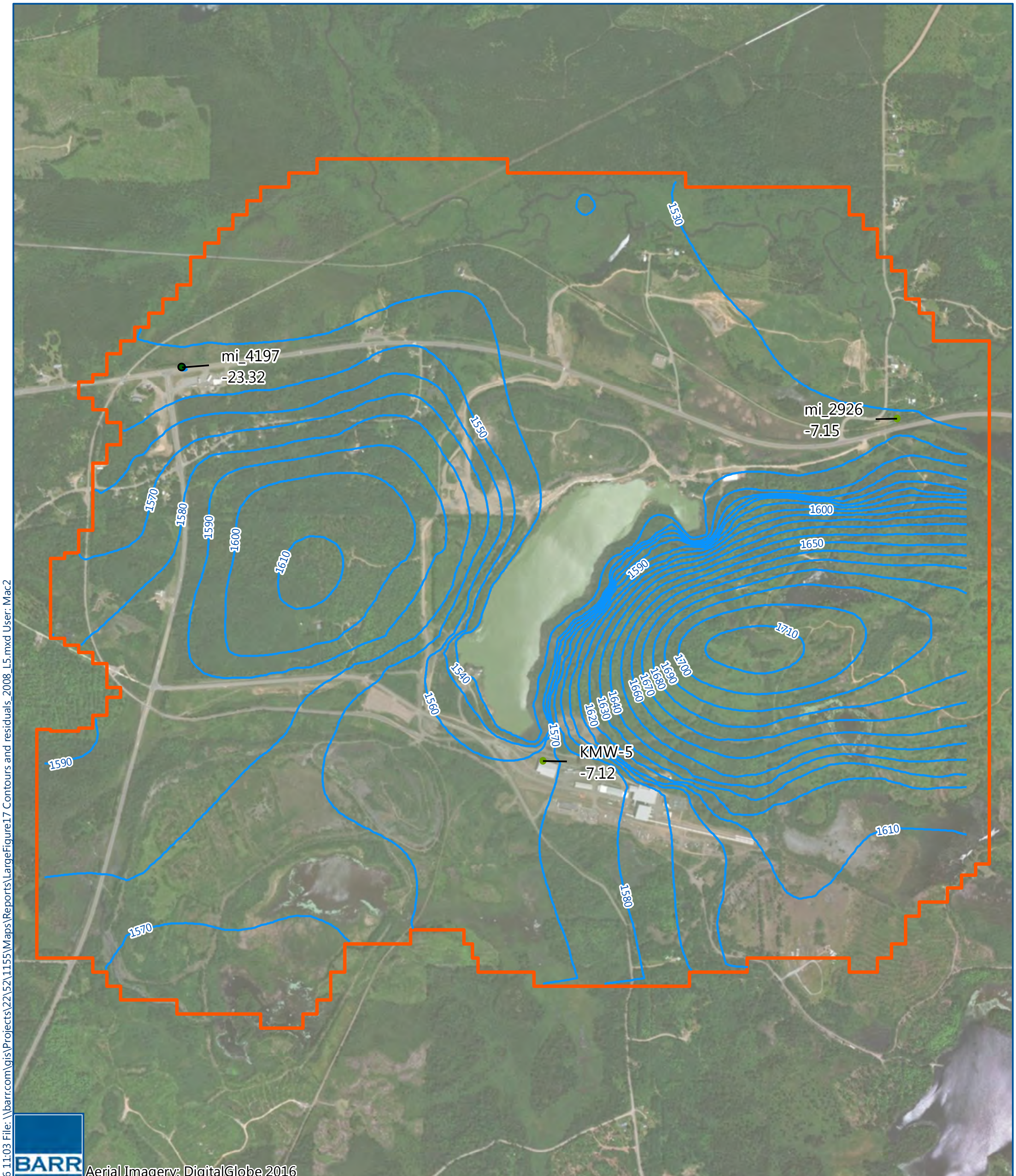
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2008 CONDITIONS - LAYER 4
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 16



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

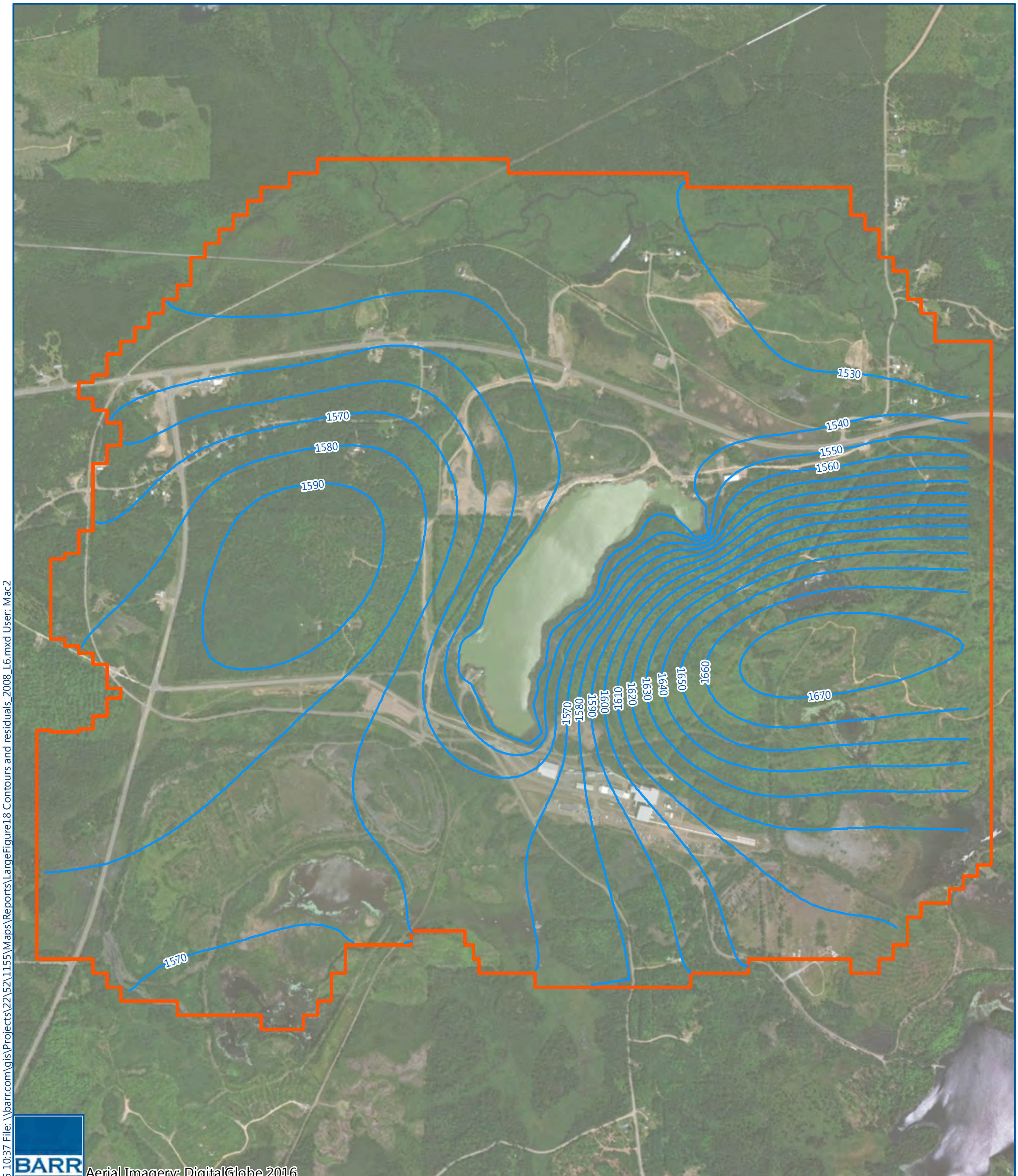
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2008 CONDITIONS - LAYER 5
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 17



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Simulated groundwater elevation [ft above mean sea level]

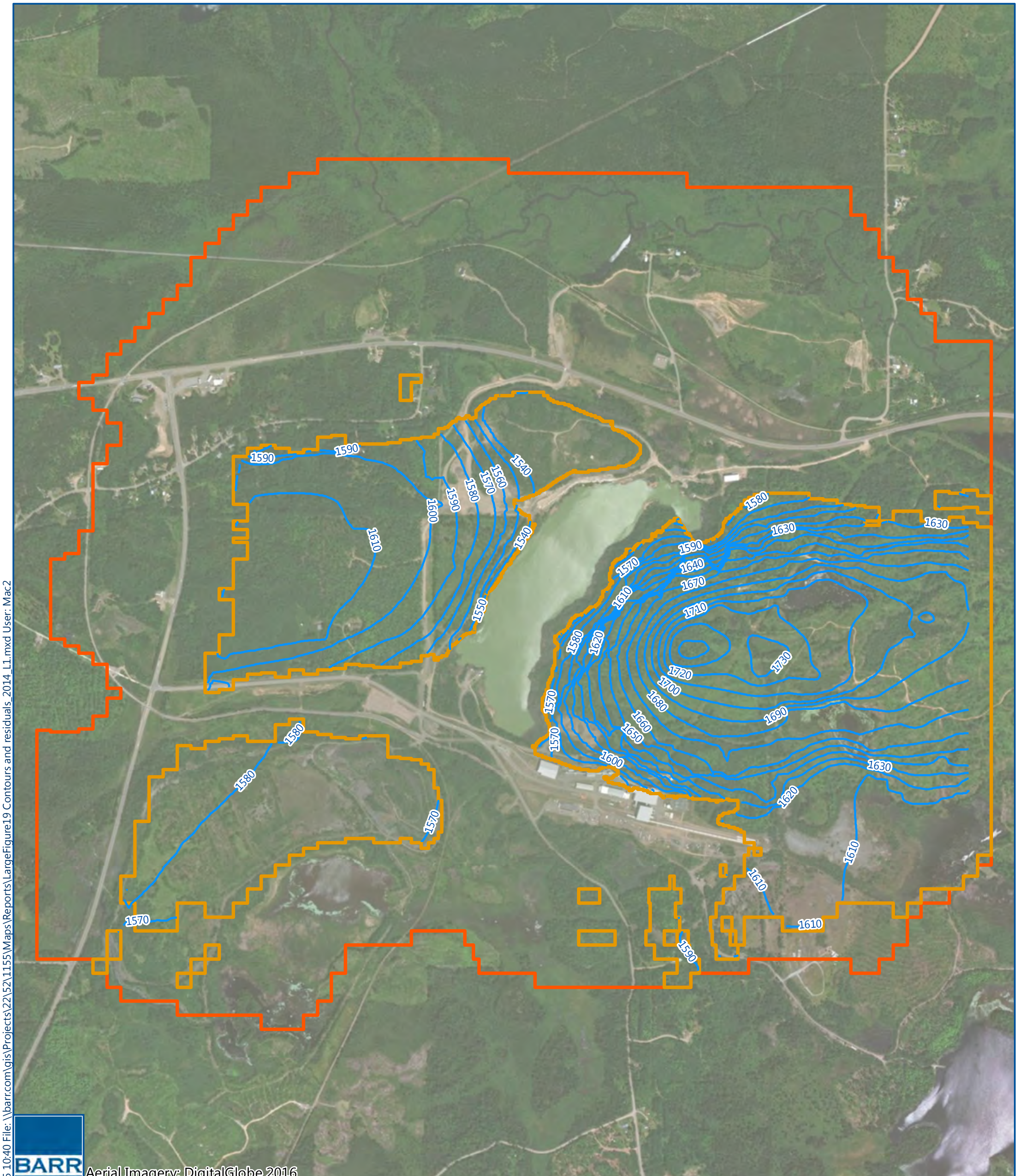
Note:
-No observed 2008 groundwater elevations in Layer 6

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2008 CONDITIONS - LAYER 6
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 18



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Layer Active Area

Simulated groundwater elevation [ft above mean sea level]

Note:
-No observed 2014 groundwater elevations in Layer 1

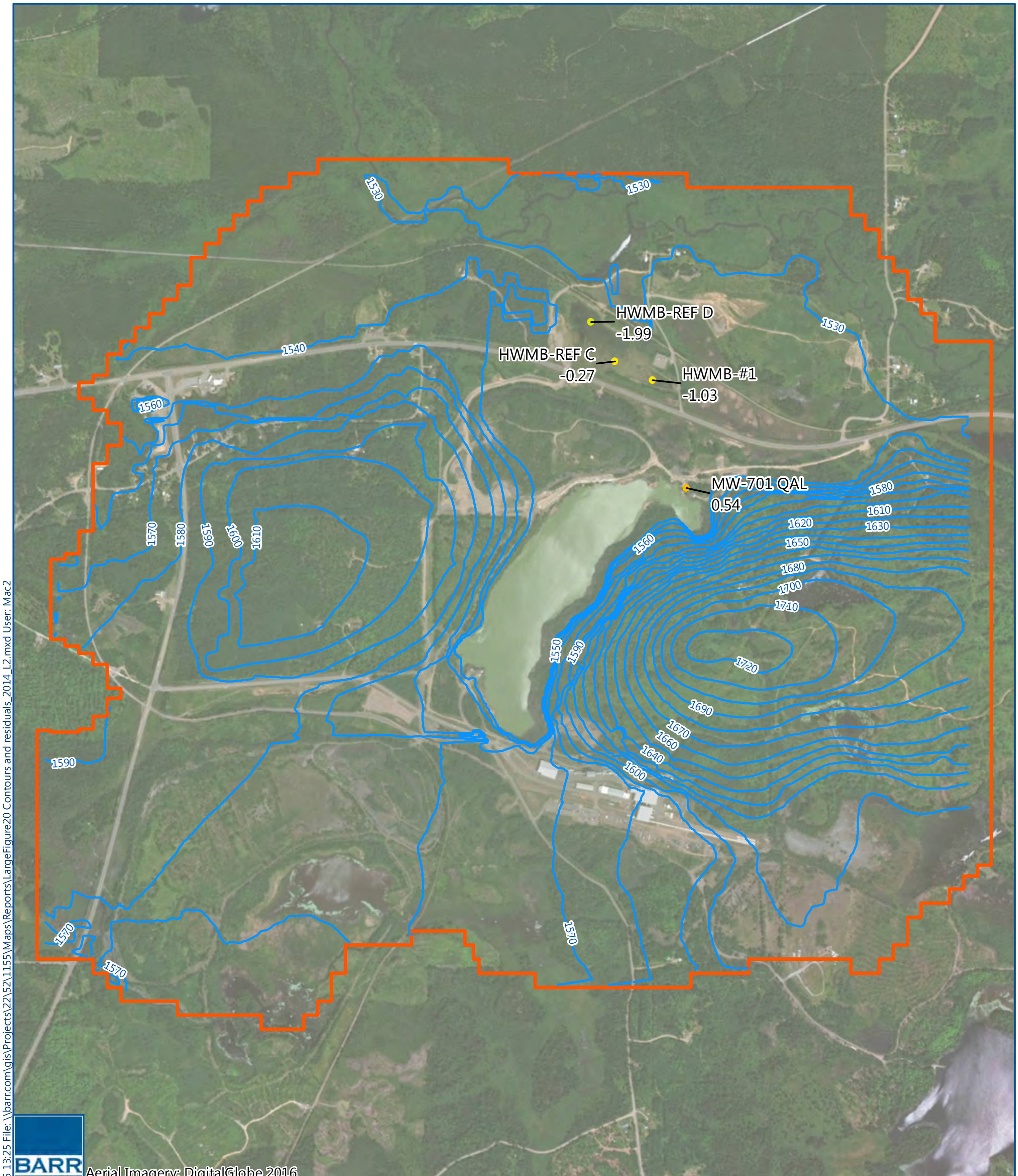
N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2014 CONDITIONS - LAYER 1
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 19

Barr Footer: ArcGIS 10.4, 2018-01-25 10:40 File: \\barr.com\gis\Projects\22\52\1155\Maps\Reports\LargeFigure19 Contours and residuals 2014 L1.mxd User: Mac2



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2014 CONDITIONS - LAYER 2
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 20

Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

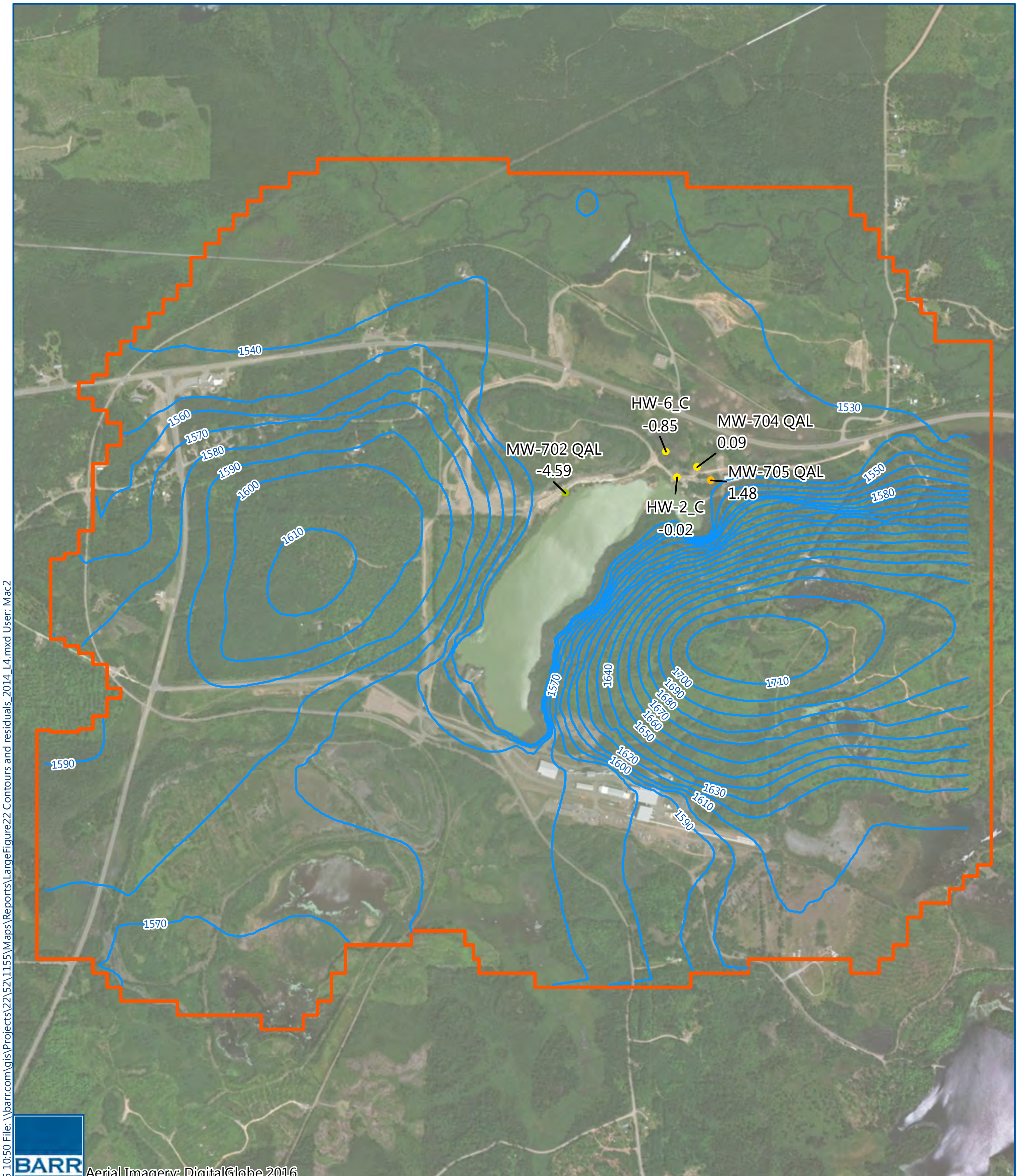
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2014 CONDITIONS - LAYER 3
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 21



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

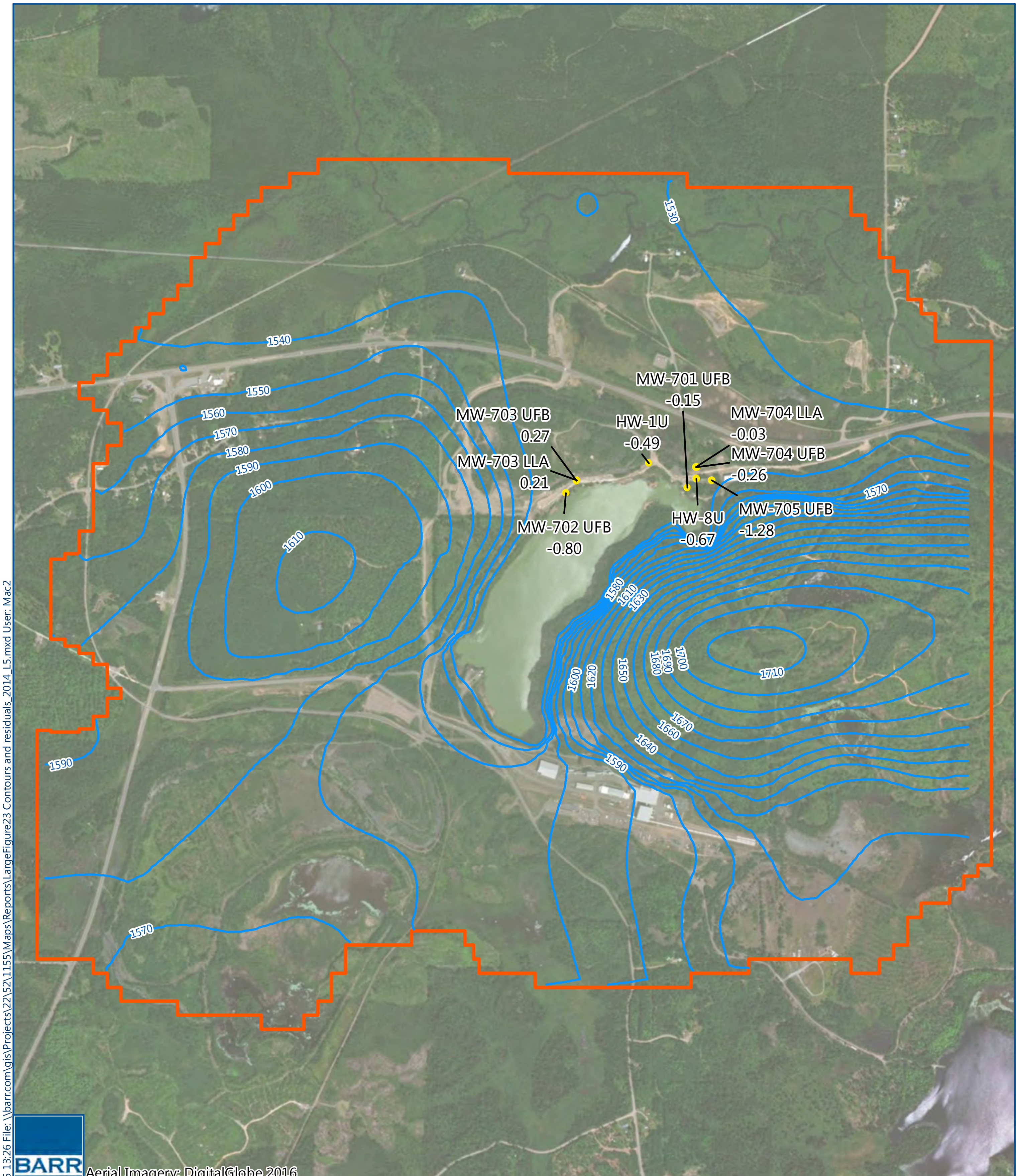
SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2014 CONDITIONS - LAYER 4

Water Balance Modeling

Eagle Mine, LLC

LARGE FIGURE 22

Barr Footer: ArcGIS 10.4, 2018-01-25 10:50 File: \\barr.com\gis\Projects\22\52\1155\Maps\Reports\LargeFigure22 Contours and residuals_2014_L4.mxd User: Mac2



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

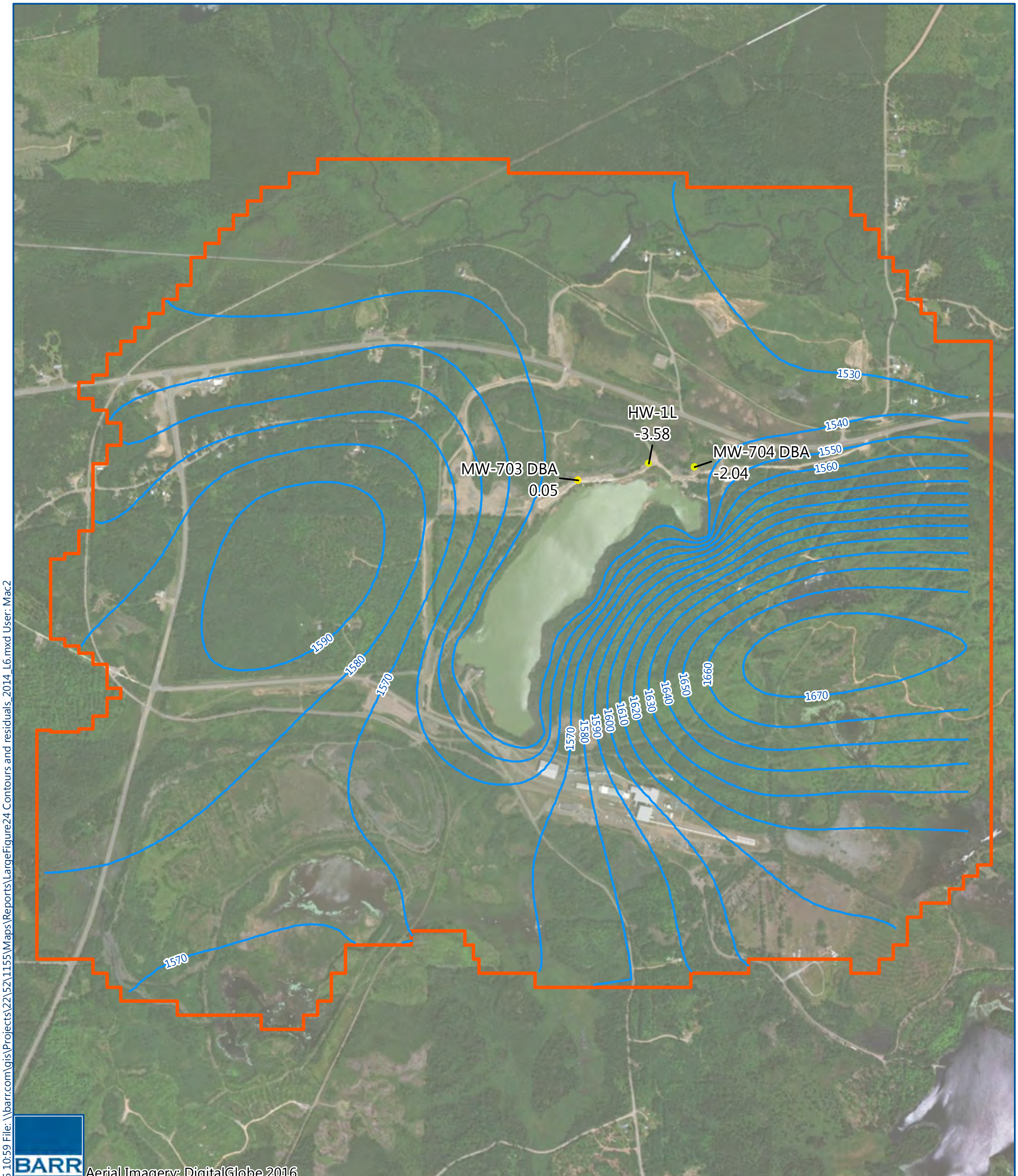
Model Active Area
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2014 CONDITIONS - LAYER 5
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 23



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

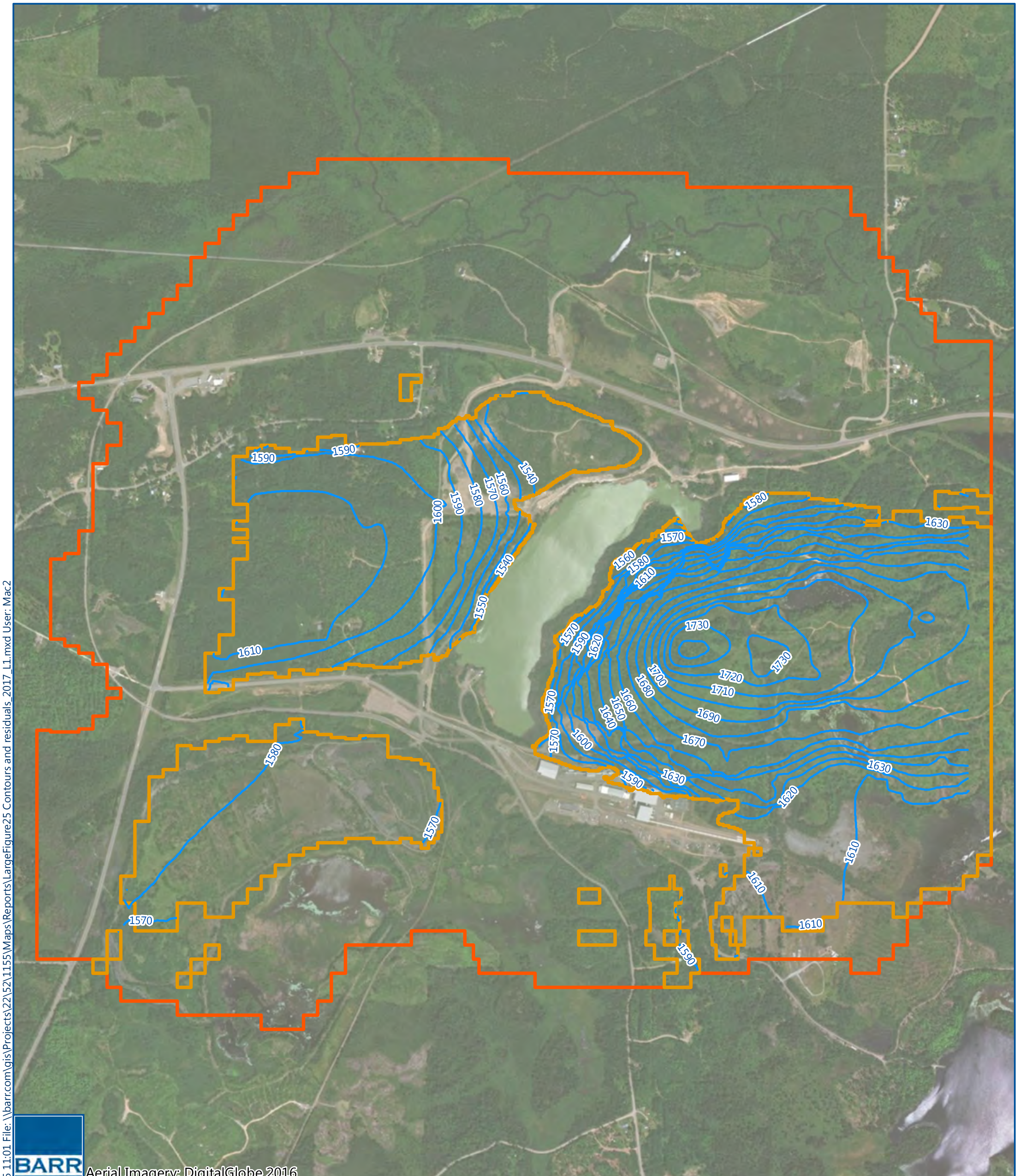
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2014 CONDITIONS - LAYER 6
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 24



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Layer Active Area

Simulated groundwater elevation [ft above mean sea level]

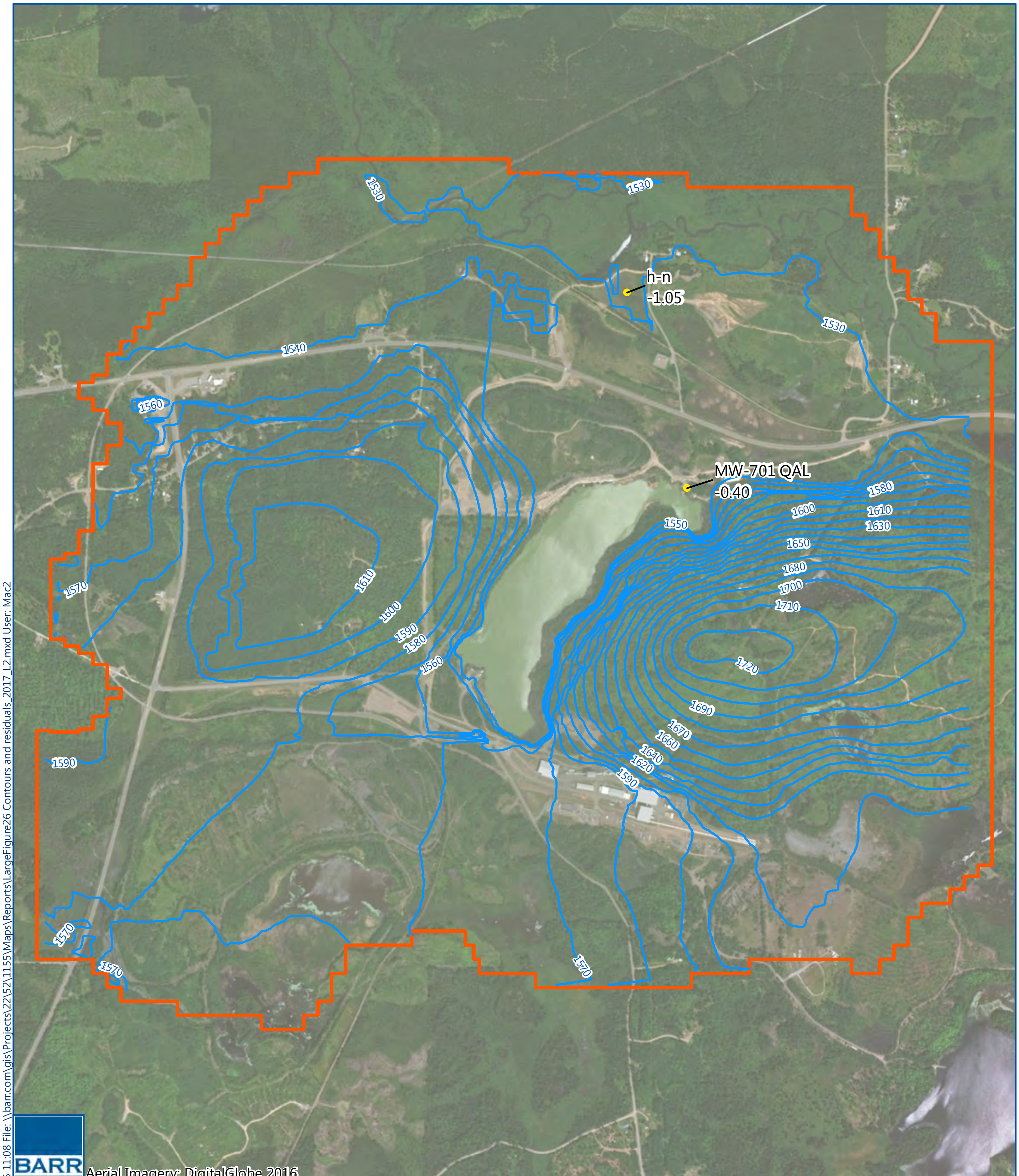
Note:
-No observed 2017 groundwater elevations in Layer 1

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2017 CONDITIONS - LAYER 1
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 25



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2017 CONDITIONS - LAYER 2
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 26

Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

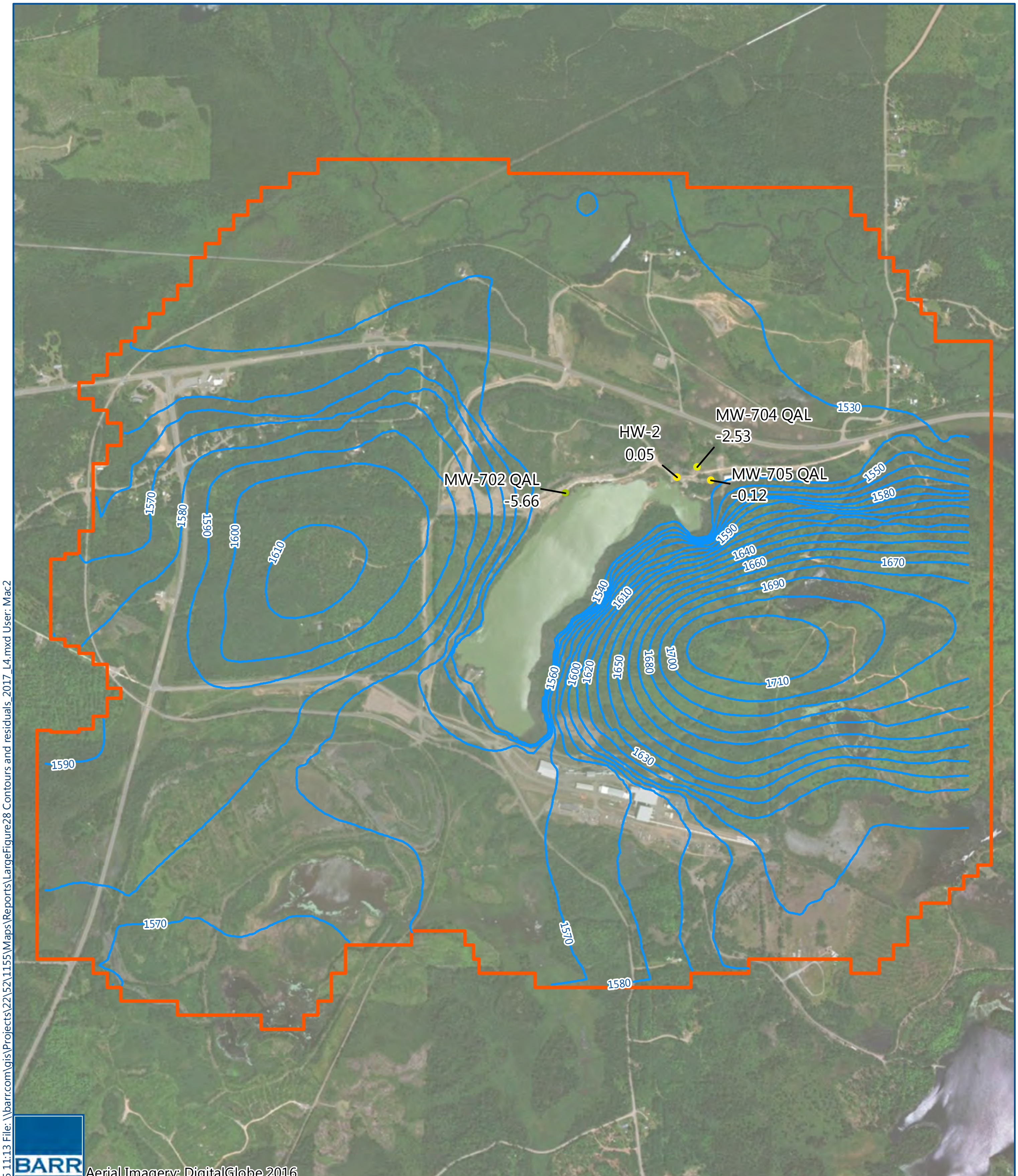
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2017 CONDITIONS - LAYER 3
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 27



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

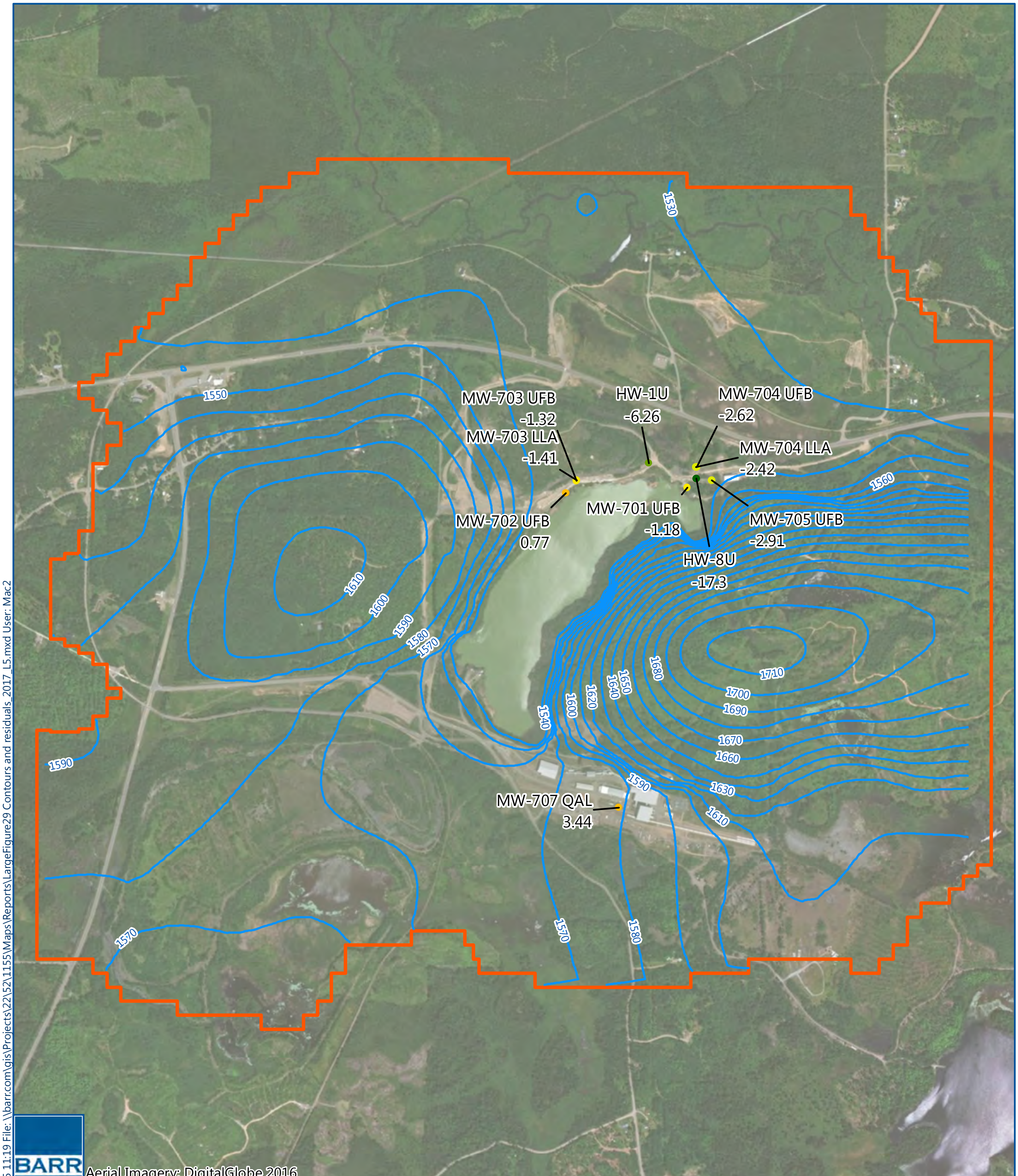
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000 Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2017 CONDITIONS - LAYER 4
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 28



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

Model Active Area

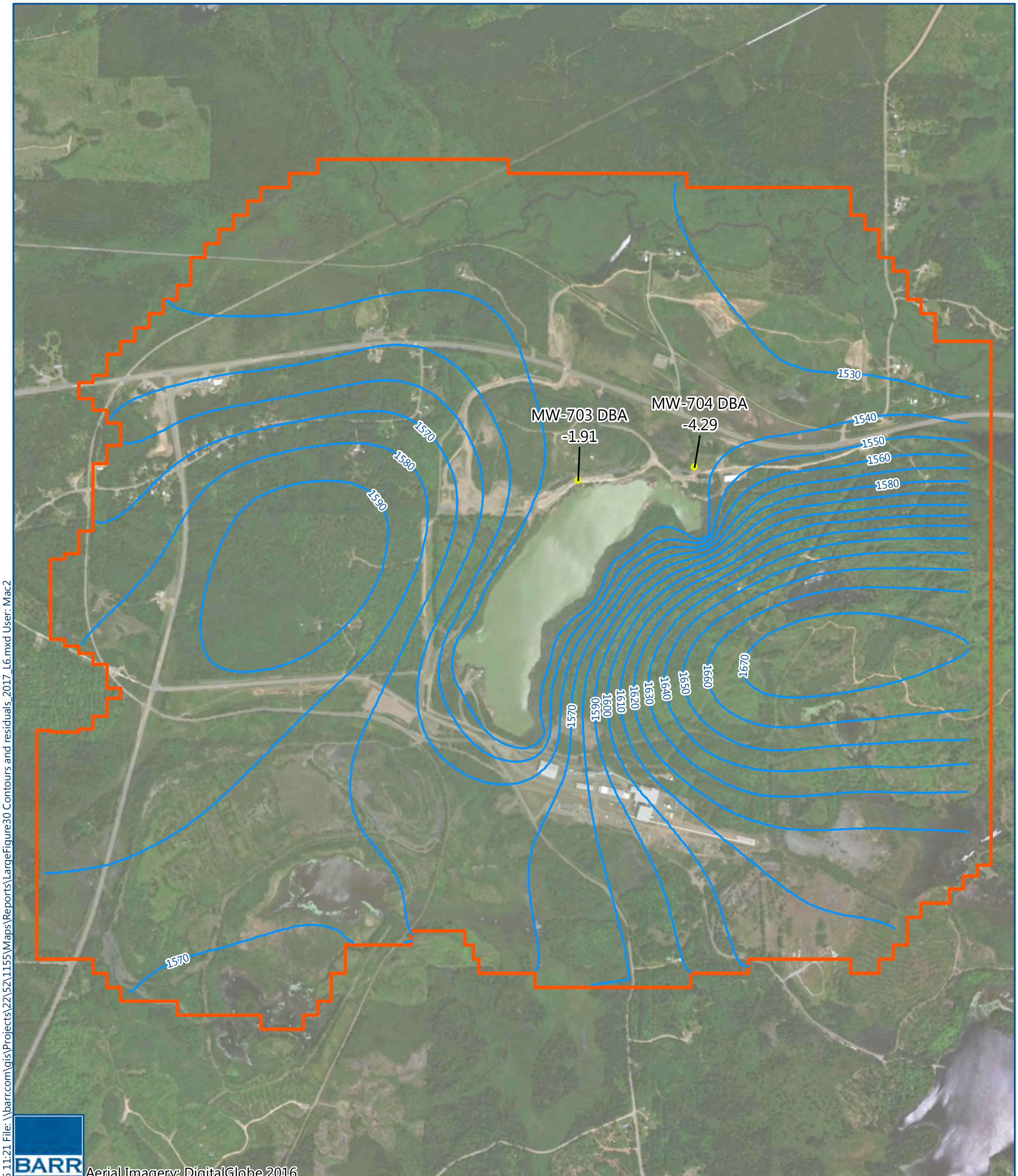
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000
Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2017 CONDITIONS - LAYER 5
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 29



Calibration residuals [ft]
(observed - simulated)

- <-15
- -15.00 to -10.00
- -9.99 to -5.95
- -5.94 to -4.50
- -4.49 to -1.50
- -1.49 to 0.46
- 0.47 to 5.00
- 5.01 to 10.00
- 10.01 to 15.00
- >15

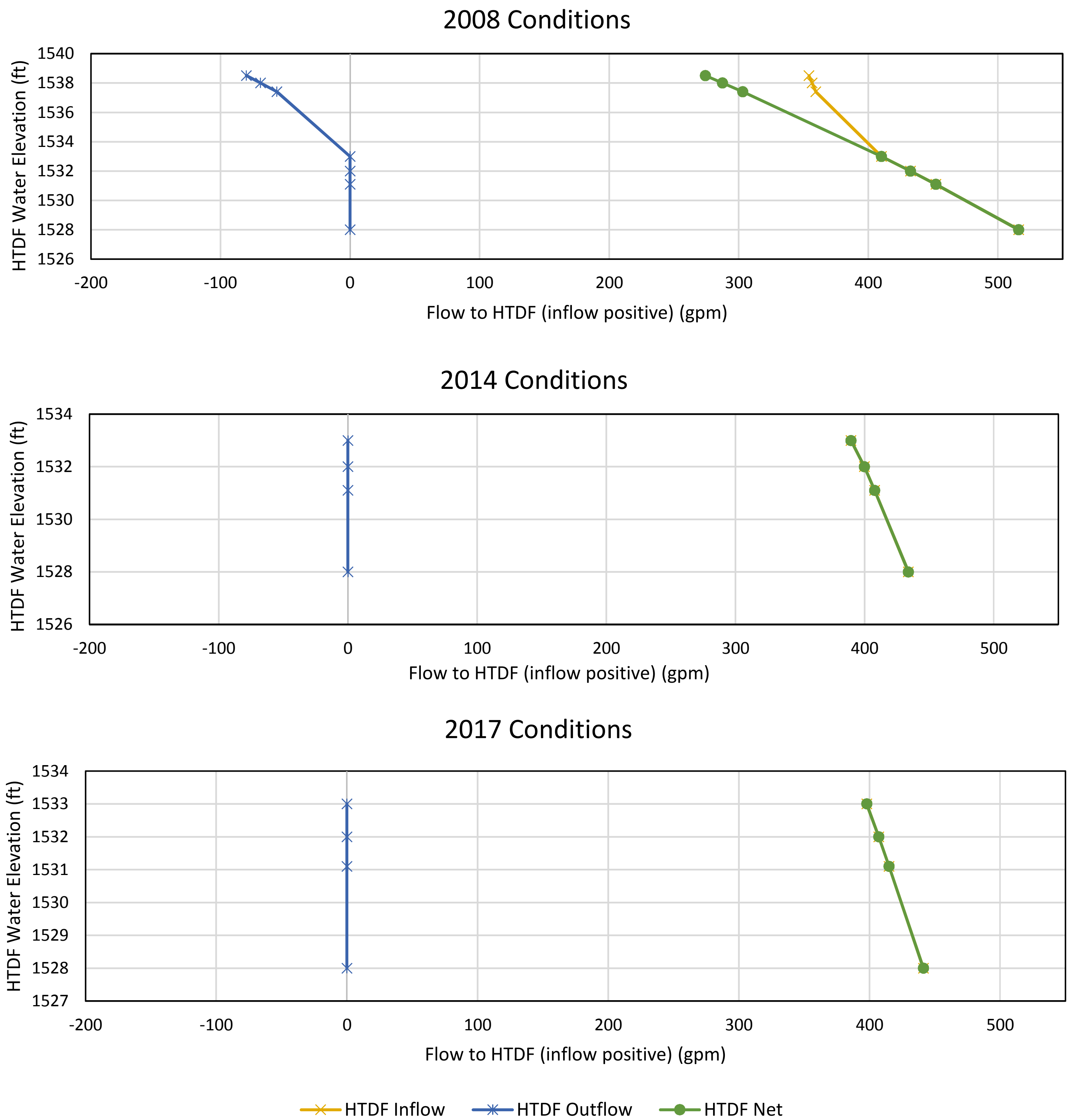
Model Active Area
Simulated groundwater elevation [ft above mean sea level]

N

0 1,500 3,000
Feet

SIMULATED GROUNDWATER ELEVATION CONTOURS AND CALIBRATION RESIDUALS 2017 CONDITIONS - LAYER 6
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 30



P:\Grand Rapids\22 MI\52\22521155 HTDF Outfall Design & Modeling\WorkFiles\Water Modeling Report 2017\Figures\xls sources\predictions_calib_4_m2_results.xlsx

HTDF - Humboldt Tailings Disposal Facility
gpm - gallons per minute

SIMULATED HTDF GROUNDWATER FLOW
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 31

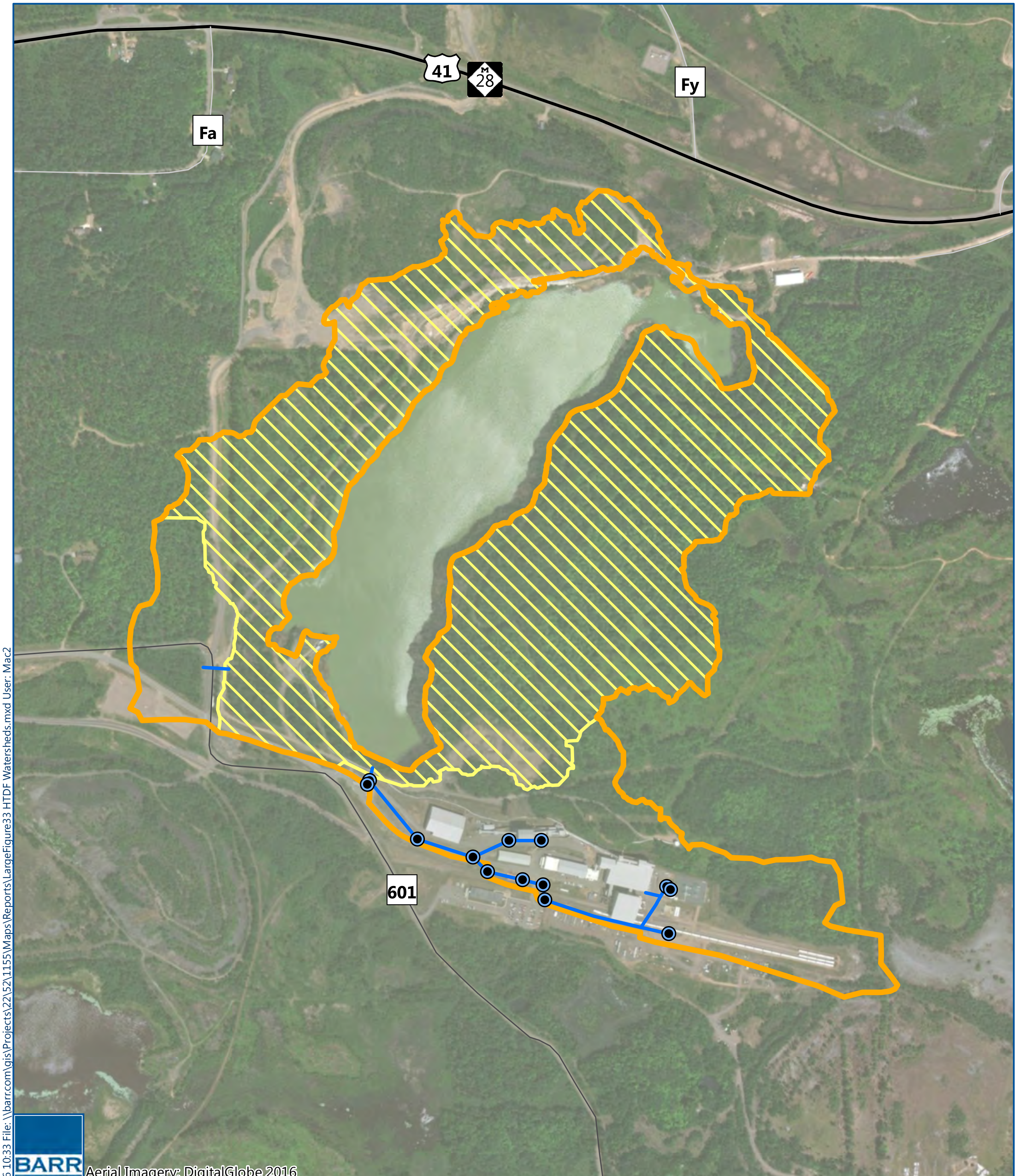
Approximate Weather Station Location

N

0 7 14 Miles

CLIMATE DATA STATIONS FOR WATER BALANCE MODELING
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 32



Approximate Catchbasin Location

Approximate Stormsewer Location

HTDF Watersheds

Pre-Eagle Condition

Eagle Condition

N

0 800 1,600 Feet

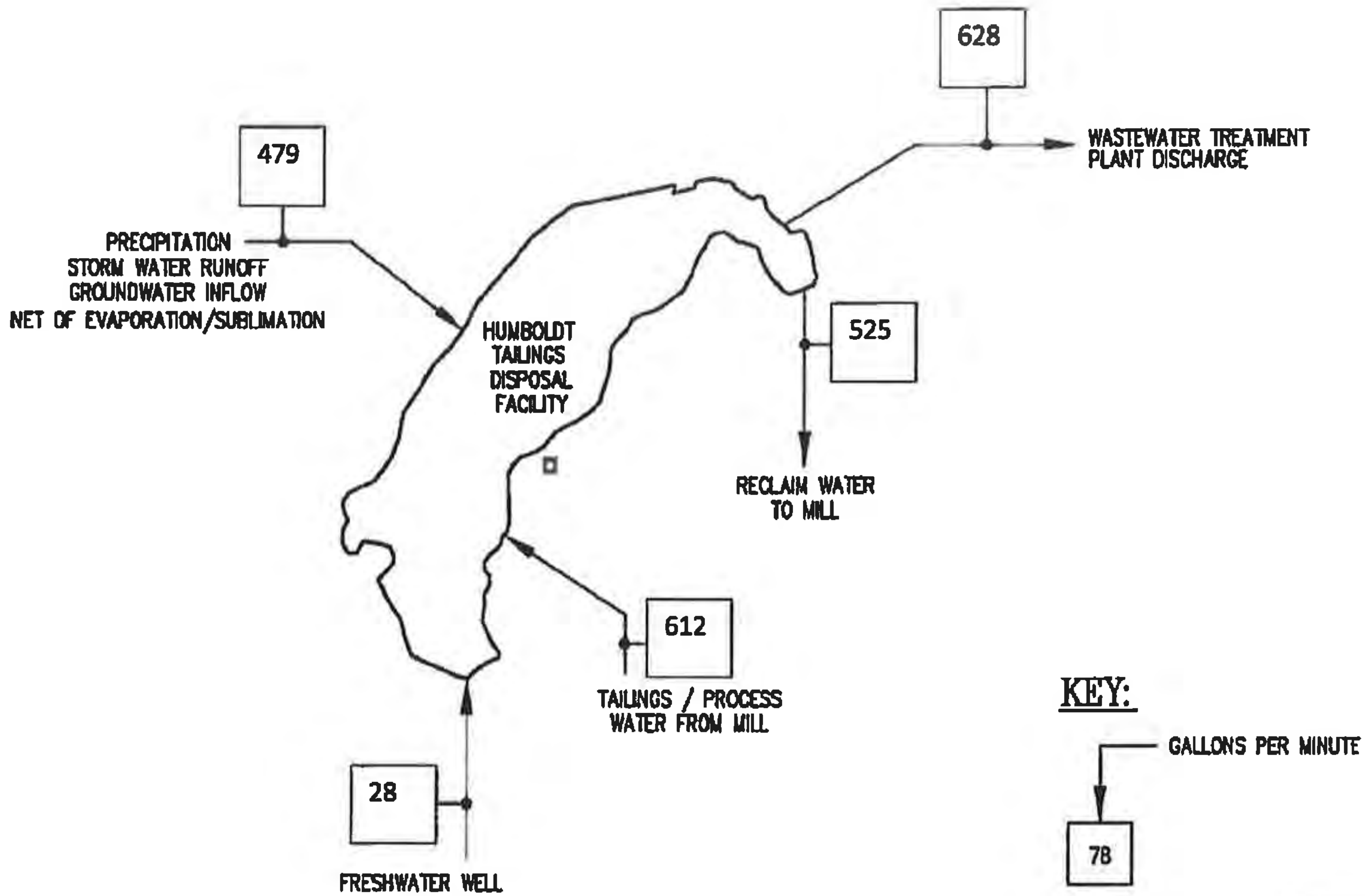
HTDF WATERSHEDS
Water Balance Modeling
Eagle Mine, LLC

LARGE FIGURE 33

Appendix E

Humboldt Mill

Water Balance Diagrams



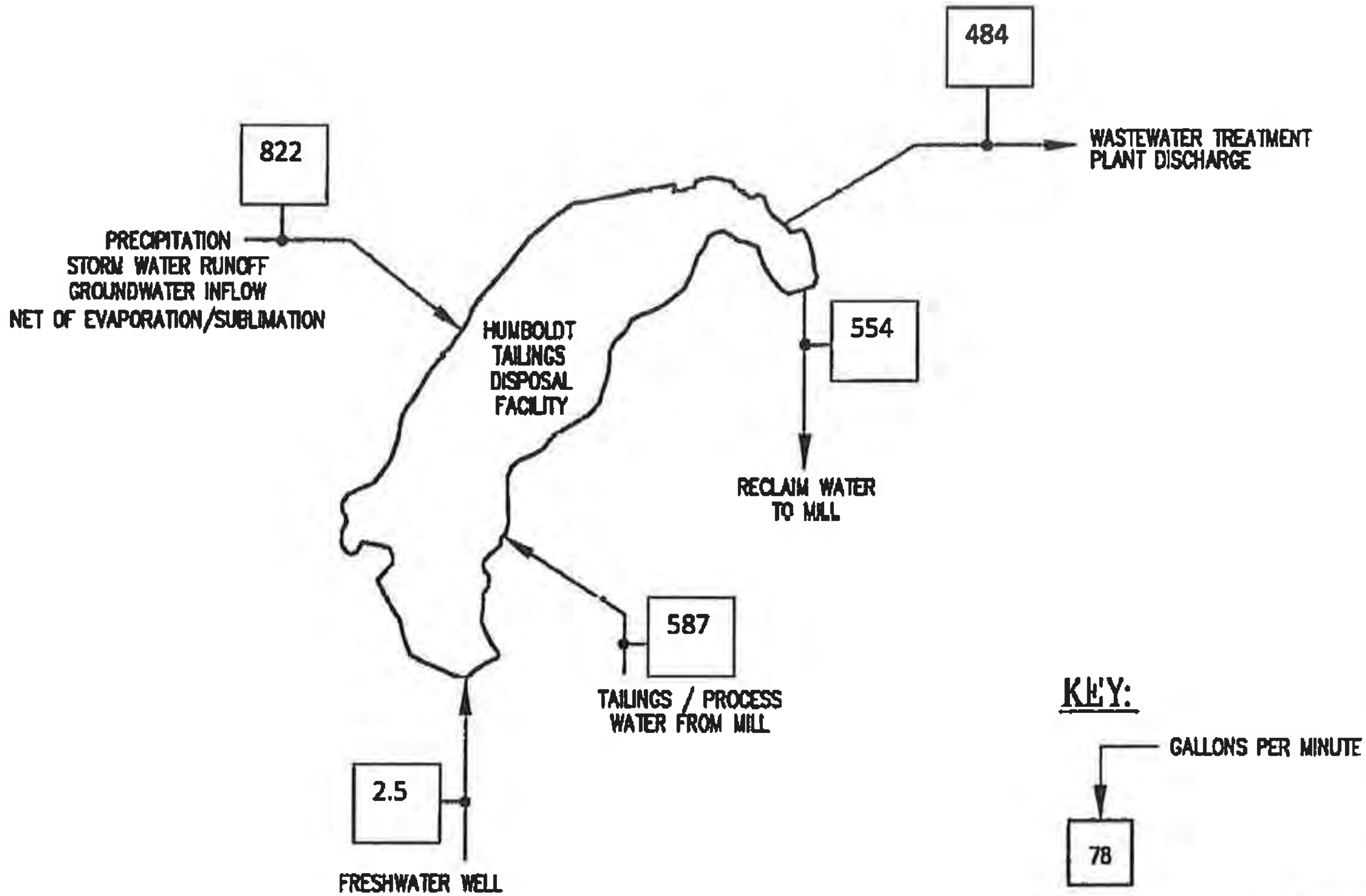
PROJECT NUMBER: KEX–0102

Eagle Mine, LLC - Humboldt Mill Facility
Humboldt Township, Marquette County, Michigan

WATER BALANCE
HUMBOLDT TAILINGS DISPOSAL FACILITY
(January 1 - March 31, 2017

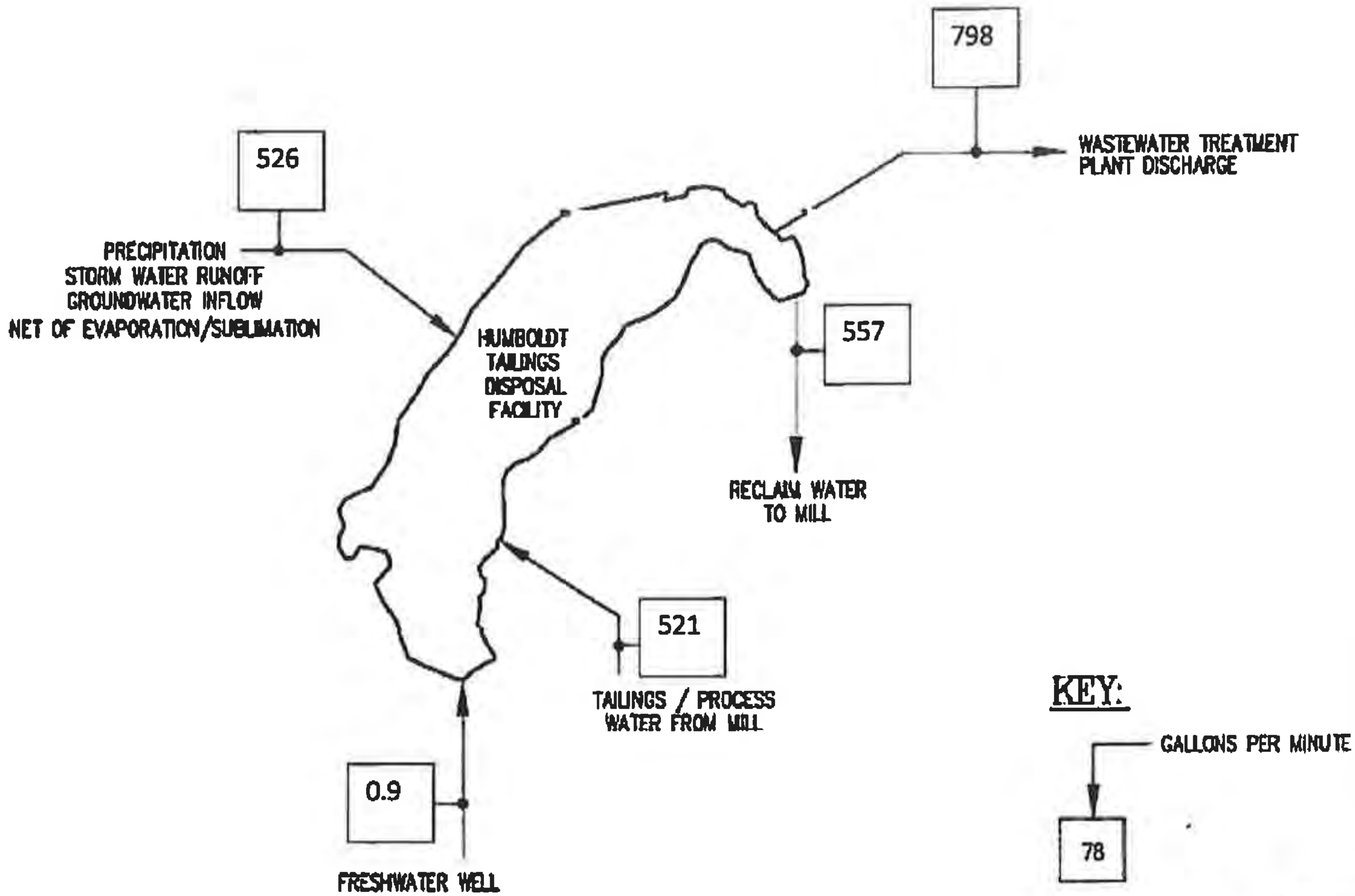
FIGURE: **1**

Tailings total includes the dry tailings volume. As such, this diagram illustrates a volume balance rather than a pure water balance.



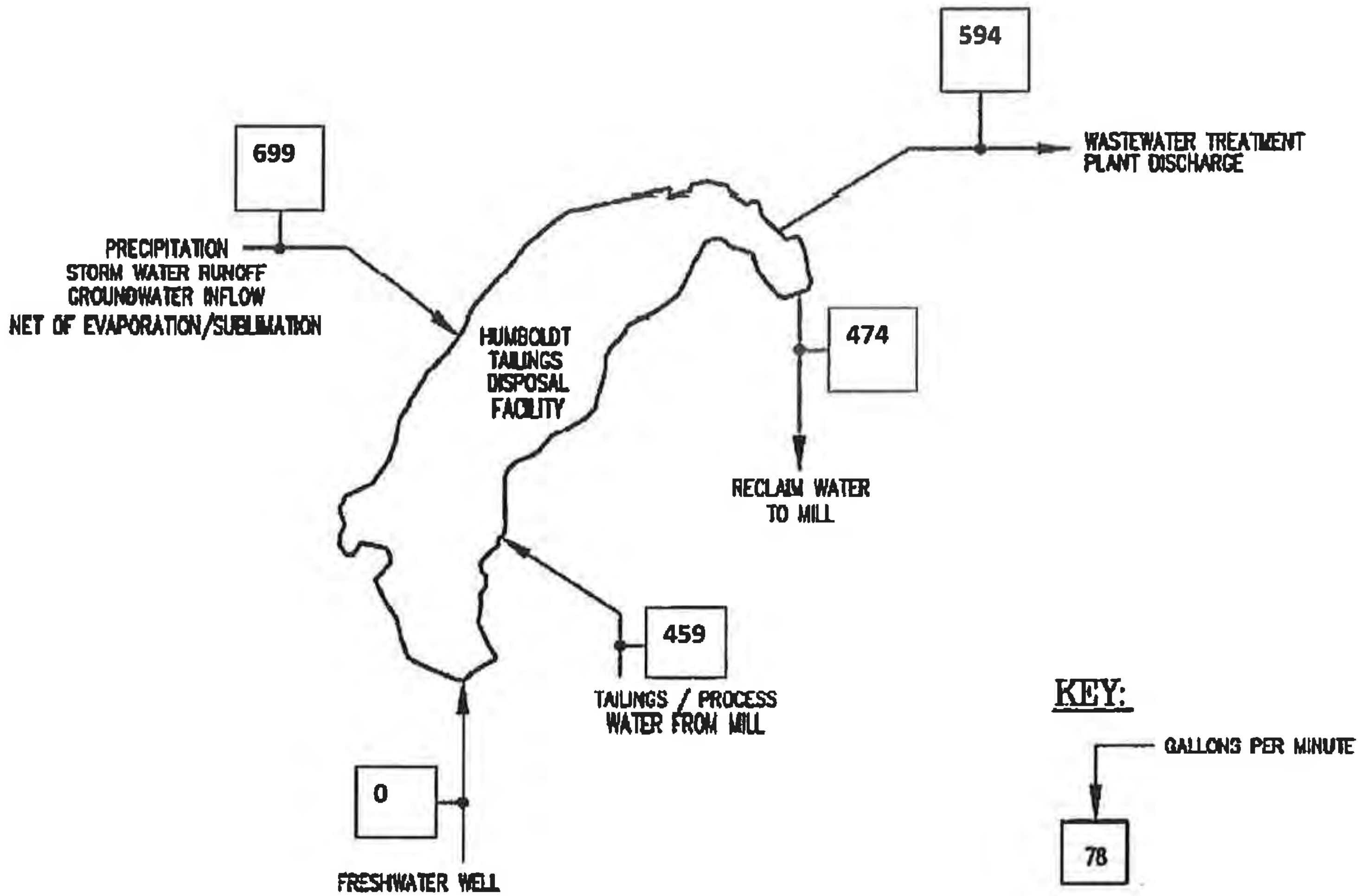
Tailings total includes the dry tailings volume. As such, this diagram illustrates a volume balance rather than a pure water balance.

	PROJECT NUMBER: KEX–0102
Eagle Mine, LLC - Humboldt Mill Facility Humboldt Township, Marquette County, Michigan	FIGURE:
WATER BALANCE HUMBOLDT TAILINGS DISPOSAL FACILTY (April 1 - June 30, 2017	1



Tailings total includes the dry tailings volume. As such, this diagram illustrates a volume balance rather than a pore water balance.

Eagle Mine, LLC - Humboldt Mill Facility Humboldt Township, Marquette County, Michigan	PROJECT NUMBER: KEx-0102
WATER BALANCE HUMBOLDT TAILINGS DISPOSAL FACILTY (July 1 - September 30, 2017	FIGURE: **1**



Tailings total includes the dry tailings volume. As such, this diagram illustrates a volume balance rather than a pore water balance.

	PROJECT NUMBER: KEX–0102
Eagle Mine, LLC - Humboldt Mill Facility Humboldt Township, Marquette County, Michigan	FIGURE:
WATER BALANCE HUMBOLDT TAILINGS DISPOSAL FACILTY (October 1 - December 31, 2017	1

Appendix F

Humboldt Mill

Groundwater Monitoring Well Location Map

CUT-OFF WALL MONITORING WELL NETWORK LOCATIONS

Legend

- Monitoring Well
- Leachate Monitoring Well per R425.406(5)(a)
- Compliance Monitoring Well per R425.406(5)(b)
- Containment Wall
- Estimated Limit of Aquifer
- Flow Divide
- Highway
- Bedrock Outcrop

Reference

Data provided by: Eagle Mine and North Jackson Company
Projection & Datum: UTM NAD 83 Zone 16N
Aerial Photo: 2006

0 200 400 Feet

1:3,500

Eagle Mine
A subsidiary of lundin mining

North Jackson Company
ENVIRONMENTAL SCIENCE & ENGINEERING

LEGEND

New Compliance Monitoring Wells

NOTES

1. SCALE OF AERIAL IMAGERY IS APPROXIMATE.
2. THIS FIGURE HAS BEEN TRANSLATED AND SCALED TO THE HORIZONTAL DATUM NAD83 MICHIGAN STATE PLANE COORDINATE SYSTEM.
3. FOR REFERENCE PURPOSES ONLY. NOT TO BE USED FOR REPORTING.

REFERENCE

1. BASE MAP TAKEN FROM GOOGLE EARTH, 2014

CLIENT
EAGLE MINE
HUMBOLDT MILL

PROJECT
GROUNDWATER MONTIORING

TITLE
EAGLE MINE HUMBOLDT MILL
COMPLIANCE MONITORING LOCATIONS

DRAFT

CONSULTANT

Golder Associates

YYYY-MM-DD	2014-08-14
PREPARED	CJS
DESIGN	CJS
REVIEW	MAC
APPROVED	GJD

PROJECT
1401484

Rev.
0

FIGURE
01

Path: C:\Users\CStacey\Documents\Eagle\1401484 Eagle Mill Monitoring\GIS\Eagle Mill MW Location Map Portrait.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

0 1 in

Appendix G

Humboldt Mill

Groundwater Monitoring Well Results

&

Benchmark Summary Table

Humboldt Mill
2017 Mine Permit Groundwater Monitoring
Benchmark Comparison Summary

Location	Location Classification	Q1	Q2	Q3	Q4
HW-1L	Monitoring	**pH, sulfate**	**pH, sulfate**	**pH, sulfate**	**pH, sulfate**
HW-1U LLA	Monitoring	iron, lead, manganese, mercury, alkalinity bicarbonate, chloride, **ammonia**, **sulfate**, calcium, magnesium, **sodium**	**iron, lead, manganese, chloride, ammonia**, nitrite, **sulfate**, **calcium, magnesium**, **sodium,** hardness	**chloride, ammonia**, nitrate, **sulfate**, **sodium**	iron, mercury, **chloride, ammonia**, **sulfate**, **sodium**
HW-2	Monitoring	**chloride, ammonia**, **sulfate, sodium**	**chloride, ammonia**, **sulfate, sodium**	**chloride**, **sulfate, sodium**	**chloride**, **sulfate, sodium**
HW-8U	Monitoring	**sulfate**	**sulfate**	**sulfate**	pH, **sulfate**, manganese
HYG-1	Monitoring	**manganese, mercury, alkalinity bicarbonate,** sulfate, calcium, magnesium, potassium, **sodium**, hardness	**manganese, mercury, alkalinity bicarbonate,** ammonia, **sulfate, potassium, sodium**, **hardness**	**manganese, mercury, alkalinity bicarbonate, ammonia, sulfate,** calcium, **potassium, sodium**, **hardness**	**manganese, mercury, alkalinity bicarbonate, ammonia, sulfate, calcium**, magnesium**, potassium, sodium**, **hardness**
KMW-5R	COSA	mercury	N/A	aluminum, arsenic, copper, iron, mercury	**copper, mercury**
MW-702 QAL	Leachate	**pH**	**pH**, sodium	**pH**	**pH**
MW-702 UFB	Leachate	pH	**pH**	**pH**	**pH**
MW-703 QAL	Compliance	**pH, nitrate**	**pH, nitrate**	**pH, nitrate**	**pH, nitrate**
MW-703 UFB	Compliance	N/A	pH	**pH**	**pH**
MW-703-DBA	Compliance	potassium	pH, **potassium**	N/A	pH, potassium
MW-704 QAL	Compliance	**mercury, ammonoia, nitrate, sulfate, magnesium**	iron, **mercury,** alkalinity bicarbonate, **ammonia, magnesium,** potassium, sodium	nitrate, sulfate, magnesium	iron, manganese, **mercury,** ammonia, **magnesium,** potassium
MW-704 UFB	Compliance	**manganese, calcium, magnesium, hardness**	**manganese, calcium, magnesium, hardness**	iron, **manganese,** chloride, **calcium, magnesium, hardness**	**iron, manganese,** alkalinity bicarbonate, **chloride, calcium, magnesium, hardness**
MW-704 LLA	Compliance	**pH**, alkalinity bicarbonate	**pH, alkalinity bicarbonate**	**pH, alkalinity bicarbonate**	**pH,** potassium
MW-704 DBA	Compliance	**alkalinity bicarbonate**	pH, **alkalinity bicarbonate,** hardness	**pH, alkalinity bicarbonate, hardness**	N/A
MW-705 QAL	Cut-off Wall Key in Well	**sulfate**	**sulfate**	mercury, ammonia, **sulfate**	**mercury, ammonia**
MW-705 UFB	Cut-off Wall Key in Well	manganese, **magnesium,** potassium, **sodium,** hardness	**manganese, magnesium, hardness**	**manganese**, calcium, **magnesium,** sodium, **hardness**	**manganese, magnesium, hardness**
MW-706 QAL	Mill Services Building/Secondary Crusher	**pH, chloride,** nitrate	**pH, chloride**	**pH, chloride**	**pH, chloride**
MW-707 QAL	Concentrator/CLO	**alkalinity bicarbonate, hardness**	**alkalinity bicarbonate, hardness**	**alkalinity bicarbonate, hardness**	**alkalinity bicarbonate, hardness**
MW-9R	Concentrator	**nitrate**	N/A	mercury	N/A

Parameters listed in this table had values reported that were equal to or greater than a site-specific benchmark. Parameters in **BOLD** are instances in which the Department was notified because benchmark deviations were identified at compliance monitoring locations for two consecutive quarters. N/A means there were no parameters outside of benchmark values for that quarter. If the location is classified as background, Department notification is not required for an exceedance.

Blank data cells indicate that no benchmark deviations occurred at the location during the specified sampling quarter.

2017
Mine Permit Groundwater Quality Monitoring Data
HW-1L (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/15/2017[D]	Q2 2017 05/22/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**0.45**	**2.8**	**1.8**	**0.22**
ORP	mV	-	**-232**	**-32**	**-193**	**-307**
pH	SU	9.0-10	**8.4**	**8.7**	**8.4**	**7.7**
Specific Conductance	uS/cm	-	**361**	**247**	**356**	**357**
Temperature	C	-	**7.5**	**8.2**	**11**	**8.4**
Turbidity	NTU	-	**29**	**11**	**4.6**	**3.5**
Water Elevation	ft MSL	-	**1465.85**	**1464.52**	**1463.67**	**1485.53**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	**632**	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	1134	**670**	**610**	**622**	**907**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	**19**	-
Manganese	ug/L	23	< 50	< 50	< 50	< 50
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	11	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	117	**84**	**82**	**81**	**82**
Alkalinity, Carbonate	mg/L	14	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	52	**46**	**45**	**46**	**46**
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.04	< 0.03	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	24	**25**	**25**	**24**	**26**
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	35	**26**	**24**	**26**	**28**
Magnesium	mg/L	17	**11**	**11**	**11**	**11**
Potassium	mg/L	11	**2.1**	**1.8**	**1.9**	**1.8**
Sodium	mg/L	27	**25**	**25**	**24**	**23**
General						
Hardness	mg/L	157	**114**	**111**	**114**	**128**

2017
Mine Permit Groundwater Quality Monitoring Data
HW-1U LLA (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/15/2017[D]	Q2 2017 05/22/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**1.1**	**2.0**	**2.1**	**3.1**
ORP	mV	-	**-143**	**-50**	**-92**	**-53**
pH	SU	8.6-9.6	**8.8**	**9.0**	**9.0**	**8.4**
Specific Conductance	uS/cm	-	**4.7**	**325**	**435**	**443**
Temperature	C	-	**7.0**	**8.2**	**11**	**8.1**
Turbidity	NTU	-	**978**	**855**	**777**	**869**
Water Elevation	ft MSL	-	**1489.96**	**1494.49**	**1495.62**	**1512.99**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	**11**	**7.4**	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	**7.1**	**4.1**	< 4.0	< 4.0
Iron	ug/L	800 (p)	**35000**	**35000**	< 200	**3230**
Lead	ug/L	12 (p)	**110**	**59**	< 3.0	**8.2**
Lithium	ug/L	40 (p)	-	-	**16**	-
Manganese	ug/L	200 (p)	**490**	**290**	< 50	< 50
Mercury	ng/L	4.0 (p)	**9.8**	< 10	< 1.0	**5.0**
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	40 (p)	**35**	**20**	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	125	**170**	**120**	**83**	**79**
Alkalinity, Carbonate	mg/L	66	< 2.0	**39**	**42**	**57**
Chloride	mg/L	40 (p)	**44**	**46**	**46**	**66**
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.10 (p)	**0.32**	**0.36**	**0.35**	**0.43**
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	**0.43**	**0.14**
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	**0.60**	< 0.10	< 0.10
Sulfate	mg/L	58	**130**	**150**	**434**	**372**
Sulfide	mg/L	0.36	< 2.0	< 5.0	< 10	< 5.0
Major Cations						
Calcium	mg/L	29	**61**	**61**	**2.6**	**7.2**
Magnesium	mg/L	15	**24**	**26**	< 1.0	**2.4**
Potassium	mg/L	50	**4.1**	**3.6**	**1.0**	**1.0**
Sodium	mg/L	33	**130**	**110**	**86**	**99**
General						
Hardness	mg/L	132	**130**	**158**	**9.8**	**30**

2017
Mine Permit Groundwater Quality Monitoring Data
HW-1U UFB (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/15/2017[D]	Q2 2017 05/22/2017[D]	Q3 2017 08/22/2017[T]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**0.59**	**0.98**	**0.40**	**0.36**
ORP	mV	-	**-234**	**-180**	**-269**	**-282**
pH	SU	8.4-9.4	**8.8**	**8.9**	**8.9**	**8.6**
Specific Conductance	uS/cm	-	**210**	**97**	**157**	**175**
Temperature	C	-	**5.8**	**8.1**	**11**	**8.6**
Turbidity	NTU	-	**3.5**	**10**	**2.0**	**4.7**
Water Elevation	ft MSL	-	**1530.25**	**1532.32**	**1532.19**	**1532.13**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	11	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	800 (p)	< 200	< 200	**296**	**224**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	< 10	-
Manganese	ug/L	75	< 50	< 50	< 50	< 50
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	40 (p)	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	127	**88**	**63**	**62**	**76**
Alkalinity, Carbonate	mg/L	14	**6.2**	**4.1**	**8.1**	**6.1**
Chloride	mg/L	121	< 10	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.12 (p)	< 0.03	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.67	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	76	**5.6**	**1.5**	< 0.10	< 0.10
Sulfide	mg/L	1.3	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	46	**15**	**14**	**14**	**17**
Magnesium	mg/L	17	**6.0**	**3.9**	**4.5**	**5.5**
Potassium	mg/L	22	**5.2**	**2.3**	**2.8**	**3.2**
Sodium	mg/L	91	**17**	**6.9**	**7.4**	**6.7**
General						
Hardness	mg/L	189	**68**	**46**	**63**	**72**

2017
Mine Permit Groundwater Quality Monitoring Data
HW-2 (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/20/2017[D]		Q2 2017 05/23/2017[D]		Q3 2017 08/22/2017[D]		Q4 2017 11/30/2017[D]	
Field										
D.O.	ppm	-	**0.30**		**0.46**		**0.40**		**0.41**	
ORP	mV	-	**-181**		**-220**		**-190**		**-82**	
pH	SU	7.7-8.7	**7.7**		**8.3**		**7.7**		**7.9**	
Specific Conductance	uS/cm	-	**644**		**456**		**454**		**672**	
Temperature	C	-	**9.0**		**10**		**11**		**11**	
Turbidity	NTU	-	**39**		**110**		**39**		**56**	
Water Elevation	ft MSL	-	**1530.24**		**1532.01**		**1531.10**		**1532.55**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	3401	**1400**		< 200		**1390**		**1290**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	324	**320**		**170**		**294**		**306**	
Mercury	ng/L	1.3	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	40 (p)	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	145	**110**		**120**		**114**		**109**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	25	**28**		**28**		**27**		**34**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.05	**0.07**		**0.06**		**0.03**		**0.03**	
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10		< 0.10		**0.11**		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	135	**150**		**150**		**142**		**156**	
Sulfide	mg/L	0.47	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	72	**59**		**56**		**54**		**59**	
Magnesium	mg/L	28	**25**		**24**		**21**		**24**	
Potassium	mg/L	7.0	**5.1**		**4.9**		**4.2**		**5.3**	
Sodium	mg/L	15	**27**		**26**		**23**		**30**	
General										
Hardness	mg/L	277	**254**		**261**		**254**		**262**	

Explanations of abbreviations are included on the final page of this table.

2017
Mine Permit Groundwater Quality Monitoring Data
HW-8U (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/16/2017[T]		Q2 2017 05/22/2017[D]		Q3 2017 08/22/2017[T]		Q4 2017 11/28/2017[T]	
Field										
D.O.	ppm	-	**0.81**		**1.8**		**1.5**		**0.20**	
ORP	mV	-	**-120**		**-92**		**-98**		**-107**	
pH	SU	6.4-7.4	**7.2**		**6.9**		**6.8**		**6.2**	
Specific Conductance	uS/cm	-	**268**		**223**		**334**		**353**	
Temperature	C	-	**7.5**		**8.3**		**10**		**8.4**	
Turbidity	NTU	-	**1.9**		**4.0**		**2.5**		**2.2**	
Water Elevation	ft MSL	-	**1531.57**		**1534.27**		**1534.38**		**1533.86**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	**7.3**		**5.3**		**6.3**		**7.9**	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	27125	**8300**		**7800**		**8010**		**7000**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	5498	**4900**		**3800**		**3840**		**5830**	
Mercury	ng/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	26	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	237	**140**		**130**		**127**		**147**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	40 (p)	**13**		**13**		**15**		**17**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		<1.0		<1.0	
Nitrogen, Ammonia	mg/L	0.04	<0.03		<0.03		<0.03		<0.03	
Nitrogen, Nitrate	mg/L	0.10	<0.10		<0.10		<0.10		<0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	<0.10		<0.10		<0.10		<0.10	
Sulfate	mg/L	2.6	**8.9**		**9.6**		**9.3**		**12**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	54	**33**		**31**		**32**		**36**	
Magnesium	mg/L	22	**11**		**12**		**12**		**11**	
Potassium	mg/L	4.1	**2.9**		**3.0**		**2.8**		**2.7**	
Sodium	mg/L	4.4	**3.3**		**3.2**		**3.5**		**3.5**	
General										
Hardness	mg/L	224	**148**		**141**		**156**		**170**	

2017
Mine Permit Groundwater Quality Monitoring Data
HYG-1 (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/20/2017[T]		Q2 2017 05/24/2017[T]		Q3 2017 08/22/2017[T]		Q4 2017 11/30/2017[T]	
Field										
D.O.	ppm	-	**0.34**		**0.22**		**0.38**		**0.41**	
ORP	mV	-	**33**		**22**		**22**		**179**	
pH	SU	6.3-7.3	**6.6**		**6.8**		**6.5**		**6.6**	
Specific Conductance	uS/cm	-	**865**		**565**		**507**		**807**	
Temperature	C	-	**8.0**		**7.5**		**8.6**		**8.9**	
Turbidity	NTU	-	**1.1**		**2.2**		**1.5**		**1.5**	
Water Elevation	ft MSL	-	**1530.72**		**1532.87**		**1533.80**		**1533.62**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		**7.4**		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		<100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	4.4	**4.2**		< 4.0		< 4.0		< 4.0	
Iron	ug/L	800 (p)	< 200		< 200		**212**		**353**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	286	**440**		**380**		**435**		**688**	
Mercury	ng/L	6.2	**26**		**29**		**17**		**21**	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	19	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	157	**370**		**250**		**246**		**297**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	12	**11**		< 10		**11**		**12**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.38	**0.34**		**0.46**		**0.52**		**0.69**	
Nitrogen, Nitrate	mg/L	0.26	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	98	**100**		**120**		**128**		**113**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	52	**61**		**50**		**53**		**61**	
Magnesium	mg/L	28	**31**		**26**		**28**		**33**	
Potassium	mg/L	8.4	**13**		**11**		**11**		**12**	
Sodium	mg/L	14	**78**		**59**		**51**		**56**	
General										
Hardness	mg/L	230	**300**		**248**		**262**		**300**	

2017
Mine Permit Groundwater Quality Monitoring Data
KMW-5R (Facility)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017[D]	Q2 2017 05/25/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 12/04/2017[D]
Field						
D.O.	ppm	-	NM	NM	NM	**5.2**
ORP	mV	-	NM	NM	NM	**286**
pH	SU	6.7-7.7	NM	NM	NM	**7.1**
Specific Conductance	uS/cm	-	NM	NM	NM	**880**
Temperature	C	-	NM	NM	NM	**8.4**
Turbidity	NTU	-	NM	NM	NM	**1455**
Water Elevation	ft MSL	-	**1557.20**	**1560.44**	**1559.68**	**1559.63**
Metals						
Aluminum	ug/L	200 (p)	-	-	**9110**	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	6.0	< 5.0	< 5.0	**10**	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	**1.6**	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	**13**	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	15	**8.0**	< 4.0	**20**	**17**
Iron	ug/L	33432	**13000**	**400**	**62700**	**22500**
Lead	ug/L	4.8	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	**31**	-
Manganese	ug/L	2815	**2100**	**1600**	**1970**	**1250**
Mercury	ng/L	2.1	**7.4**	< 1.0	**11**	**9.6**
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	**23**	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	**13**	-
Zinc	ug/L	19	< 10	< 10	**17**	**13**
Major Anions						
Alkalinity, Bicarbonate	mg/L	486	**380**	**400**	**390**	**378**
Alkalinity, Carbonate	mg/L	3.3	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	139	**17**	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.76	**0.03**	**0.05**	**0.03**	**0.03**
Nitrogen, Nitrate	mg/L	0.11	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.06	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	123	**120**	**110**	**108**	**99**
Sulfide	mg/L	3.8	< 0.20	< 0.20	< 1.0	< 1.0
Major Cations						
Calcium	mg/L	169	**130**	**120**	**115**	**108**
Magnesium	mg/L	67	**51**	**47**	**53**	**46**
Potassium	mg/L	9.1	**7.6**	**7.3**	**7.5**	**7.3**
Sodium	mg/L	50	**5.8**	**7.2**	**7.4**	**7.4**
General						
Hardness	mg/L	800	**504**	**277**	**480**	**484**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-701 QAL (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/16/2017[T]		Q2 2017 05/23/2017[D]		Q3 2017 08/22/2017[D]		Q4 2017 11/30/2017[T]	
Field										
D.O.	ppm	-	**5.1**		**7.7**		**7.5**		**6.0**	
ORP	mV	-	**182**		**148**		**152**		**313**	
pH	SU	5.8-6.8	**5.9**		**5.8**		**5.8**		**5.9**	
Specific Conductance	uS/cm	-	**143**		**97**		**89**		**118**	
Temperature	C	-	**6.6**		**7.7**		**10**		**8.7**	
Turbidity	NTU	-	**2.2**		**4.0**		**17**		**1.6**	
Water Elevation	ft MSL	-	**1530.36**		**1532.50**		**1531.66**		**1531.62**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	459	< 200		< 200		< 200		< 200	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	4801	< 50		< 50		< 50		< 50	
Mercury	ng/L	11	**1.2**		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	40 (p)	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	189	**41**		**44**		**37**		**30**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	19	< 10		< 10		< 10		< 10	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.39	< 0.03		< 0.03		< 0.03		< 0.03	
Nitrogen, Nitrate	mg/L	3.1	**0.94**		**0.50**		**0.14**		**0.45**	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	110	**19**		**20**		**14**		**16**	
Sulfide	mg/L	0.22	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	57	**10**		**10**		**9.1**		**9.2**	
Magnesium	mg/L	26	**4.7**		**4.5**		**4.1**		**4.3**	
Potassium	mg/L	9.2	**3**		**2.5**		**2.4**		**2.4**	
Sodium	mg/L	14	**6.6**		**6.6**		**5.5**		**5.1**	
General										
Hardness	mg/L	272	**48**		**48**		**42**		**48**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-701 UFB (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/16/2017[D]	Q2 2017 05/23/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/30/2017[D]
Field						
D.O.	ppm	-	**0.09**	**0.20**	**0.37**	**0.46**
ORP	mV	-	**-216**	**-238**	**-189**	**-30**
pH	SU	7.2-8.2	**7.3**	**7.5**	**7.3**	**7.3**
Specific Conductance	uS/cm	-	**394**	**360**	**251**	**383**
Temperature	C	-	**7.5**	**7.7**	**8.5**	**7.8**
Turbidity	NTU	-	**49**	**48**	**21**	**6.5**
Water Elevation	ft MSL	-	**1530.55**	**1532.83**	**1531.08**	**1531.90**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	**135**	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	30	< 4.0	**9.0**	< 4.0	< 4.0
Iron	ug/L	27405	**18000**	**16000**	**14400**	**16200**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	**11**	-
Manganese	ug/L	6881	**2200**	**1900**	**2340**	**2390**
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	26	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	172	**150**	**140**	**141**	**133**
Alkalinity, Carbonate	mg/L	18	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	43	< 10	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	1.6	< 0.03	**0.05**	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	80	**16**	**6.8**	**16**	**21**
Sulfide	mg/L	1.7	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	40	**32**	**30**	**32**	**34**
Magnesium	mg/L	16	**14**	**13**	**14**	**15**
Potassium	mg/L	13	**3.0**	**3.2**	**2.8**	**2.9**
Sodium	mg/L	56	**4.6**	**4.7**	**4.4**	**4.7**
General						
Hardness	mg/L	163	**152**	**141**	**144**	**152**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-702 QAL (Leachate)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/20/2017[D]	Q2 2017 05/24/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**1.1**	**1.5**	**1.2**	**0.68**
ORP	mV	-	**123**	**-48**	**-47**	**42**
pH	SU	9.8-11	**6.9**	**11**	**9.2**	**7.5**
Specific Conductance	uS/cm	-	**488**	**444**	**288**	**320**
Temperature	C	-	**7.0**	**7.1**	**7.6**	**7.1**
Turbidity	NTU	-	**31**	**6.2**	**11**	**4.8**
Water Elevation	ft MSL	-	**1529.76**	**1531.47**	**1529.90**	**1529.87**
Metals						
Aluminum	ug/L	200 (p)	-	-	**90**	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	7.5	< 5.0	**5.4**	< 5.0	< 5.0
Barium	ug/L	155	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	386	< 200	< 200	< 200	< 200
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	< 10	-
Manganese	ug/L	717	**91**	< 50	< 50	< 50
Mercury	ng/L	4.0 (p)	**1.3**	< 1.0	**2.5**	**2.6**
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	**4.6**	-
Zinc	ug/L	40 (p)	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	194	**130**	**80**	**95**	**116**
Alkalinity, Carbonate	mg/L	54	< 2.0	**12**	**12**	< 2.0
Chloride	mg/L	12	< 10	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.03	< 0.03	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	1.8	**0.52**	**1.1**	**0.61**	**0.29**
Nitrogen, Nitrite	mg/L	0.12	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	148	**84**	**86**	**72**	**62**
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	99	**34**	**34**	**29**	**26**
Magnesium	mg/L	17	**9.7**	**5.8**	**6.6**	**6.9**
Potassium	mg/L	36	**4.7**	**12**	**10**	**7**
Sodium	mg/L	42	**41**	**60**	**40**	**35**
General						
Hardness	mg/L	286	**124**	**113**	**108**	**100**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-702 UFB (Leachate)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/14/2017[D]		Q2 2017 05/22/2017[D]		Q3 2017 08/22/2017[D]		Q4 2017 11/27/2017[D]	
Field										
D.O.	ppm	-	**5.8**		**3.3**		**1.9**		**3.9**	
ORP	mV	-	**-72**		**-111**		**-174**		**-134**	
pH	SU	8.5-9.5	**8.1**		**8.0**		**7.8**		**7.7**	
Specific Conductance	uS/cm	-	**118**		**171**		**261**		**260**	
Temperature	C	-	**5.6**		**6.9**		**9.4**		**5.9**	
Turbidity	NTU	-	**8.1**		**13**		**5.1**		**5.2**	
Water Elevation	ft MSL	-	**1533.03**		**1531.08**		**1528.15**		**1521.18**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	2484	**650**		**640**		**908**		**828**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	126	**79**		**75**		**75**		**78**	
Mercury	ng/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	66	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	125	**94**		**93**		**94**		**92**	
Alkalinity, Carbonate	mg/L	15	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	40 (p)	< 10		< 10		< 10		< 10	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.12 (p)	< .01		< 0.03		< 0.03		< 0.03	
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	36	**34**		**35**		**33**		**34**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	49	**31**		**30**		**30**		**29**	
Magnesium	mg/L	14	**10**		**9.8**		**9.7**		**8.9**	
Potassium	mg/L	22	**3.4**		**2.9**		**2.9**		**2.8**	
Sodium	mg/L	8	**3.4**		**3.1**		**3.3**		**2.9**	
General										
Hardness	mg/L	160	**112**		**121**		**118**		**120**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-703 DBA (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/15/2017[T]	Q2 2017 05/22/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**0.92**	**1.6**	**1.8**	**0.45**
ORP	mV	-	**-255**	**-164**	**-156**	**-199**
pH	SU	8.7-9.7	**9.4**	11	**9.4**	10
Specific Conductance	uS/cm	-	**252**	**200**	**261**	**270**
Temperature	C	-	**5.1**	**6.9**	**9.1**	**6.7**
Turbidity	NTU	-	**2.3**	**21**	**50**	**5.7**
Water Elevation	ft MSL	-	**1530.61**	**1532.65**	**1531.84**	**1531.32**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	2738	< 200	< 200	< 200	**798**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	17	-	-	**16**	-
Manganese	ug/L	60	< 50	< 50	< 50	< 50
Mercury	ng/L	4.0 (p)	< 1.0	< 1.00	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20.0
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	22	< 10	< 10	< 10	**15**
Major Anions						
Alkalinity, Bicarbonate	mg/L	74	**58**	**53**	**67**	**43**
Alkalinity, Carbonate	mg/L	27	**25**	**21**	**8.1**	**16**
Chloride	mg/L	20	**16**	**17**	**17**	**16**
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.12	< 0.03	**0.04**	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.11	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	91	**16**	**19**	**27**	**24**
Sulfide	mg/L	0.80 (p)	**0.78**	**0.43**	**0.34**	**0.29**
Major Cations						
Calcium	mg/L	29	**11**	**9.3**	**17**	**12**
Magnesium	mg/L	17	**9.4**	**7.1**	**9.8**	**6.1**
Potassium	mg/L	15	21	24	**12**	25
Sodium	mg/L	14	**11**	**13**	**8.9**	**12**
General						
Hardness	mg/L	137	**68**	**55**	**96**	**70**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-703 LLA (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/15/2017[D]		Q2 2017 05/22/2017[D]		Q3 2017 08/22/2017[T]		Q4 2017 11/28/2017[D]	
Field										
D.O.	ppm	-	**0.26**		**0.55**		**0.42**		**0.52**	
ORP	mV	-	**-271**		**-257**		**-242**		**-257**	
pH	SU	8.2-9.2	**8.4**		**8.4**		**8.3**		**8.2**	
Specific Conductance	uS/cm	-	**270**		**183**		**271**		**269**	
Temperature	C	-	**6.3**		**6.9**		**7.9**		**6.5**	
Turbidity	NTU	-	**6.1**		**4.9**		**2.3**		**14**	
Water Elevation	ft MSL	-	**1531.33**		**1533.27**		**1532.59**		**1534.61**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 300		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	2966	**560**		**580**		**676**		**2090**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	30	-		-		< 10		-	
Manganese	ug/L	101	**73**		**82**		**74**		**59**	
Mercury	ng/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	40+	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	84	**83**		**81**		**77**		**80**	
Alkalinity, Carbonate	mg/L	4.0	< 2.0		< 2.0		**3.1**		< 2.0	
Chloride	mg/L	124	**11**		**11**		**20**		**11**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.08	< 0.03		**0.04**		< 0.03		< 0.03	
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	44	**32**		**32**		**22**		**32**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	39	**26**		**24**		**26**		**25**	
Magnesium	mg/L	13	**11**		**10**		**10**		**10**	
Potassium	mg/L	10	**3.8**		**2.9**		**3.0**		**3.2**	
Sodium	mg/L	67	**8.3**		**6.3**		**6.5**		**6.6**	
General										
Hardness	mg/L	138	**108**		**111**		**96**		**120**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-703 QAL (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/20/2017[T]	Q2 2017 05/24/2017[D]	Q3 2017 08/22/2017[T]	Q4 2017 11/30/2017[D]
Field						
D.O.	ppm	-	**6.6**	**6.8**	**7.5**	**5.8**
ORP	mV	-	**104**	**164**	**122**	**382**
pH	SU	7.2-8.2	**6.3**	**6.1**	**6.1**	**6.1**
Specific Conductance	uS/cm	-	**260**	**127**	**121**	**195**
Temperature	C	-	**6.4**	**6.4**	**7.0**	**6.4**
Turbidity	NTU	-	**1.8**	**4.6**	**2.9**	**7.2**
Water Elevation	ft MSL	-	**1532.86**	**1535.25**	**1535.77**	**1534.51**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	255	< 200	< 200	< 200	< 200
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	< 10	-
Manganese	ug/L	105	< 50	< 50	< 50	< 50
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	40 (p)	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	100	**56**	**58**	**49**	**50**
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	40 (p)	< 10	< 10	< 10	< 10
Fluoride	mg/L	131	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.12 (p)	< 0.03	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.22	**1.3**	**1.3**	**1.9**	**1.9**
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	50	**14**	**20**	**29**	**31**
Sulfide	mg/L	0.30	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	40	**15**	**18**	**19**	**19**
Magnesium	mg/L	11	**6.0**	**7.4**	**8.2**	**8.8**
Potassium	mg/L	3.1	**1.4**	**1.7**	**1.5**	**1.6**
Sodium	mg/L	11	**2.3**	**2.3**	**2.2**	**2.2**
General						
Hardness	mg/L	136	**70**	**77**	**80**	**80**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-703 UFB (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/14/2017[D]	Q2 2017 05/22/2017[D]	Q3 2017 08/22/2017[T]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**1.5**	**1.4**	**0.82**	**0.55**
ORP	mV	-	**3.5**	**-165**	**-194**	**-231**
pH	SU	8.3-9.3	**8.4**	**7.9**	**8.0**	**8.0**
Specific Conductance	uS/cm	-	**156**	**187**	**280**	**282**
Temperature	C	-	**6.2**	**6.5**	**8.4**	**6.3**
Turbidity	NTU	-	**8.6**	**4.6**	**5.4**	**4.8**
Water Elevation	ft MSL	-	**1531.45**	**1533.05**	**1531.13**	**1532.43**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	2441	**640**	**610**	**1640**	**1820**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	< 10	-
Manganese	ug/L	194	**160**	**180**	**168**	**184**
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	14	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	127	**83**	**85**	**82**	**82**
Alkalinity, Carbonate	mg/L	28	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	40 (p)	< 10	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.47	< 0.03	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	53	**46**	**46**	**46**	**47**
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	53	**31**	**31**	**32**	**32**
Magnesium	mg/L	17	**11**	**11**	**11**	**11**
Potassium	mg/L	5.8	**2.4**	**2.4**	**2.3**	**2.3**
Sodium	mg/L	35	**2.9**	**2.9**	**3.0**	**3.0**
General						
Hardness	mg/L	193	**124**	**127**	**65**	**144**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-704 DBA (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/16/2017[D]	Q2 2017 05/23/2017[D]	Q3 2017 08/22/2017[T]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**0.51**	**0.68**	**1.2**	**0.25**
ORP	mV	-	**-324**	**-210**	**-229**	**-306**
pH	SU	8.6-9.6	**8.7**	**8.4**	**8.3**	**8.9**
Specific Conductance	uS/cm	-	**218**	**218**	**251**	**269**
Temperature	C	-	**8.1**	**7.9**	**11**	**8.9**
Turbidity	NTU	-	**3.5**	**10**	**3.0**	**3.4**
Water Elevation	ft MSL	-	**1531.08**	**1533.89**	**1532.60**	**1531.80**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1480	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	9645	**650**	**800**	**888**	**792**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	**15**	-
Manganese	ug/L	58	< 50	**54**	**53**	**52**
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	11	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	129	**130**	**140**	**130**	**119**
Alkalinity, Carbonate	mg/L	32	**2.1**	**2.0**	**2.0**	**4.0**
Chloride	mg/L	40 (p)	< 10	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.04	< 0.03	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	6.0	< 1.0	< 1.0	< 1.0	< 1.0
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	<0.20	< 0.20
Major Cations						
Calcium	mg/L	27	**20**	**22**	**21**	**18**
Magnesium	mg/L	14	**10**	**12**	**11**	**9.3**
Potassium	mg/L	4.0	**2.4**	**2.6**	**2.5**	**2.3**
Sodium	mg/L	14	**10**	**11**	**11**	**9.1**
General						
Hardness	mg/L	111	**100**	**113**	**116**	**110**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-704 LLA (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/15/2017[D]	Q2 2017 05/23/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/28/2017[D]
Field						
D.O.	ppm	-	**0.72**	**1.7**	**1.1**	**0.32**
ORP	mV	-	**-180**	**-140**	**-214**	**-289**
pH	SU	8.2-9.2	**8.0**	**8.0**	**8.1**	**8.1**
Specific Conductance	uS/cm	-	**296**	**266**	**291**	**305**
Temperature	C	-	**4.2**	**7.8**	**11**	**9.9**
Turbidity	NTU	-	**10**	**24**	**5.7**	**39**
Water Elevation	ft MSL	-	**1530.88**	**1533.63**	**1534.17**	**1534.69**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	4974	**870**	**730**	**538**	< 200
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	**15**	-
Manganese	ug/L	90	**84**	**83**	**64**	< 50
Mercury	ng/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	11	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	132	**150**	**140**	**135**	**87**
Alkalinity, Carbonate	mg/L	10	< 2.0	< 2.0	< 2.0	**5.0**
Chloride	mg/L	40 (p)	< 10	< 10	< 10	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.12 (p)	< 0.03	**0.03**	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	23	**9.1**	**7.8**	**5.3**	**2.2**
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	33	**31**	**28**	**27**	**13**
Magnesium	mg/L	17	**14**	**13**	**14**	**11**
Potassium	mg/L	5.0	**4.5**	**3.9**	**4.3**	**10**
Sodium	mg/L	5.0	**3.8**	**3.6**	**4.0**	**5.5**
General						
Hardness	mg/L	149	**140**	**145**	**134**	**88**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-704 QAL (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/16/2017[T]	Q2 2017 05/23/2017[D]	Q3 2017 08/22/2017[T]	Q4 2017 11/28/2017[T]
Field						
D.O.	ppm	-	**0.11**	**0.50**	**0.35**	**0.45**
ORP	mV	-	**55**	**-45**	**129**	**66**
pH	SU	5.5-6.5	**5.9**	**6.0**	**5.7**	**6.3**
Specific Conductance	uS/cm	-	**451**	**503**	**247**	**810**
Temperature	C	-	**7.3**	**7.1**	**10**	**9.2**
Turbidity	NTU	-	**2.0**	**4.1**	**1.9**	**1.8**
Water Elevation	ft MSL	-	**1530.39**	**1533.08**	**1533.94**	**1534.17**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	24	< 5.0	< 5.0	< 5.0	**17**
Barium	ug/L	400 (p)	-	-	<100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	16 (p)	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	37038	**6900**	**86000**	**506**	**103000**
Lead	ug/L	12 (p)	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	< 10	-
Manganese	ug/L	7914	**7000**	< 50	**1170**	**5600**
Mercury	ng/L	6.0	**18**	**12**	**2.4**	**47**
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	44 (p)	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	241	**160**	**250**	**97**	**283**
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	18	**16**	**16**	**17**	< 10
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.04	**0.10**	**0.23**	< 0.03	**1.7**
Nitrogen, Nitrate	mg/L	0.17	**0.47**	< 0.10	**0.81**	**0.13**
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	23	**32**	**9.2**	**40**	**15.6**
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	< 0.20	< 0.20
Calcium	mg/L	51	**38**	**42**	**33**	**37**
Magnesium	mg/L	9.0	**10**	**15**	**12**	**15**
Potassium	mg/L	3.1	**2.7**	**3.7**	**2.5**	**9.0**
Sodium	mg/L	27	**22**	**29**	**11**	**26**
General						
Hardness	mg/L	185	**160**	**192**	**136**	**150**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-704 UFB (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/16/2017[D]	Q2 2017 05/23/2017[D]	Q3 2017 08/22/2017[D]	Q4 2017 11/30/2017[D]
Field						
D.O.	ppm	-	**0.09**	**0.89**	**1.5**	**0.58**
ORP	mV	-	**-150**	**-172**	**-80**	**30**
pH	SU	6.4-7.4	**7.0**	**7.2**	**6.4**	**6.7**
Specific Conductance	uS/cm	-	**506**	**298**	**364**	**608**
Temperature	C	-	**7.6**	**7.7**	**8.8**	**8.5**
Turbidity	NTU	-	**149**	**44**	**24**	**35**
Water Elevation	ft MSL	-	**1530.75**	**1533.42**	**1534.64**	**1534.74**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	8.0 (p)	-	-	< 2.0	-
Arsenic	ug/L	20 (p)	< 5.0	< 5.0	< 5.0	< 5.0
Barium	ug/L	400 (p)	-	-	< 100	-
Beryllium	ug/L	4.0 (p)	-	-	< 1.0	-
Boron	ug/L	1200 (p)	-	-	< 300	-
Cadmium	ug/L	4.0 (p)	-	-	< 1.0	-
Chromium	ug/L	40 (p)	-	-	< 10	-
Cobalt	ug/L	80 (p)	-	-	< 20	-
Copper	ug/L	5.0	< 4.0	< 4.0	< 4.0	< 4.0
Iron	ug/L	23040	**14000**	**20000**	**24200**	**45100**
Lead	ug/L	4.0	< 3.0	< 3.0	< 3.0	< 3.0
Lithium	ug/L	40 (p)	-	-	< 10	-
Manganese	ug/L	618	**1000**	**1300**	**693**	**873**
Mercury	ng/L	2.0	< 1.0	< 1.0	< 1.0	**1.3**
Molybdenum	ug/L	200 (p)	-	-	< 50	-
Nickel	ug/L	80 (p)	< 20	< 20	< 20	< 20
Selenium	ug/L	20 (p)	-	-	< 5.0	-
Silver	ug/L	0.80 (p)	-	-	< 0.20	-
Thallium	ug/L	8.0 (p)	-	-	< 2.0	-
Vanadium	ug/L	16 (p)	-	-	< 4.0	-
Zinc	ug/L	15	< 10	< 10	< 10	< 10
Major Anions						
Alkalinity, Bicarbonate	mg/L	181	**170**	**170**	**149**	**188**
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	18	**15**	**12**	**23**	**23**
Fluoride	mg/L	4.0 (p)	< 1.0	< 1.0	< 1.0	< 1.0
Nitrogen, Ammonia	mg/L	0.27	**0.03**	< 0.03	< 0.03	< 0.03
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10	< 0.10	**0.33**	< 0.10
Nitrogen, Nitrite	mg/L	0.14	< 0.10	< 0.10	< 0.10	< 0.10
Sulfate	mg/L	38	**31**	**12**	**38**	**29**
Sulfide	mg/L	0.80 (p)	< 0.20	< 0.20	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	38	**50**	**47**	**44**	**57**
Magnesium	mg/L	7.0	**9.8**	**10**	**11**	**13**
Potassium	mg/L	4.0	**3.8**	**3.9**	**2.8**	**3.3**
Sodium	mg/L	65	**6.4**	**6.2**	**8.5**	**11**
General						
Hardness	mg/L	106	**186**	**180**	**170**	**192**

2017
Mine Permit Groundwater Quality Monitoring Data
MW-705 QAL (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/20/2017^T		Q2 2017 05/23/2017^T		Q3 2017 08/23/2017^T		Q4 2017 11/30/2017^T	
Field										
D.O.	ppm	-	**0.48**		**2.0**		**0.49**		**0.41**	
ORP	mV	-	**-54**		**140**		**31**		**158**	
pH	SU	5.6-6.6	**6.3**		**5.7**		**6.0**		**6.1**	
Specific Conductance	uS/cm	-	**345**		**125**		**181**		**223**	
Temperature	C	-	**6.3**		**7.0**		**12**		**8.5**	
Turbidity	NTU	-	**1.6**		**2.8**		**1.9**		**2.1**	
Water Elevation	ft MSL	-	**1533.45**		**1536.89**		**1534.64**		**1535.31**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	14081	**10000**		**1900**		**6000**		**6670**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	1674	< 1200		**280**		**630**		**601**	
Mercury	ng/L	1.0	< 1.0		< 1.0		**1.5**		**1.1**	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	174	< 10		< 10		<10		<10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	94	**78**		**35**		**51**		**47**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	66	**25**		**29**		**38**		**27**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.10	**0.08**		**0.06**		**0.11**		**0.11**	
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	6.0	**11**		**13**		**6.0**		**5.9**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	27	**16**		**13**		**15**		**14**	
Magnesium	mg/L	13	**7.1**		**5.6**		**6.4**		**6.1**	
Potassium	mg/L	3.0	**2.5**		**2.1**		**2.5**		**2.4**	
Sodium	mg/L	17	**13**		**11**		**14**		**14**	
General										
Hardness	mg/L	115	**74**		**59**		**68**		**60**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-705 UFB (Monitoring)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017[D]		Q2 2017 05/23/2017[D]		Q3 2017 08/22/2017[D]		Q4 2017 11/29/2017[D]	
Field										
D.O.	ppm	-	**1.0**		**0.43**		**0.45**		**0.45**	
ORP	mV	-	**-106**		**-111**		**-90**		**26**	
pH	SU	6.7-7.7	**6.9**		**6.9**		**6.8**		**7.0**	
Specific Conductance	uS/cm	-	**38**		**303**		**212**		**312**	
Temperature	C	-	**7.3**		**7.2**		**8.4**		**8.7**	
Turbidity	NTU	-	**25**		**6.7**		**6.0**		**21**	
Water Elevation	ft MSL	-	**1533.16**		**1536.87**		**1534.61**	`	**1535.41**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	11214	**10000**		**10000**		**9150**		**8350**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		**11**		-	
Manganese	ug/L	866	**900**		**910**		**894**		**873**	
Mercury	ng/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	17	< 10		< 10		**12**		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	103	**84**		**88**		**86**		**84**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	40 (p)	**25**		**28**		**31**		**32**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.12 (p)	< 0.03		< 0.03		< 0.03		< 0.03	
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		**0.11**	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	15	**2.7**		**3.4**		**3.9**		**5.6**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	26	**23**		**23**		**26**		**25**	
Magnesium	mg/L	12	**12**		**12**		**14**		**12**	
Potassium	mg/L	4.0	**4.1**		**3.3**		**3.6**		**3.4**	
Sodium	mg/L	3.0	**3.1**		**2.9**		**3.1**		**2.8**	
General										
Hardness	mg/L	111	**114**		**121**		**134**		**120**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-706 QAL (Facility)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/20/2017[D]		Q2 2017 05/26/2017[T]		Q3 2017 08/23/2017[T]		Q4 2017 12/04/2017[D]	
Field										
D.O.	ppm	-	**0.30**		**0.71**		**0.31**		**0.43**	
ORP	mV	-	**39**		**56**		**62**		**199**	
pH	SU	6.2-7.2	**6.0**		**5.9**		**5.8**		**5.8**	
Specific Conductance	uS/cm	-	**1021**		**842**		**714**		**1020**	
Temperature	C	-	**7.8**		**10**		**9.4**		**8.4**	
Turbidity	NTU	-	**20**		**2.0**		**1.7**		**3.1**	
Water Elevation	ft MSL	-	**1558.91**		**1562.28**		**1561.16**		**1561.17**	
Metals										
Aluminum	ug/L	200 (p)	-		-		**80**		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	16	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		**27**		-	
Copper	ug/L	16 (p)	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	10846	**4700**		**3900**		**3960**		**3500**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		**11**		-	
Manganese	ug/L	27225	**18000**		**17000**		**16700**		**14800**	
Mercury	ng/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	**25**		**23**		**23**		**23**	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	55	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	153	**78**		**71**		**72**		**71**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	105	**150**		**150**		**143**		**139**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	1.4	**0.45**		**0.48**		**0.48**		**0.48**	
Nitrogen, Nitrate	mg/L	0.40 (p)	**0.44**		< 0.10		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	479	**210**		**210**		**199**		**196**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 1.0		< 0.20	
Major Cations										
Calcium	mg/L	183	**88**		**86**		**82**		**79**	
Magnesium	mg/L	56	**35**		**35**		**33**		**31**	
Potassium	mg/L	6.0	**4.7**		**5.2**		**4.8**		**4.5**	
Sodium	mg/L	234	**37**		**36**		**40**		**36**	
General										
Hardness	mg/L	609	**80**		**6.0**		**372**		**6.0**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-707 QAL (Facility)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017[T]		Q2 2017 05/25/2017[T]		Q3 2017 08/22/2017[T]		Q4 2017 12/04/2017[T]	
Field										
D.O.	ppm	-	**0.50**		**0.56**		**0.43**		**0.42**	
ORP	mV	-	**-150**		**-117**		**-133**		**-1.4**	
pH	SU	6.3-7.3	**7.1**		**6.8**		**7.0**		**7.1**	
Specific Conductance	uS/cm	-	**402**		**252**		**236**		**339**	
Temperature	C	-	**7.3**		**7.7**		**8.7**		**8.9**	
Turbidity	NTU	-	**1.3**		**1.8**		**1.4**		**1.9**	
Water Elevation	ft MSL	-	**1582.30**		**1583.80**		**1581.34**		**1582.67**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	20 (p)	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	16 (p)	< 4.0		**4.8**		< 4.0		< 4.0	
Iron	ug/L	7493	**5200**		**4800**		**5110**		**4580**	
Lead	ug/L	12 (p)	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	1189	**1000**		**910**		**885**		**893**	
Mercury	ng/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	< 20		< 20		< 20		< 20	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	19	< 10		< 10		< 10		< 10	
Major Anions										
Alkalinity, Bicarbonate	mg/L	150	**160**		**170**		**160**		**157**	
Alkalinity, Carbonate	mg/L	8.0 (p)	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	40 (p)	< 10		< 10		< 10		< 10	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.34	**0.26**		**0.30**		**0.29**		**0.23**	
Nitrogen, Nitrate	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.40 (p)	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	8.0	**5.3**		**5.4**		**6.9**		**6.8**	
Sulfide	mg/L	0.80 (p)	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	51	**42**		**40**		**44**		**42**	
Magnesium	mg/L	15	**12**		**12**		**13**		**12**	
Potassium	mg/L	3.0	**2.6**		**2.4**		**2.5**		**2.4**	
Sodium	mg/L	4.0	**2.8**		**3.1**		**3.0**		**3.0**	
General										
Hardness	mg/L	149	**154**		**160**		**160**		**158**	

2017
Mine Permit Groundwater Quality Monitoring Data
MW-9R (Facility)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017[T]		Q2 2017 05/25/2017[D]		Q3 2017 08/22/2017[D]		Q4 2017 12/04/2017[D]	
Field										
D.O.	ppm	-	**4.0**		**1.7**		**1.9**		**0.52**	
ORP	mV	-	**199**		**129**		**106**		**220**	
pH	SU	5.4-6.4	**5.9**		**6.0**		**6.1**		**6.1**	
Specific Conductance	uS/cm	-	**736**		**215**		**330**		**451**	
Temperature	C	-	**9.0**		**9.4**		**13**		**11**	
Turbidity	NTU	-	**1.8**		**384**		**4.2**		**363**	
Water Elevation	ft MSL	-	**1596.87**		**1597.03**		**1592.03**		**1595.16**	
Metals										
Aluminum	ug/L	200 (p)	-		-		< 50		-	
Antimony	ug/L	8.0 (p)	-		-		< 2.0		-	
Arsenic	ug/L	25	< 5.0		< 5.0		< 5.0		< 5.0	
Barium	ug/L	400 (p)	-		-		< 100		-	
Beryllium	ug/L	4.0 (p)	-		-		< 1.0		-	
Boron	ug/L	1200 (p)	-		-		< 300		-	
Cadmium	ug/L	4.0 (p)	-		-		< 1.0		-	
Chromium	ug/L	40 (p)	-		-		< 10		-	
Cobalt	ug/L	80 (p)	-		-		< 20		-	
Copper	ug/L	5.0	< 4.0		< 4.0		< 4.0		< 4.0	
Iron	ug/L	25558	< 200		< 200		< 200		**1840**	
Lead	ug/L	0.04	< 3.0		< 3.0		< 3.0		< 3.0	
Lithium	ug/L	40 (p)	-		-		< 10		-	
Manganese	ug/L	1694	**63**		< 50		**255**		**580**	
Mercury	ng/L	1.0	< 1.0		< 1.0		**1.3**		< 1.0	
Molybdenum	ug/L	200 (p)	-		-		< 50		-	
Nickel	ug/L	80 (p)	**28**		**33**		**22**		**58**	
Selenium	ug/L	20 (p)	-		-		< 5.0		-	
Silver	ug/L	0.80 (p)	-		-		< 0.20		-	
Thallium	ug/L	8.0 (p)	-		-		< 2.0		-	
Vanadium	ug/L	16 (p)	-		-		< 4.0		-	
Zinc	ug/L	25	**16**		**40**		**21**		**25**	
Major Anions										
Alkalinity, Bicarbonate	mg/L	137	**30**		**23**		**63**		**41**	
Alkalinity, Carbonate	mg/L	2.0	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	711	**77**		**17**		< 10		**11**	
Fluoride	mg/L	4.0 (p)	< 1.0		< 1.0		< 1.0		< 1.0	
Nitrogen, Ammonia	mg/L	0.36	< 0.03		< 0.03		< 0.03		**0.08**	
Nitrogen, Nitrate	mg/L	1.0	**2.7**		**0.53**		**0.36**		< 0.10	
Nitrogen, Nitrite	mg/L	0.07	< 0.10		< 0.10		< 0.10		< 0.10	
Sulfate	mg/L	343	**180**		**65**		**120**		**141**	
Sulfide	mg/L	1.0	< 0.20		< 0.20		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	123	**78**		**23**		**39**		**45**	
Magnesium	mg/L	48	**30**		**8.8**		**16**		**16**	
Potassium	mg/L	8.0	**3.6**		**2.0**		**2.8**		**2.6**	
Sodium	mg/L	289	**15**		**7.2**		**9.7**		**7.7**	
General										
Hardness	mg/L	510	**300**		**103**		**174**		**182**	

2017

Mine Permit Groundwater Quality Monitoring Data Abbreviations & Data Qualifiers

Humboldt Mill

Notes:
Benchmarks are calculated based on guidance from Eagles Mine's Development of Site Specific Benchmarks for Mine Permit Water Quality Monitoring.
Results in **bold** text indicate that the parameter was detected at a level greater than the laboratory reporting limit.
Highlighted Cell = Value is equal to or above site-specific benchmark. An exceedance occurs if there are 2 consecutive sampling events with a value equal to or greater than the benchmark at a compliance monitoring location.
(p) = Due to less than two detections in baseline dataset, benchmark defaulted to four times the reporting limit.
--Denotes no benchmark required or parameter was not required to be collected during the sampling quarter.
NM = Not measured during the sampling event.
^{T} = Sample was not filtered and all values are total concentrations.
^{D} = Sample for metals and major cation parameters was filtered and values are dissolved concentrations.

Appendix H

Humboldt Mill

Groundwater Trend Analysis Summary

2017
Groundwater Trend Analysis Summary
Humboldt Mill

Location	Classification	Parameter	Unit	Count (n)	Number of Non-Detects	Mean	UCL	Median	Standard Deviation	Coefficient of Variation	Skewness	Minimum	Maximum	Man-Kendall S	Sen Slope	Positive or Negative Trend (Minimum 95% Confidence)
HW-1L	Monitoring	Alkalinity Bicarbonate	mg/L	14	12	75.54	83.47	81.00	16.76	0.22	-3.26	20.00	84.00	56	0.3833	Positive
HW-1L	Monitoring	Ammonia	mg/L	14	13	22.43	64.80	25.00	15.93	0.71	0.85	0.03	64.00	-41	0.0000	Negative
HW-1L	Monitoring	Calcium	mg/L	14	0	23.11	25.78	24.50	5.64	0.24	-2.86	5.00	27.90	49	0.5182	Positive
HW-1L	Monitoring	Hardness	mg/L	14	0	104.40	116.5	111.00	25.66	0.25	-2.9	22.00	128.00	61	2.000	Positive
HW-1L	Monitoring	Magnesium	mg/L	14	0	10.04	11.13	11.00	2.30	0.23	-3.252	2.40	11.20	51	0.100	Positive
HW-1L	Monitoring	Potassium	mg/L	14	0	2.55	3.406	1.90	1.81	0.71	2.669	1.60	8.00	-37	-0.0400	Negative
HW-1L	Monitoring	Sulfate	mg/L	14	0	19.81	27.5	22.00	6.60	0.33	-1.91	1.60	25.80	81	1.000	Positive
HW-1U LLA	Monitoring	Alkalinity Carbonate	mg/L	12	4	14.44	39.18	3.55	19.66	1.36	1.42	2.00	56.60	30	1.433	Positive
HW-1U LLA	Monitoring	Chloride	mg/L	12	0	33.15	40.41	26.00	14.00	0.42	1.354	22.00	65.80	40	2.611	Positive
HW-1U LLA	Monitoring	Iron	µg/L	12	8	6,275.00	44893	200.00	13,445.00	2.14	2.037	200.00	35,000.00	27	0.000	Positive
HW-1U LLA	Monitoring	Potassium	mg/L	12	0	4.91	9.367	3.75	5.98	1.22	2.896	0.57	23.00	-45	-0.639	Negative
HW-1U LLA	Monitoring	Sodium	mg/L	12	0	64.08	82.27	47.00	35.10	0.55	0.726	31.00	130.00	51	6.958	Positive
HW-1U LLA	Monitoring	Sulfate	mg/L	12	0	124.60	295	54.50	135.40	1.09	1.82	41.00	434.00	52	15.202	Positive
HW-1U LLA	Monitoring	Sulfide	mg/L	12	11	1.97	10.96	0.20	3.13	1.59	1.883	0.20	10.00	34	0.327	Positive
HW-1U UFB	Monitoring	Alkalinity Bicarbonate	mg/L	17	0	88.78	95.57	91.00	16.02	0.18	0.12	62.10	120.00	-63	-2.25	Negative
HW-1U UFB	Monitoring	Arsenic	µg/L	18	15	5.40	5.91	5.00	1.24	0.23	3.36	5.00	9.90	-36	0.0000	Negative
HW-1U UFB	Monitoring	Calcium	mg/L	18	0	18.34	21.62	15.90	8.00	0.44	1.53	9.10	39.00	-44	-0.6000	Negative
HW-1U UFB	Monitoring	Chloride	mg/L	17	7	33.76	65.52	22.00	30.04	0.89	1.116	10.00	98.00	-96	-3.240	Negative
HW-1U UFB	Monitoring	Hardness	mg/L	17	0	79.28	94.26	70.00	35.37	0.45	1.282	45.00	165.00	-47	-3.780	Negative
HW-1U UFB	Monitoring	Magnesium	mg/L	18	0	8.16	9.881	5.90	4.19	0.51	0.695	3.80	16.00	-77	-0.625	Negative
HW-1U UFB	Monitoring	Potassium	mg/L	18	0	9.63	16.62	6.05	6.80	0.71	0.49	2.30	21.00	-115	-1.083	Negative
HW-1U UFB	Monitoring	Sodium	mg/L	18	0	35.22	44.16	33.50	21.81	0.62	0.419	6.70	77.00	-109	-4.000	Negative
HW-1U UFB	Monitoring	Sulfate	mg/L	17	2	26.3	46.45	18.0	23.8	0.91	0.716	1.0	73.0	-118	-4.204	Negative
HW-1U UFB	Monitoring	Sulfide	mg/L	17	12	0.65	1.69	0.20	0.99	1.53	2.886	0.20	4.00	-47	0.0000	Negative
HW-2	Monitoring	Calcium	mg/L	19	0	52.66	56.37	55.00	9.32	0.18	-0.87	34.00	65.00	63	1.0000	Positive
HW-2	Monitoring	Chloride	mg/L	18	0	20.39	23.33	19.00	7.17	0.35	0.271	12.00	33.70	123	1.192	Positive
HW-2	Monitoring	Hardness	mg/L	18	0	240.80	252.3	248.50	28.03	0.12	-0.564	190.00	284.00	75	3.286	Positive
HW-2	Monitoring	Manganese	µg/L	19	3	187.20	216.9	170.00	74.57	0.40	0.386	77.00	320.00	61	5.714	Positive
HW-2	Monitoring	Sodium	mg/L	19	0	18.07	20.29	15.00	5.58	0.31	0.887	13.00	29.50	111	0.813	Positive
HW-2	Monitoring	Sulfate	mg/L	18	0	132.50	141.3	125.00	21.42	0.16	0.206	97.00	170.00	76	2.857	Positive
HW-8U	Monitoring	Alkalinity Bicarbonate	mg/L	18	0	156.30	168.20	148.50	28.92	0.19	1.09	127.00	220.00	-80	-4.000	Negative
HW-8U	Monitoring	Arsenic	µg/L	19	11	6.07	6.70	5.00	1.59	0.26	1.31	5.00	10.00	83	0.0867	Positive
HW-8U	Monitoring	Chloride	mg/L	18	12	11.17	12.05	10.00	2.15	0.19	1.874	10.00	17.40	72	0.0000	Positive
HW-8U	Monitoring	Iron	µg/L	19	0	13,037	14974	12,000	4,868	0.37	0.776	7,000	23,000	-144	-800.000	Negative
HW-8U	Monitoring	Magnesium	mg/L	19	0	13.51	14.53	13.00	2.58	0.19	1.293	11.00	19.00	-104	-0.300	Negative
HW-8U	Monitoring	Sulfate	mg/L	18	4	5.44	6.856	5.05	3.44	0.63	0.109	1.00	11.60	139	0.640	Positive
HYG-1	Monitoring	Alkalinity, Bicarbonate	mg/L	16	0	220.80	253.30	215.00	74.07	0.34	0.566	140.00	370.00	74	10.000	Positive
HYG-1	Monitoring	Calcium	mg/L	16	0	48.64	52.14	48.50	7.99	0.16	0.23	35.00	61.30	38	0.775	Positive
HYG-1	Monitoring	Manganese	mg/L	16	3	264.80	341.4	230.00	174.70	0.66	0.985	66.00	688.00	85	30.000	Positive
HYG-1	Monitoring	Mercury	ng/L	16	0	15.83	20.39	16.85	10.41	0.66	0.409	4.23	36.70	68	1.324	Positive
HYG-1	Monitoring	Nitrate	µg/L	16	13	95.64	244.5	100.00	59.85	0.63	0.249	0.10	240.00	-52	-5.035	Negative
HYG-1	Monitoring	Potassium	mg/L	16	0	8.97	9.812	8.25	1.92	0.21	0.777	6.60	13.00	62	0.284	Positive
HYG-1	Monitoring	Sodium	mg/L	16	0	36.81	46.14	43.50	21.29	0.58	0.177	12.00	78.00	87	3.558	Positive
KMW-5R	COSA	Alkalinity Bicarbonate	mg/L	16	0	363.60	373.00	360.00	21.47	0.06	-0.69	310.00	400.00	71	3.333	Positive
KMW-5R	COSA	Chloride	mg/L	16	3	78.31	102.3	83.00	54.68	0.70	0.0434	10.00	160.00	-55	-7.336	Negative
KMW-5R	COSA	Lithium	µg/L	8	1	16.64	21.1	15.50	6.66	0.40	1.653	10.00	31.10	23	1.583	Positive
KMW-5R	COSA	Sodium	mg/L	17	0	4.66	5.43	3.90	1.53	0.33	0.845	3.20	7.40	99	0.235	Positive
KMW-5R	COSA	Sulfate	mg/L	16	0	96.71	106.1	96.70	21.47	0.22	0.164	67.00	130.00	80	3.944	Positive
MW-701 QAL	Leachate	Alkalinity Bicarbonate	mg/L	17	0	55.04	70.05	41.00	31.39	0.57	2.01	29.00	150.00	-87	-3.683	Negative
MW-701 QAL	Leachate	Ammonia	mg/L	17	11	65.48	298.50	25.00	96.57	1.48	1.83	0.03	300.00	-86	-4.995	Negative
MW-701 QAL	Leachate	Calcium	mg/L	17	0	19.02	31.72	13.00	12.01	0.63	1.08	8.50	44.00	-111	-1.926	Negative

2017
Groundwater Trend Analysis Summary
Humboldt Mill

Location	Classification	Parameter	Unit	Count (n)	Number of Non-Detects	Mean	UCL	Median	Standard Deviation	Coefficient of Variation	Skewness	Minimum	Maximum	Man-Kendall S	Sen Slope	Positive or Negative Trend (Minimum 95% Confidence)
MW-701 QAL	Leachate	Chloride	mg/L	17	11	11.94	13.39	10.00	3.42	0.29	1.653	10.00	21.00	-42	0.000	Negative
MW-701 QAL	Leachate	Hardness	mg/L	17	0	86.76	146.1	54.00	56.14	0.65	1.292	36.00	228.00	-105	-8.730	Negative
MW-701 QAL	Leachate	Magnesium	mg/L	17	0	8.16	13.69	5.20	5.24	0.64	1.387	3.90	21.00	-108	-0.715	Negative
MW-701 QAL	Leachate	Manganese	μg/L	17	10	1,096	4631	50	1,465	1.34	1.14	50	4,100	-100	-228.462	Negative
MW-701 QAL	Leachate	Mercury	ng/L	17	8	2.06	4.362	1.20	2.18	1.06	2.692	1.00	9.04	-80	-0.094	Negative
MW-701 QAL	Leachate	Nitrate	mg/L	17	0	724.20	2246	560.00	630.40	0.87	1.507	0.14	2,400.00	-68	-56.130	Negative
MW-701 QAL	Leachate	Potassium	mg/L	17	0	4.71	5.608	4.00	2.12	0.45	0.511	2.40	8.30	-124	-0.400	Negative
MW-701 QAL	Leachate	Sodium	mg/L	17	0	7.78	8.602	7.00	1.95	0.25	0.597	5.10	11.00	-100	-0.314	Negative
MW-701 QAL	Leachate	Sulfate	mg/L	17	0	38.10	51.17	27.00	23.77	0.62	1.067	14.20	91.00	-121	-4.000	Negative
MW-701 UFB	Leachate	Ammonia	mg/L	18	14	118.80	893.30	25.00	330.30	2.78	3.87	0.03	1,400.00	-61	-1.784	Negative
MW-701 UFB	Leachate	Barium	mg/L	9	3	197.80	447.80	110.00	172.10	0.87	1.58	100.00	500.00	23	6.905	Positive
MW-701 UFB	Leachate	Chloride	mg/L	18	15	12.61	15.56	10.00	7.20	0.57	3.113	10.00	38.00	-48	0.000	Negative
MW-701 UFB	Leachate	Manganese	μg/L	19	2	2,493	3498	2,500	1,005	0.40	1.646	180	5,900	-50	-27.273	Negative
MW-701 UFB	Leachate	Potassium	mg/L	19	0	4.26	5.133	3.20	2.19	0.51	2.056	2.70	11.00	-117	-0.210	Negative
MW-701 UFB	Leachate	Sodium	mg/L	19	0	10.66	22.22	5.00	11.55	1.08	2.348	4.30	48.00	-126	-0.525	Negative
MW-701 UFB	Leachate	Sulfate	mg/L	18	0	22.87	29.68	21.00	14.66	0.64	2.317	6.80	71.00	-45	-1.000	Negative
MW-701 UFB	Leachate	Sulfide	mg/L	18	14	0.31	0.643	0.20	0.32	1.04	3.406	0.20	1.50	-48	0.000	Negative
MW-702 QAL	Leachate	Ammonia	mg/L	17	14	21.83	48.13	25.00	10.90	0.50	-1.41	0.03	38.00	-53	0.000	Negative
MW-702 QAL	Leachate	Calcium	mg/L	18	0	48.99	56.15	46.00	17.47	0.36	1.19	26.20	93.00	-121	-2.733	Negative
MW-702 QAL	Leachate	Hardness	mg/L	17	0	163.60	182.1	167.00	43.83	0.27	0.767	100.00	270.00	-121	-7.854	Negative
MW-702 QAL	Leachate	Magnesium	mg/L	18	0	9.12	10.13	9.05	2.48	0.27	0.397	5.30	14.00	-37	-0.225	Negative
MW-702 QAL	Leachate	Manganese	μg/L	18	7	190.40	291.7	113.50	173.80	0.91	1.23	50.00	580.00	-80	-22.222	Negative
MW-702 QAL	Leachate	Potassium	mg/L	18	0	10.42	14.00	7.05	7.53	0.72	1.609	4.70	28.00	-75	-0.500	Negative
MW-702 QAL	Leachate	Sodium	mg/L	18	0	33.79	39.1	35.45	12.94	0.38	0.393	17.00	60.00	55	1.250	Positive
MW-702 QAL	Leachate	Sulfate	mg/L	17	0	96.58	104.3	96.00	18.31	0.19	0.31	61.50	130.00	-105	-3.333	Negative
MW-702 UFB	Leachate	Manganese	μg/L	18	1	87.57	94.3	87.50	16.40	0.19	0.446	50.00	130.00	-56	-1.007	Negative
MW-702 UFB	Leachate	Potassium	mg/L	18	0	3.94	5.389	3.15	3.52	0.89	4.185	2.60	18.00	-49	-0.040	Negative
MW-703 DBA	Compliance	Alkalinity Bicarbonate	mg/L	18	0	33.28	63.06	25.00	26.75	0.80	0.45	0.03	100.00	-50	3.345	Negative
MW-703 DBA	Compliance	Calcium	mg/L	19	0	14.83	17.72	14.00	7.25	0.49	0.114	4.10	25.00	-64	-0.719	Negative
MW-703 DBA	Compliance	Chloride	mg/L	18	0	18.04	18.5	18.00	1.12	0.06	-0.373	16.00	20.00	-102	-0.167	Negative
MW-703 DBA	Compliance	Hardness	mg/L	18	0	82.00	94.69	79.50	30.94	0.38	-0.0187	29.00	130.00	-62	-3.400	Negative
MW-703 DBA	Compliance	Lithium	μg/L	9	3	13.06	14.92	12.00	3.01	0.23	0.187	10.00	17.00	20	0.958	Positive
MW-703 DBA	Compliance	Magnesium	mg/L	19	0	10.86	12.32	10.00	3.67	0.34	-0.2	4.20	16.00	-88	-0.494	Negative
MW-703 DBA	Compliance	Sodium	mg/L	19	0	12.30	13.05	13.00	1.88	0.15	-0.838	8.20	15.00	-52	-0.125	Negative
MW-703 DBA	Compliance	Sulfate	mg/L	18	1	27.43	37.71	18.00	25.08	0.92	0.94	1.00	80.00	-44	-2.967	Negative
MW-703 DBA	Compliance	Sulfide	mg/L	18	8	0.41	0.74	0.32	0.32	0.77	-1.099	0.20	1.40	36	0.006	Positive
MW-703 LLA	Compliance	Alkalinity Bicarbonate	mg/L	17	0	79.41	82.10	79.80	6.35	0.08	-0.59	66.00	87.00	46	0.750	Positive
MW-703 LLA	Compliance	Chloride	mg/L	17	0	38.22	69.06	22.00	29.18	0.76	0.692	11.00	100.00	-113	-5.545	Negative
MW-703 LLA	Compliance	Iron	mg/L	18	0	903.10	1175	673.00	585.00	0.65	2.002	280.00	2,600.00	-36	-22.000	Negative
MW-703 LLA	Compliance	Potassium	mg/L	18	0	4.74	5.357	4.40	1.51	0.32	0.461	2.90	7.60	-121	-0.250	Negative
MW-703 LLA	Compliance	Sodium	mg/L	18	0	20.94	36.87	16.50	15.51	0.74	0.647	6.30	53.00	-124	-2.470	Negative
MW-703 QAL	Compliance	Alkalinity Bicarbonate	mg/L	17	0	65.61	71.27	60.00	13.36	0.20	0.73	49.20	91.00	-109	-2.450	Negative
MW-703 QAL	Compliance	Calcium	mg/L	18	0	21.03	23.53	18.90	6.10	0.29	1.052	13.00	33.00	-99	-0.831	Negative
MW-703 QAL	Compliance	Hardness	mg/L	17	0	83.71	90.44	80.00	15.91	0.19	1.169	64.00	119.00	-71	-2.333	Negative
MW-703 QAL	Compliance	Magnesium	mg/L	18	0	7.73	8.214	7.40	1.19	0.15	0.273	5.90	9.70	-47	-0.140	Negative
MW-703 QAL	Compliance	Manganese	μg/L	18	11	60.50	66.94	50.00	15.72	0.26	1.115	50.00	91.00	-70	-0.875	Negative
MW-703 QAL	Compliance	Potassium	mg/L	18	0	1.86	2.035	1.80	0.42	0.23	0.461	1.30	2.70	-105	-0.067	Negative
MW-703 QAL	Compliance	Sodium	mg/L	18	0	4.14	4.968	3.45	2.01	0.49	0.647	2.20	7.80	-139	-0.317	Negative
MW-703 QAL	Compliance	Sulfate	mg/L	17	0	24.07	27.56	22.00	8.24	0.34	0.518	12.00	40.00	-50	-1.000	Negative
MW-703 UFB	Compliance	Ammonia	mg/L	17	14	67.12	390.30	25.00	133.90	2.00	2.64	0.03	460.00	-42	0.000	Negative
MW-703 UFB	Compliance	Alkalinity Bicarbonate	mg/L	17	0	78.63	85.58	82.40	16.40	0.21	-3.89	16.00	91.00	45	0.329	Positive

2017
Groundwater Trend Analysis Summary
Humboldt Mill

Location	Classification	Parameter	Unit	Count (n)	Number of Non-Detects	Mean	UCL	Median	Standard Deviation	Coefficient of Variation	Skewness	Minimum	Maximum	Man-Kendall S	Sen Slope	Positive or Negative Trend (Minimum 95% Confidence)
MW-703 UFB	Compliance	Magnesium	mg/L	18	0	10.05	10.83	10.55	1.91	0.19	-3.697	2.70	11.00	37	0.040	Positive
MW-703 UFB	Compliance	Manganese	µg/L	18	3	156.70	176.4	160.00	48.18	0.31	-0.0515	50.00	250.00	116	5.750	Positive
MW-703 UFB	Compliance	Potassium	mg/L	18	0	2.76	3.055	2.50	0.73	0.27	2.798	2.20	5.30	-119	-0.056	Negative
MW-703 UFB	Compliance	Sodium	mg/L	18	0	4.72	10.99	3.00	6.10	1.29	4.147	2.70	29.00	-68	-0.080	Negative
MW-703 UFB	Compliance	Sulfate	mg/L	17	0	44.93	45.86	45.00	2.20	0.05	0.959	41.00	51.00	63	0.200	Positive
MW-704 DBA	Compliance	Alkalinity Bicarbonate	mg/L	17	0	110.10	120.30	120.00	24.18	0.22	-1.70	39.00	140.00	93	3.345	Positive
MW-704 DBA	Compliance	Alkalinity Carbonate	mg/L	17	1	8.04	11.02	7.70	7.03	0.87	1.68	2.00	29.00	-76	-0.864	Negative
MW-704 DBA	Compliance	Hardness	mg/L	17	0	96.76	103.7	100.00	16.45	0.17	-1.766	48.00	116.00	103	2.196	Positive
MW-704 DBA	Compliance	Iron	µg/L	18	3	852.20	2165	625.00	1,277.00	1.50	4.046	200.00	5,900.00	73	34.000	Positive
MW-704 DBA	Compliance	Magnesium	mg/L	18	0	10.34	10.96	10.50	1.51	0.15	-1.455	5.90	12.00	36	0.071	Positive
MW-704 DBA	Compliance	Potassium	mg/L	18	0	2.74	2.886	2.70	0.31	0.11	1.182	2.30	3.50	-50	-0.025	Negative
MW-704 DBA	Compliance	Sulfate	mg/L	17	9	2.01	3.466	1.00	1.38	0.69	0.999	1.00	4.60	-94	-0.200	Negative
MW-704 LLA	Compliance	Lithium	µg/L	10	3	14.75	17.9	13.00	5.43	0.37	1.267	10.00	26.00	21	1.125	Positive
MW-704 LLA	Compliance	Magnesium	mg/L	20	0	12.29	12.98	12.00	1.80	0.15	0.0141	9.20	15.00	-55	-0.138	Negative
MW-704 LLA	Compliance	Potassium	mg/L	20	0	6.43	7.452	5.10	2.64	0.41	0.557	3.80	11.00	69	0.267	Positive
MW-704 LLA	Compliance	Sulfate	mg/L	19	0	10.15	12.42	9.10	5.71	0.56	0.592	2.20	22.00	-124	-1.000	Negative
MW-704 QAL	Compliance	Calcium	mg/L	19	0	30.97	34.20	32.00	8.11	0.26	-0.281	18.00	42.00	63	0.900	Positive
MW-704 QAL	Compliance	Hardness	mg/L	18	0	126.20	139.5	124.50	32.49	0.26	0.0368	71.00	192.00	68	4.182	Positive
MW-704 QAL	Compliance	Magnesium	mg/L	19	0	8.89	10.02	8.00	2.85	0.32	0.917	5.70	15.00	127	0.413	Positive
MW-704 QAL	Compliance	Mercury	ng/L	19	6	7.51	13.03	4.45	10.87	1.45	2.955	1.00	47.00	70	0.541	Positive
MW-704 QAL	Compliance	Potassium	mg/L	19	0	2.74	3.388	2.50	1.62	0.59	3.462	1.50	9.00	78	0.083	Positive
MW-704 QAL	Compliance	Sodium	mg/L	19	0	14.23	17.77	13.00	8.90	0.63	0.0718	2.40	29.00	66	0.743	Positive
MW-704 QAL	Compliance	Sulfate	mg/L	18	1	19.18	27.09	15.00	12.74	0.66	1.094	1.00	49.00	62	1.214	Positive
MW-704 UFB	Compliance	Ammonia	mg/L	18	5	48.89	180.50	29.50	56.11	1.15	2.00	0.03	200.00	-93	-4.163	Negative
MW-704 UFB	Compliance	Alkalinity Bicarbonate	mg/L	18	0	145.40	156.20	149.50	26.40	0.18	-0.47	91.00	188.00	63	3.333	Positive
MW-704 UFB	Compliance	Calcium	mg/L	19	0	37.19	42.86	38.00	14.25	0.38	-0.372	10.00	57.20	117	2.364	Positive
MW-704 UFB	Compliance	Chloride	mg/L	18	7	14.35	16.21	13.50	4.55	0.32	0.69	10.00	23.40	85	0.692	Positive
MW-704 UFB	Compliance	Hardness	mg/L	18	0	136.30	154.7	148.00	44.92	0.33	-0.272	68.00	198.00	122	8.000	Positive
MW-704 UFB	Compliance	Iron	µg/L	19	0	15,683.00	21183	14,000.00	13,824.00	0.88	0.678	210.00	45,100.00	97	1,666.667	Positive
MW-704 UFB	Compliance	Magnesium	mg/L	19	0	7.49	8.749	7.90	3.17	0.42	-0.223	1.80	13.40	143	0.513	Positive
MW-704 UFB	Compliance	Manganese	µg/L	19	2	676.40	820.3	650.00	361.80	0.54	0.042	89.00	1,300.00	122	60.000	Positive
MW-704 UFB	Compliance	Potassium	mg/L	19	0	2.84	3.312	3.20	1.18	0.42	-0.471	0.81	4.80	71	0.137	Positive
MW-704 UFB	Compliance	Sodium	mg/L	19	0	15.37	22.05	10.00	13.47	0.88	1.628	5.00	50.00	-88	-0.867	Negative
MW-705 QAL	Monitoring	Alkalinity Bicarbonate	mg/L	18	0	58.50	64.02	60.50	13.45	0.23	0.49	35.00	90.00	-72	-1.500	Negative
MW-705 QAL	Monitoring	Calcium	mg/L	19	0	17.76	19.15	17.00	3.49	0.20	0.695	13.00	24.00	-120	-0.500	Negative
MW-705 QAL	Monitoring	Hardness	mg/L	18	0	79.61	85.77	75.00	15.02	0.19	0.637	59.00	109.00	-111	-2.500	Negative
MW-705 QAL	Monitoring	Iron	µg/L	19	0	8,588.00	9528	8,700.00	2,364.00	0.28	-0.943	1,900.00	12,000.00	-51	-183.333	Negative
MW-705 QAL	Monitoring	Magnesium	mg/L	19	0	7.92	8.595	7.40	1.71	0.22	0.876	5.60	11.00	-121	-0.257	Negative
MW-705 QAL	Monitoring	Manganese	µg/L	19	3	967	1088	890	304	0.31	-0.286	280	1,500	-110	-37.500	Negative
MW-705 QAL	Monitoring	Sodium	mg/L	19	0	12	12.51	12	2	0.21	-1.31	4	15	67	0.235	Positive
MW-705 QAL	Monitoring	Sulfate	mg/L	18	0	6.98	9.712	5.05	7.11	1.02	3.204	1.80	33.00	73	0.344	Positive
MW-705 UFB	Monitoring	Alkalinity Bicarbonate	mg/L	19	0	91.83	96.93	88.00	12.81	0.14	3.22	81.00	140.00	-94	-0.833	Negative
MW-705 UFB	Monitoring	Chloride	mg/L	19	9	16.60	19.78	12.00	8.00	0.48	0.772	10.00	31.90	135	1.300	Positive
MW-705 UFB	Monitoring	Hardness	mg/L	19	0	106.10	110.5	103.00	10.18	0.10	1.337	92.00	134.00	51	0.917	Positive
MW-705 UFB	Monitoring	Iron	µg/L	20	0	7,904	10394	8,600	2,554	0.32	-1.409	680	12,000	107	233.333	Positive
MW-705 UFB	Monitoring	Magnesium	mg/L	20	0	11	11.48	11	1	0.10	-0.223	9	14	52	0.050	Positive
MW-705 UFB	Monitoring	Manganese	µg/L	20	1	763	823.5	745	157	0.21	0.913	530	1,250	88	12.000	Positive
MW-705 UFB	Monitoring	Sulfate	mg/L	19	0	7.50	9.416	5.60	3.67	0.49	0.372	2.70	13.00	-134	-0.640	Negative
MW-706 QAL	Mill Services	Ammonia	mg/L	17	0	405.40	1066.00	420.00	273.70	0.68	1.10	0.45	1,200.00	-44	-27.222	Negative
MW-706 QAL	Mill Services	Alkalinity Bicarbonate	mg/L	17	0	91.83	100.30	89.00	19.97	0.22	1.04	71.00	140.00	-122	-3.308	Negative
MW-706 QAL	Mill Services	Arsenic	µg/L	18	8	6.75	7.74	5.95	2.42	0.36	1.85	5.00	14.00	-101	-0.225	Negative

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Location	Classification	Parameter	Unit	Count (n)	Number of Non-Detects	Mean	UCL	Median	Standard Deviation	Coefficient of Variation	Skewness	Minimum	Maximum	Man-Kendall S	Sen Slope	Positive or Negative Trend (Minimum 95% Confidence)
MW-706 QAL	Mill Services	Calcium	mg/L	18	0	94.43	102.40	88.00	19.36	0.21	1.138	57.00	150.00	-82	-1.946	Negative
MW-706 QAL	Mill Services	Chloride	mg/L	17	0	116.60	126.9	100.00	24.23	0.21	0.306	86.00	150.00	77	4.083	Positive
MW-706 QAL	Mill Services	Cobalt	µg/L	8	2	23.96	26.34	24.00	3.55	0.15	0.419	20.00	30.00	18	1.000	Positive
MW-706 QAL	Mill Services	Hardness	mg/L	17	0	227.80	310.7	188.00	195.60	0.86	0.112	6.00	503.00	-63	-22.250	Negative
MW-706 QAL	Mill Services	Iron	µg/L	18	0	5,131.00	5707	4,950.00	1,405.00	0.27	0.124	2,200.00	7,800.00	-76	-233.333	Negative
MW-706 QAL	Mill Services	Nickel	µg/L	18	5	22.62	23.52	22.90	2.20	0.10	0.142	20.00	26.00	83	0.275	Positive
MW-706 QAL	Mill Services	Sodium	mg/L	18	0	55.19	102.3	36.55	45.90	0.83	1.959	24.00	190.00	-61	-2.600	Negative
MW-706 QAL	Mill Services	Sulfate	mg/L	17	0	262.60	298.8	210.00	85.44	0.33	1.008	180.00	430.00	-100	-13.486	Negative
MW-707 QAL	Concentrator/CLO	Ammonia	mg/L	17	0	228.30	495.70	270.00	110.80	0.49	-1.71	0.23	320.00	-53	-6.667	Negative
MW-707 QAL	Concentrator/CLO	Alkalinity Bicarbonate	mg/L	17	0	156.30	158.80	160.00	6.00	0.04	0.41	150.00	170.00	57	0.561	Positive
MW-707 QAL	Concentrator/CLO	Hardness	mg/L	17	0	152.90	154.9	154.00	4.68	0.03	-0.161	145.00	160.00	107	0.875	Positive
MW-707 QAL	Concentrator/CLO	Iron	µg/L	17	0	5,658.00	5967	5,700.00	728.60	0.13	0.303	4,580.00	7,200.00	-107	-126.136	Negative
MW-707 QAL	Concentrator/CLO	Sulfate	mg/L	17	0	6.79	7.335	6.90	1.28	0.19	0.262	4.40	9.80	-46	-0.1050	Negative
MW-9R	Concentrator	Ammonia	µg/L	15	10	38.41	159.70	25.00	47.23	1.23	2.65	0.03	190.00	-60	-3.560	Negative
MW-9R	Concentrator	Chloride	mg/L	15	1	57.63	126.4	24.00	61.10	1.06	1.3	10.00	190.00	-61	-5.500	Negative
MW-9R	Concentrator	Hardness	mg/L	15	0	252.70	304.3	242.00	113.40	0.45	0.457	103.00	473.00	-35	-15.667	Negative
MW-9R	Concentrator	Iron	µg/L	15	8	1,027.00	2322	200.00	1,150.00	1.12	1.334	200.00	3,800.00	-39	-90.000	Negative
MW-9R	Concentrator	Manganese	µg/L	15	3	466.20	649	370.00	402.00	0.86	1.015	50.00	1,400.00	-52	-52.222	Negative
MW-9R	Concentrator	Nitrate	mg/L	15	3	80.02	2805	100.00	41.36	0.52	1.344	0.10	100.00	-34	0.000	Negative
MW-9R	Concentrator	Potassium	mg/L	15	0	3.36	3.78	3.50	0.92	0.28	-0.103	2.00	4.60	-48	-0.1333	Negative
MW-9R	Concentrator	Sodium	mg/L	15	0	21.05	29.55	15.00	13.25	0.63	0.837	7.20	47.00	-72	-2.4	Negative

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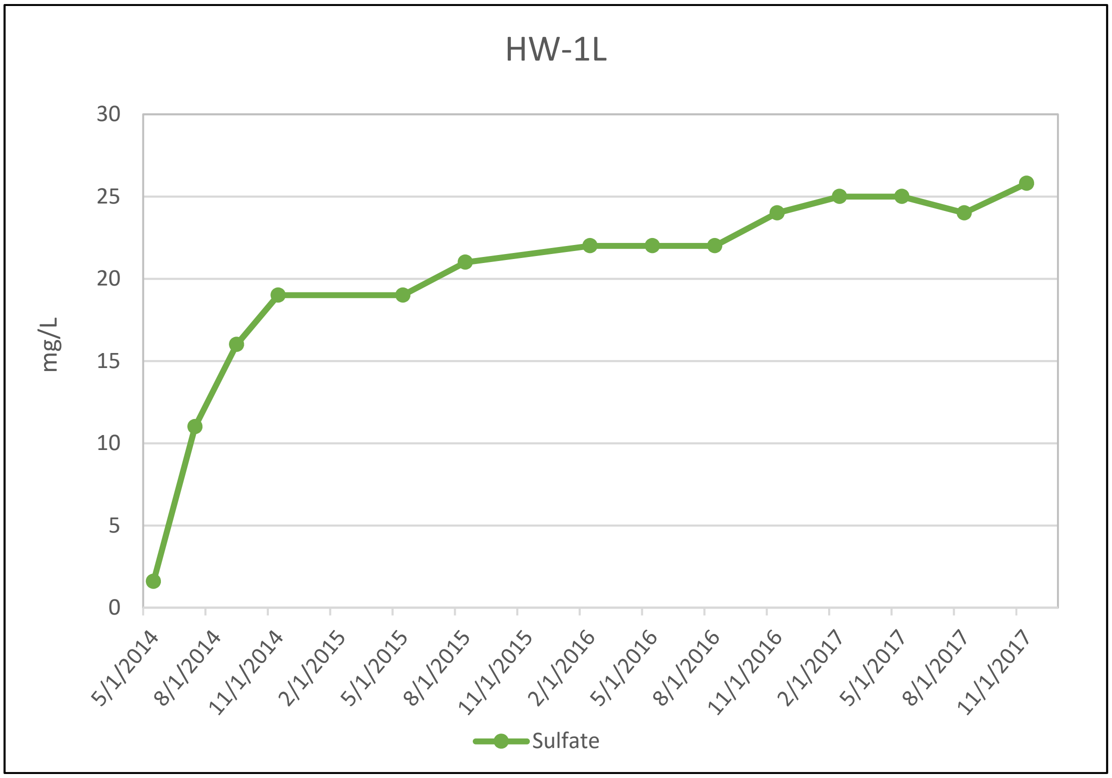

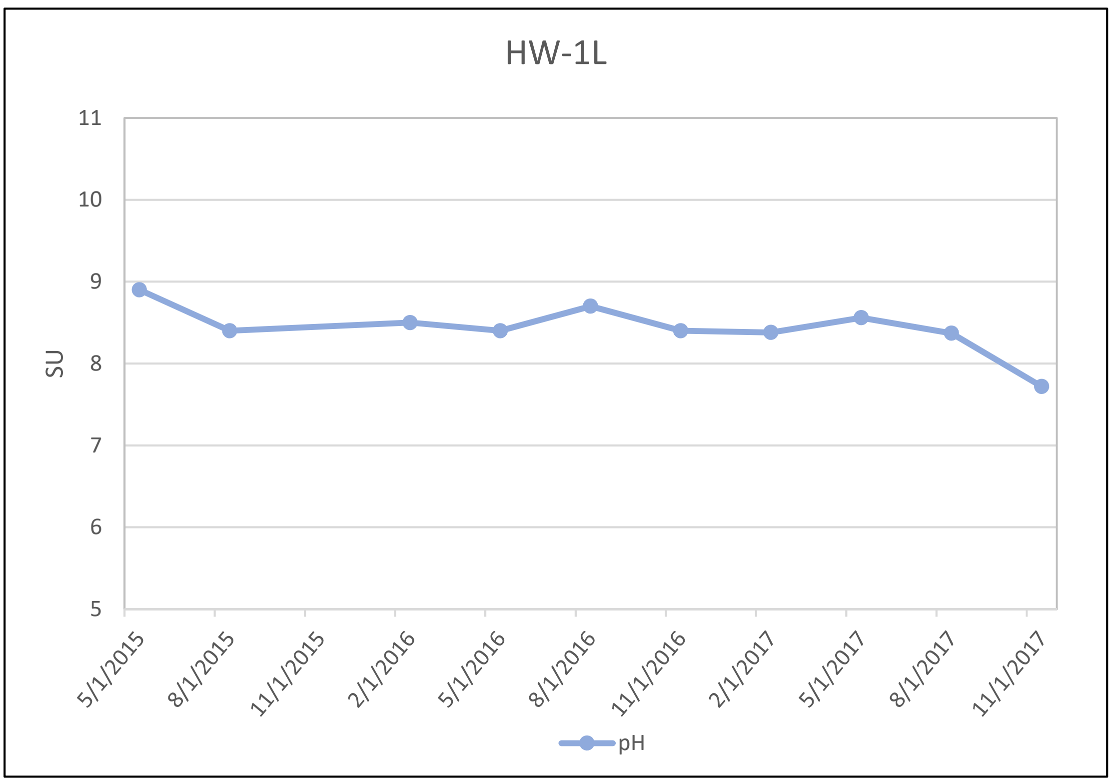

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Groundwater Trend Analysis Summary Charts
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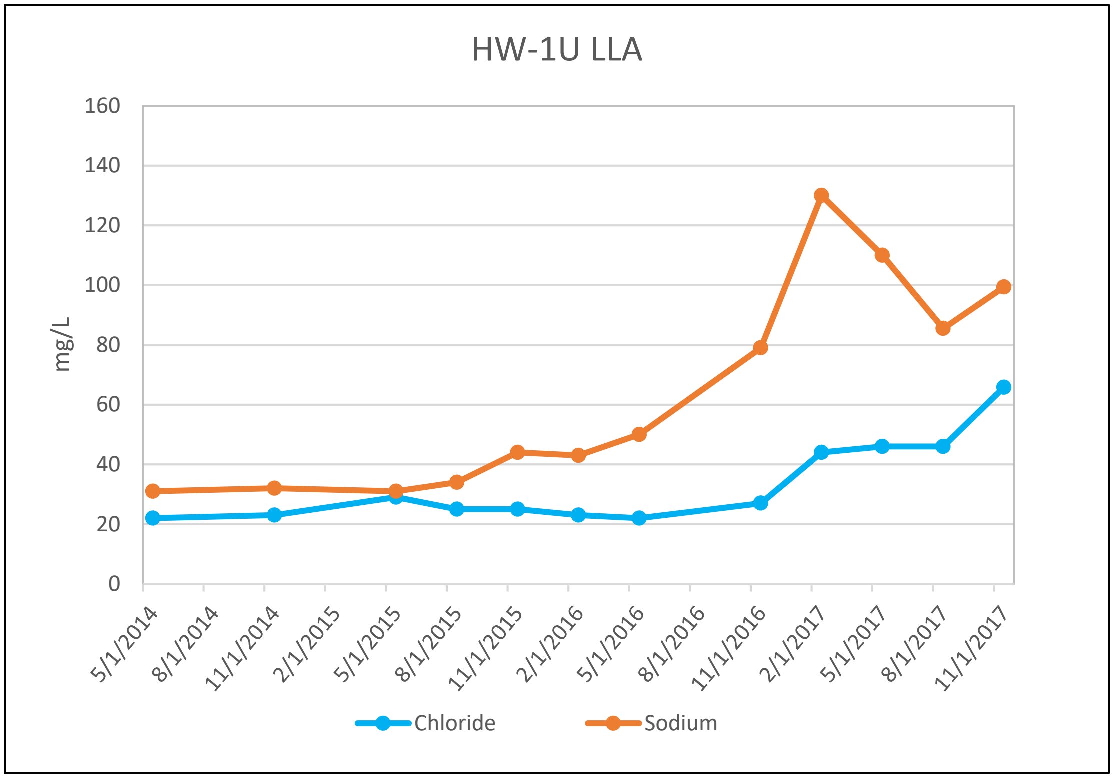

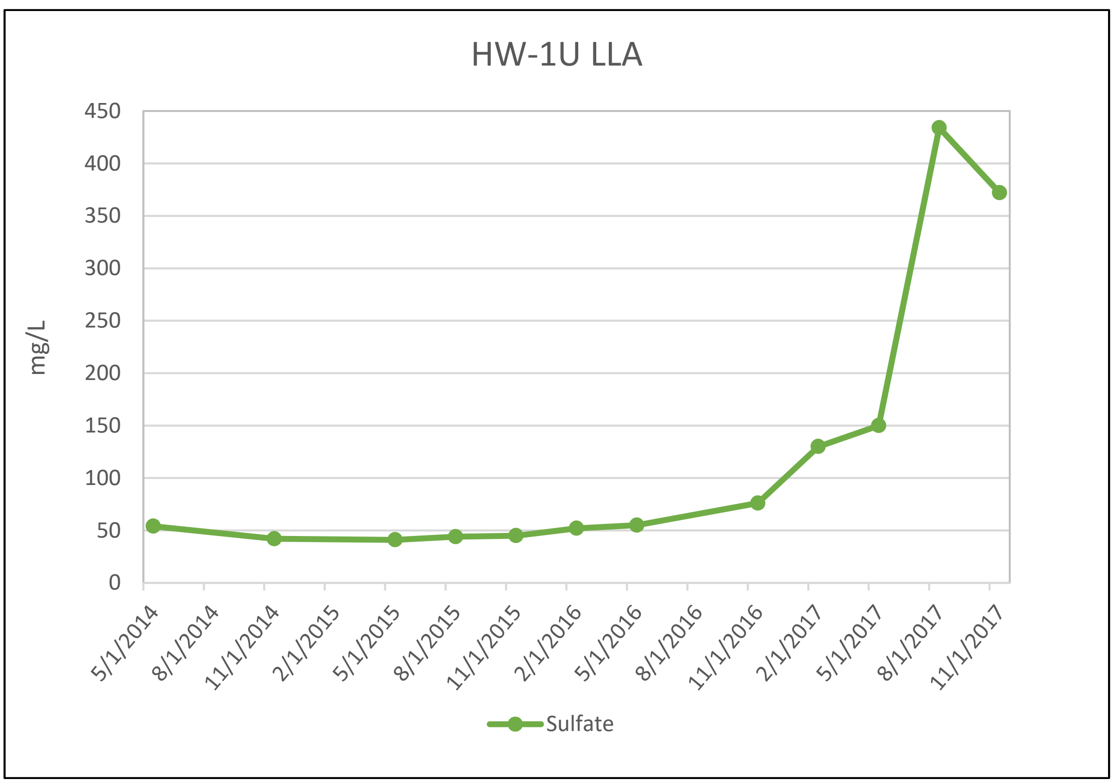

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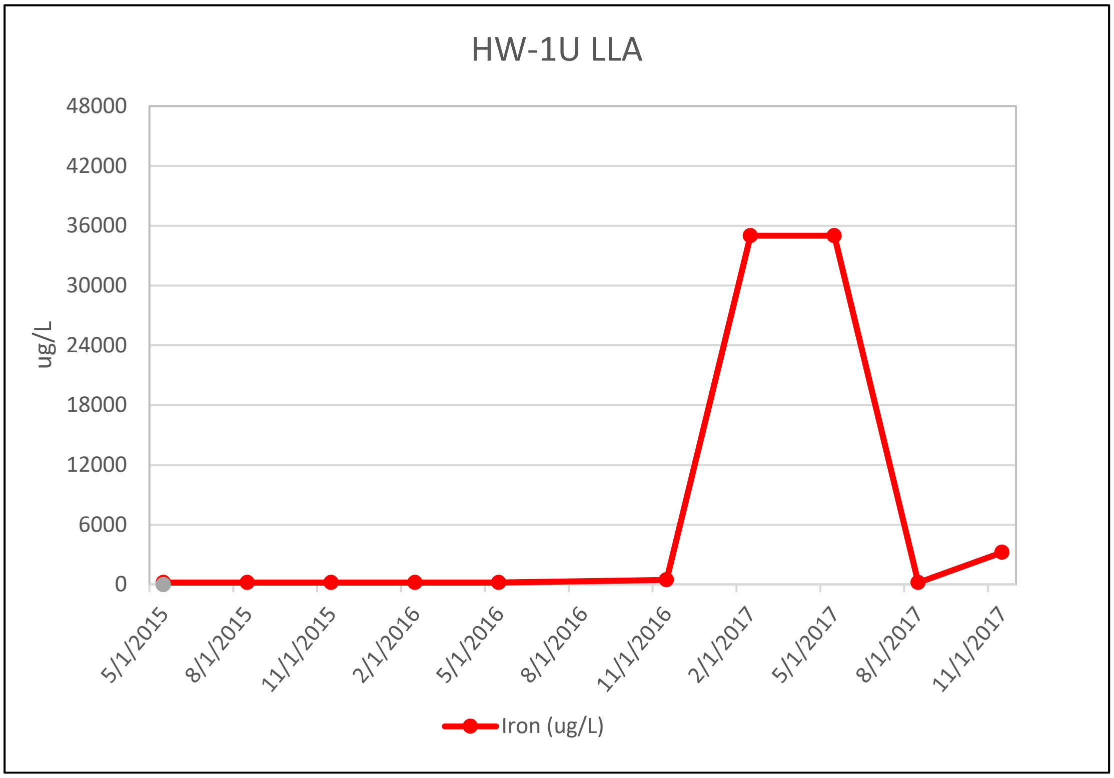

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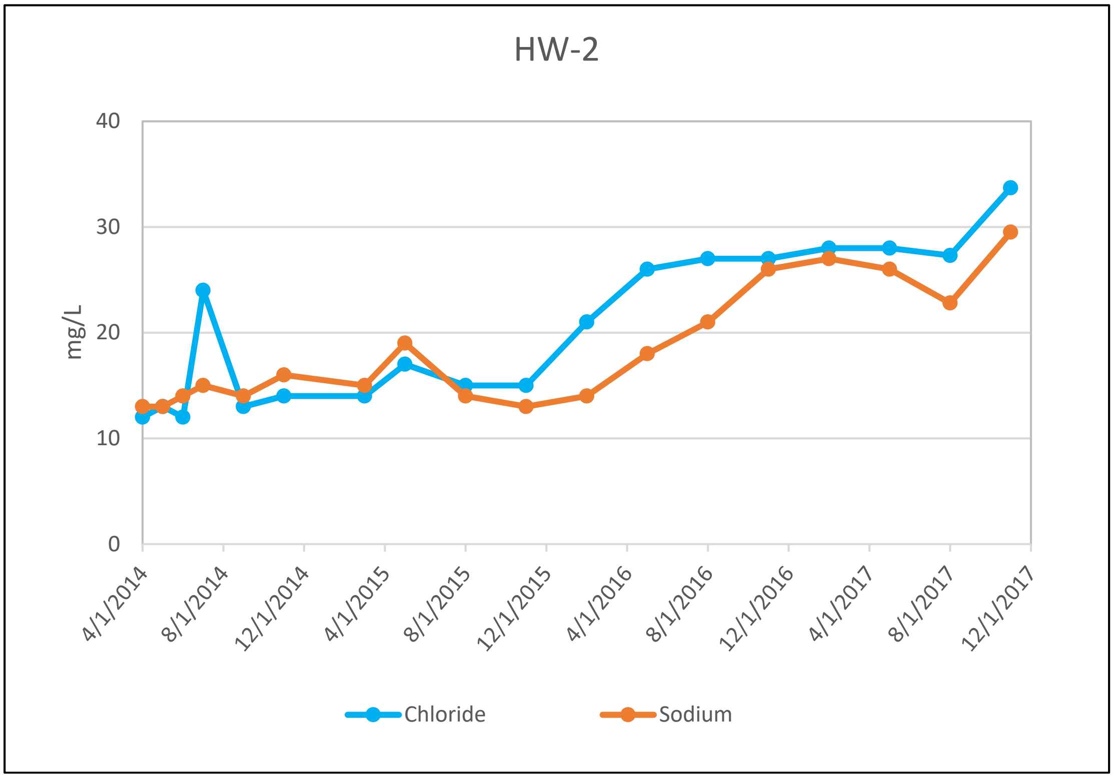

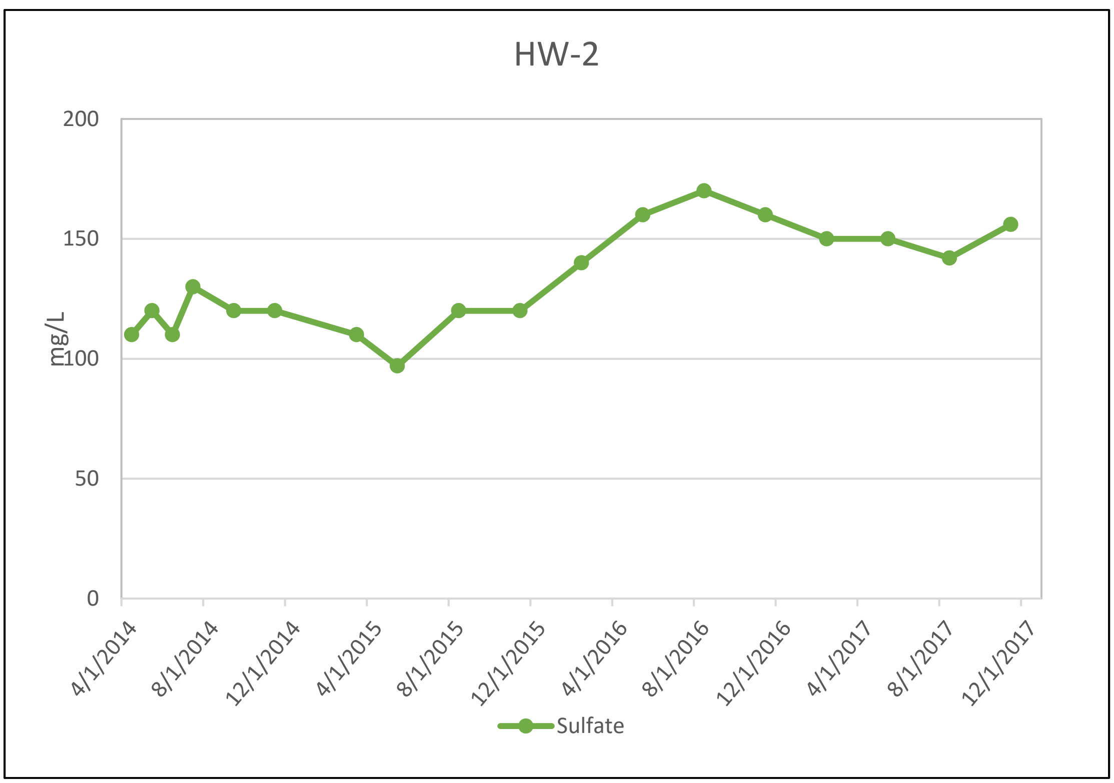

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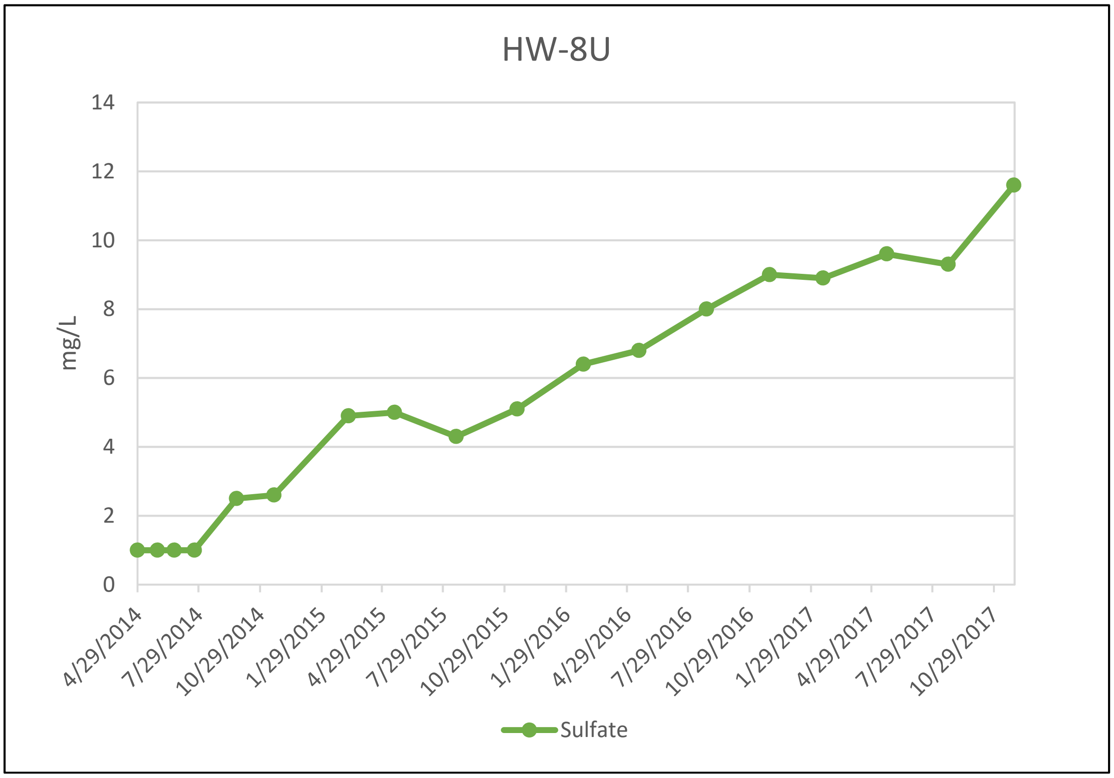

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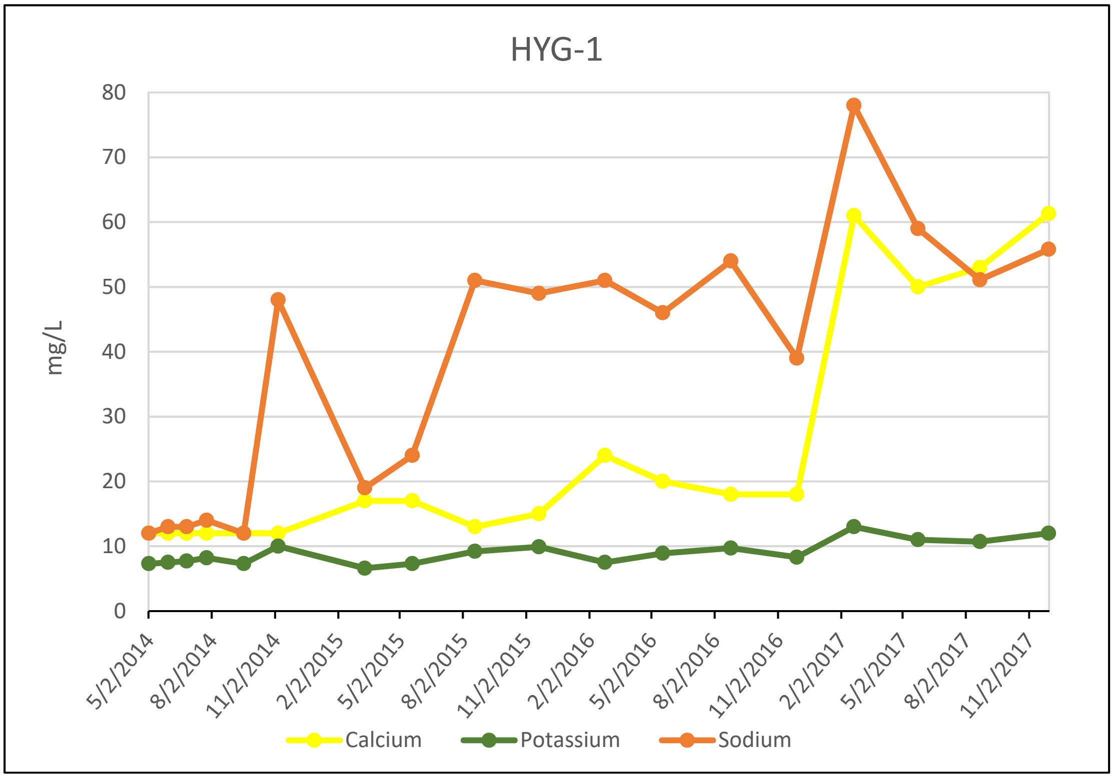

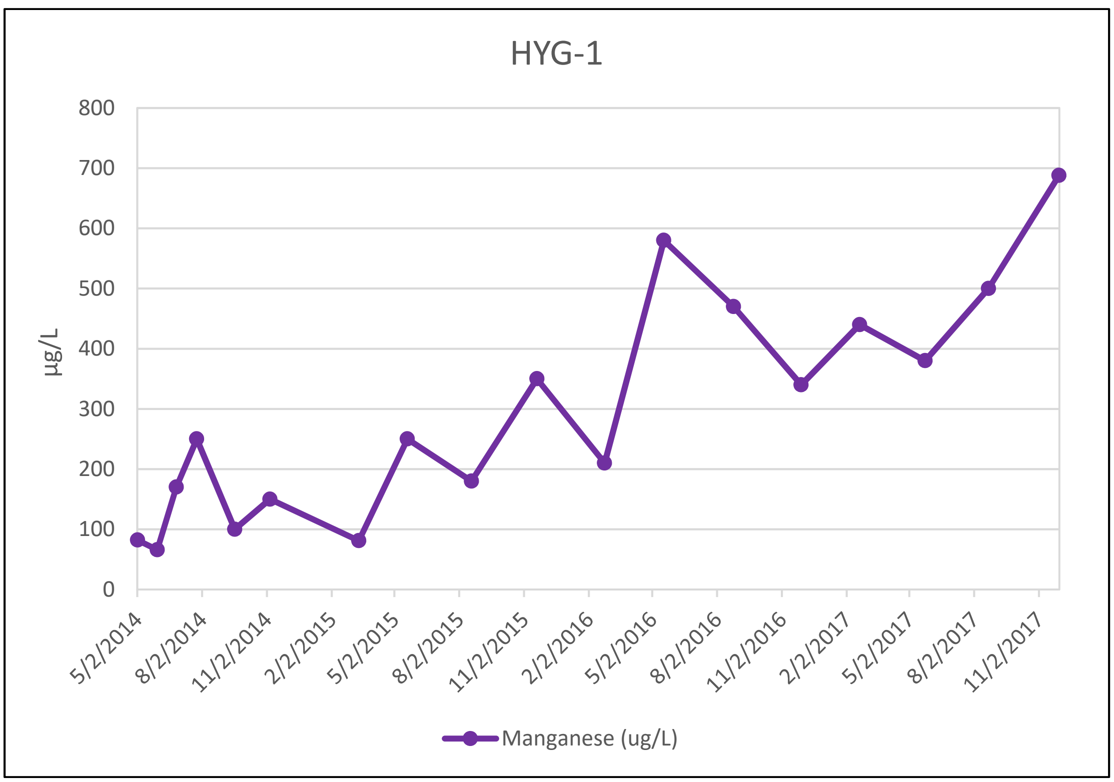

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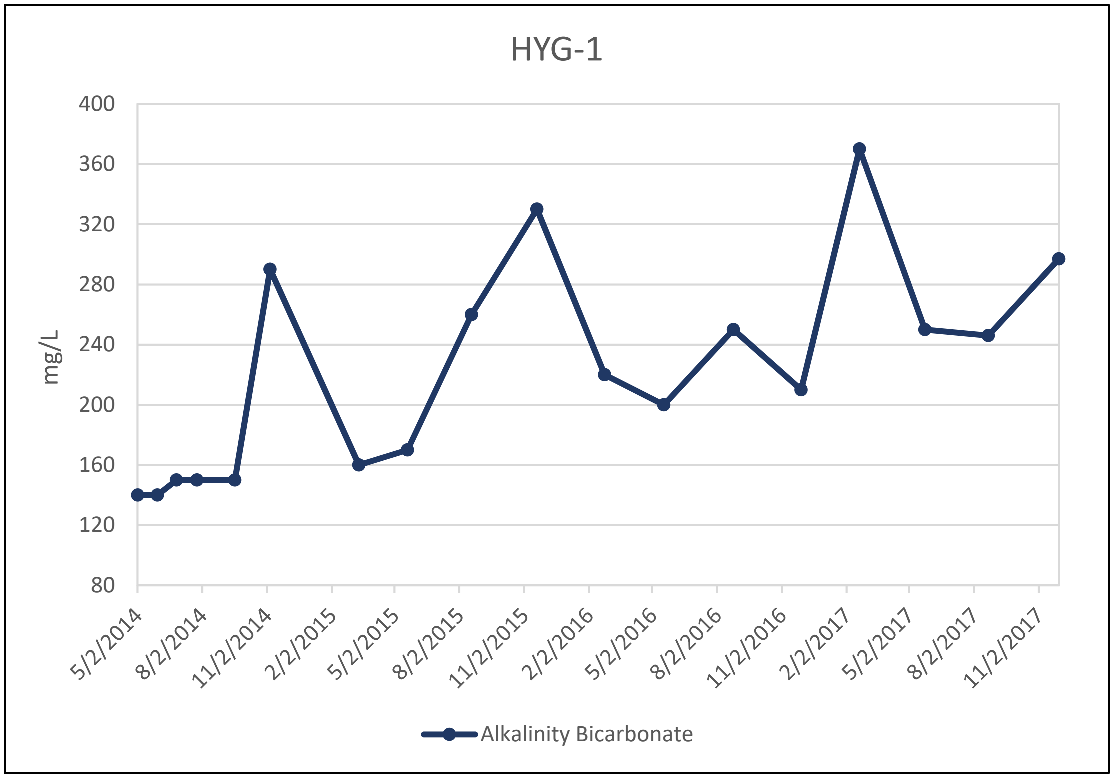

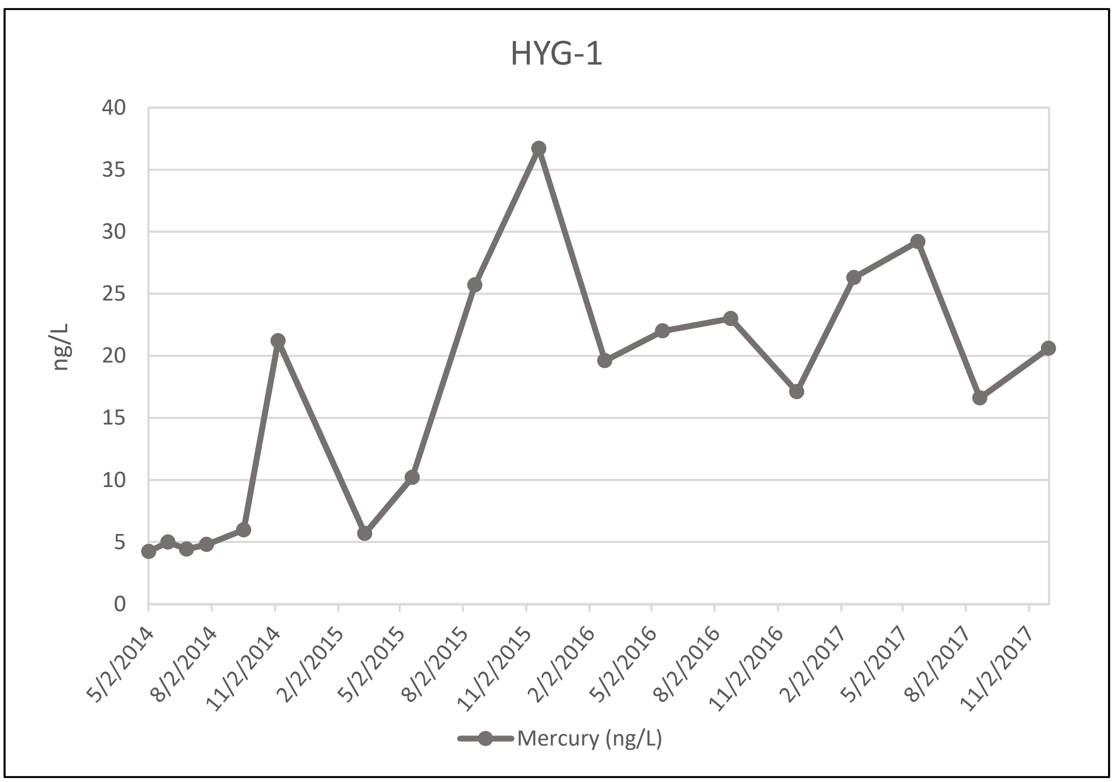

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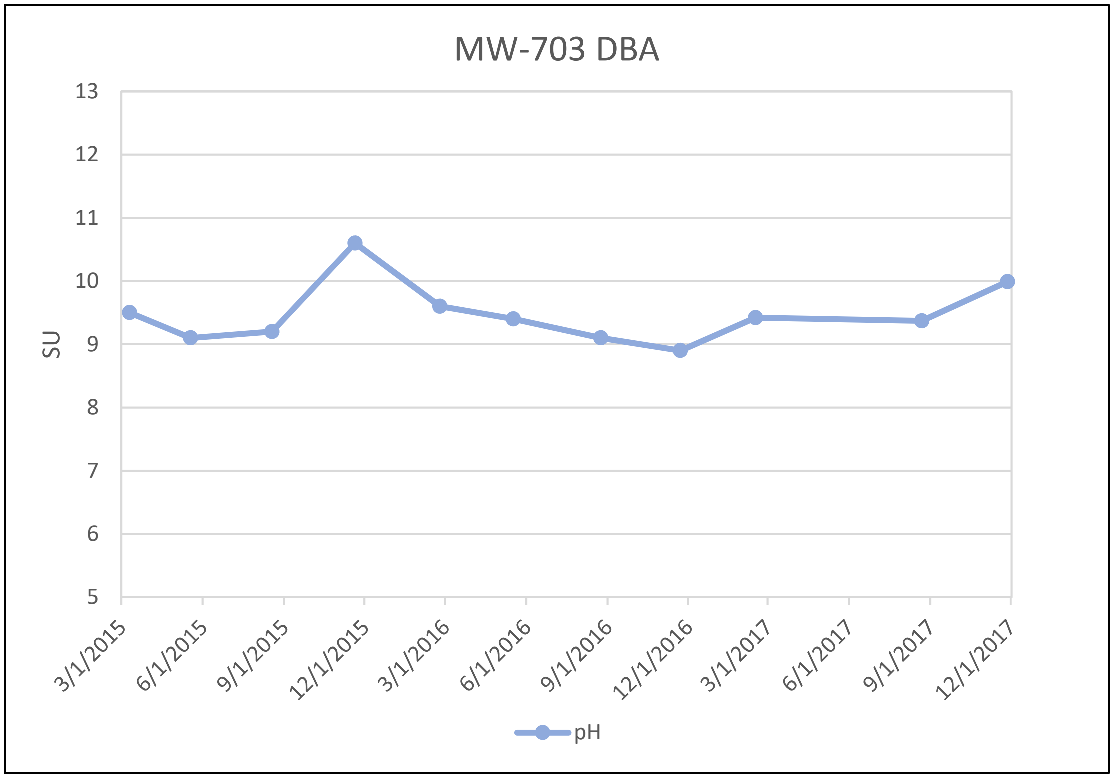

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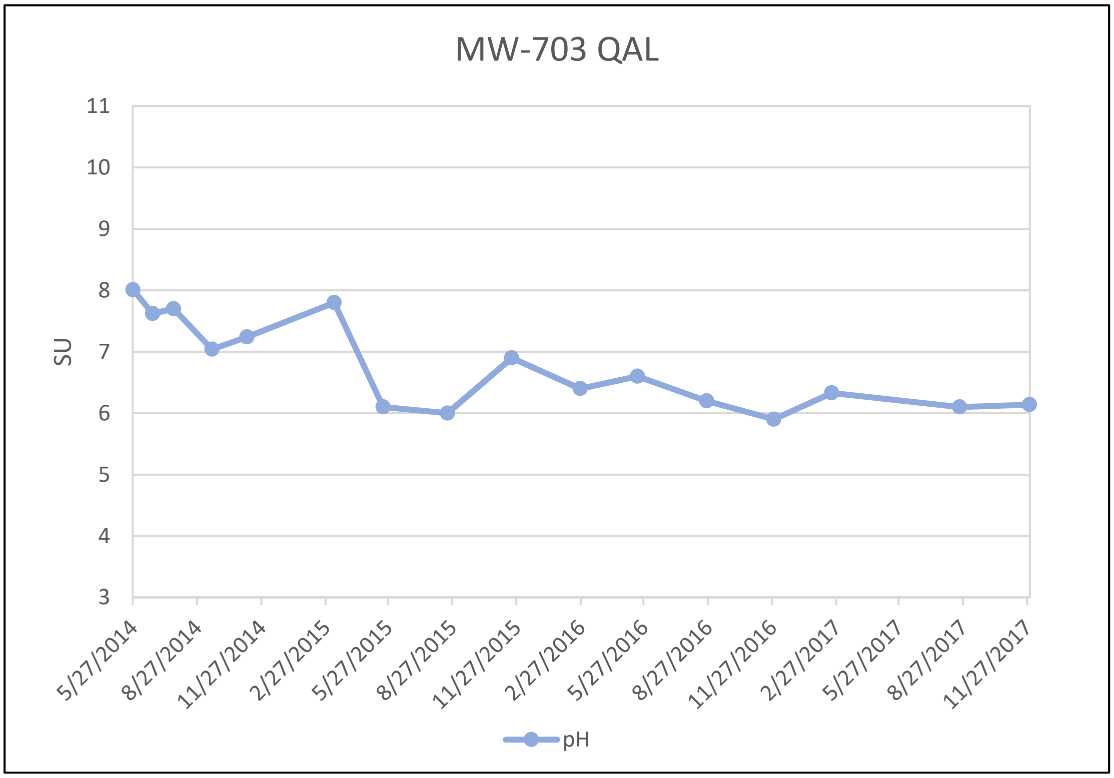

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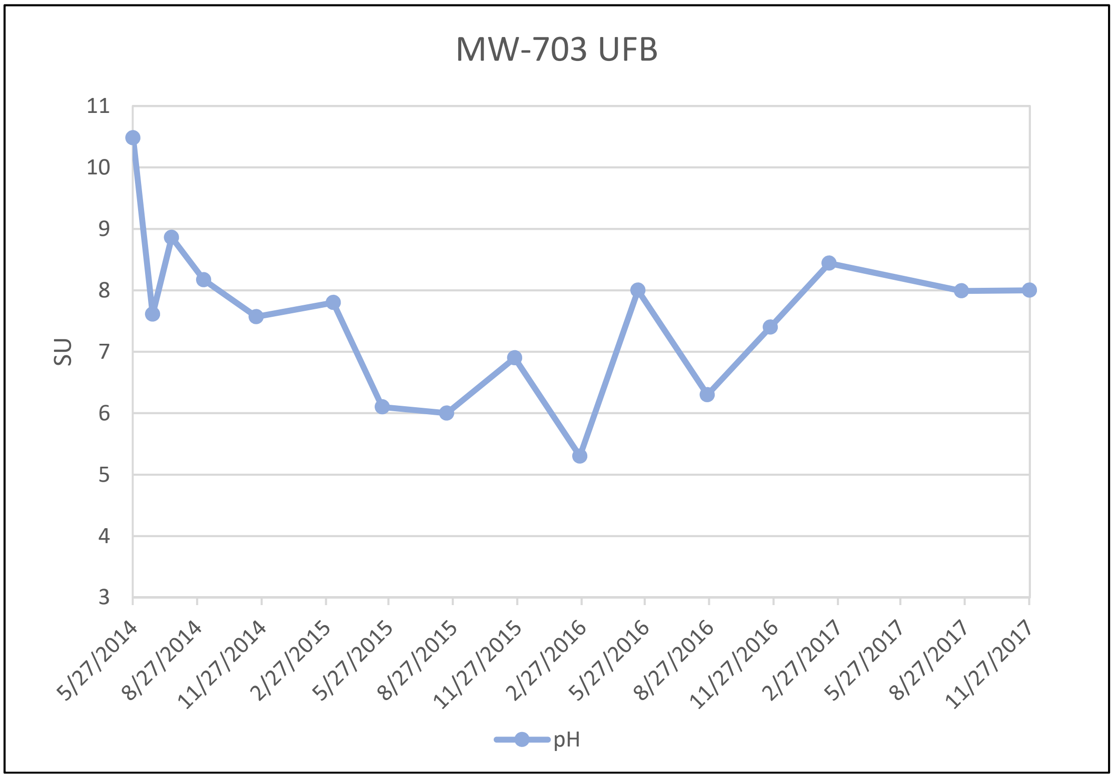

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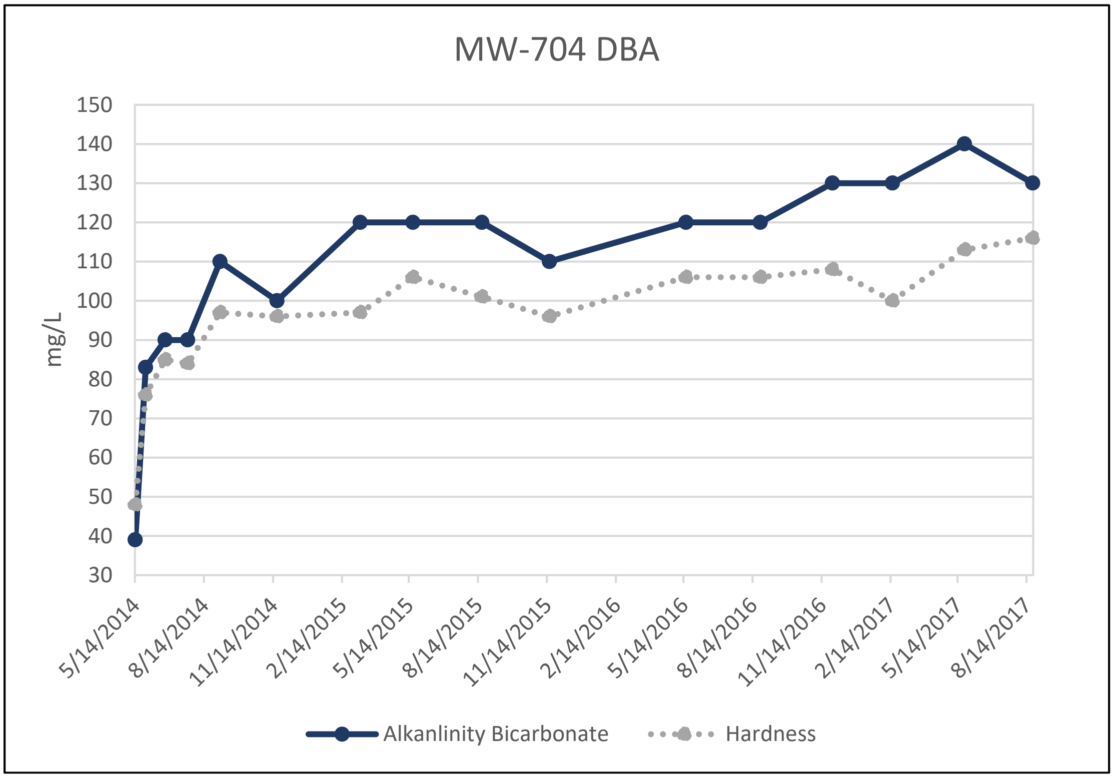

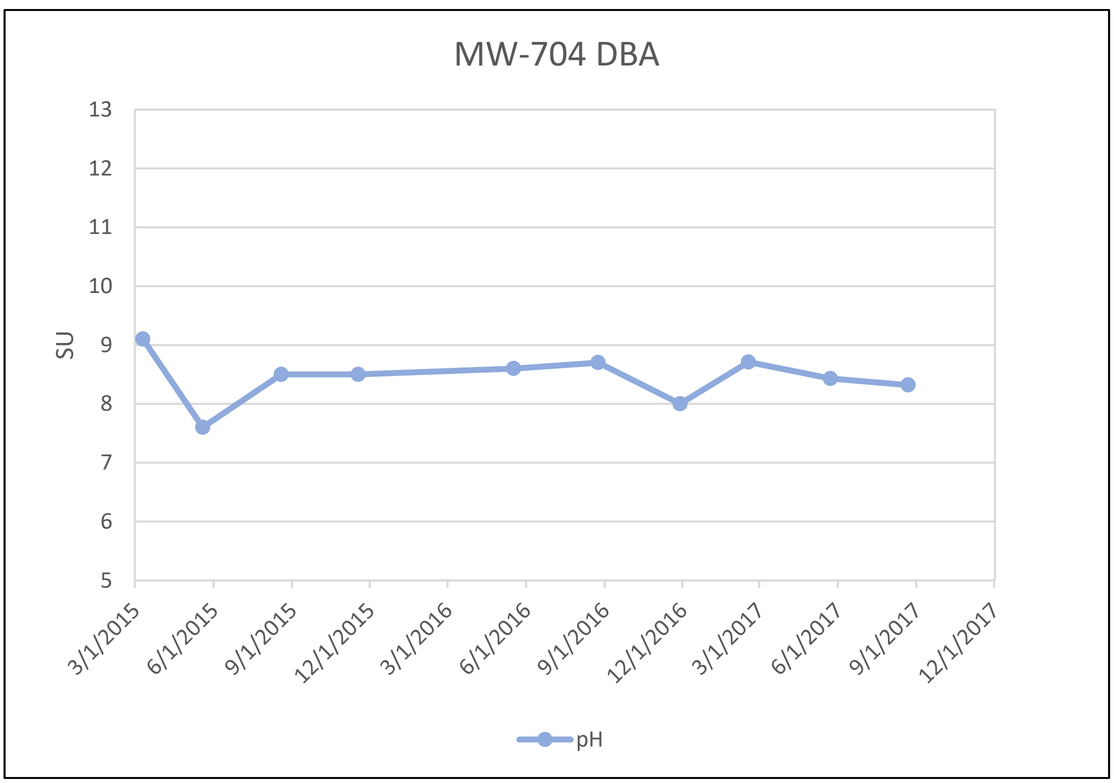

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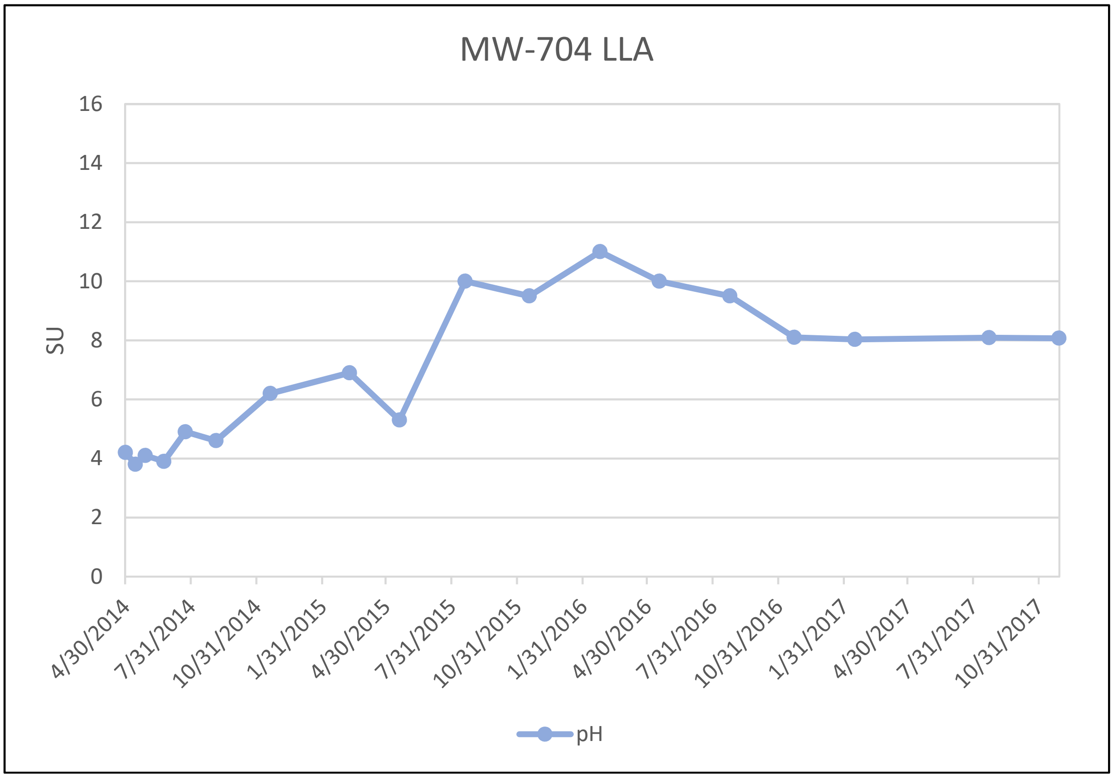

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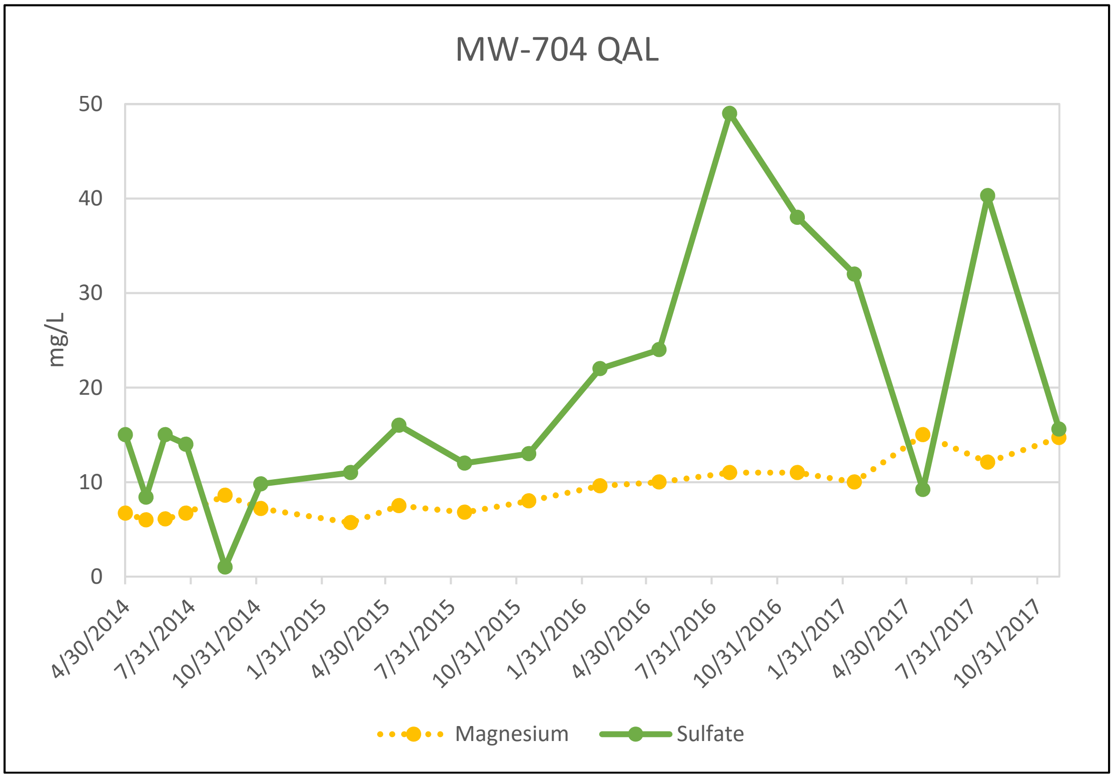

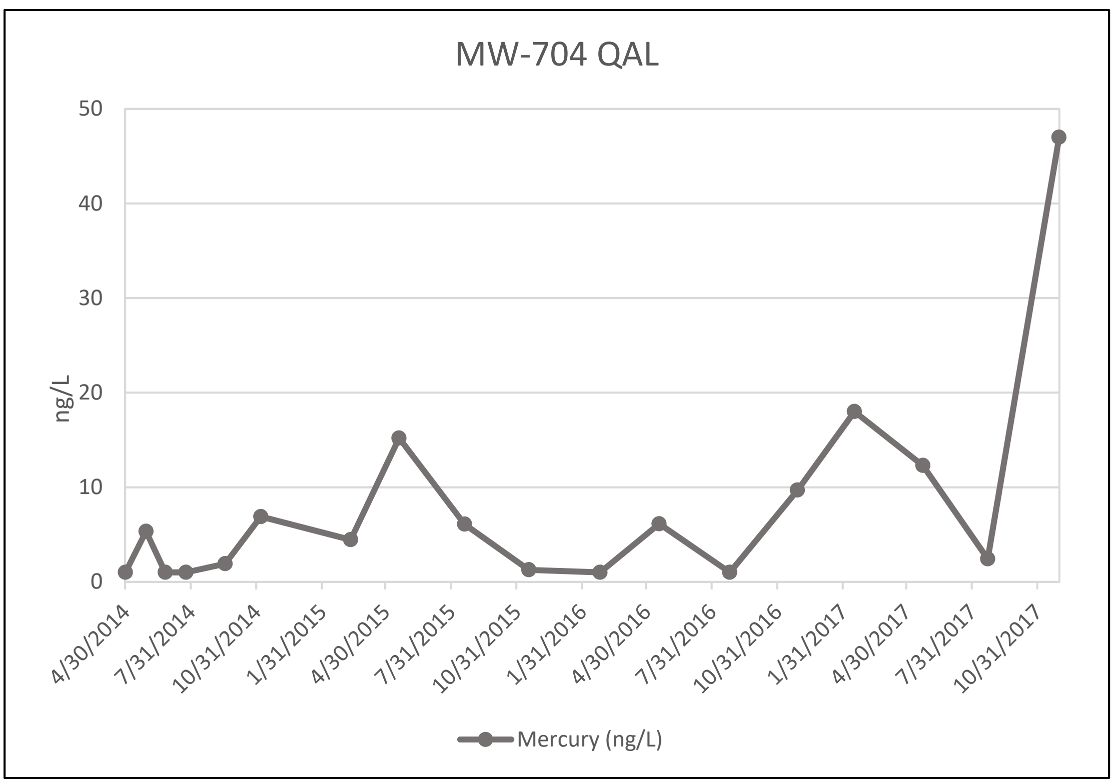

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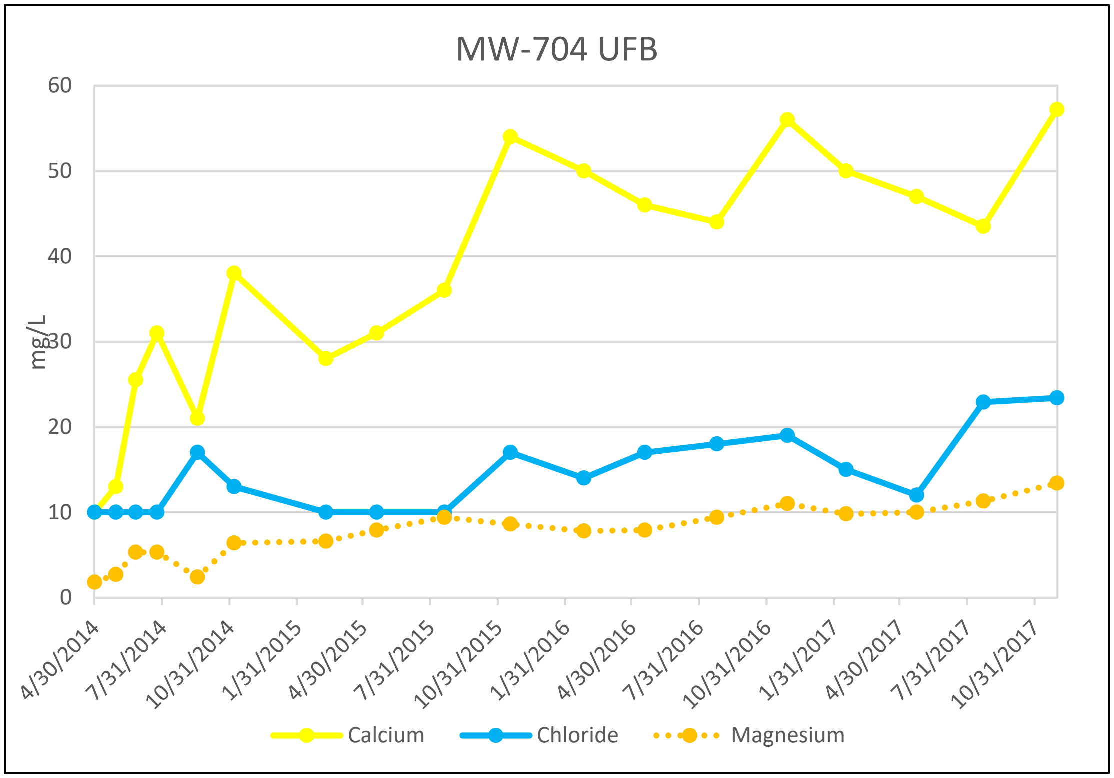

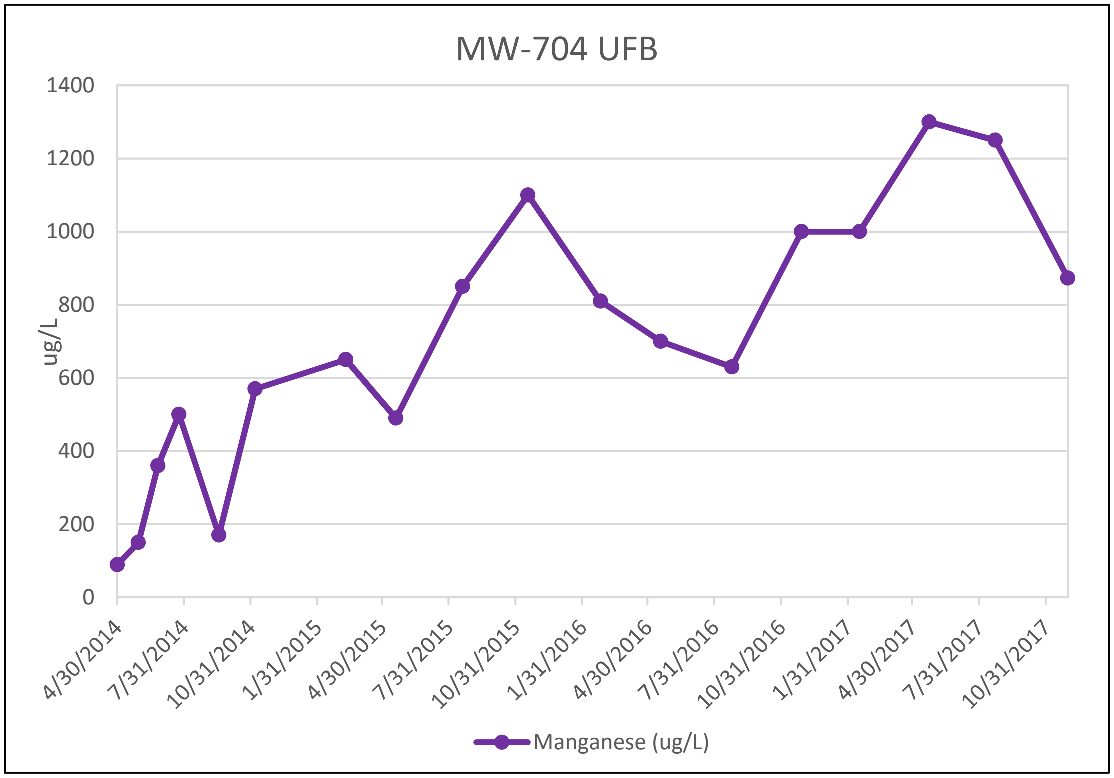

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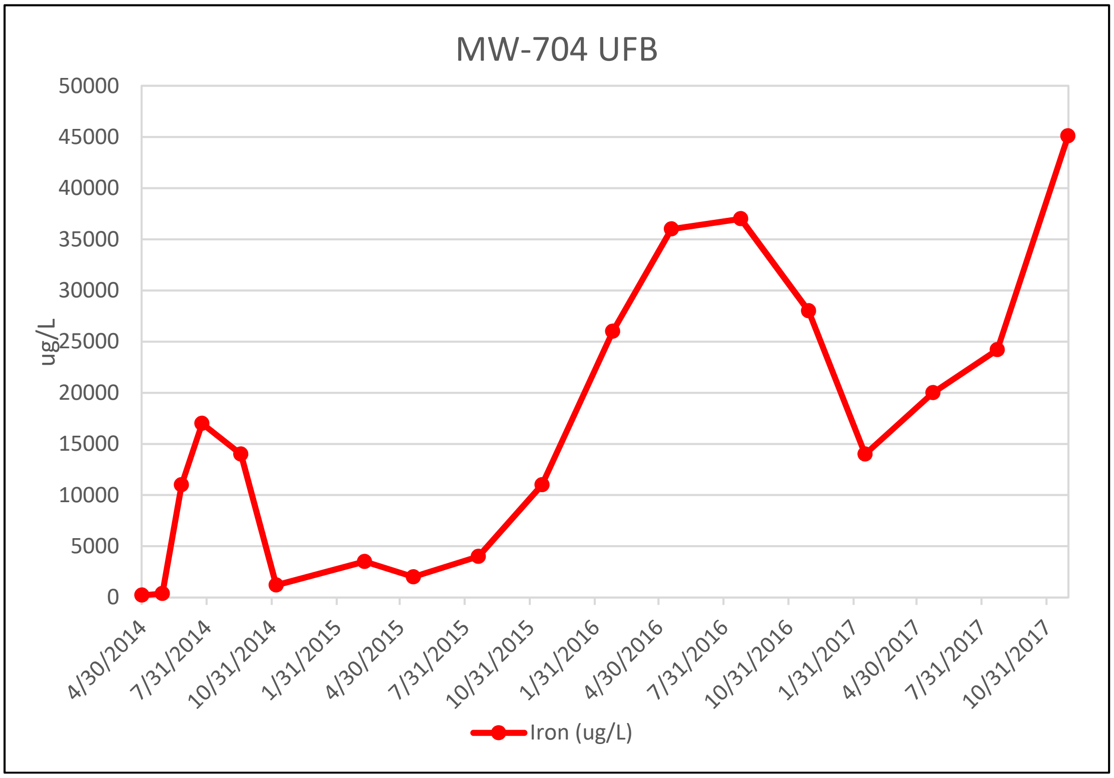

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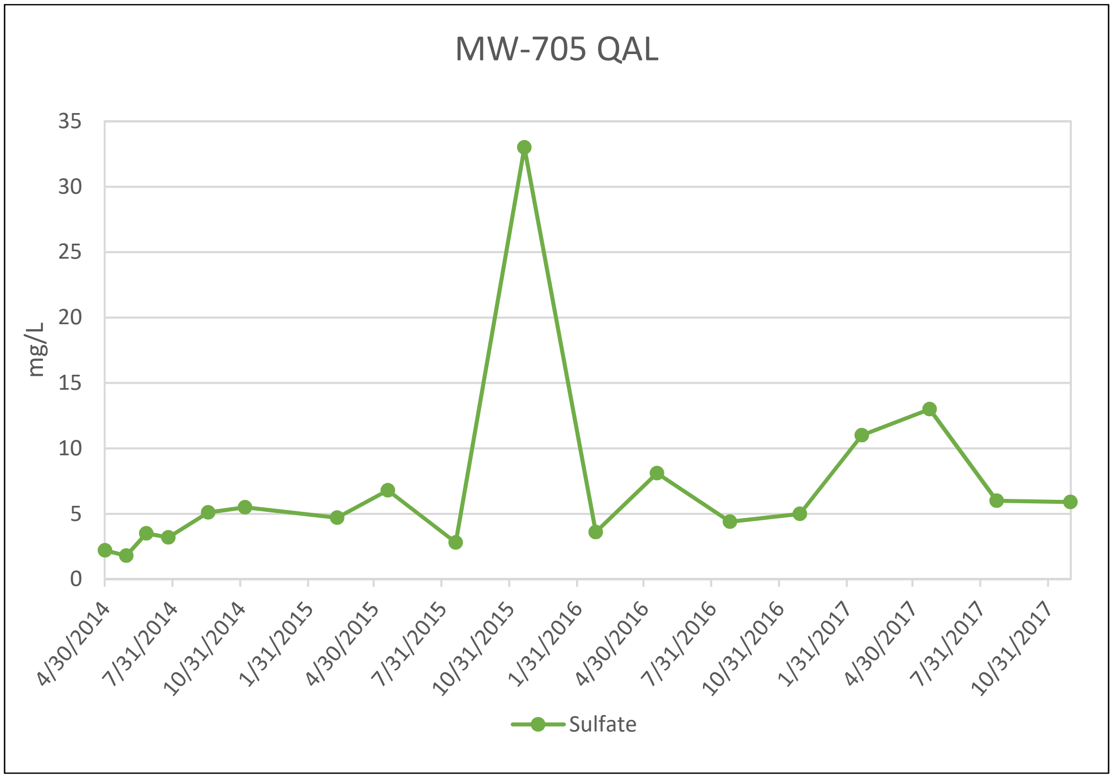

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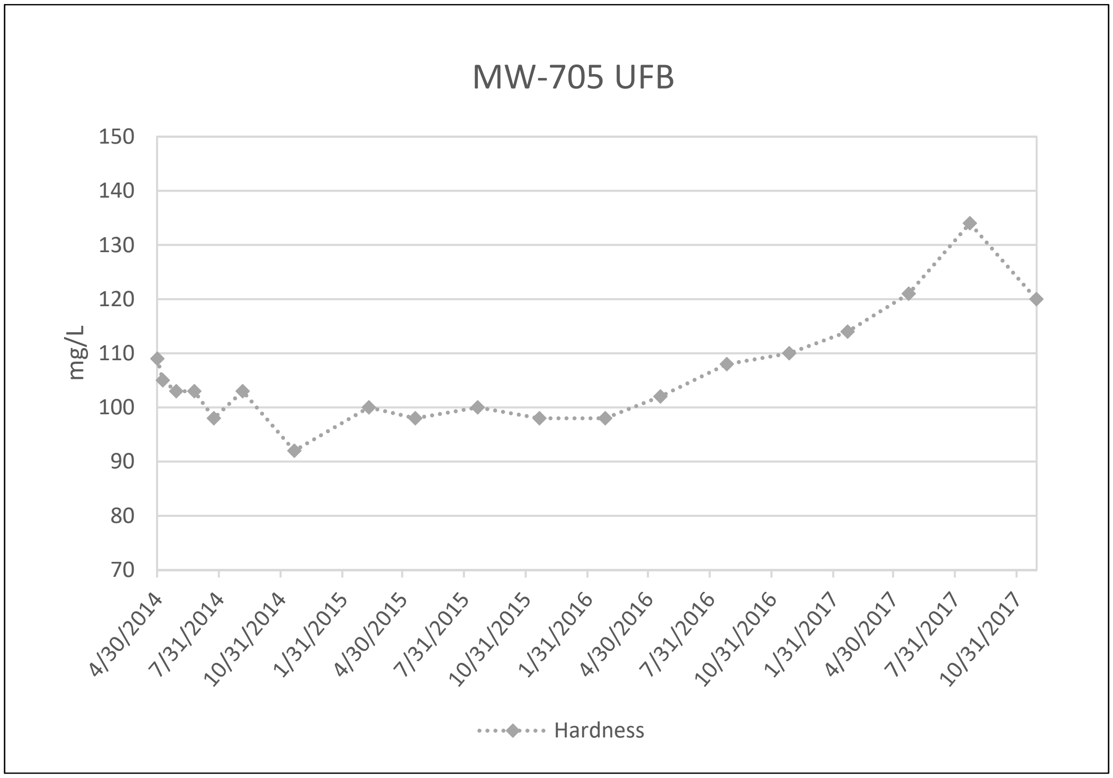

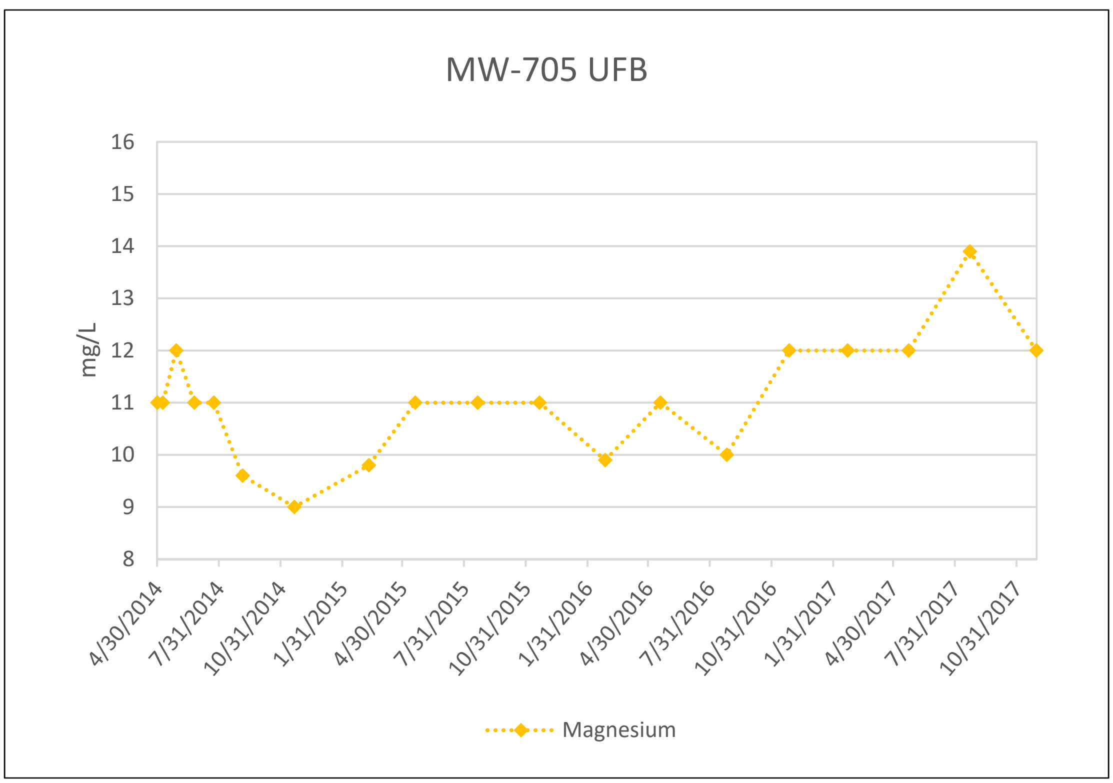

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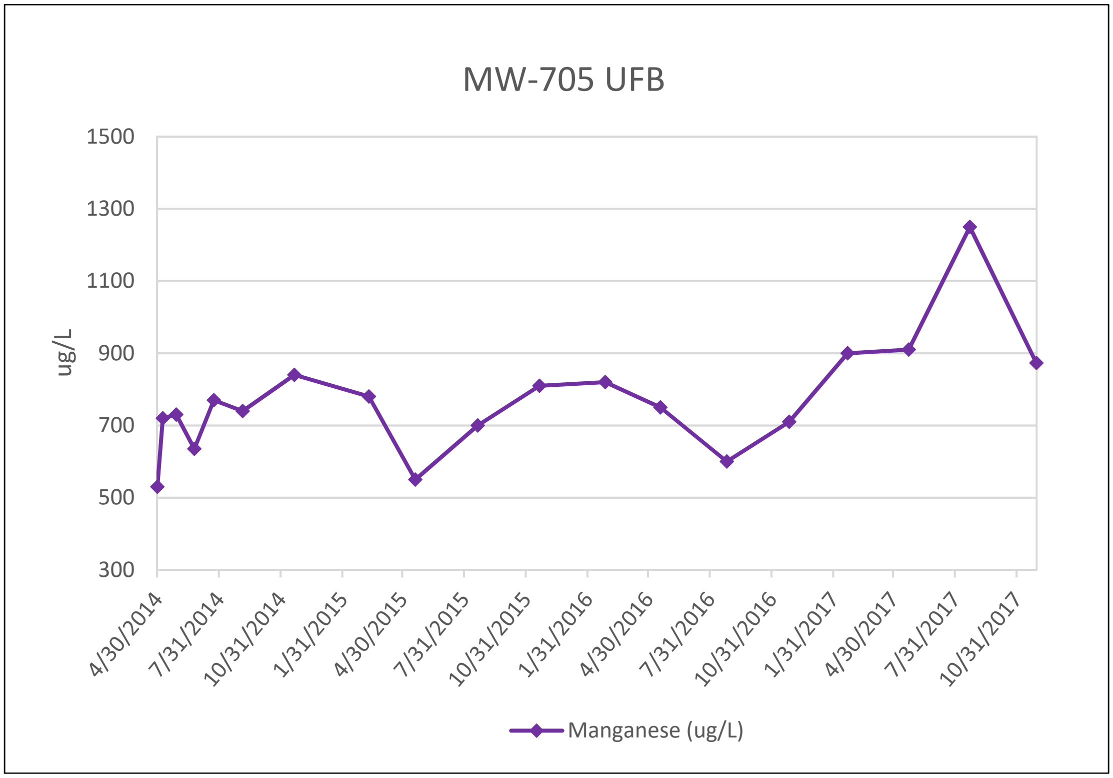

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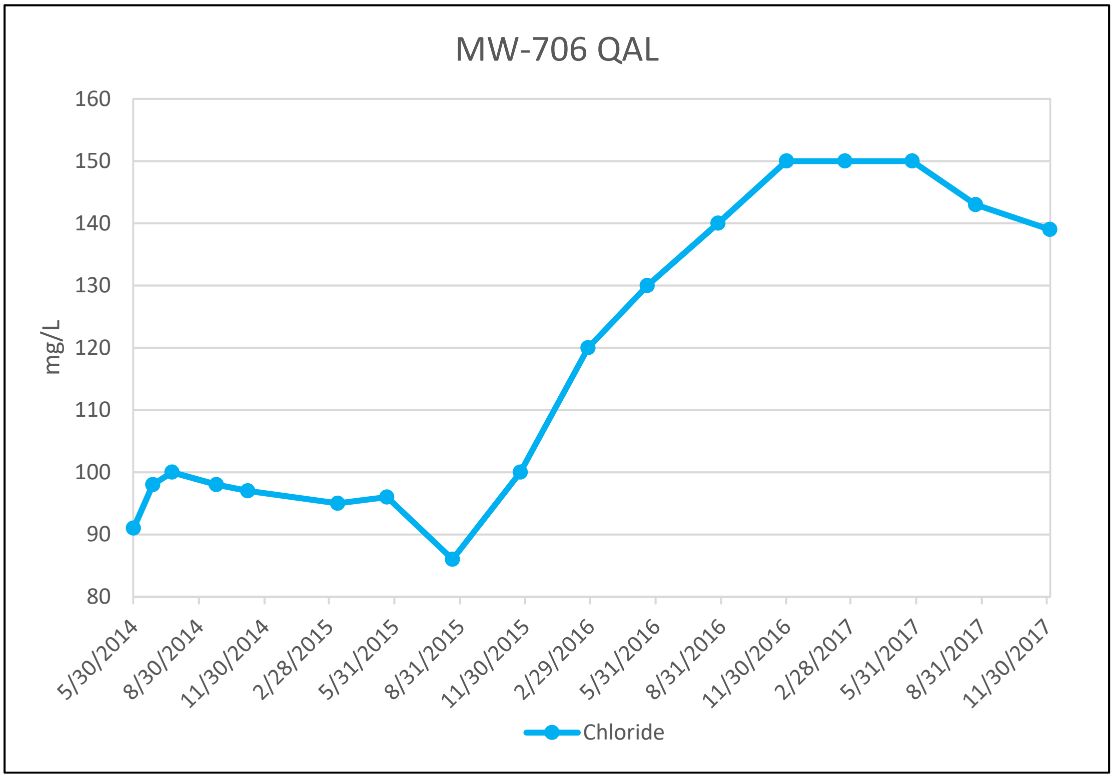

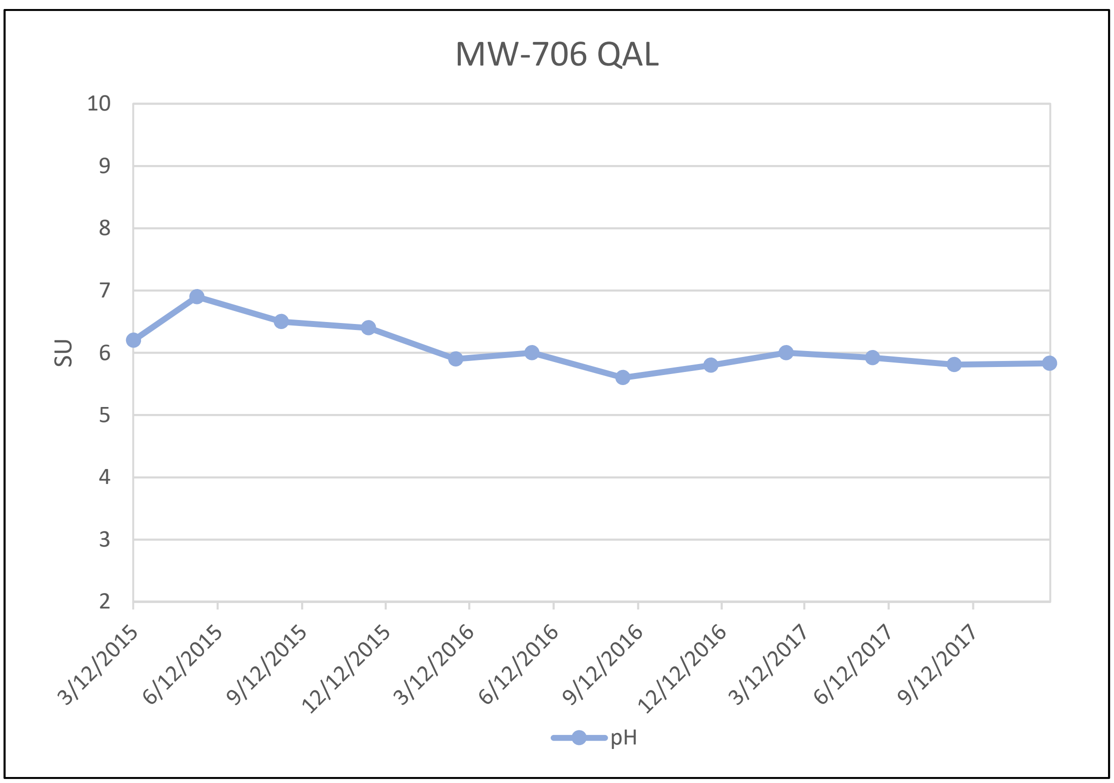

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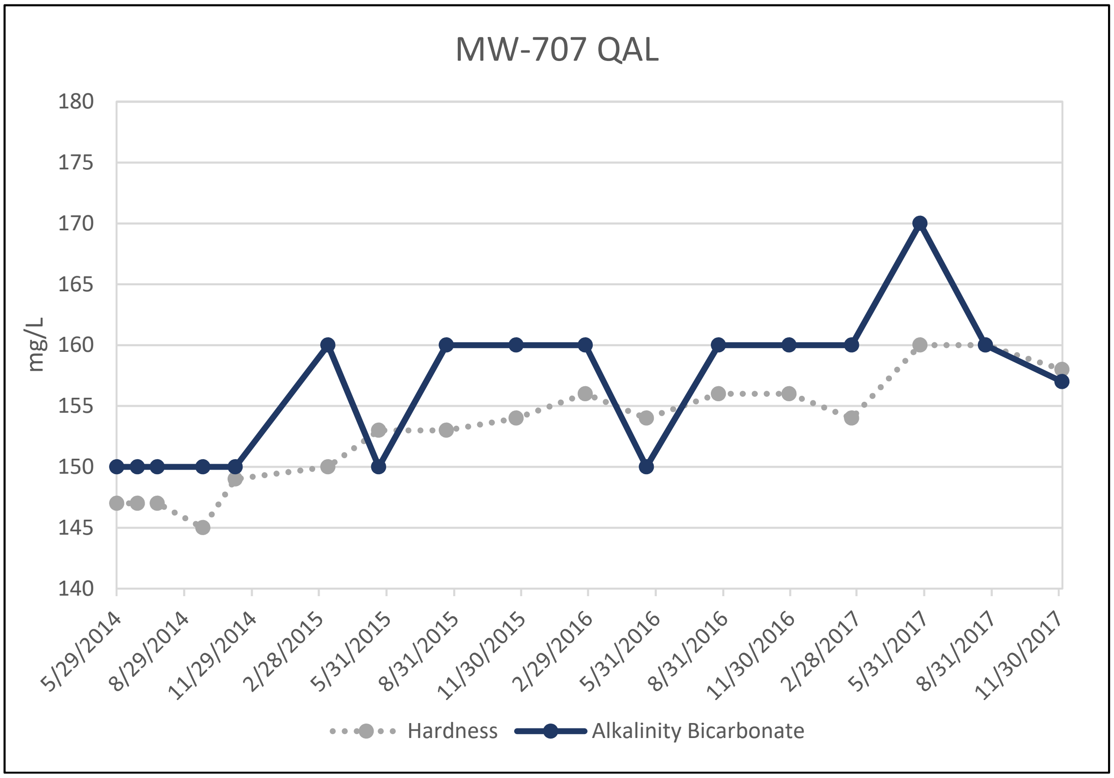
Groundwater Trend Analysis Summary Charts
Humboldt Mill

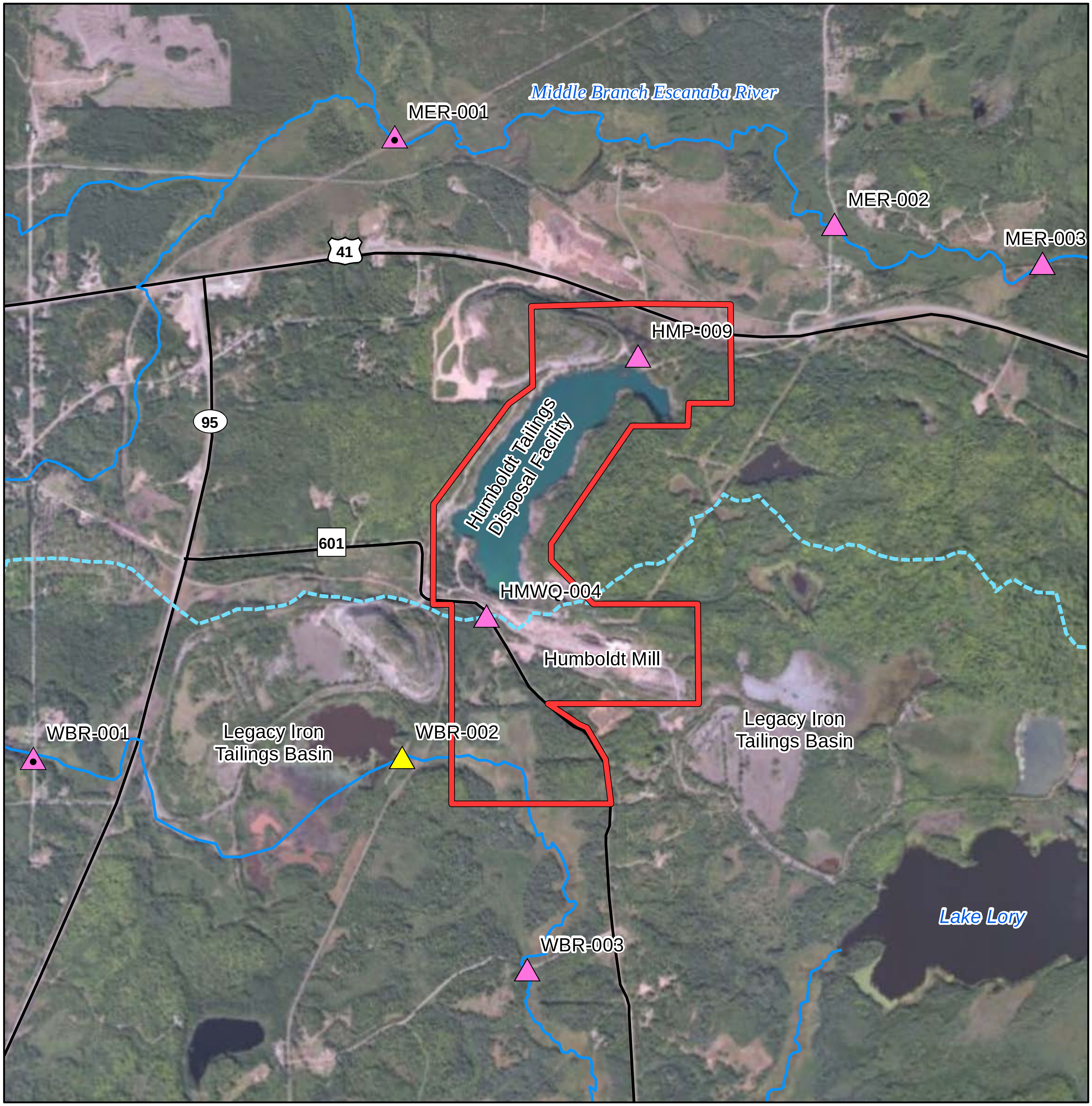


Appendix I

Humboldt Mill

Surface Water Monitoring Location Map

HUMBOLDT MILL
PROPOSED SURFACE WATER AND SEDIMENT MONITORING LOCATIONS



Legend

- Reference Monitoring Station
- Proposed Surface Water Monitoring Location
- Proposed Surface Water and Sediment Monitoring Location
- Road
- River
- Watershed Boundary
- Humboldt Mill Property

Reference:

Data provided by: Eagle Mine, ESRI, and North Jackson Company

Projection & Datum: NAD 1927 UTM Zone 16N

Aerial Photo: 2010

0 2,000 4,000 Feet

1:32,000

Eagle Mine
a subsidiary of lundin mining

North Jackson Company
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 1

Appendix J

Humboldt Mill

Surface Water Results

&

Benchmark Summary Table

Humboldt Mill
2017 Mine Permit Surface Water Monitoring
Benchmark Comparison Summary

Location	Location Classification	Q1	Q2	Q3	Q4
HMP-009	Compliance - HTDF subwatershed				*
MER-001	Reference - HTDF subwatershed		pH	**pH**, iron, total dissolved solids	**pH**, zinc
MER-002	Compliance - HTDF subwatershed	pH		boron, total dissolved solids	selenium
MER-003	Compliance - HTDF subwatershed	pH	fluoride, total suspended solids	pH, boron, nickel, sulfate	
WBR-001	Reference - Mill subwatershed				aluminum
WBR-002	Compliance - Mill subwatershed	pH, lead, nickel, alkalinity bicarbonate	copper, **lead, nickel,** total dissolved solids	pH, **lead, nickel**, **total dissolved solids**	**pH,** copper**, nickel**, selenium
WBR-003	Compliance - Mill subwatershed			pH, total dissolved solids, total suspended solids	**pH**, selenium

Parameters listed in this table had values reported that were equal to or greater than a site-specific benchmark. Parameters in **BOLD** are instances in which the Department was notified because benchmarks deviations were identified at compliance monitoring locations for two consecutive sampling events. If the location is classified as background, Department notification is not required for an exceedance.

* = Multiple parameters reported outside of benchmark values. Due to conditions during sampling event, the results are likely not representative of actual surface water quality for this location. See Section 7.1.2 of Annual Report for details.

2017
Mine Permit Surface Water Quality Monitoring Data
MER-001 (Reference)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017		Q2 2017 05/18/2017		Q3 2017 8/22/2017		Q4 2017 11/30/2017	
Field										
D.O.	ppm	-	**12**		**7.9**		**7.0**		**11**	
ORP	mV	-	**97**		**193**		**177**		**150**	
pH	SU	6.1-7.1	**6.7**		**6.0**		**7.2**		**6.0**	
Specific Conductance	uS/cm	-	**38**		**68**		**109**		**79**	
Temperature	C	-	**0.41**		**11**		**17**		**0.18**	
Turbidity	NTU	-	**7.3**		**1.8**		**7.4**		**2.1**	
Flow	cfs	-	NM		NM		NM		NM	
Metals										
Aluminum	ug/L	200 (p)	-		-		**50**		-	
Antimony	ug/L	0.73	-		-		< 1.0		-	
Arsenic	ug/L	3.4	< 1.0		< 1.0		**2.1**		< 1.0	
Barium	ug/L	12	-		-		**9.2**		-	
Beryllium	ug/L	0.73	-		-		< 1.0		-	
Boron	ug/L	15	-		-		< 10		-	
Cadmium	ug/L	0.10	-		-		< 0.2		**0.01**	
Chromium	ug/L	1.2	-		-		< 1.0		-	
Cobalt	ug/L	0.42	-		-		< 1.0		**0.13**	
Copper	ug/L	0.86	**0.55**		**0.70**		**0.42**		**0.53**	
Iron	ug/L	3255	**1700**		**920**		**3300**		**985**	
Lead	ug/L	0.35	**0.17**		**0.17**		**0.16**		**0.15**	
Lithium	ug/L	5.7	-		-		< 8.0		-	
Manganese	ug/L	226	**130**		**61**		**183**		**66**	
Mercury	ng/L	8.5	**4.5**		**5.1**		**2.8**		**3.1**	
Molybdenum	ug/L	1.0	-		-		< 1.0		-	
Nickel	ug/L	1.0	**0.62**		**0.71**		**0.77**		**0.53**	
Selenium	ug/L	0.19	-		-		< 1.0		**0.22**	
Silver	ug/L	0.12	-		-		< 0.2		-	
Thallium	ug/L	0.75	-		-		< 1.0		-	
Vanadium	ug/L	1.5	-		-		< 1.0		-	
Zinc	ug/L	2.6	**2.4**		**2.4**		**1.3**		**2.6**	
Major Anions										
Alkalinity, Bicarbonate	mg/L	50	**21**		**15**		**38**		**16**	
Alkalinity, Carbonate	mg/L	2.0	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	13	**4.2**		**5.7**		**10**		< 10	
Fluoride	mg/L	0.19	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Ammonia	mg/L	2.0 (P)	< 0.50		< 0.50		< 0.03		**0.03**	
Nitrogen, Nitrate	mg/L	0.34	< 0.50		< 0.50		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.36	< 0.50		< 0.50		< 0.10		< 0.10	
Sulfate	mg/L	10	< 1.0		< 1.0		< 1.0		< 5.0	
Sulfide	mg/L	3.2	< 5.0		< 5.0		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	15	**6.6**		**5.3**		**12**		**5.4**	
Magnesium	mg/L	4.1	**2.0**		**1.5**		**3.4**		**1.6**	
Potassium	mg/L	1.0	**0.68**		**0.54**		**0.83**		**0.52**	
Sodium	mg/L	6.9	**2.5**		**3.2**		**5.5**		**2.4**	
General										
Hardness	mg/L	56	**36**		**22**		**53**		**28**	
Total Dissolved Solids	mg/L	111	**82**		**86**		**132**		**54**	
Total Suspended Solids	mg/L	4.0	-		**4.3**		< 3.3		< 3.3	

2017
Mine Permit Surface Water Quality Monitoring Data
MER-002 (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017		Q2 2017 05/18/2017		Q3 2017 8/22/2017		Q4 2017 11/30/2017	
Field										
D.O.	ppm	-	**11**		**7.4**		**6.6**		**11**	
ORP	mV	-	**38**		**132**		**153**		**112**	
pH	SU	6.0-7.0	**7.1**		**6.4**		**6.9**		**6.2**	
Specific Conductance	uS/cm	-	**57**		**74**		**127**		**84**	
Temperature	C	-	**0.29**		**12**		**18**		**0.25**	
Turbidity	NTU	-	**8.3**		**1.8**		**6.7**		**2.3**	
Flow	cfs	-	**55.00**		**143.00**		**17.70**		**59.50**	
Metals										
Aluminum	ug/L	200 (p)	-		-		**52**		-	
Antimony	ug/L	0.72	-		-		< 1.0		-	
Arsenic	ug/L	5.1	**1.4**		< 1.0		**2.7**		< 1.0	
Barium	ug/L	20	-		-		**11**		-	
Beryllium	ug/L	0.73	-		-		< 1.0		-	
Boron	ug/L	14	-		-		**14**		-	
Cadmium	ug/L	0.09	-		-		< 0.20		**0.01**	
Chromium	ug/L	1.2	-		-		< 1.0		-	
Cobalt	ug/L	0.65	-		-		< 1.0		**0.18**	
Copper	ug/L	0.90	**0.49**		**0.67**		**0.39**		**0.50**	
Iron	ug/L	6440	**2400**		**1300**		**3420**		**1170**	
Lead	ug/L	0.37	**0.15**		**0.16**		**0.15**		**0.15**	
Lithium	ug/L	5.7	-		-		< 8.0		-	
Manganese	ug/L	560	**180**		**91**		**194**		**77**	
Mercury	ng/L	7.5	**4.0**		**4.8**		**2.8**		**3.6**	
Molybdenum	ug/L	0.73	-		-		< 1.0		-	
Nickel	ug/L	1.2	**1.0**		**0.73**		**1.1**		**0.54**	
Selenium	ug/L	0.19	-		-		< 1.0		**0.23**	
Silver	ug/L	0.12	-		-		< 0.20		-	
Thallium	ug/L	0.73	-		-		< 1.0		-	
Vanadium	ug/L	3.0	-		-		**1.1**		-	
Zinc	ug/L	3.0	**2.0**		**2.3**		**1.3**		**1.9**	
Major Anions										
Alkalinity, Bicarbonate	mg/L	53	**24**		**17**		**45**		**16**	
Alkalinity, Carbonate	mg/L	2.0	< 2.0		< 2.0		< 2.0		< 2.0	
Chloride	mg/L	16	**7.2**		**5.9**		**12**		< 10	
Fluoride	mg/L	0.19	< 0.10		< 0.10		< 0.10		< 0.10	
Nitrogen, Ammonia	mg/L	2.0 (P)	< 0.50		< 0.50		< 0.03		**0.03**	
Nitrogen, Nitrate	mg/L	0.40	< 0.50		< 0.50		< 0.10		< 0.10	
Nitrogen, Nitrite	mg/L	0.37	< 0.50		< 0.50		< 0.10		< 0.10	
Sulfate	mg/L	14	**7.9**		< 1.0		**13**		< 5.0	
Sulfide	mg/L	3.2	< 5.0		< 5.0		< 0.20		< 0.20	
Major Cations										
Calcium	mg/L	18	**9**		**5.5**		**15**		**6.1**	
Magnesium	mg/L	4.9	**2.7**		**1.7**		**4.4**		**1.8**	
Potassium	mg/L	1.2	**0.95**		**0.51**		**1.1**		**0.54**	
Sodium	mg/L	9.4	**4.4**		**3.6**		**7.8**		**3.1**	
General										
Hardness	mg/L	67	**36**		**22**		**57**		**24**	
Total Dissolved Solids	mg/L	125	**60**		**78**		**190**		**60**	
Total Suspended Solids	mg/L	12	-		**4.0**		< 3.3		< 3.3	

2017
Mine Permit Surface Water Quality Monitoring Data
MER-003 (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017	Q2 2017 05/18/2017	Q3 2017 8/22/2017	Q4 2017 11/30/2017
Field						
D.O.	ppm	-	**11**	**7.6**	**6.7**	**11**
ORP	mV	-	**38**	**155**	**166**	**86**
pH	SU	6.0-7.0	**7.2**	**6.8**	**7.0**	**6.3**
Specific Conductance	uS/cm	-	**59**	**85**	**127**	**97**
Temperature	C	-	**0.28**	**12**	**18**	**0.31**
Turbidity	NTU	-	**9.8**	**2.3**	**7.2**	**2.8**
Flow	cfs	-	NM	NM	**331.21**	**198.03**
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	0.70	-	-	< 1.0	-
Arsenic	ug/L	3.3	**1.5**	**1.2**	**2.6**	< 1.0
Barium	ug/L	15	-	-	**12**	-
Beryllium	ug/L	0.73	-	-	< 1.0	-
Boron	ug/L	15	-	-	**16**	-
Cadmium	ug/L	0.09	-	-	< 0.20	<0.02
Chromium	ug/L	0.85	-	-	< 1.0	-
Cobalt	ug/L	0.65	-	-	< 1.0	**0.20**
Copper	ug/L	0.92	**0.51**	**0.73**	**0.39**	**0.52**
Iron	ug/L	4268	**2500**	**1500**	**3050**	**1180**
Lead	ug/L	0.35	**0.16**	**0.19**	**0.13**	**1.1**
Lithium	ug/L	5.7	-	-	< 8.0	-
Manganese	ug/L	280	**200**	**110**	**182**	**83**
Mercury	ng/L	7.6	**4.0**	**4.7**	**2.7**	**3.5**
Molybdenum	ug/L	0.80	-	-	< 1.0	-
Nickel	ug/L	1.3	**1.2**	**0.89**	**1.6**	**0.69**
Selenium	ug/L	0.20	-	-	< 1.0	**0.22**
Silver	ug/L	0.12	-	-	< 0.20	-
Thallium	ug/L	0.70	-	-	< 1.0	-
Vanadium	ug/L	1.2	-	-	**1.1**	-
Zinc	ug/L	2.9	**2.2**	**2.5**	**1.3**	**2.0**
Major Anions						
Alkalinity, Bicarbonate	mg/L	56	**25**	**18**	**45**	**17**
Alkalinity, Carbonate	mg/L	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	19	**8.1**	**7.3**	**15**	< 10
Fluoride	mg/L	0.29	< 0.10	**0.37**	< 0.10	< 0.10
Nitrogen, Ammonia	mg/L	2.0 (P)	< 0.50	< 0.50	**0.03**	**0.05**
Nitrogen, Nitrate	mg/L	0.34	< 0.50	< 0.50	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.37	< 0.50	< 0.50	< 0.10	< 0.10
Sulfate	mg/L	16	**9.1**	< 1.0	**17**	**3.5**
Sulfide	mg/L	3.2	< 5.0	< 5.0	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	19	**9.0**	**5.9**	**14**	**6.2**
Magnesium	mg/L	5.3	**2.8**	**1.9**	**4.4**	**1.9**
Potassium	mg/L	1.4	**1.0**	**0.57**	**1.2**	**0.67**
Sodium	mg/L	11	**4.8**	**5.0**	**9.4**	**4.2**
General						
Hardness	mg/L	71	**36**	**22**	**63**	**12**
Total Dissolved Solids	mg/L	141	**68**	**54**	**114**	**114**
Total Suspended Solids	mg/L	3.1	-	**5.2**	< 3.3	< 3.3

2017
Mine Permit Surface Water Quality Monitoring Data
WBR-001 (Reference)
Humboldt Mill

Parameter	**Unit**	**Recommended Benchmark 2014**	**Q1 2017 02/21/2017**	**Q2 2017 05/18/2017**	**Q3 2017 (No Samples Collected)**	**Q4 2017 11/30/2017**
Field						
D.O.	ppm	-	**9.7**	**6.6**	NM	**9.3**
ORP	mV	-	**196**	**212**	NM	**222**
pH	SU	5.0-6.0	**5.3**	**5.1**	NM	**5.1**
Specific Conductance	uS/cm	-	**35**	**72**	NM	**82**
Temperature	C	-	**0.12**	**11**	NM	**0.55**
Turbidity	NTU	-	**4.2**	**0.30**	NM	**13**
Flow	cfs	-	**0.17**	NM	NM	NM
Metals						
Aluminum	ug/L	200 (p)	-	-	NM	**241**
Antimony	ug/L	0.70	-	-	NM	< 1.0
Arsenic	ug/L	8.7	**1.1**	< 1.0	NM	**1.1**
Barium	ug/L	26	-	-	NM	**9.5**
Beryllium	ug/L	0.73	-	-	NM	< 1.0
Boron	ug/L	12	-	-	NM	< 10
Cadmium	ug/L	0.06	-	-	NM	**0.04**
Chromium	ug/L	2.7	-	-	NM	< 1.0
Cobalt	ug/L	0.85	-	-	NM	**0.25**
Copper	ug/L	1.0	**0.77**	**0.83**	NM	**0.65**
Iron	ug/L	11056	**1300**	**1000**	NM	**1680**
Lead	ug/L	1.8	**0.80**	**0.75**	NM	**1.1**
Lithium	ug/L	8.6	-	-	NM	< 8.0
Manganese	ug/L	641	**97**	**45**	NM	**104**
Mercury	ng/L	17	**8.3**	**10**	NM	**10**
Molybdenum	ug/L	8.1	-	-	NM	< 1.0
Nickel	ug/L	1.9	**0.71**	**0.67**	NM	**0.80**
Selenium	ug/L	0.33	-	-	NM	**0.31**
Silver	ug/L	0.12	-	-	NM	< 0.20
Thallium	ug/L	0.70	-	-	NM	< 1.0
Vanadium	ug/L	4.2	-	-	NM	< 1.0
Zinc	ug/L	9.2	**5.5**	**5.3**	NM	**5.7**
Major Anions						
Alkalinity, Bicarbonate	mg/L	15	**5.1**	**3.8**	NM	**3.4**
Alkalinity, Carbonate	mg/L	2.0	< 2.0	< 2.0	NM	< 2.0
Chloride	mg/L	24	**10**	**13**	NM	**16**
Fluoride	mg/L	0.26	< 0.10	< 0.10	NM	< 0.10
Nitrogen, Ammonia	mg/L	0.78	< 0.50	< 0.50	NM	**0.04**
Nitrogen, Nitrate	mg/L	0.34	< 0.50	< 0.50	NM	0.12
Nitrogen, Nitrite	mg/L	0.37	< 0.50	< 0.50	NM	< 0.10
Sulfate	mg/L	9.3	< 120	< 25	NM	< 5.0
Sulfide	mg/L	3.2	< 5.0	< 5.0	NM	< 0.20
Major Cations						
Calcium	mg/L	8.3	**3.5**	**2.9**	NM	**4.2**
Magnesium	mg/L	3.3	**1.4**	**1.1**	NM	**1.6**
Potassium	mg/L	2.6	**0.91**	**0.69**	NM	**0.76**
Sodium	mg/L	11	**4.7**	**6.5**	NM	**7.1**
General						
Hardness	mg/L	38	**16**	**16**	NM	**18**
Total Dissolved Solids	mg/L	204	**60**	**167**	NM	**80**
Total Suspended Solids	mg/L	34	-	< 3.3	NM	< 3.3

2017
Mine Permit Surface Water Quality Monitoring Data
WBR-002 (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017	Q2 2017 05/18/2017	Q3 2017 8/22/2017	Q4 2017 11/30/2017
Field						
D.O.	ppm	-	**1.6**	**8.6**	**6.6**	**8.4**
ORP	mV	-	**116**	**134**	**158**	**205**
pH	SU	6.3-7.3	**6.2**	**6.6**	**7.4**	**5.9**
Specific Conductance	uS/cm	-	**141**	**167**	**172**	**165**
Temperature	C	-	**1.3**	**13**	**20**	**1.7**
Turbidity	NTU	-	**22**	**13**	**29**	**13**
Flow	cfs	-	NM	**2.7**	**8.2**	**1.7**
Metals						
Aluminum	ug/L	200 (p)	-	-	**90**	-
Antimony	ug/L	0.72	-	-	< 1.0	-
Arsenic	ug/L	10	**3.5**	**1.0**	**4.0**	**2.8**
Barium	ug/L	19	-	-	**8.7**	-
Beryllium	ug/L	0.73	-	-	< 1.0	-
Boron	ug/L	18	-	-	**17**	-
Cadmium	ug/L	0.09	-	-	< 0.20	<0.02
Chromium	ug/L	10	-	-	< 1.0	-
Cobalt	ug/L	0.80	-	-	< 1.0	**0.74**
Copper	ug/L	1.3	**1.2**	**1.4**	**0.99**	**1.5**
Iron	ug/L	15593	**7300**	**2300**	**9740**	**5340**
Lead	ug/L	0.25	**0.29**	**0.26**	**0.33**	**0.46**
Lithium	ug/L	5.6	-	-	< 8.0	-
Manganese	ug/L	1295	**890**	**95**	**278**	**337**
Mercury	ng/L	4.3	**2.7**	**2.8**	**1.9**	**4.1**
Molybdenum	ug/L	2.8	-	-	< 1.0	-
Nickel	ug/L	1.9	**2.7**	**1.9**	**2.0**	**1.9**
Selenium	ug/L	0.18	-	-	< 1.0	**0.49**
Silver	ug/L	0.12	-	-	< 0.20	-
Thallium	ug/L	0.72	-	-	< 1.0	-
Vanadium	ug/L	0.83	-	-	< 1.0	-
Zinc	ug/L	4.5	**2.9**	**1.7**	**1.8**	**4.2**
Major Anions						
Alkalinity, Bicarbonate	mg/L	41	**98**	**13**	**31**	**18**
Alkalinity, Carbonate	mg/L	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	56	**48**	**32**	**43**	**41**
Fluoride	mg/L	0.31	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Ammonia	mg/L	0.61	< 0.50	< 0.50	**0.03**	**0.09**
Nitrogen, Nitrate	mg/L	0.36	< 0.50	< 0.50	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.37	< 0.50	< 0.50	< 0.10	< 0.10
Sulfate	mg/L	10	< 1.0	< 1.0	< 1.0	< 5.0
Sulfide	mg/L	3.2	< 5.0	< 5.0	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	13	**10**	**4.7**	**9.0**	**7.5**
Magnesium	mg/L	5.8	**4.9**	**2.2**	**4.2**	**3.7**
Potassium	mg/L	2.7	**1.9**	**1.3**	**0.97**	**1.3**
Sodium	mg/L	28	**24**	**16**	**22**	**21**
General						
Hardness	mg/L	56	**40**	**22**	**43**	**30**
Total Dissolved Solids	mg/L	182	**126**	**198**	**197**	**104**
Total Suspended Solids	mg/L	9.8	-	**6.9**	**3.9**	**5.6**

2017
Mine Permit Surface Water Quality Monitoring Data
WBR-003 (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 02/21/2017	Q2 2017 05/18/2017	Q3 2017 8/22/2017	Q4 2017 11/30/2017
Field						
D.O.	ppm	-	**5.1**	**3.7**	**5.6**	**5.0**
ORP	mV	-	**22**	**117**	**69**	**176**
pH	SU	6.1-7.1	**6.7**	**6.2**	**7.5**	**6.0**
Specific Conductance	uS/m	-	**102**	**135**	**175**	**141**
Temperature	C	-	**0.18**	**11**	**18**	**0.15**
Turbidity	NTU	-	**19**	**6.6**	**39**	**8.8**
Flow	cfs	-	NM	NM	NM	NM
Metals						
Aluminum	ug/L	200 (p)	-	-	< 50	-
Antimony	ug/L	0.70	-	-	< 1.0	-
Arsenic	ug/L	4.4	**2.8**	**1.4**	**4.2**	**1.9**
Barium	ug/L	19	-	-	**18**	-
Beryllium	ug/L	0.70	-	-	< 1.0	-
Boron	ug/L	19	-	-	**13**	-
Cadmium	ug/L	0.09	-	-	< 0.20	<0.02
Chromium	ug/L	0.74	-	-	< 1.0	-
Cobalt	ug/L	1.2	-	-	< 1.0	**0.21**
Copper	ug/L	1.0	**0.54**	**0.67**	**0.50**	**0.72**
Iron	ug/L	11315	**9300**	**3100**	**10200**	**3820**
Lead	ug/L	0.44	**0.17**	**0.17**	**0.10**	**0.21**
Lithium	ug/L	5.5	-	-	< 8.0	-
Manganese	ug/L	2101	**790**	**130**	**1090**	**115**
Mercury	ng/L	6.0	**2.8**	**2.9**	**3.1**	**2.4**
Molybdenum	ug/L	1.9	-	-	< 1.0	-
Nickel	ug/L	1.8	**1.4**	**1.1**	**1.7**	**1.2**
Selenium	ug/L	0.19	-	-	< 1.0	**0.25**
Silver	ug/L	0.12	-	-	< 0.20	-
Thallium	ug/L	0.72	-	-	< 1.0	-
Vanadium	ug/L	0.82	-	-	< 1.0	-
Zinc	ug/L	10	**3.3**	**1.9**	**2.2**	**3.4**
Major Anions						
Alkalinity, Bicarbonate	mg/L	56	**28**	**17**	**49**	**19**
Alkalinity, Carbonate	mg/L	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Chloride	mg/L	43	**31**	**20**	**33**	**32**
Fluoride	mg/L	0.34	< 0.10	< 0.10	< 0.10	< 0.10
Nitrogen, Ammonia	mg/L	2.0 (P)	< 0.50	< 0.50	**0.08**	**0.07**
Nitrogen, Nitrate	mg/L	0.30	< 0.50	< 0.50	< 0.10	< 0.10
Nitrogen, Nitrite	mg/L	0.37	< 0.50	< 0.50	< 0.10	< 0.10
Sulfate	mg/L	14	< 1.0	< 1.0	< 1.0	< 1.0
Sulfide	mg/L	3.2	< 5.0	< 5.0	< 0.20	< 0.20
Major Cations						
Calcium	mg/L	16	**9.0**	**5.3**	**12**	**6.9**
Magnesium	mg/L	6.6	**4.1**	**2.6**	**5.0**	**3.3**
Potassium	mg/L	2.0	**1.9**	**1.2**	**1.9**	**1.1**
Sodium	mg/L	21	**15**	**12**	**16**	**16**
General						
Hardness	mg/L	69	**40**	**24**	**57**	**30**
Total Dissolved Solids	mg/L	184	**144**	**104**	**307**	**92**
Total Suspended Solids	mg/L	15	-	**5.0**	**18**	**8.4**

2017
Mine Permit Surface Water Quality Monitoring Data
HMWQ-004 (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 (No Samples Collected)		Q2 2017 (No Samples Collected)		Q3 2017 (No Samples Collected)		Q4 2017 (No Samples Collected)	
Field										
D.O.	ppm	-	NM		NM		NM		NM	
ORP	mV	-	NM		NM		NM		NM	
pH	SU	5.7-6.7	NM		NM		NM		NM	
Specific Conductance	uS/m	-	NM		NM		NM		NM	
Temperature	C	-	NM		NM		NM		NM	
Turbidity	NTU	-	NM		NM		NM		NM	
Flow	cfs	-	NM		NM		NM		NM	
Metals										
Aluminum	ug/L	200 (p)	NM		NM		NM		NM	
Antimony	ug/L	2.3	NM		NM		NM		NM	
Arsenic	ug/L	35	NM		NM		NM		NM	
Barium	ug/L	118	NM		NM		NM		NM	
Beryllium	ug/L	4.0 (p)	NM		NM		NM		NM	
Boron	ug/L	36	NM		NM		NM		NM	
Cadmium	ug/L	0.10	NM		NM		NM		NM	
Chromium	ug/L	14	NM		NM		NM		NM	
Cobalt	ug/L	3.0	NM		NM		NM		NM	
Copper	ug/L	11	NM		NM		NM		NM	
Iron	ug/L	73,409	NM		NM		NM		NM	
Lead	ug/L	2.1	NM		NM		NM		NM	
Lithium	ug/L	16	NM		NM		NM		NM	
Manganese	ug/L	2541	NM		NM		NM		NM	
Mercury	ng/L	43	NM		NM		NM		NM	
Molybdenum	ug/L	4.7	NM		NM		NM		NM	
Nickel	ug/L	5.6	NM		NM		NM		NM	
Selenium	ug/L	0.44	NM		NM		NM		NM	
Silver	ug/L	0.35	NM		NM		NM		NM	
Thallium	ug/L	4.0 (p)	NM		NM		NM		NM	
Vanadium	ug/L	39	NM		NM		NM		NM	
Zinc	ug/L	44	NM		NM		NM		NM	
Major Anions										
Alkalinity, Bicarbonate	mg/L	68	NM		NM		NM		NM	
Alkalinity, Carbonate	mg/L	8.0 (p)	NM		NM		NM		NM	
Chloride	mg/L	68	NM		NM		NM		NM	
Fluoride	mg/L	0.23	NM		NM		NM		NM	
Nitrogen, Ammonia	mg/L	1.9	NM		NM		NM		NM	
Nitrogen, Nitrate	mg/L	2.0 (p)	NM		NM		NM		NM	
Nitrogen, Nitrite	mg/L	2.0 (p)	NM		NM		NM		NM	
Sulfate	mg/L	4.0 (p)	NM		NM		NM		NM	
Sulfide	mg/L	20 (p)	NM		NM		NM		NM	
Major Cations										
Calcium	mg/L	21	NM		NM		NM		NM	
Magnesium	mg/L	8.1	NM		NM		NM		NM	
Potassium	mg/L	3.3	NM		NM		NM		NM	
Sodium	mg/L	49	NM		NM		NM		NM	
General										
Hardness	mg/L	88	NM		NM		NM		NM	
Total Dissolved Solids	mg/L	209	NM		NM		NM		NM	
Total Suspended Solids	mg/L	353	NM		NM		NM		NM	

2017
Mine Permit Surface Water Quality Monitoring Data
HMP-009 (Compliance)
Humboldt Mill

Parameter	Unit	Recommended Benchmark 2014	Q1 2017 (No Samples Collected)		Q2 2017 (No Samples Collected)		Q3 2017 (No Samples Collected)		Q4 2017 12/04/2017	
Field										
D.O.	ppm	-	NM		NM		NM		**9.0**	
ORP	mV	-	NM		NM		NM		**175**	
pH	SU	7.0-8.0	NM		NM		NM		**7.0**	
Specific Conductance	uS/m	-	NM		NM		NM		**309**	
Temperature	C	-	NM		NM		NM		**5.2**	
Turbidity	NTU	-	NM		NM		NM		**2.7**	
Flow	cfs	-	NM		NM		NM		NM	
Metals										
Aluminum	ug/L	200 (p)	NM		NM		NM		**790**	
Antimony	ug/L	12	NM		NM		NM		**6.7**	
Arsenic	ug/L	2.2	NM		NM		NM		**4.1**	
Barium	ug/L	27	NM		NM		NM		**37**	
Beryllium	ug/L	0.67	NM		NM		NM		< 1.0	
Boron	ug/L	113	NM		NM		NM		**68**	
Cadmium	ug/L	0.10	NM		NM		NM		**0.04**	
Chromium	ug/L	1.3	NM		NM		NM		**2.4**	
Cobalt	ug/L	3.0	NM		NM		NM		**3.1**	
Copper	ug/L	7.9	NM		NM		NM		**8.7**	
Iron	ug/L	1620	NM		NM		NM		**163000**	
Lead	ug/L	1.0	NM		NM		NM		**1.8**	
Lithium	ug/L	5.3	NM		NM		NM		< 8.0	
Manganese	ug/L	337	NM		NM		NM		**98**	
Mercury	ng/L	1.1	NM		NM		NM		**87**	
Molybdenum	ug/L	13	NM		NM		NM		**8.3**	
Nickel	ug/L	17	NM		NM		NM		**20**	
Selenium	ug/L	0.36	NM		NM		NM		**2.9**	
Silver	ug/L	0.12	NM		NM		NM		< 0.20	
Thallium	ug/L	0.68	NM		NM		NM		< 1.0	
Vanadium	ug/L	1.7	NM		NM		NM		**3.3**	
Zinc	ug/L	6.1	NM		NM		NM		**7.6**	
Major Anions										
Alkalinity, Bicarbonate	mg/L	124	NM		NM		NM		**53**	
Alkalinity, Carbonate	mg/L	2.0	NM		NM		NM		< 2.0	
Chloride	mg/L	15	NM		NM		NM		**32**	
Fluoride	mg/L	0.41	NM		NM		NM		**0.10**	
Nitrogen, Ammonia	mg/L	2.0 (P)	NM		NM		NM		**62**	
Nitrogen, Nitrate	mg/L	2.5	NM		NM		NM		**126**	
Nitrogen, Nitrite	mg/L	0.34	NM		NM		NM		< 100	
Sulfate	mg/L	138	NM		NM		NM		**178**	
Sulfide	mg/L	3.0	NM		NM		NM		< 0.20	
Major Cations										
Calcium	mg/L	68	NM		NM		NM		**33**	
Magnesium	mg/L	26	NM		NM		NM		**15**	
Potassium	mg/L	9.4	NM		NM		NM		**7.9**	
Sodium	mg/L	15	NM		NM		NM		**40**	
General										
Hardness	mg/L	251	NM		NM		NM		**138**	
Total Dissolved Solids	mg/L	361	NM		NM		NM		**630**	
Total Suspended Solids	mg/L	13	NM		NM		NM		**464**	

2017
Mine Permit Surface Water Quality Monitoring Data Abbreviations & Data Qualifiers
Humboldt Mill

Notes:
Benchmarks are calculated based on guidance from Eagles Mine's Development of Site Specific Benchmarks for Mine Permit Water Quality Monitoring.
Results in **bold** text indicate that the parameter was detected at a level greater than the laboratory reporting limit.
Highlighted Cell = Value is equal to or above site-specific benchmark. An exceedance occurs if there are 2 consecutive sampling events with a value equal to or greater than the benchmark at a compliance monitoring location.
(p) = Due to less than two detections in baseline dataset, benchmark defaulted to four times the reporting limit.
--Denotes no benchmark required or parameter was not required to be collected during the sampling quarter.
NM = Not measured during the sampling event.

Appendix K

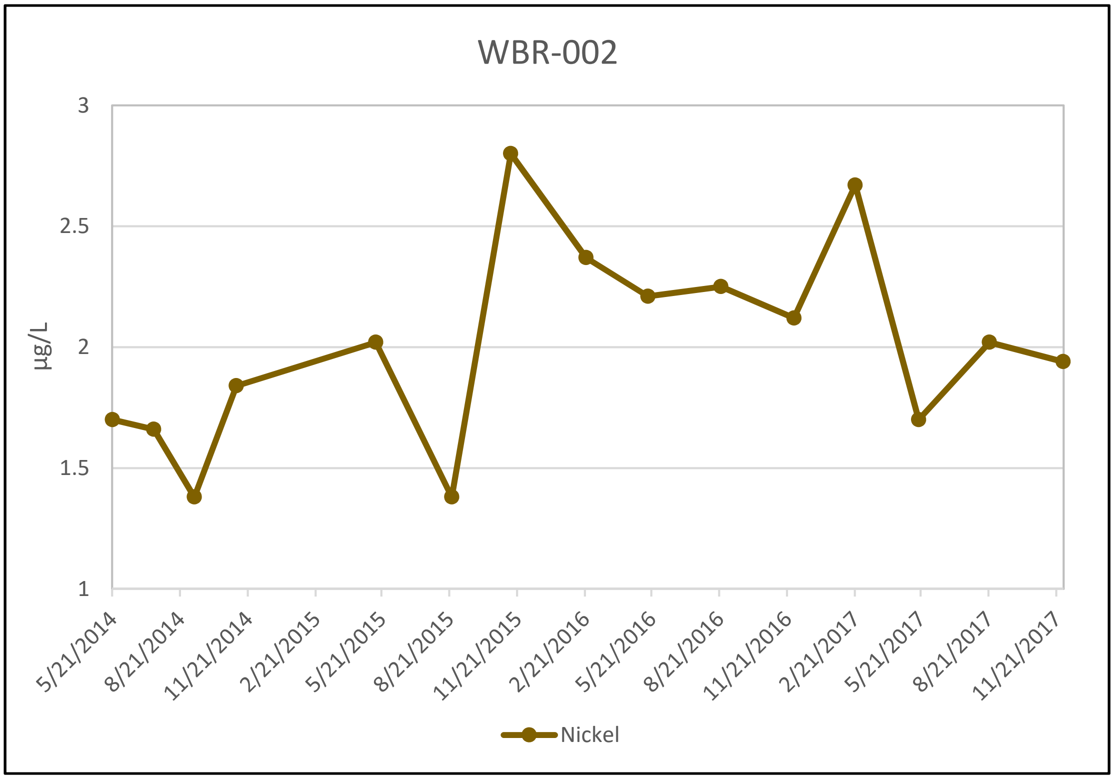
Humboldt Mill

Surface Water Trend Analysis Summary

2017
Surface Water Trend Analysis Summary
Humboldt Mill

Location	Classification	Parameter	Unit	Count (n)	Number of Non-Detects	Mean	UCL	Median	Standard Deviation	Coefficient of Variation	Skewness	Minimum	Maximum	Mann-Kendall S	Sen Slope	Positive or Negative Trend (Minimum 95% Confidence)
WBR-001	Reference	Calcium	mg/L	15	0	4.6	5.041	4.4	1.1	0.24	0.816	2.9	7.1	-42	-0.150	Negative
WBR-001	Reference	Chloride	mg/L	15	0	17.46	19.2	18.00	3.84	0.22	-0.407	10.00	23.00	-48	-0.6000	Negative
WBR-001	Reference	Magnesium	mg/L	15	0	1.8	2.018	1.8	0.44	0.24	0.529	1.10	2.8	-40	-0.05	Negative
WBR-001	Reference	Sodium	mg/L	15	0	7.95	8.735	8.00	1.72	0.22	10.23	4.70	11.00	-41	-0.2000	Negative
WBR-002	Compliance	Nickel	µg/L	23	0	1.932	1.315	1.94	0.408	0.211	2.64	1.3	2.8	74	0.0292	Positive

2017
Surface Water Trend Analysis Summary Charts
Humboldt Mill

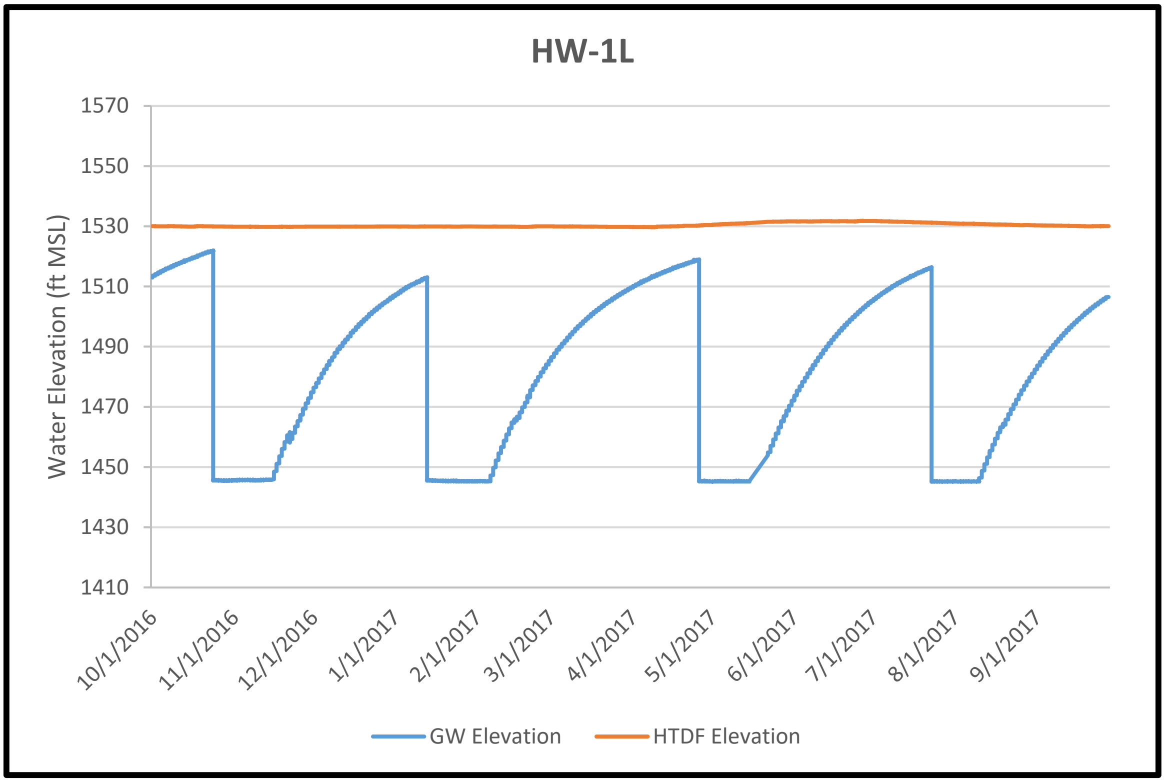


Appendix L

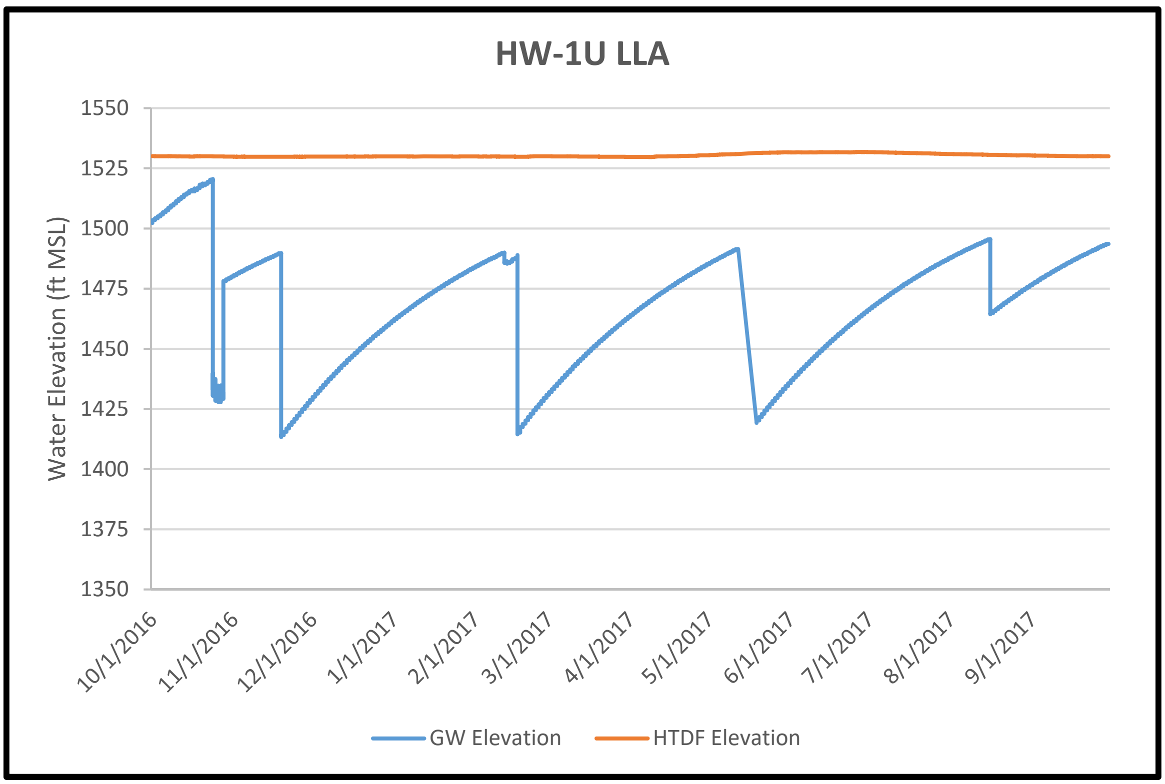
Humboldt Mill

Groundwater Hydrographs

2017 Groundwater Hydrographs
Humboldt Mill

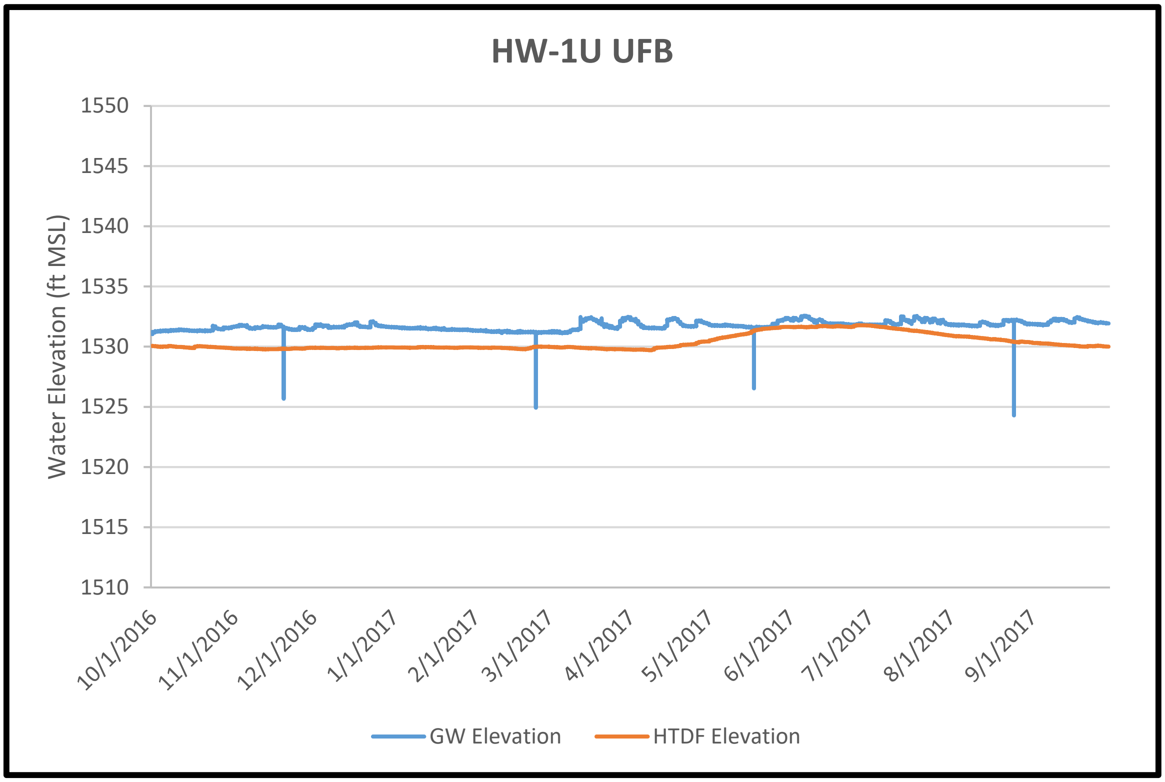


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

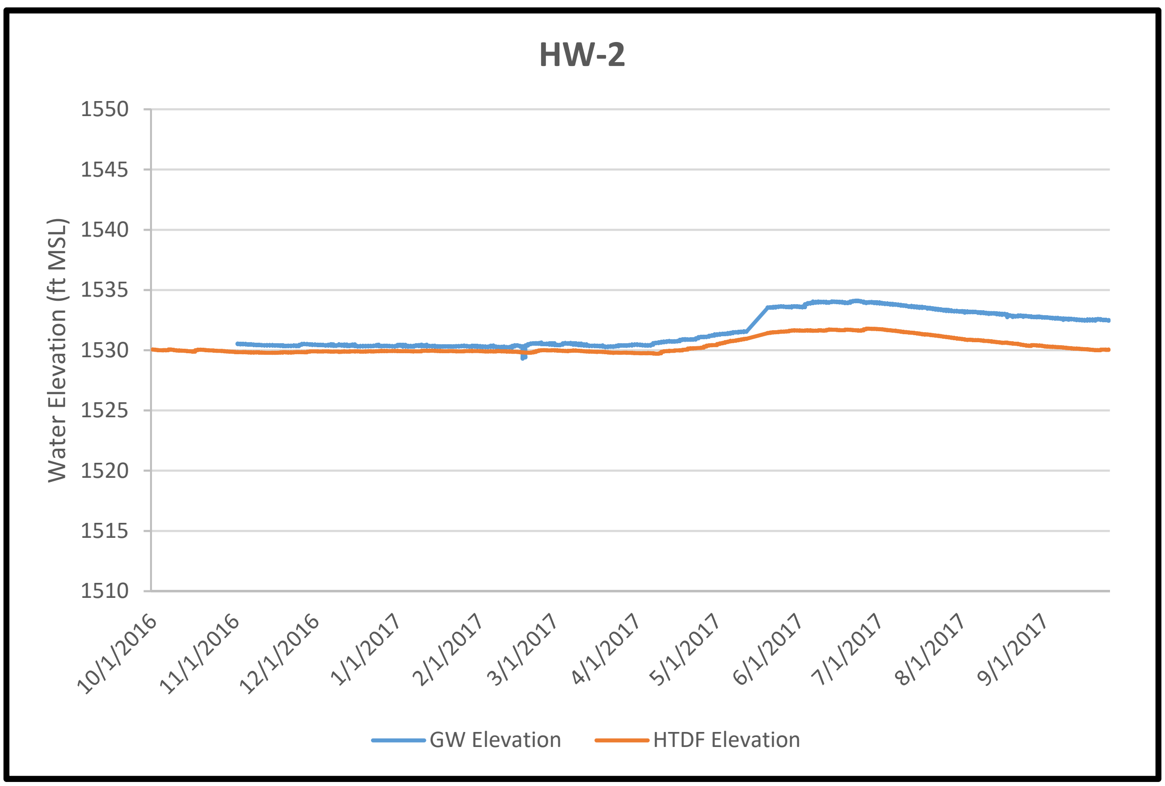


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

2017 Groundwater Hydrographs
Humboldt Mill

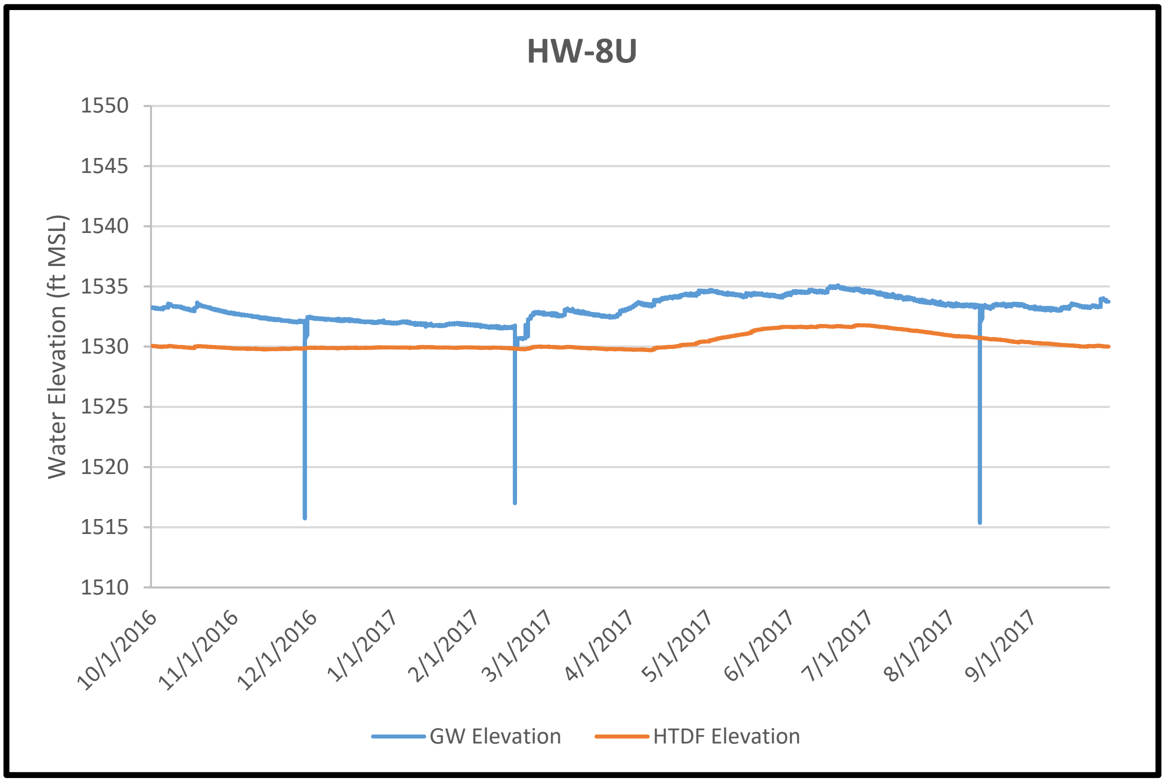


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

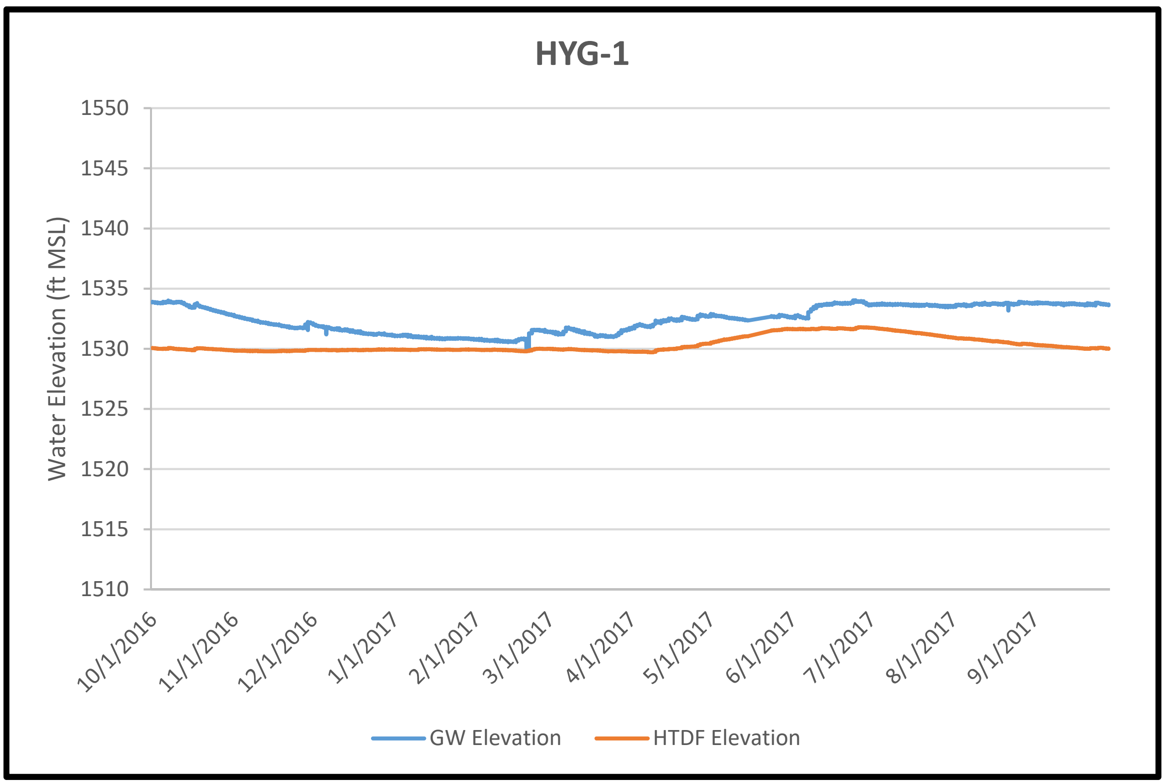


Note: Data from 10-01-2016 through 11-01-2016 was not recorded due to equipment malfunction.

2017 Groundwater Hydrographs
Humboldt Mill

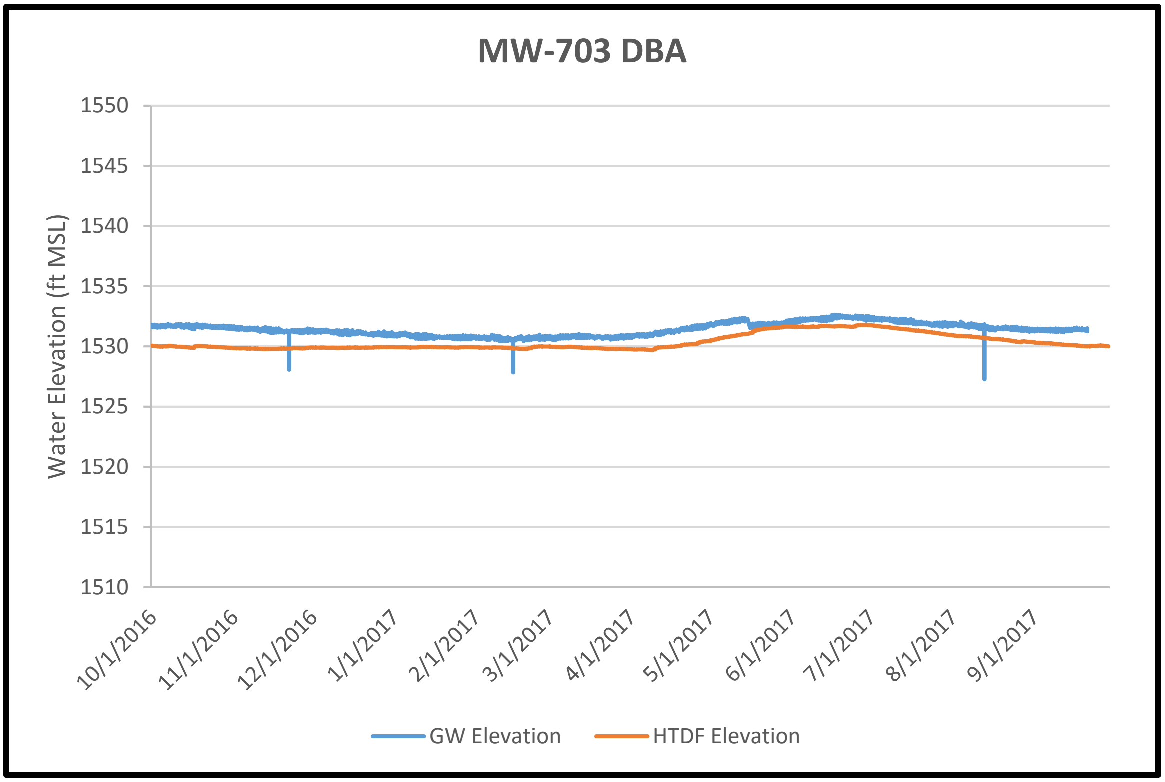


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

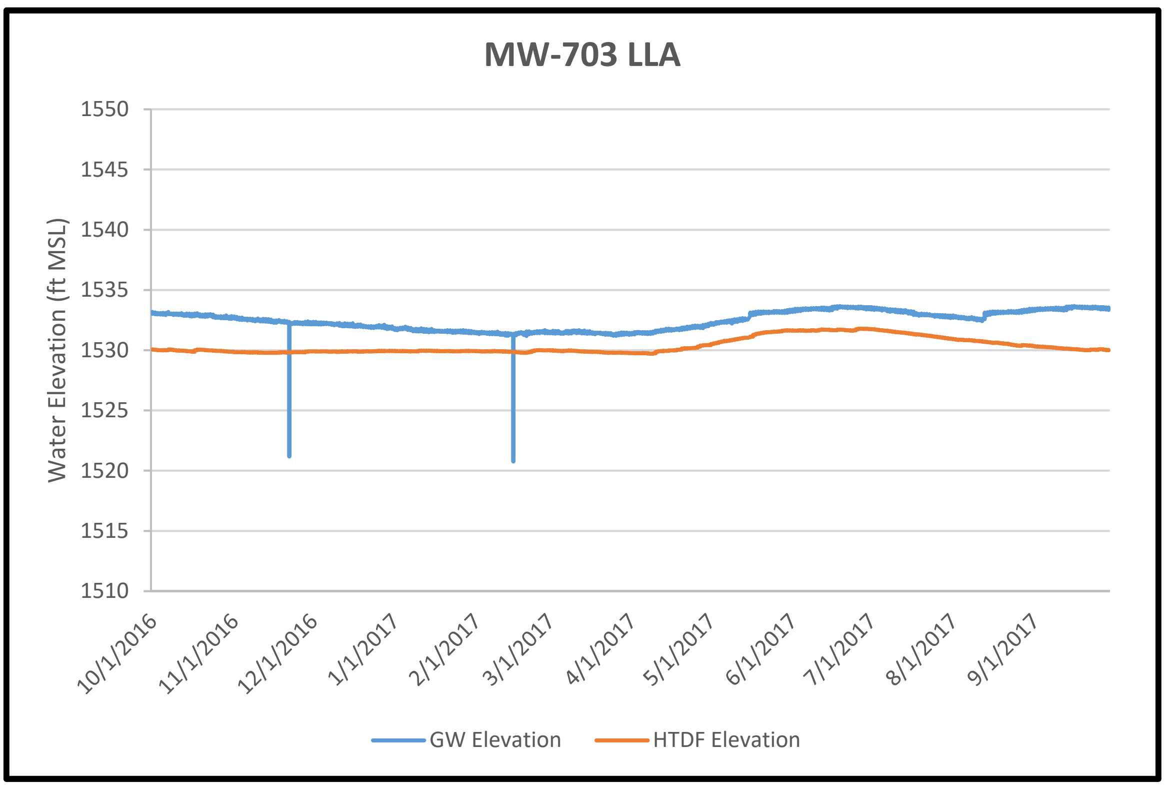


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

2017 Groundwater Hydrographs
Humboldt Mill

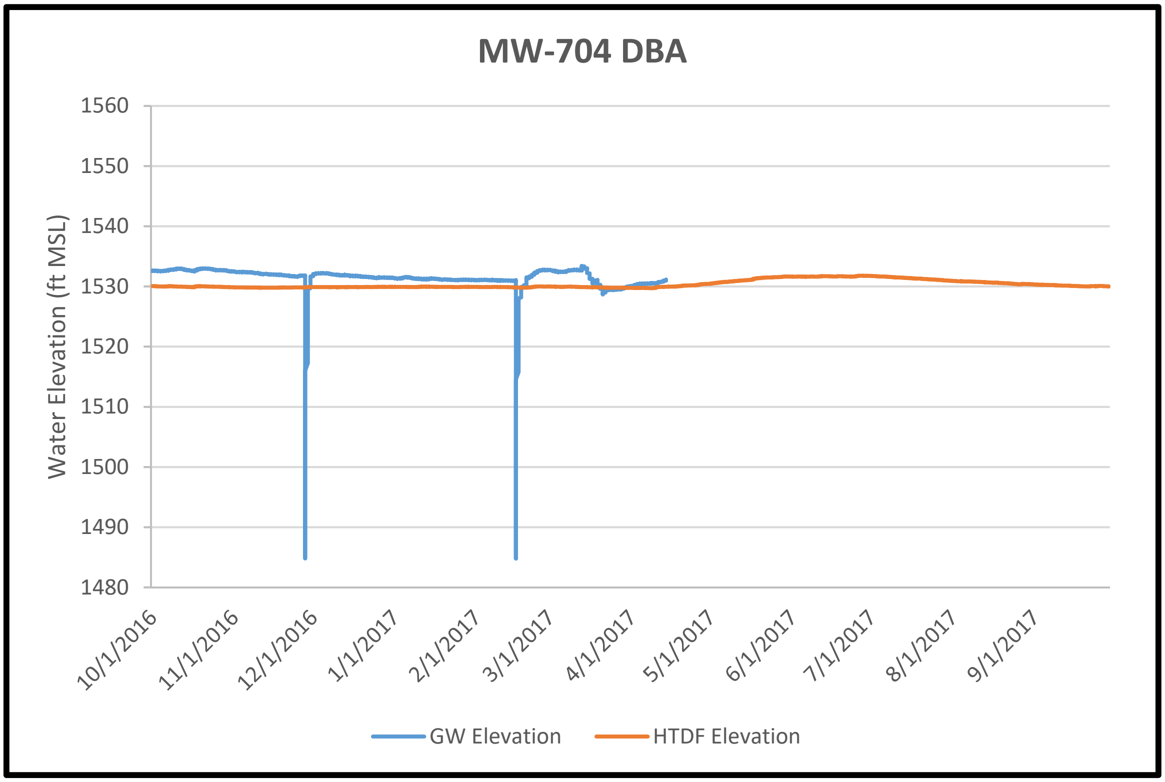


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

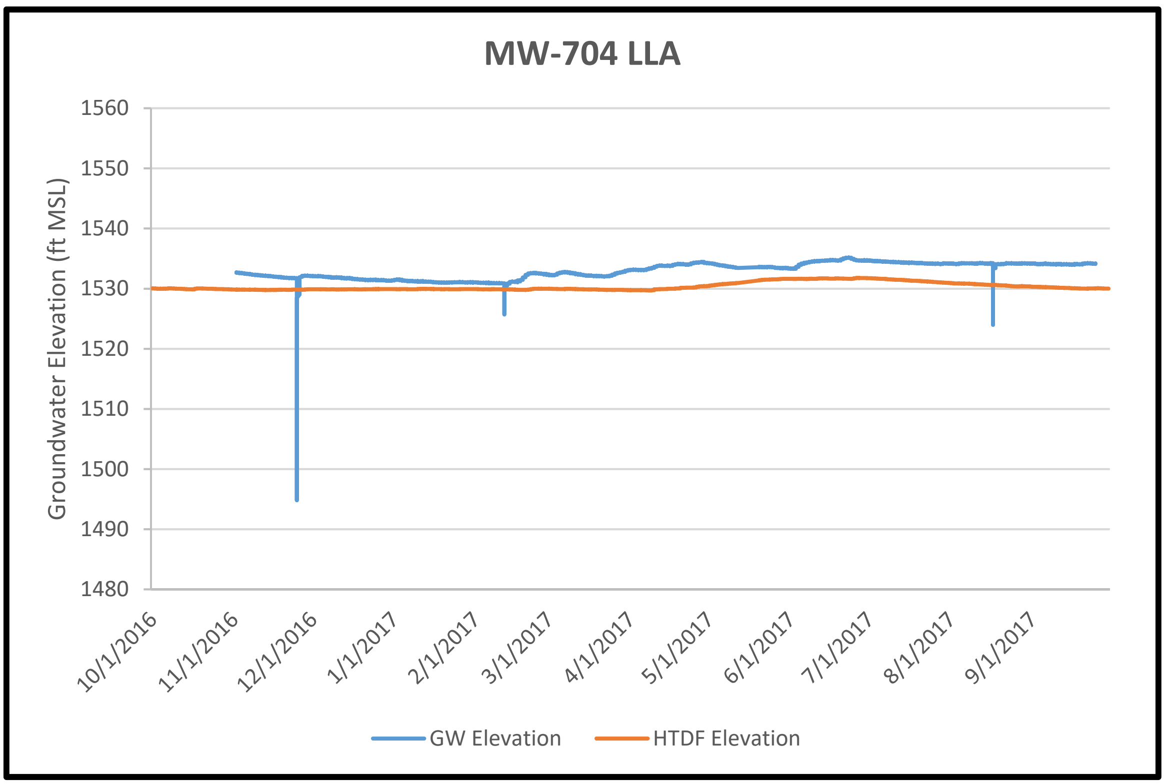


Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

2017 Groundwater Hydrographs
Humboldt Mill

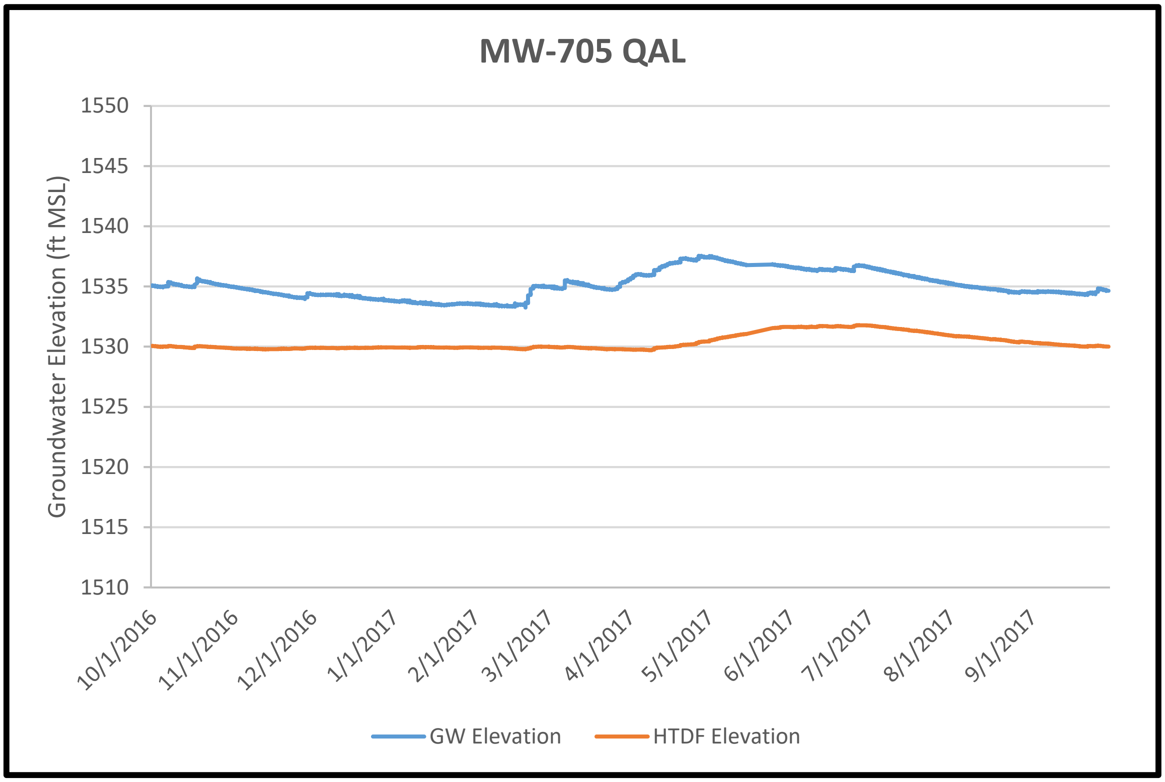


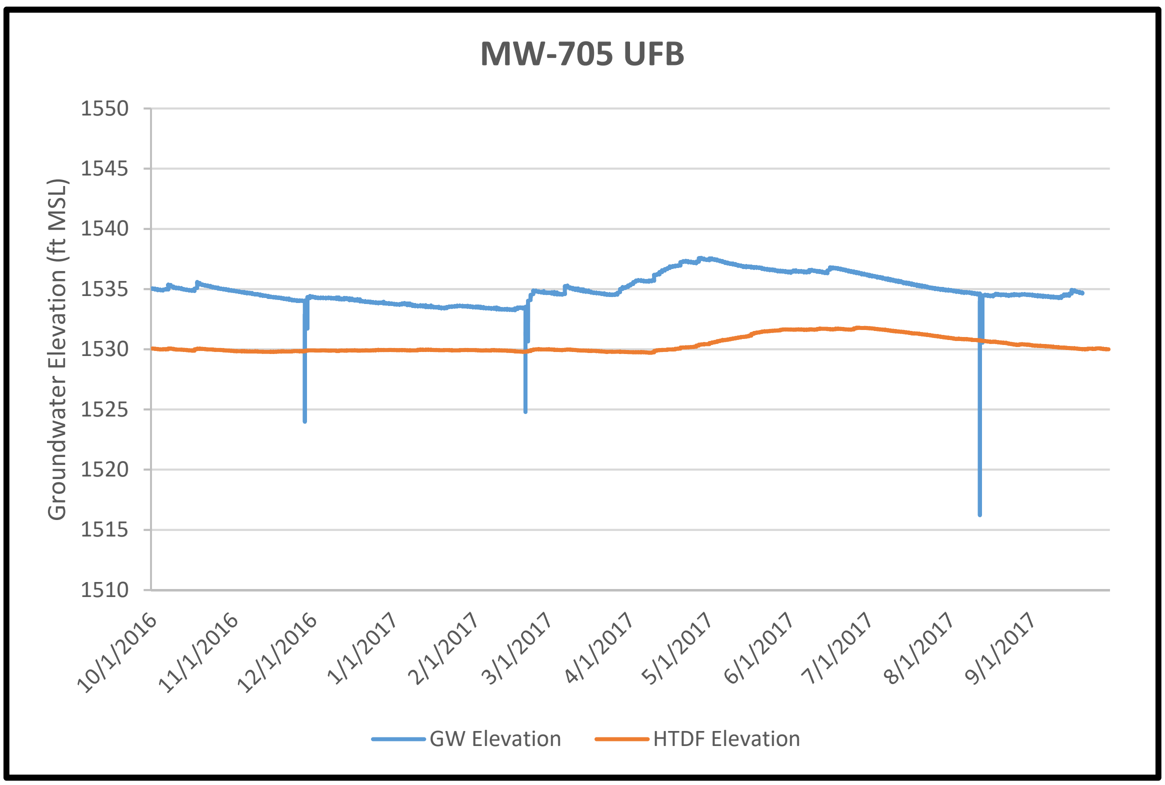
Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.
Note: Data from 04-15-2017 through 09-30-2017 was not recorded due to equipment malfunction.



Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.
Note: Data from 10-01-2016 through 11-01-2016 was not recorded due to equipment malfunction.

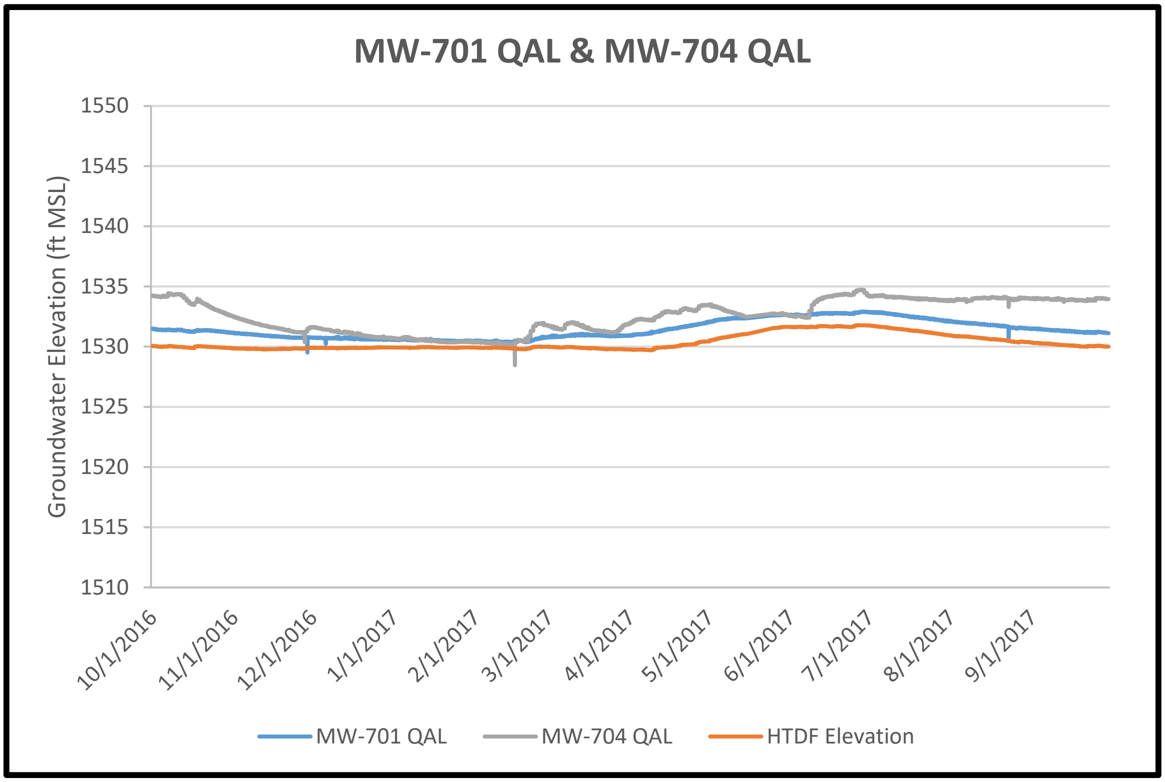
2017 Groundwater Hydrographs
Humboldt Mill

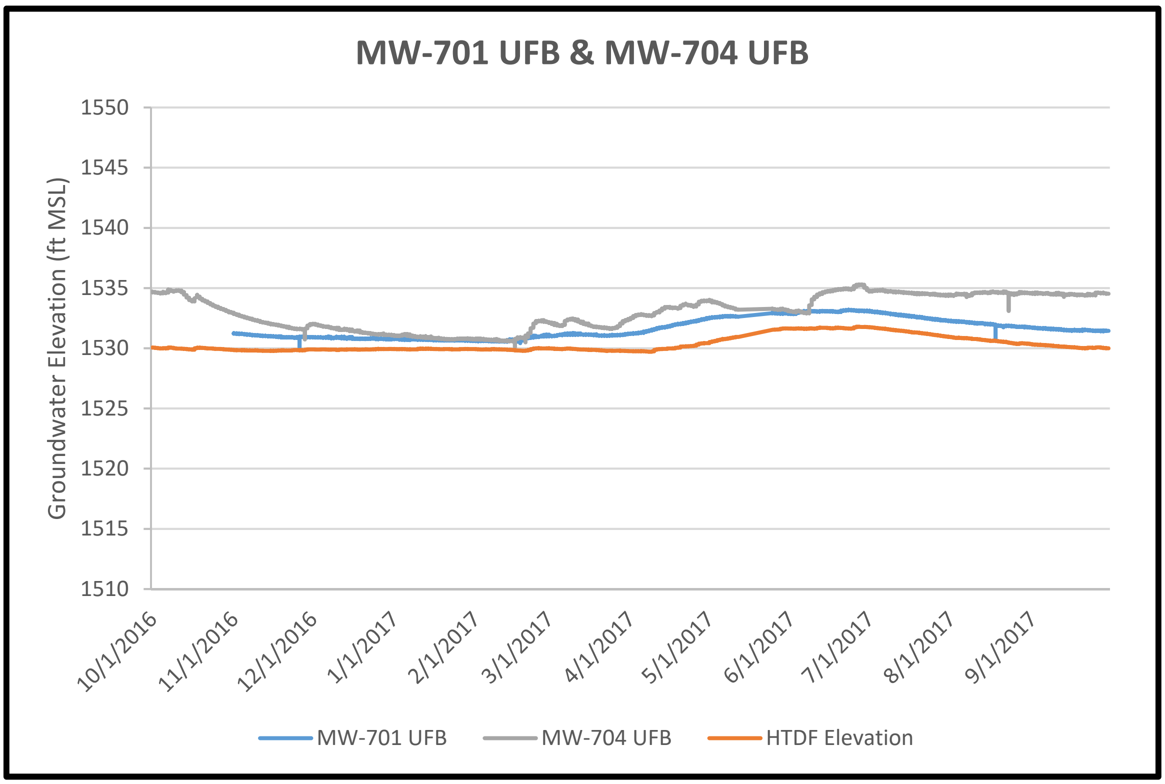




Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.

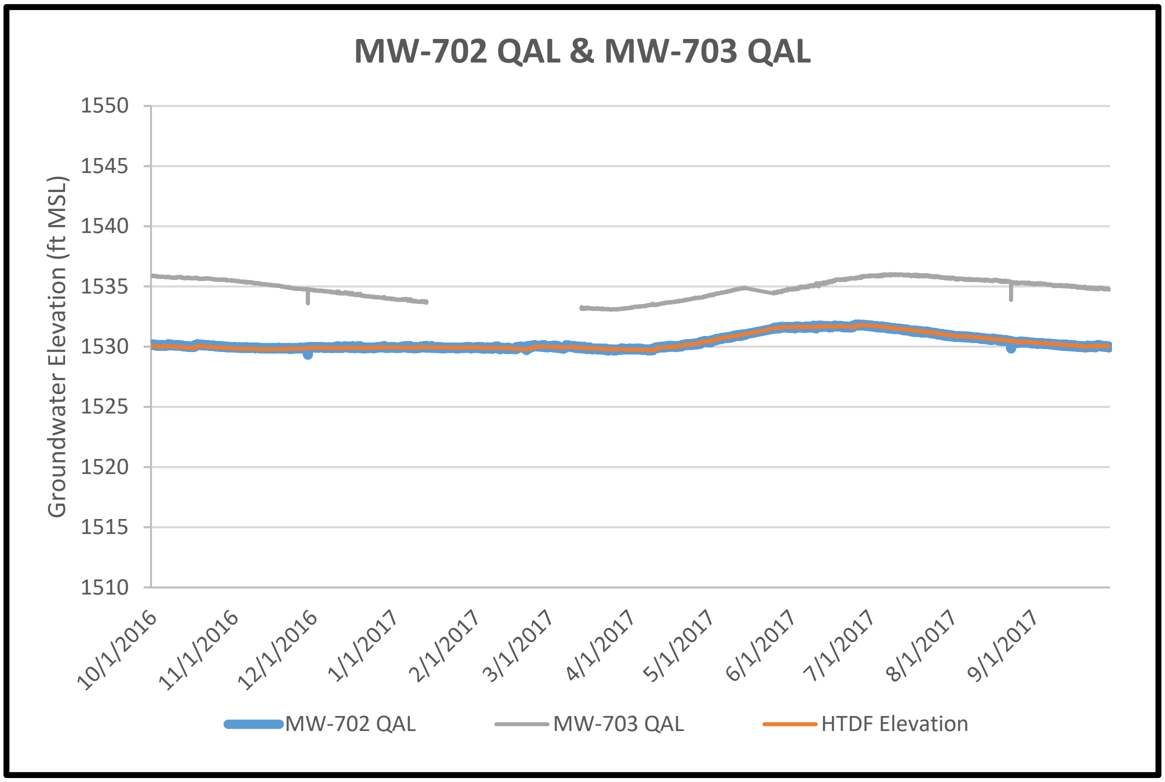
2017 Groundwater Hydrographs
Humboldt Mill



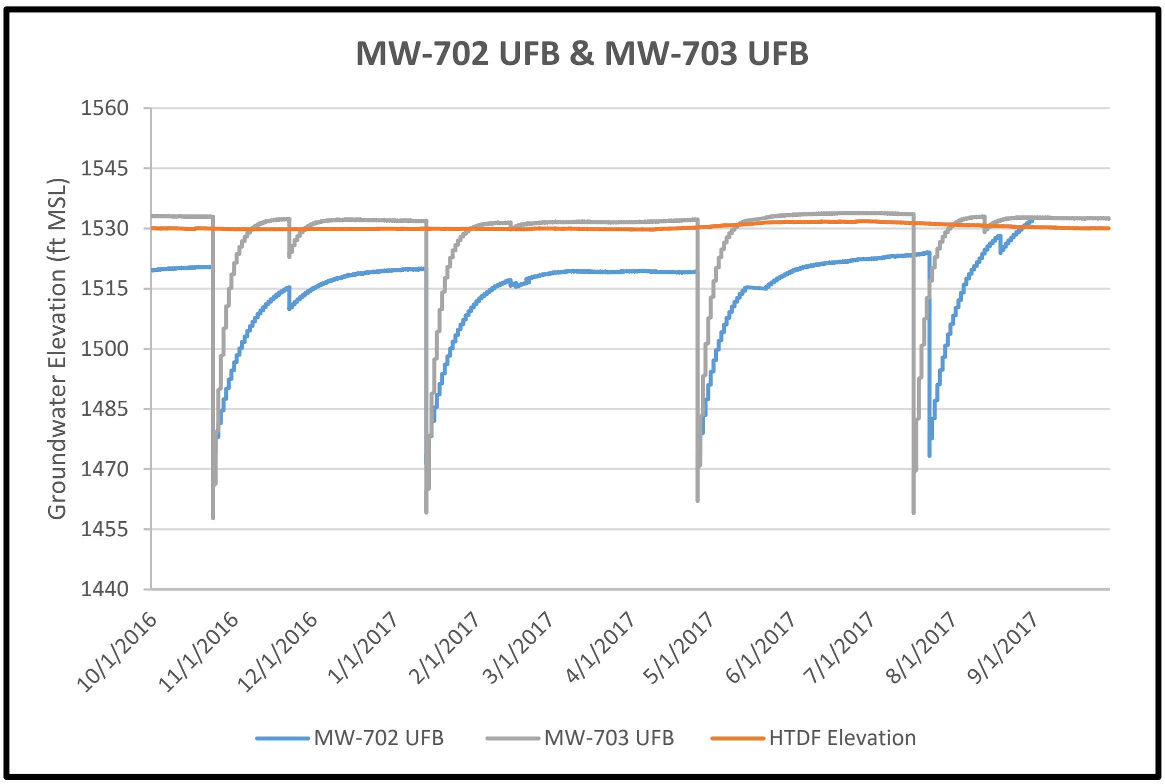


Note: Data from 10-01-2016 through 11-01-2016 was not recorded due to equipment malfunction.

2017 Groundwater Hydrographs
Humboldt Mill



Note: Data from 01-13-2017 through 03-13-2017 was not recorded due to equipment malfunction.



Note: The large drops in water level are associated with the location being pumped down in preparation of sampling.
Note: Data beyond 09-01-2017 was not recorded for MW-702 UFB due to equipment malfunction.

Appendix M

Humboldt Mill

Flora & Fauna Survey Location Maps

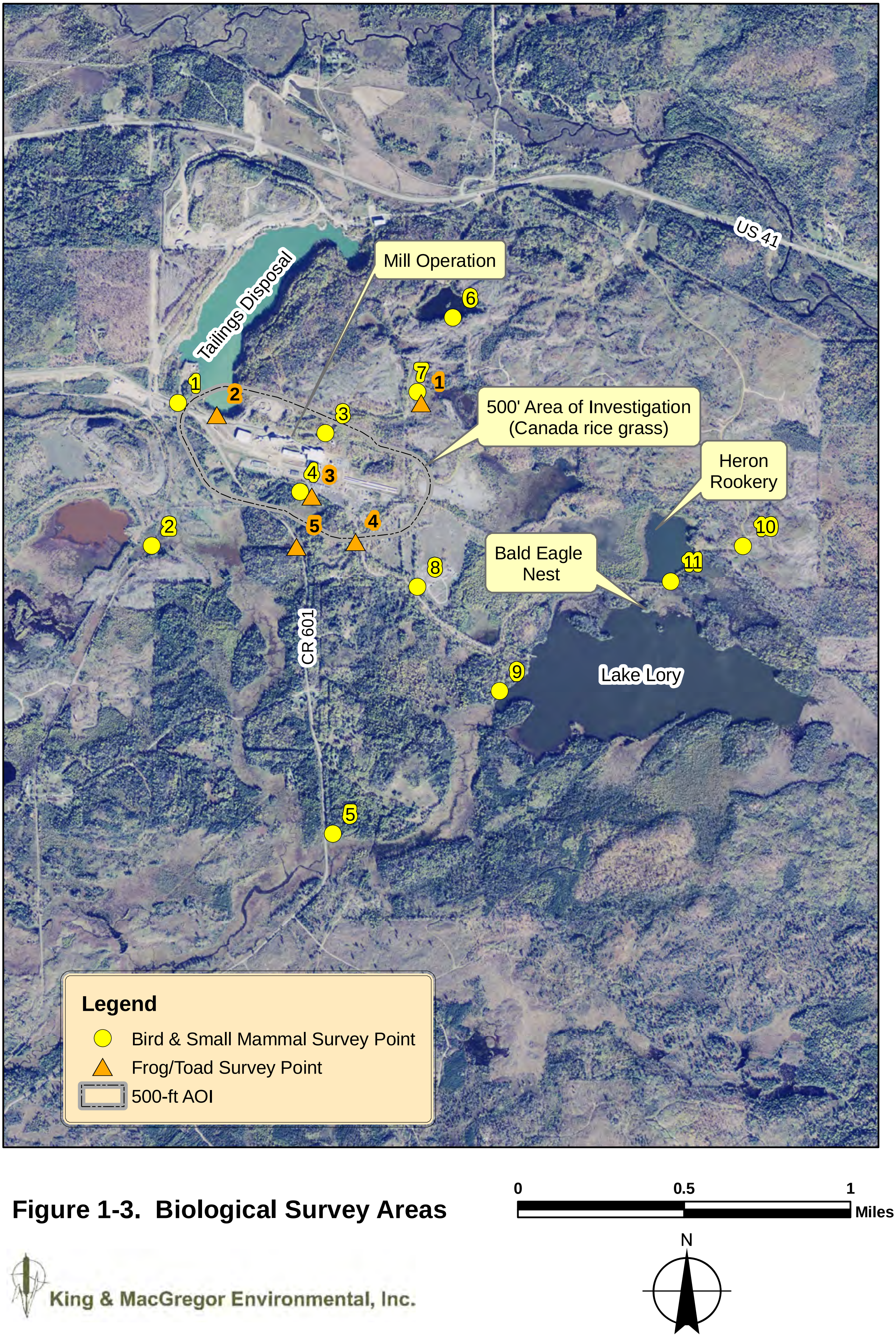


Figure 1-3. Biological Survey Areas

King & MacGregor Environmental, Inc.

Appendix N

Humboldt Mill

Aquatic Survey Location Maps

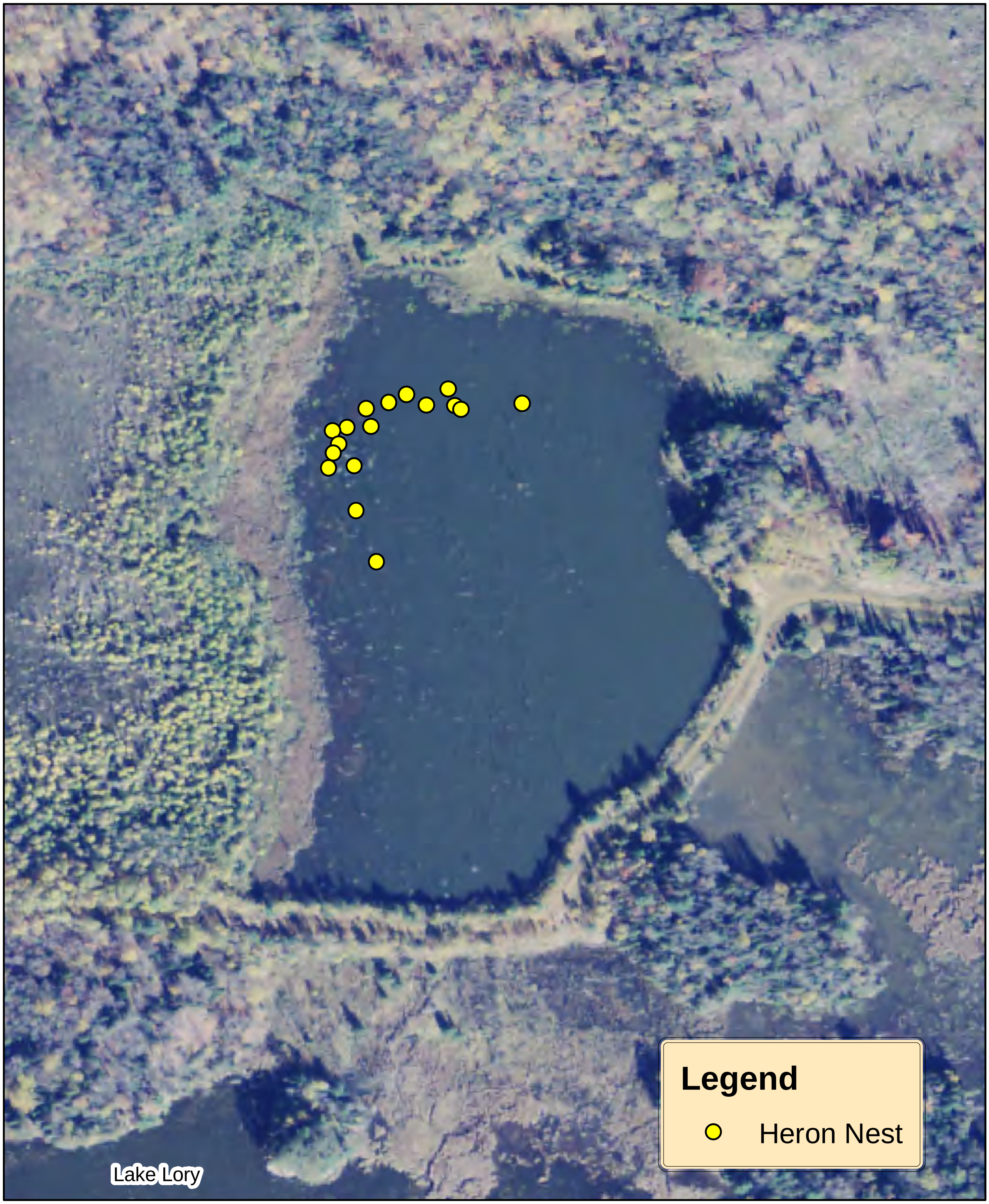
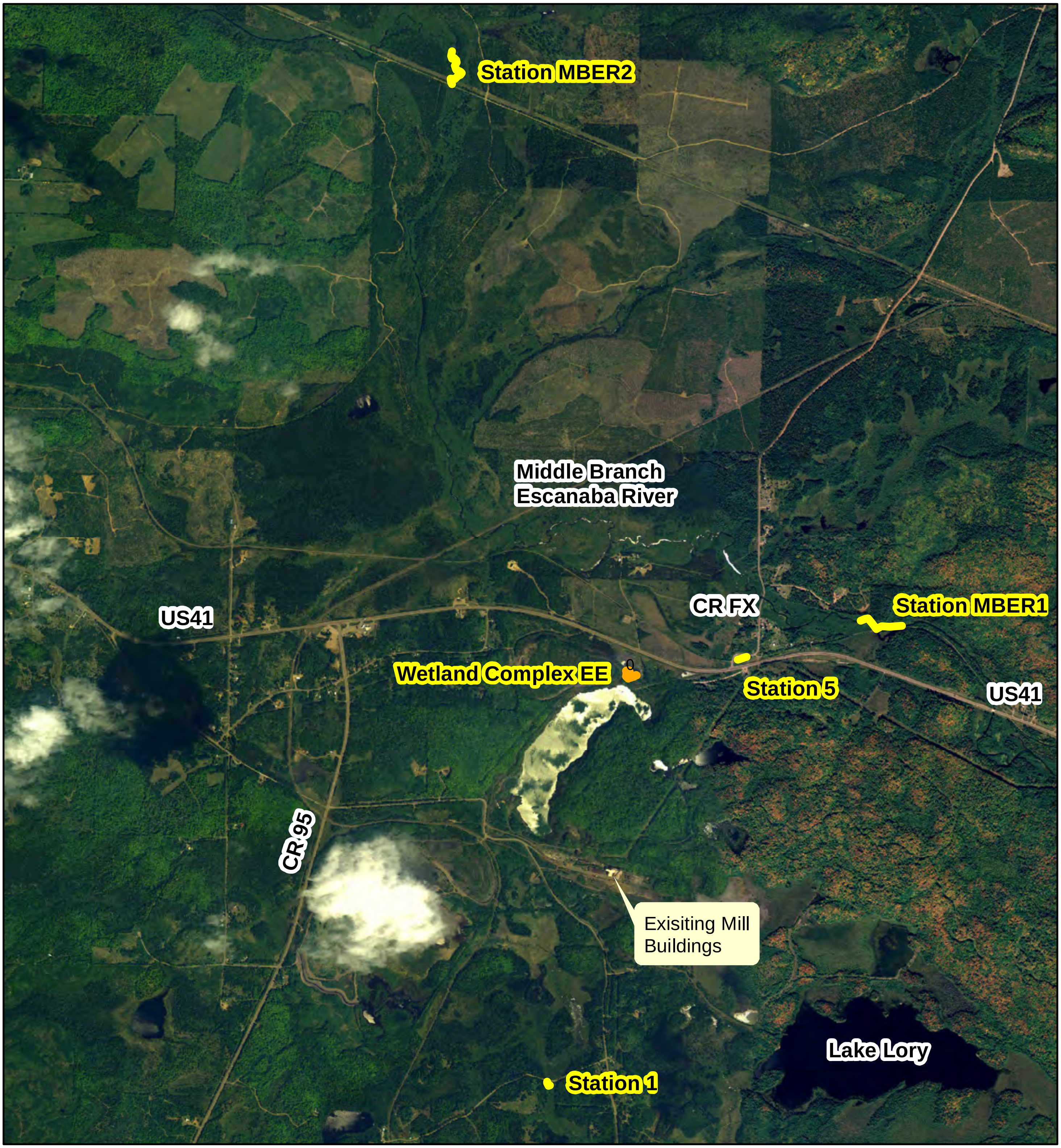


Figure 5-1. Great Blue Heron Rookery

King & MacGregor Environmental, Inc.



Legend

Wetland Complex EE Station

Stream Sample Station Locations

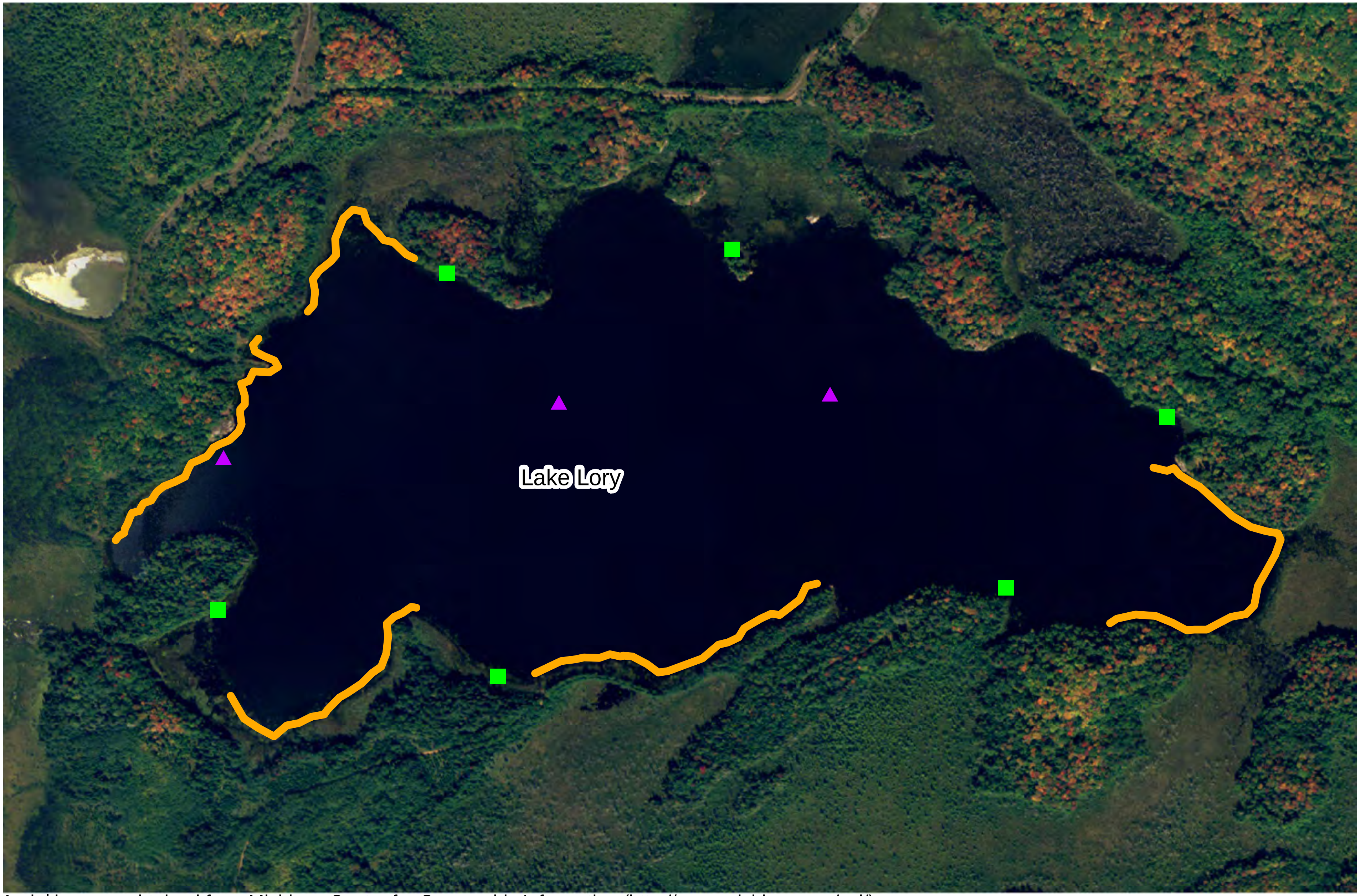
0 875 1,750 3,500 5,250 7,000 Feet

N

AeM ADVANCED ECOLOGICAL MANAGEMENT

PROJECT	Humboldt Mill - Eagle Mine
TITLE	Sample Station Locations
FIGURE	1-2

Aerial imagery obtained from Michigan Center for Geographic Information (http://www.michigan.gov/cgi/)



Aerial imagery obtained from Michigan Center for Geographic Information (http://www.michigan.gov/cgi/)

Legend

- Fyke Net Locations
- Gill Net Locations
- Electroshocker Transect Locations

0 275 550 1,100 1,650 2,200 Feet

N

AeM ADVANCED ECOLOGICAL MANAGEMENT

PROJECT	Humboldt Mill - Eagle Mine
TITLE	Lake Lory Gear Locations
FIGURE	1-3

Appendix O

Humboldt Mill

Contingency Plan Update

1 Contingency Plan – Humboldt Mill

This contingency plan addresses requirements defined in R 425.205. This includes a qualitative assessment of the risk to public health and safety or the environment (HSE risks) associated with potential accidents or failures involving activities at the Humboldt Mill. Engineering or operational controls to protect human health and the environment are discussed in Section 4 and Section 5 of this document. The focus of this contingency plan is on possible HSE risks and contingency measures. Possible HSE risks to on-site workers will be addressed by Eagle Mine through HSE procedures in accordance with Mine Safety and Health Administration (MSHA) requirements.

The Humboldt Mill involves processing ore, as well as storing and treating by-products of that process. The milling, storage, and treatment facilities have been designed, constructed, and are operated in a manner that is protective of the environment through the use of proven technologies and engineering practices.

1.1 Contingency Items

This contingency plan addresses the items listed below in this Section in accordance with R 425.205 (1)(a)(i) - (xii).

- Release or threat of release of toxic or acid-forming materials
- Storage, transportation and handling of explosives
- Fuel storage and distribution
- Fires
- Wastewater collection and treatment system
- Air emissions
- Spills of hazardous substances
- Other natural risks defined in the EIA
- Power disruption, and
- Leaks from containment systems for stockpiles or disposal and storage facilities.

For each contingency item, a description of the risk is provided, followed by a qualitative assessment of the risk(s) to the environment or public health and safety. Next, the response measures to be taken in the event of an accident or failure are described.

1.1.1 Release of Toxic or Acid-Forming Materials

Potentially reactive materials generated as a result of processing operations include ore concentrate and tailings. Both materials have the potential to leach metals constituents when exposed to air and water. As described in the following sub-sections, handling and temporary storage of both the ore concentrate and tailings have been carefully considered in the design of the Humboldt Mill so as to prevent the uncontrolled release of acid rock drainage (ARD).

1.1.1.1 Coarse Ore Storage Area (COSA) and Concentrate Load-Out (CLO) Areas

Potential environmental risks associated with the COSA is the release of contact water to the environment via cracks in the floor areas or collection sumps. The COSA is a steel sided building with a full roof that is used for temporary storage of stockpiled coarse ore that has been transported from the mine and is awaiting crushing. The COSA has a concrete floor that is sloped to keep any water associated with the ore inside the facility. The lower level of the facility is equipped with an epoxy lined sump and any water collected is pumped to the Humboldt Tailings Disposal Facility (HTDF) for eventual treatment by the water treatment plant.

Contingency planning for this facility includes timely repair of cracks in the floors and walls that could allow the release of material into the environment. An impermeable surface inspection plan has been developed and describes procedures for routine impermeable surface inspections, preventative and remedial actions as well as documentation procedures. Also, in accordance with Air Permit (No. 405-08) all overhead doors must be closed during loading or unloading of ore and a sweeping program is in place to minimize the generation of dust.

1.1.1.2 Concentrate Load-Out (CLO)

Potential environmental risks associated with the CLO is the release of acid generating material via track out and fugitive emissions. The CLO is a steel sided building with a full roof that is used for temporary storage of stockpiled nickel and copper concentrate prior to loading the material into railcars destined for customers. The CLO has concrete floors and does not contain any floor drains as water use is discouraged in this area.

Contingency planning for this facility includes timely repair of cracks in the floors and walls that could allow the release of material into the environment. An impermeable surface inspection plan has been developed and describes procedures for routine impermeable surface inspections, preventative and remedial actions as well as documentation procedures. Also, in accordance with Air Permit (No. 405-08) all overhead doors must be closed during loading operations and a sweeping program in place to minimize the generation of dust and track out of material. Track out is also managed in accordance with procedures outlined in the facilities standard operating procedures and includes inspecting and removing any residual concentrate from the exterior of the railcars prior to leaving the facility.

1.1.1.3 Humboldt Tailings Disposal Facility (HTDF)

Potential contaminant release from the HTDF could be waters having elevated metal concentrations that impact surface water or groundwater quality. The HTDF is a former open pit mine that was allowed to fill with water. Process tailings are sub-aqueously disposed which is industry best practice for materials that could be potentially acid generating. The anoxic environment minimizes the potential for generation of ARD. The HTDF was originally comprised of bedrock walls on three sides and alluvial soils on the north end in which water was allowed to naturally flow into the nearby wetland. A cut-off wall has been installed on the north end to prevent the release of water from the HTDF through the alluvial soils. Therefore, groundwater quality surrounding the HTDF will not be influenced by HTDF operations. Natural discharges from the HTDF have been essentially eliminated and any water that leaves the HTDF must now pass through the water treatment plant prior to discharge into the environment. Surface water discharge from the HTDF will be treated through the water treatment plant prior to discharge to a nearby wetland. In addition, the installation of the cut-off wall in the alluvial soils along the north perimeter of the HTDF will prevent release to the groundwater.

Groundwater seeps from the HTDF will not occur due to the low permeability of the surrounding Precambrian geologic formation. Furthermore, groundwater and surface water quality and elevations/flow are routinely monitored in accordance with the Part 632 Mining and NPDES permits and will quickly identify changes to surrounding water quality that would be indicative of groundwater release from the HTDF. Contingency planning from an unlikely groundwater release from the HTDF includes:

- Identify the nature and extent of the release,
- Implement additional monitoring to ascertain extent of release,
- Develop a remedial action plan to bring facility back into compliance,
- Implement remedial action plan.

Specific details of the remedial action plan would be developed based upon the nature of the release and with agreements with the MDEQ.

As a further contingency against groundwater seepage from the HTDF, the operating level has been lowered to a level below that of the adjacent wetland creating a reverse gradient that does not facilitate the movement of water from the HTDF to the adjoining wetlands. The lower operating level of the HTDF also provides for additional freeboard in the event of a significant weather event or operational situation that results in the inability to operate the WTP and discharge water.

Eagle will monitor water quality in the HTDF during operations and post-closure. The WTP and associated infrastructure will remain in place after tailings disposal has ceased until water quality meets applicable standards. If monitoring indicated that there are elevated metals in the HTDF that could impact surface water one of the following treatment options may be implemented:

- Continue the treatment of the HTDF water through the WTP until water quality conditions in the HTDF meet surface water standards; and/or
- Amend the HTDF with appropriate reagents to reduce elevated metal parameters in order to meet surface water standards.

Specific reagents and application rate(s) would be identified upon determination of elevated metal parameters of concern. Past phosphate seeding of HTDF by previous owners was shown to be effective for nickel concentration reduction.

1.1.1.4 Tailings Transport System

Tailings are transported to the HTDF via slurry contained within a double-cased HDPE pipe conveyance system. The pipe conveyance system consists of a 4-in diameter carrier pipe within an 8-in outer containment pipe. Two tailings lines are available for use, but only one is utilized at a time. In addition, the tailings lines are equipped with a leak detection system; any water released into the outer piping would drain to the shore vault and trigger an alarm, notifying operations of a potential system breach. The shore vault is also visually inspected twice per day (once per shift) by operators and the Environmental Department checks the tailings lines for signs of leakage once per week.

If a breach is identified, the slurry pumps will be shut-down until the source of breach is identified and repaired. The contingency plan for moving tailings to the HTDF facility is to use the second set of tailings lines that are already in place. In the event both lines were down, they could either be pumped into a truck with a sealed cargo area or the tailings will be held within the plant thickener vessel until the pipeline is repaired.

1.1.2 Storage, Transportation and Handling of Chemicals

Potential risks associated with chemical use include surface and groundwater quality impacts. Chemicals are brought to the site by certified chemical haulers, meeting MDOT transportation requirements. Storage of these chemicals are provided in secure locations within building(s) or outdoor bulk storage silos designed for that application. Transferring chemicals is conducted by qualified site personnel. Bulk granular products are conveyed pneumatically to the storage silos. Specific procedures for chemical storage and emergency response procedures are included in the facilities Pollution Incident Prevention Plan (PIPP).

Because chemicals will be stored in secure areas, the potential for release into the environment is very remote. If a breach of contaminant vessel does occur, the chemical will be contained within the secondary containment area. The spill or release will be immediately cleaned using appropriate methods specified in the Safety Data Sheets (SDS). SDS are maintained on-site for all chemicals.

1.1.3 Fuel Storage and Distribution

There is currently one 4,000 gallon diesel mobile fueling truck located onsite. This truck is used to fuel all mobile equipment onsite. A fuel provider refills this fuel truck on an as needed basis. The fuel truck is parked on an asphalt surface in which any spills or leaks would be captured in a catch basin and routed to the HTDF.

In general, fuel spills and leaks will be minimized by the following measures:

- A Spill Prevention Control and Countermeasures Plan (SPCC) has been written and implemented.
- Training of personnel responsible for handling fuel in proper procedures and emergency response;
- Regular equipment inspections and documentation of findings, and
- Staging of on-site emergency response equipment to quickly respond to unanticipated spills or leaks.

Specific procedures have been prepared as part of the project's SPCC Plan. In addition, a Pollution Incident Prevention Plan (PIPP) has been prepared which addresses potential spillage of fuels and other polluting materials.

Diesel fuel and propane (fuels) are transported to the Eagle Project by tanker truck from local petroleum distributors. The probability of an accidental release during transportation will be dependent on the location of the supplier(s) and the frequency of shipment. A fuel release resulting from a vehicular accident during transportation is judged to be a low probability event. Transport of fuel in tanker trucks does not pose an unusual risk to the region since tanker trucks currently travel to the region on a regular basis to deliver fuels to gasoline stations located in the communities surrounding the Eagle Mine.

Three potential release events associated with the surface-stored fuels are a bulk tank failure, mishandling/leaking hoses, and a construction/reclamation phase release.

<u>Bulk Tank Failure</u> – A release may result from a failure of the storage tank on the fuel truck. This type of release is judged to be low probability as the vehicle is inspected on a daily basis prior to use for signs of leakage or potential failure. In addition, as stated above the fuel truck is parked and utilized in locations in which asphalt is present and any spills would be directed to catch basins or sumps in which the fuel would be directed to the HTDF and not to an offsite or unprotected surface location. In addition, a spill

response trailer is located onsite and contains spill containment and clean-up equipment in the event of a spill. Eagle also has a spill response contractor on call to immediately respond to situations that cannot be handled by onsite personnel.

<u>Mishandling/Leaking Hoses</u> - A release might result from leaking hoses or valves, or from operator mishandling. This type of release is likely to be small in volume and is judged to be a low probability event

given that operators will be trained to manage these types of potential releases. These small spills will be cleaned up by using on-site spill response equipment such as absorbent materials and/or removing impacted soils.

Construction/Reclamation Phase Release - A major fuel spill during the construction or reclamation phases could occur from a mobile storage tank failure or mishandling of fuels. Such a release is also considered to be a low probability event given that operators will be trained to manage these types of potential releases and all tanks are required to have secondary containment. As with mishandling or leaking hoses, these small spills will be cleaned up by using on-site spill response equipment such as absorbent materials and/or removing impacted soils.

Absorptive materials may be used initially to contain a potential spill. After the initial response, soil impacted with residual fuel would be addressed. Remedial efforts could include, if necessary, the removal of soil to preclude migration of fuel to groundwater or surface water. The project's PIPP and SPCC plans addresses fueling operations, fuel spill prevention measures, inspections, training, security, spill reporting, and equipment needs. In addition standard operating procedures have been developed which cover fueling operations and spill response activities. All responses to a fuel spill, both large and small, will follow the guidelines dictated by the spill response plan and be reported internally. The tanks will be inspected regularly, and records of spills will be kept and reported to MDEQ and other agencies as required.

Contingency plans for responding to fuel spills from tanker trucks are required of all mobile transport owners as dictated by Department of Transportation (DOT) regulation 49 CFR 130. These response plans require appropriate personnel training and the development of procedures for timely response to spills. The plan must identify who will respond to the spill and describe the response actions to potential releases, including the complete loss of cargo. The plan must also list the names and addresses of regulatory contacts to be notified in the event of a release.

1.1.4 Fires

Surface fires can be started by a variety of causes including vehicular accidents, accidental ignition of fuels or flammable chemical reagents, and lightning strikes. Smoking is only allowed in designated areas on the site. Contingency measures include having the required safety equipment, appropriate personnel training and standard operating procedures. In addition, muster points have been established and all employees and visitors are trained on their location. Given these measures, uncontrolled or large surface fires are considered a low probability event with negligible risk.

Because the Humboldt Mill is situated in a forested region, forest fires started off-site could potentially impact the mill site. The cleared area in the vicinity of the surface facilities serves as a fire break to protect surface facilities. Contingency measures discussed below can be implemented in the event of an off-site forest fire.

In order to minimize the risk of a fire on-site, stringent safety standards are being followed. All vehicles/equipment are required to be equipped with fire extinguishers and all personnel trained in their use. Water pipelines and network of fire hydrants have been installed throughout the site and additional fire extinguishers are also located in high risk areas. On-site firefighting equipment includes an above ground water storage tank and distribution system for fire suppression. At Humboldt Mill a Wildfire Response Guideline has been developed in conjunction with Michigan DNR Fire Division to ensure the best possible response to a wildland fire.

Contingency planning for managing materials that oxidize includes training equipment operators on the material characteristics. Because the concentrate is only present for short periods of time in either the mill building or concentrate load-out building, and given that the concentrate will have a moisture content of at least 15%, the likelihood of an oxidation is very remote. The temperature of the material is routinely measured and any material exhibiting signs of self-heating is immediately compacted or exposed and spread out depending on the situation.

1.1.5 Wastewater Collection and Treatment

The major source of water from the facility requiring treatment is process water and tailings, groundwater infiltration into the HTDF, precipitation, and storm water runoff. The HTDF is sized to provide wastewater storage and equalization capacity. Water from the HTDF is conveyed to the WTP which is comprised of several unit processes, including: oxidation, metals precipitation, ultra-filtration and reverse-osmosis filtration (when necessary). The final product water is discharged to a nearby wetland area. This discharge is authorized by the State of Michigan under an NPDES permit.

The water treatment system is designed to handle various process upset conditions such as power disruption (Section 1.1.9) or maintenance of the various process units. The effluent is continually monitored for key indicator parameters to verify the proper operation. Effluent not meeting treatment requirements is pumped back to the HTDF for re-treatment. The water level of the HTDF is maintained at a level that provides ample storage capacity that would allow for sufficient time to correct a process upset condition. Potential hazards and chemical reagents associated with the WTP are discussed in Section 1.1.7.

1.1.6 Air Emissions

The operation and reclamation phases of the project will be performed in a manner to minimize the potential for accidents or failures that could result in off-site air quality impacts. All phases of the project will incorporate a combination of operating and work practices, maintenance practices, emission controls and engineering design to minimize potential accidents or failures. Below is a description of identified areas of risk and associated contingency measures that may be required. As part of a comprehensive environmental control plan, these contingency measures will assist in minimizing air impacts to the surrounding area.

1.1.6.1 Air Emissions during Operations

During operation of the mine, potential emissions from the facility will be controlled as detailed in the project's current Michigan Air Use Permit (No. 405-08). These controls include use of building enclosures for material handling, installation of dust collection or suppression systems to control dust during ore crushing and transfer operations and following prescribed preventive maintenance procedures for the facility. Tailings generated during the milling process are transported to the HTDF via slurry and therefore will not generate particulate matter. Ore brought from off-site is transported in covered trucks to minimize dust emissions. Below is a more detailed discussion of potential airborne risks associated with proposed operations at the facility.

To minimize dust emissions from the COSA and concentrate load-out building, these areas are fully enclosed. Ore transported from the mine site may only be dumped in the COSA when the doors are closed to minimize dust emissions from the building. A sweeping and housekeeping program is in place in the COSA and throughout the crushing circuit including the primary crusher, rock breaker, and conveyor transfer points located in the conveyor transfer station and mill building.

Fabric filter baghouses are used throughout the facility to minimize emissions of dust. Bag houses are located in the Secondary Crusher building and the Fine Ore Bins. Two insertable filter systems are installed in the transfer building. Baghouse malfunction is a possibility and can include a bag break or offset and excessive dust loading. These potential malfunctions are addressed in the malfunction prevention and abatement plan. The plan includes regular inspections and maintenance activities of dust collection and suppression systems which is accomplished through monitoring of pressure drop across the bags, monitoring of gas flow, and visual observations of stack emissions to assess opacity per permit conditions. In the event the monitoring program indicates a malfunction, a thorough investigation of the cause will occur. If necessary, ore processing operations will be shut down until the problem is corrected.

During facility operations, Eagle Mine will utilize certain pieces of mobile equipment to move material about the site. Equipment includes front end loaders, product haul trucks, and miscellaneous delivery trucks. Although the movement of most vehicles across the site is on asphalt surfaces, a comprehensive on-site sweeping and watering program has been developed to control potential fugitive sources of dust. If excessive dust emissions should occur, the facility will take appropriate corrective action, which may include intensifying and/or adjusting the sweeping/watering program to properly address the problem.

1.1.6.2 Air Emissions during Reclamation

Once milling operations are completed at the site, reclamation will commence in accordance with R 425.204. Similar to construction activities, there is a moderate risk fugitive dust emissions could be released during certain re-vegetation activities and during temporary storage of materials in stockpiles. Similar to controls employed during the construction phase, areas that are reclaimed will be re-vegetated to stabilize soil and reduce dust emissions. If severe wind or an excessive rain event reduces the effectiveness of these protective measures, appropriate action will take place as soon as possible to restore vegetated areas to their previous effectiveness and replace covers as necessary.

To the extent necessary, areas being reclaimed will be kept in a wet state by continuing the watering program. It is anticipated this program should minimize the possibility of excessive dust associated with mobile equipment. In the event fugitive dust is identified as an issue, corrective action will determine the cause of the problem and appropriate action will occur.

1.1.7 Spills of Hazardous Substances

Chemical reagents onsite are primarily used for the ore flotation and water treatment plant processes. Table 1.1.8 includes a list of reagents reported under the SARA Tier II Emergency and Hazardous Chemical Inventory that are being used onsite along with the approximate storage volumes and storage location. The storage volume is the calculated volume of chemical within each solution based on percentage.

Table 1.1.7 Chemical Reagents Used at the Water Treatment Plant & Mill Building

Item No.	Chemical Name	Trade Name	CAS No.	Storage Volumes	Storage Areas
1	Hydrochloric Acid/Hydrogen Chloride 31.5%	Muriatic Acid	7647-01-0	1,395 lbs	WTP chemical storage
2	Sodium Bisulfite 38%	Sodium Bisulfite	7631-90-5	1,331 lbs	WTP chemical storage
3	Sodium Hydroxide 25%	Sodium Hydroxide/Caustic Soda	1310-73-2	10,630 lbs	WTP chemical storage
4	Sodium Hypochlorite 12.5%	Chlorine/Bleach	7681-52-9	626 lbs	WTP chemical storage
5	1) Ferric Chloride 35% 2) Hydrochloric Acid 1%	Ferric Chloride	1) 7705-08-0, 2) 7647-01-0	30,660 lbs	WTP Reactor Area (West of WTP)
6	1) Sodium Hydroxide 50% 2) Sodium Chloride 5%	Sodium Hydroxide/Causic Soda	1) 1310-73-2, 2) 7647-14-5	53,466 lbs	WTP chemical storage
7	Sulfuric Acid 93.19%	Sulfuric Acid, 66 Deg	7664-93-9	3,565 lbs	WTP chemical storage
8	Aluminum chloride hydroxide sulphate	Nalco 8136/PAC	39290-78-3	13,213 lbs	WTP chemical storage
9	1) Sodium Chloride 2) Sodium Sulphide, 3) Sodium Hydroxide	Nalmet 1689	1) 7647-14-5, 2) 1313-82-2, 3) 1310-73-2	805 lbs	WTP chemical storage
10	Hydrotreated Light Distillate	Nalclear 7766 Plus/Flocculant	64742-47-8	294 lbs	WTP chemical storage
11	Hydrogen Peroxide 50%	Hydrogen Peroxide	7722-84-1	34,720 lbs	WTP reactor Area
12	Sodium carboxymethyl cellulose	CMC/Depramin C	9004-32-4	20 tons	Reagent storage area
13	Calcium Oxide	High Calcium Quick Lime	1305-78-8	39 tons	Lime silo
14	Optimer 83949	Flocculant	Unknown	2 tons	Reagent storage area
15	Methyl isobutyl carbinol (MIBC)	MIBC/Frother	108-11-2	2.2 tons	MIBC tank
16	Sodium isopropyl xanthane (SIPX)	SIPX	140-93-2	15 tons	Reagent storage area
17	Sodium carbonate	Soda Ash	497-19-8	54 tons	Soda ash silo

Chemical storage and delivery systems follow current standards that are designed to prevent and to contain spills. All use areas and indoor storage areas were designed, constructed and/or protected to prevent run-on and run-off to surface or groundwater. This includes development of secondary containment areas for liquids. The secondary containment area is constructed of materials that are compatible with and impervious to the liquids that are being stored. A release in the WTP or concentrator building from the associated piping would be contained within the contained plant area, neutralized, and sent to the HTDF for disposal. Absorbent materials are available to contain acid or caustic spills. Eagle Mine has an emergency response contractor on call to immediately respond to environmental incidents, assist with clean-up efforts, and conduct environmental monitoring associated with any spills.

Spill containment measures for chemical storage and handling will reduce the risk of a spill from impacting the environment. Due to the low volatility of these chemicals, fugitive emissions from the WTP or concentrator building to the atmosphere during a spill incident are likely to be negligible. Off-site exposures are not expected. It is therefore anticipated that management and handling of WTP and processing reagents will not pose a significant risk to human health or the environment.

1.1.8 Other Natural Risks

Earthquakes – The Upper Peninsula of Michigan is in a seismically stable area. The USGS seismic impact zone maps show the maximum horizontal acceleration to be less than 0.1 g in 250 years at 90% probability. Therefore, the mine site is not located in a seismic impact zone and the risk of an earthquake is minimal. Therefore, no contingency measures are discussed in this section.

Floods - High precipitation events have been discussed previously in the section that describes the HTDF. High precipitation could also lead to the failure of erosion control structures. The impacts of such an event would be localized erosion. Contingency measures to control erosion include sandbag sediment barriers and temporary diversion berms. Long term or off-site impacts would not be expected. Failed erosion control structures would be repaired or rebuilt. Impacts from high precipitation are reversible and off-site impacts are not expected to occur. Given the considerable planning and engineering efforts to manage high precipitation events, the risk posed by high precipitation is considered negligible.

Severe Thunderstorms or Tornadoes – Severe thunderstorms or tornadoes are addressed in the emergency procedures developed for the Eagle Mine and Humboldt Mill. Certain buildings are designated shelters in the event of severe weather. Evacuation procedures are part of the on- site training of all employees.

Blizzard – The mill site will be designed to accommodate the winter conditions anticipated in the Upper Peninsula of Michigan. The Marquette County Road Commission is responsible for maintaining roadways near the Humboldt Mill. If road conditions deteriorate beyond the capability of the county or township maintenance equipment, Eagle will have provisions to keep workers housed on-site for extended periods, as needed.

Forest Fires – Forest fires were discussed in Section 1.1.4.

1.1.9 Power Disruption

Electrical power for the Humboldt Mill is provided by two utility power companies; Wisconsin Electric (WE) Energies and Upper Peninsula Power Company (UPPCO). The mill facility and production buildings are presently served by a 69 kV overhead electric feeder to an on-site UPPCO electrical substation. The substation supplies three underground 13.8 kV feeders; two to our main mill switchgear and one to our fire water system.

The production support buildings and Water Treatment Plant infrastructure for the mill are fed from a WE Energies 25 kV overhead line. These buildings include the Security Building, Administration Building, Mill Services Building, Water Treatment Plant Building which includes Water Treatment Plant Intake Pump Building.

In the unlikely event that power is disrupted, backup generators are installed to ensure mill critical loads remain energized. The buildings where "critical loads" have been identified and generators have been installed are Concentrator Building; which powers essential loads in the Concentrator and Concentrate Load Out Buildings, Coarse Ore Storage Area, Tailings Vault/Reclaim Pump Structure, Administration Building, Mill Services Building, Security Building and Water Treatment Plant.

In the event the WTP would need to be temporarily shut down during power disruptions, the water level of the HTDF is maintained at a level that provides enough capacity to store water for an extended period of time if necessary.

1.2 Emergency Procedures

This section includes the emergency notification procedures and contacts for the Humboldt Mill Site. In accordance with R 425.205(2), a copy of this contingency plan will be provided to each emergency management coordinator having jurisdiction over the affected area at the time the application is submitted to the MDEQ.

<u>Emergency Notification Procedures</u> – An emergency will be defined as any unusual event or circumstance that endangers life, health, property or the environment. If an incident were to occur, all employees are instructed to contact Security via radio or phone. Security then makes the proper notifications to the facility managers and activates the Eagle Mine Emergency Response Guideline as needed. If personnel on site need to be notified of such an event an emergency toned broadcast via radio and all-call speakers will be made with instructions.

Eagle Mine has adopted an emergency response structure that allows key individuals to take immediate responsibility and control of the situation and ensures appropriate public authorities, safety agencies and the general public are notified, depending on the nature of the emergency. A brief description of the key individuals is as follows:

- <u>Health & Safety Officer</u>: The facility H&S manager and H&S staff are responsible for monitoring activities in response to any emergencies. During an emergency, H&S representatives will manage special situations that expose responders to hazards, coordinate emergency response personnel, mine rescue teams, fire response, and ensure relevant emergency equipment is available for emergency service. This individual will also ensure appropriate personnel are made available to respond to the situation.

- Environmental Officer: The facility environmental manager will be responsible for managing any environmental aspects of an emergency situation. This individual will coordinate with personnel to ensure environmental impact is minimized, determine the type of response that is needed and act as a liaison between environmental agencies and mine site personnel.

- Public Relations Officer: The facility external relations manager will be responsible for managing all contacts with the public and will coordinate with the safety and environmental officers to provide appropriate information to the general public.

In addition to the emergency response structure cited above, a Crisis Management Team (CMT) has also been established for situations that may result in injuries, loss of life, environmental damage, property or asset loss, or business interruption. If a situation is deemed a "crisis" the CMT immediately convenes to actively manage the situation. The following is a description of the core members and their roles:

Crisis Management Team – Core Members and Roles

Core Members	**Role**
Team Leader	Responsible for strategy and decision making by the CMT during a crisis and maintaining a strategic overview.
Coordinator	Ensures a plan is followed and all logistical/administrative support required is provided.
Administrator	Records key decisions and actions and provides appropriate administrative supports to the CMT.
Information Lead	Gathers, shares, and updates facts on a regular basis.
Emergency Services and Security	Liaises with external response agencies and oversees requests for resources. Maintains a link between the ERT and CMT and oversees and necessary evacuations.
Communications Coordinator	Develops and implements the communications plan with support from an external resource.
Spokesperson	Conducts media interviews and stakeholder briefings.

Evacuation Procedures – While the immediate surrounding area is sparsely populated, if it is necessary to evacuate the general public, this activity will be handled in conjunction with emergency response agencies. The Public Relations Officer will be responsible for this notification, working with other site personnel, including the H&S and environmental officers.

In the event evacuation of mill personnel is required, Eagle Mine has developed emergency response procedures for all surface facilities. All evacuation procedures were developed in compliance with MSHA regulations. In addition, an Emergency Response Team was formed to assist in emergency response situations should they arise. This team is not required by MSHA but was established to help ensure the safety of employee while at work. The team is comprised of 17 individuals that are divided into four teams each of which includes at least one licensed EMS professional and one NFPA certified firefighter. Training occurs on a monthly basis and may include first aid, rapid trauma assessments, emergency shutdown procedures for equipment, industrial firefighting, and vehicle and building extrications.

In addition to the Emergency Response Team, security personnel are EMTs and paramedics who are trained in accordance with state and federal regulations. This allows for immediate response to medical emergency situations.

Emergency Equipment – Emergency equipment includes but is not limited to the following:

- ABC Rechargeable fire extinguishers
- Radios
- First aid kits, stretchers, backboards, and appropriate medical supplies
- Gas detection monitors that detect 5 gases and LEL
- High angle rescue ropes
- Self-Contained Breathing Apparatus (SCBA)
- Spill Kits (hydrocarbon and chemical)
- Certified EMT's Basic and Paramedics are on site at all times to respond in the event of an emergency.
- A trained Emergency Response Team with specialized training in fire, EMS and rescue.

This equipment is located at the surface facilities. Fire extinguishers are located at appropriate locations throughout the facility, in accordance with MSHA requirements. Surface facility personnel are also equipped with radios for general communications and emergencies. Other emergency response equipment is located at appropriate and convenient locations for easy access for response personnel.

Emergency Telephone Numbers – Emergency telephone numbers are included for site and emergency response agencies, as required by R 425.205(1)(c). They are as follows:

- Mill Security: (906) 339-7017
- Local Ambulance Services: UP Health Systems Bell. Contact Security at Extension 7017, or by radio using the Emergency Channel to alert on site responders. Dial 911.
- Hospitals: Marquette General Hospital – (906) 225-3560
  Bell Hospital – (906) 485-2200
- Local Fire Departments: Humboldt Township, Ishpeming Township – 911
- Local Police: Marquette County Central Dispatch – 911
  Marquette County Sheriff Department – (906) 225-8435
  Michigan State Police – (906) 475-9922
- Trimedia 24-hr emergency spill response: (906) 360-1545
- MDEQ Marquette Office: (906) 228-4853
- Michigan Pollution Emergency Alerting System: (800) 292-4706
- Federal Agencies: EPA Region 5 Environmental Hotline: (800) 621-8431
  EPA National Response Center: (800) 424-8802
  MSHA North Central District: (218) 720-5448
- MDNR Marquette Field Office: (906) 228-6561
- Humboldt Township Supervisor: Tom Prophet, (906) 339-4477

1.3 Testing of Contingency Plan

During the course of each year, the facility will test the effectiveness of the Contingency Plan. Conducting an effective test will be comprised of two components. The first component will include participation in adequate training programs on emergency response procedures for those individuals that will be involved in responding to emergencies. These individuals will include the Incident Commander, Safety Officer, Environmental Officer, Public Relations Officer and other individuals designated to respond to fires and participate in emergency response activities. Individuals will receive appropriate information with respect to their specific roles, including procedures and use of certain emergency response equipment.

The second component of an effective Contingency Plan will be to conduct mock field tests. At least one mock field test will be performed each year. The Safety Officer will work with the Environmental Officer and Emergency Response Coordinator to first define the situation that will be tested. The types of test situations may include responding to a release of a hazardous substance, responding to a fire (aboveground or underground) or responding to a natural disaster such as a tornado. A list of objectives will be developed for planning and evaluating each identified test situation. A date and time will then be established to carry out the test. Local emergency response officials may be involved, depending on the type of situation selected.

Once the test is completed, members of the crisis management team and emergency response team will evaluate the effectiveness of the response and make recommendations to improve the system. These recommendations will then be incorporated into a revision of the facility Contingency Plan.

Appendix P

Humboldt Mill

Financial Assurance

EAGLE MINE LLC CLOSURE AND POST-CLOSURE COST ESTIMATE

Environmental Resource Management (ERM) - January 13, 2015 - Updated February 2018 with Eagle Mine Estimated Additions

	Description	Units	Humboldt Mill	Eagle Mine	Totals	Comments
1	Operation / Site		Humboldt Mill	Eagle Mine		
2	Business Unit		Eagle Mine LLC	Eagle Mine LLC		
3	Functional Currency		USD	USD		
4	Current Day Cost		2014	2014		
5	Expected Operations Completion Date		2023	2023		Updated operation completion date to end of 2023 per latest published reserve and resource estimate published on SEDAR (Canadian)
6	Expected Closure Completion Date		2025	2025		Minor closure activities to commence mid-year 2023; 2 years of full-time closure activities from 2024 through 2025
7	Expected Post-Closure Completion Date		2027	2028		Mine Site - 3 years of post-closure activities 2026 through 2029 Mill Site - 1.5 years of post-closure activities 2026 to mid 2027
8	Post-Closure Monitoring Completion Date		2047	2048		20 years of post-closure monitoring
	Closure Costs					
A	Structural and Equipment Demolition	LS	$ 3,857,433	$ 1,847,081	$ 5,704,514	Includes shut down and removal of equipment utilities; removal of salvageable material from buildings; removal of equipment within buildings; and demolition of structures and buildings to grade
B	Slab and Foundation Excavation	LS	$ 1,229,574	$ 1,035,513	$ 2,265,086	Break-out the slab and foundations (assumes average building slabs of 1 ft and average foundations of 2-3 ft (4-ft max.)) and transport and dispose off-site
C	Equipment and Facilities Decontamination	5%	$ 176,681	$ 89,423	$ 266,103	Assumes 5% of demolition cost for wash-down of equipment and facilities prior to demolition
D	Demolition Debris Transport and Off-site Disposal	LS	$ 258,318	$ 285,634	$ 543,952	Transport & off-site disposal of generated demolition debris (non-slab & foundation)
E	Asphalt and Concrete Removal, Transport and Off-site Disposal	LS	$ 472,742	$ 1,507,438	$ 1,980,180	Asphalt and concrete transport and off-site disposal costs (includes excavation, load, transfer to off-site disposal, and cover to grade)
F	Remediation & Reclamation	LS	$ 545,366	$ 981,989	$ 1,527,355	Subsurface remediation and reclamation costs (assumes that CERCLA is not triggered)
G	EPCM (A through F)	10%	$ 654,000	$ 574,700	$ 1,228,700	Engineering, Procurement & Construction Management
H	Monitoring	LS	$ 523,333	$ 1,117,333	$ 1,640,667	2 years based on current annual environmental monitoring budget
I	WTP Operation Labor	LS		$ 520,080	$ 520,080	Mine Site - 2 years of wages/benefits based on HR closure costs
J	WTP Operation Materials / Supplies	LS		$ 879,920	$ 879,920	Mine Site - 2 years of reagents, power, and materials based on operations costs
ADD	Minor additions since last estimate	LS	$ 103,103	$ 158,650	$ 261,753	Mine Site-Building additions and changes since last estimate (based cost on the same calculations as the engineer estimate - 11 Conexes, 2 Cold Storage, Electrical Fab Shop, MCC Vent Raise minor addition) Mill Site-minor additions since last estimate (based on the same calculations as the engineer est - 60x200 Cold Storage Building, 4-4'x6'x4" generator pads, fire tank concrete 48"x70", large generator pad 8'x27'x4')
ADD	Re-estimate of Mill WTP Labor/Materials/Supplies for this update	LS	$ 7,000,000	$ -	$ 7,000,000	Mill Water Treatment operation for 2 years at $3.5M/year -DO NOT INFLATE IN 2018 $'S
ADD	Fill Open Stopes with CRF & Clear TDRSA of waste material	LS	$ -	$ 1,732,442	$ 1,732,442	From mine file "Reclamation Estimate_Backfill-TDRSA_20171231" Not part of Eagle Estimate - DO NOT INFLATE in 2018 $'s
	Subtotal (A through L)		$ 14,820,550	$ 10,730,202	$ 25,550,752	
	Post-Closure Costs					
K	Monitoring	LS	$ 3,797,000	$ 9,004,000	$ 12,801,000	20 years based on current annual environmental monitoring budget
L	Monitoring System Abandonment	LS	$ 99,965	$ 106,594	$ 206,559	Abandonment of monitoring wells at completion of post-closure monitoring
M	WTP Operation Labor	LS	$ -	$ 780,120	$ 780,120	Mine Site - 3 years of wages/benefits based on HR closure costs
N	WTP Operation Materials / Supplies	LS	$ -	$ 1,319,880	$ 1,319,880	Mine Site - 3 years of reagents, power, and materials based on operations costs
	Re-estimate of Mill WTP Labor/Materials/Supplies for this update	LS	$ 5,250,000	$ -	$ 5,250,000	Mill Water Treatment operation for 1.5 years at $3.5M/year -DO NOT INFLATE IN 2018 $'S
	Subtotal (O through S)		$ 9,146,965	$ 11,210,594	$ 20,357,559	
	Total for Project		$ 23,967,515	$ 21,940,796	$ 45,908,311	
O	Contingency (A through S)	10%	$ 2,396,751	$ 2,194,080	$ 4,590,831	Contingency costs for data gaps and unknowns
	Total for Project before inflation		**$ 26,364,266**	**$ 24,134,876**	**$ 50,499,142**	
	Escalation Factor since 2014 - Detroit CPI (2015-2017) = (0.1%)+2.4%+2.7%	5.0%	$ 585,876	$ 1,010,417.71	$ 1,596,293	Per Part 632, utilize Detroit Consumer Price Index inflation factor for cost adjustment
	Total for Project including inflation (excludes Contingency)		**$ 26,950,141**	**$ 25,145,294**	**$ 52,095,435**	
	MDEQ Adminstrative Oversight		$ 2,589,102	$ 3,394,758	$ 5,983,860	2016 Added by MDEQ as if Eagle were to abandon the site. Part 425.301 (b) of the permit notes "The department (MDEQ) may require financial assurance in an amount larger than calculated by operator…"
	Estimate to MDEQ - Total for Project		**$ 29,539,243**	**$ 28,540,052**	**$ 58,079,295**	

	Humboldt Mill	Eagle Mine	Totals
Previous Estimate	**$ 24,164,914**	**$ 31,684,422**	**$ 55,849,336**
Difference	**$ 5,374,329**	**$ (3,144,370)**	**$ 2,229,959**

Appendix Q

Humboldt Mill

Organizational Information

Eagle Mine
4547 County Road 601
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Fax: (906) 339-7005
www.eaglemine.com

Organizational Information

Eagle Mine LLC

January 29, 2018

Registered Address:	Eagle Mine, LLC 1209 Orange Street Wilmington, DE 19801	**Business Address:**	Eagle Mine, LLC 4547 County Road 601 Champion, MI 49814

Board of Directors

Inkster, Marie	4547 County Road 601 Champion, MI 49814
McRae, Paul M.	4547 County Road 601 Champion, MI 49814
Richardson, Jonas Peter Haddock	4547 County Road 601 Champion, MI 49814

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Officers

Jinhee Magie	Treasurer	4547 County Road 601 Champion, MI 49814
Annie Laurenson	Secretary	4547 County Road 601 Champion, MI 49814
Kristen Mariuzza	Vice President	4547 County Road 601 Champion, MI 49814
John Kenneth McGonigle	President and CFO	4547 County Road 601 Champion, MI 49814