

2023-2025 San Juan County Beaver Habitat and Mine Remediation Study

Summary Report

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Abbreviations

AWR	Alpine Water Resources
BPMD	Bonita Peak Mining District
MIW	Mine Impacted Water
CDPHE	Colorado Department of Health and Environment
EPA	U.S. Environmental Protection Agency
BLM	Bureau of Land Management
USFS	United States Forest Service
SJC	San Juan County
PBR	Process Based Restoration
GAL	Green Analytical Laboratory
in.	inch
GPM	Gallons per Minute
MDL	method detection limit
mL	milliliter
µg/L	micrograms per liter

Section 1

Introduction

1.1 Background

The Animas River Watershed has a long history of the existence of the North American Beaver (*Castor Canadensis*) which predates the Euro-American Trapping era of the early 1800's. There were 200-400 million beavers in the Western US prior to European arrival, and nearly every headwater stream and river was trapped in the Western US between 1800-1840, reducing beaver populations by upwards of 95% in most Western US watersheds. The rapid removal of the beaver was quickly followed by the mining booms of the late 1800's with heavy mining activity focused in the same watersheds where beaver had been removed. As a result, by the mid-twentieth century many Western US headwater watersheds, Including the Animas River, were left with the negative impacts of not one but two distinct Euro-American extractive industry practices. Therefore, there is a need to incorporate beaver ecosystem resilience with the remediation of legacy mine sites.

In recent decades there has been a gradual recovery and expansion of beaver populations in headwater streams of the Animas River Watershed near Silverton, CO. Beaver dams, lodges, and feeding areas have increased in number and location in areas of the watershed, including directly within mine discharges at several abandoned mine sites. The beavers have been able to follow the surface channels of mine discharges up and away from the mainstream channels and have begun to dam the waters near mine portals and in and around areas of legacy mine sites. At some mine locations the beavers have built dams and expanded habitat directly on top of legacy mine waste rock and tailings piles. Due to degradation and/or elimination of many of the historic riparian and floodplain areas along the river channels (caused by mining activity, development, and increased incision of channels void of beavers) the present-day beaver populations are

forced to search for suitable habitat which can include the use of mine water discharges and the associated areas around mine portals.

At numerous mines in San Juan County, the beavers have voluntarily established residence in recent years. There is a desire to assess passive attenuation of metals in natural beaver dominated ecosystems. There is a desire to encourage re-establishment of beaver presence near mine sites to promote ecosystem enhancement including improvement of the quality of discharging mine waters (through passive filtration, settlement, and uptake of mine water contaminants etc.) and increasing biodiversity in and around reclaimed mine sites. Monitoring sites have served to measure and understand how beaver ecosystems can exist within mining impacted areas and can potentially support passive remediation of mine discharge while improving overall watershed ecosystem health and resiliency.

1.2 Project Goals

- Study relationship between beavers, mine impacted water (MIW) and mine impacted landscapes in the San Juan Mountains.
- Work with collaborators to explore possible solutions at the intersection between beaver and areas affected by legacy mining
- Explore the role of beaver in mountain ecosystem restoration through diverse stakeholder and financial avenues

1.3 Principal Study Questions

The following questions created the basis for developing and deploying the techniques used in this study.

Principal Study Question 1

- Where in San Juan County are beavers living currently?

Principal Study Question 2

- What are the ecosystem issues impacting beavers? (infrastructure, channel incision, loss of habitat etc.)

Principal Study Question 3

- How do the beavers interact with mine sites and Mine impacted waters (draining adits etc.)

Principal Study Question 4

- What is the water quality in active beaver habitat?

Principal Study Question 5

- How does beaver habitat affect water quality?

1.4 Report Scope

This report summarizes the activities completed and methods used, data collected, conclusions made and suggested next steps. Analytical and water quality monitoring data, graphs, figures, and a copy of the final presentation are included as appendices to this report.

This report includes the following appendices:

Appendix A Analytical chemistry data tables

Appendix A1 Analytical Chemistry Graphs

Appendix B Water Quality Parameters

Appendix C Photo Logs

Appendix D Final Presentation

Appendix E Site Maps

Section 2

Field Activities and Methods

Field activities took place from May to November 2023, and May to December 2024. Most of the monitoring, sampling, and process-based restoration efforts took place in the summer and fall of 2024. Monitoring captured pre and post high flow conditions in summer 2024, and baseline surface water chemistry sampling occurred in September 2024.

2.1 Habitat Mapping and Characterization Efforts

Habitat and beaver activity characterization efforts took place in the three main tributaries to the Animas River downstream of Silverton, CO. These include Mineral creek (and South Mineral Creek), Cement Creek, and the Upper Animas River. Public lands make up 87% of the land ownership in San Juan County, where Mineral creek is managed by the United States Forest Service (USFS), and Cement Creek and the Upper Animas River are owned and managed by the Bureau of Land Management (BLM).

Focus Areas: Animas River Tributaries

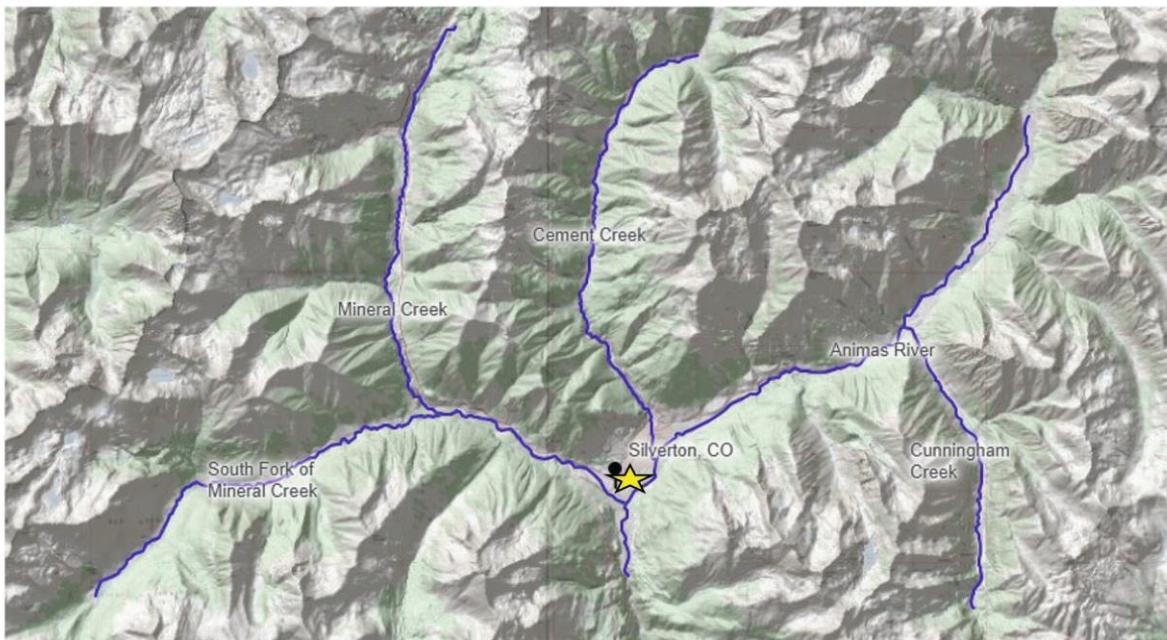


Figure 1-1. Overview map of the three focus area tributaries to the Animas River, downstream of Silverton, CO. These include Mineral Creek, Cement Creek, and the Upper Animas River.

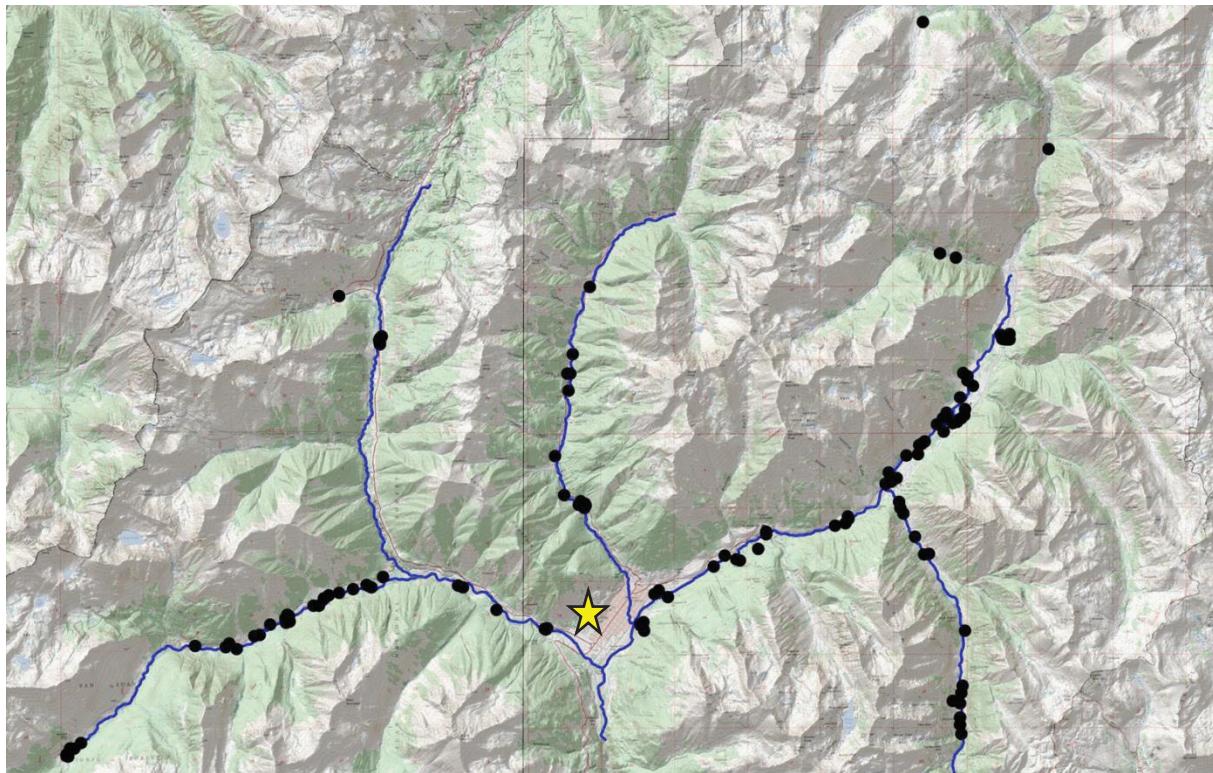


Figure 1-2. Documented Current and Historic Beaver Activity along Animas River Tributaries in San Juan County.

Routine monitoring efforts included documenting evidence of current or historic beaver activity throughout the late spring, summer and fall of 2023 and 2024. Initial characterization efforts included examination of satellite imagery and in addition to local knowledge and communications with scientists and community members to identify existing activity and potential beaver habitat along SJC riparian corridors. Preliminary satellite-based characterization mapping was completed according to the Beaver Restoration Assessment Tool (BRAT) lines of evidence including factors like availability of water, trees, and vegetation.

Subsequent ground-based characterization efforts involved identifying direct evidence of beaver activity, as well as characterizing habitat for potential of future low-tech Process-Based Restoration (PBR) activities. Direct evidence included actual sightings, beaver ponds, dams, lodges, recent or historic skid trails, beaver channels, chewed trees and branches, fresh woody debris additions, etc. Direct evidence was

recorded with photo documentation and given a unique numerical identifier characterizing the type of information and location along the tributary (Ex: South Mineral Creek mile 2.1: SMC 2.1), and color coded to denote direct evidence or a potential location for PBR activities.

Beavers were found to be currently living in all three major drainages to the Animas River (Mineral Creek, Cement Creek, and the Upper Animas River), in addition to the sub tributaries of South Mineral Creek and Cunningham Creek. These sites are often adjacent to or directly in mine impacted waters (MIW). After each major tributary was characterized, existing SJC beaver habitat was overlayed with locations of abandoned mine sites. When compared geospatially, many of the 48 BPMD sites as well as unlisted abandoned mines were found to be located near historic or current beaver activity (see figure below), and all sites had existing beaver activity and habitat downstream.

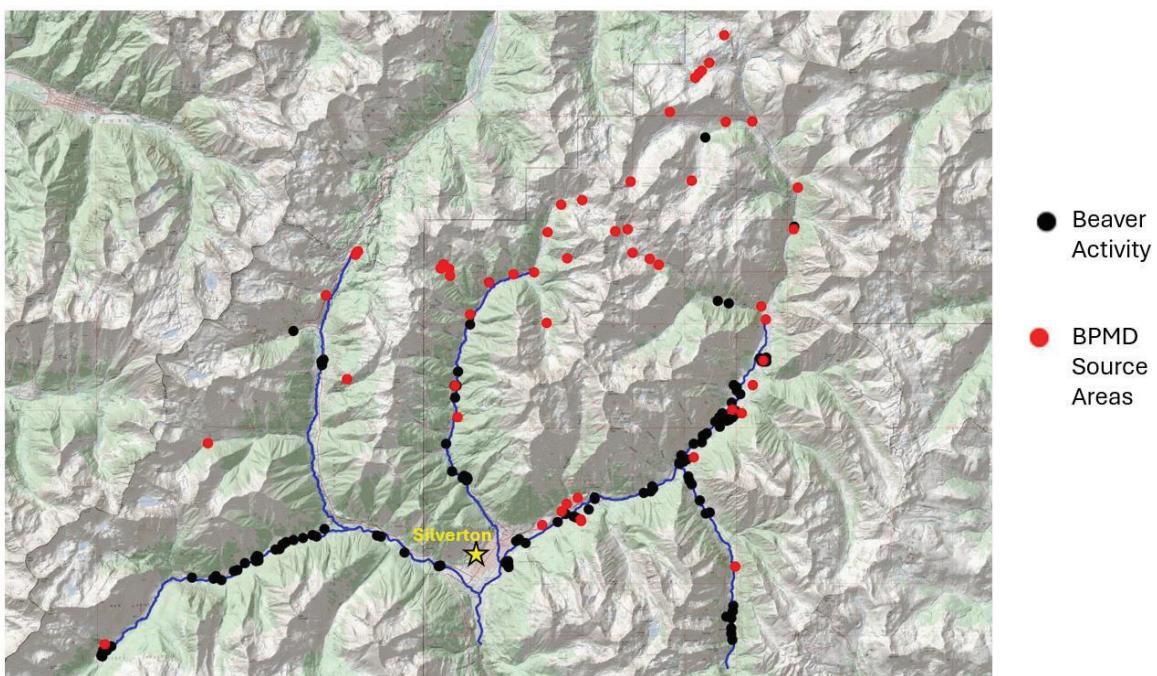


Figure 1-3. Proximity of documented beaver habitat to BPMD Source areas in San Juan County.

2.1.1 Focus Area Investigations

Upon completion of beaver activity mapping, a handful of focus areas were selected from each drainage to conduct more detailed monitoring and characterization (figure 1-4). Locations were chosen to represent the known variations of water quality, landscape characteristics, and mining impacts across the watershed. In Mineral Creek there were 3 focus areas; the Bandora Mine in South Mineral Creek, The Chattanooga fen area south of Red Mountain Pass, and the North Star Mine site near Silverton. In Cement Creek there were 2 focus areas; the Lower Cement Creek Beaver Complex near Silverton, and the Anglo Saxon mine area. For the Upper Animas there were four focus areas; The Mighty Monarch mine/ Kendal Ponds near Silverton, Cunningham Gulch and the Pride of the West and Old One Hundred Mines, the Pride of the West Mill area, and the Forrest Queen mine area south of Eureka.

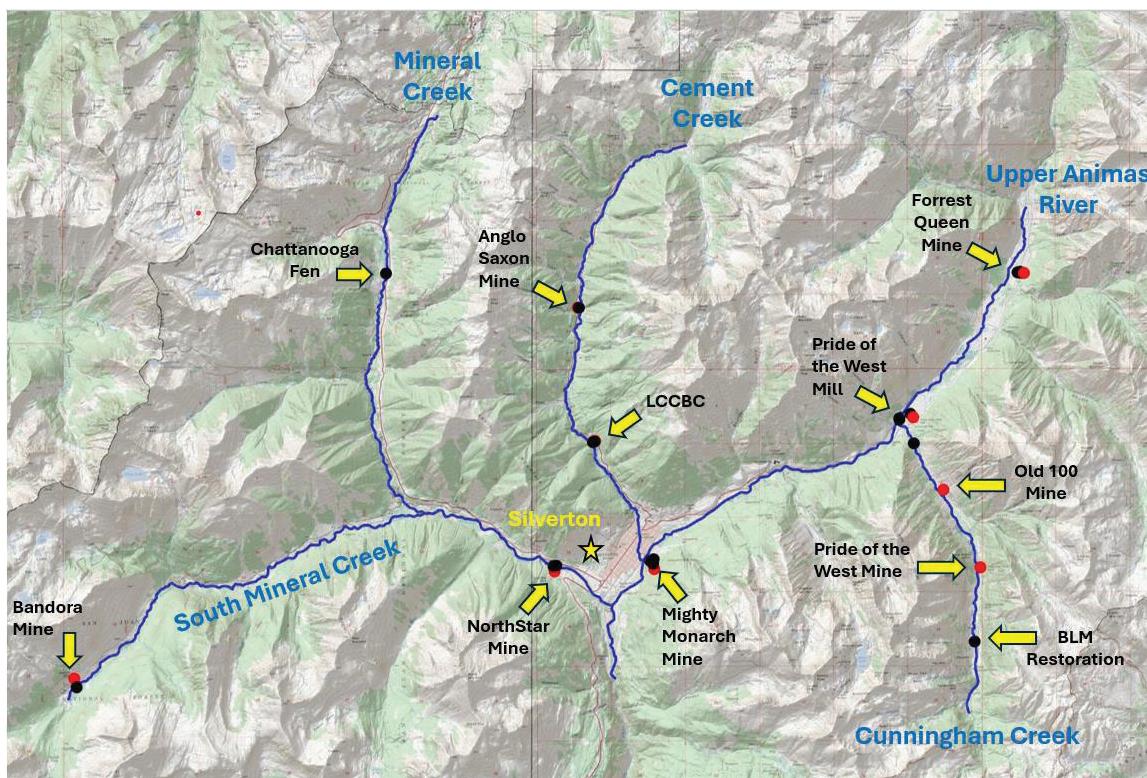


Figure 1-4. Monitoring focus areas. Areas include Bandora Mine, Chattanooga Fen, NorthStar Mine, Anglo Saxon Mine, Lower Cement Creek Beaver Complex (LCCBC), Forrest Queen Mine, Pride of the West Mill, Pride of the West Mine, Old One Hundred Mine, and the Mighty Monarch Mine.

2.2 Water Quality Monitoring Methods

At each of the beaver habitat focus areas water quality was measured in the field during multiple site visits. Water samples were also collected and sent to Green Analytical Laboratory in Durango Colorado for analysis of total and dissolved metals concentrations. All water quality monitoring was conducted following methods and approved techniques as outlined in the Bonita Peak Mining District site wide Quality Assurance Project Plan (QAPP) (EPA, 2021). Detailed methods for water quality monitoring are described below.

2.2.1 Field Water Quality Parameter Collection

Water quality parameters were collected to begin to establish an understanding of water quality variability across existing active beaver habitats. A YSI ProDSS digital multiparameter water quality was used to collect In-field surface water measurements. These included pH, oxidation-reduction potential (ORP), specific conductance (SPC), dissolved oxygen (DO), and water temperature. After surface water sample collection activities, the final stabilized field parameters were summarized and submitted to the Green Analytical Laboratory (GAL) along with analytical samples. Water Quality Parameters were measured during routine monitoring events and during analytical sampling events.

Additional focus was given to establishing transects to monitor longitudinal water quality above and below active beaver habitat that resides between a mine water discharge point (adit) and the downstream confluence with the nearest surface water body. The development of the long-term monitoring locations creates a standardized methodology for future monitoring of these locations that can be correlated with ongoing mine remediation activities.

2.2.2 Water Quality: Analytical Samples for surface water

The surface water samples were collected as discrete grab samples from field determined sampling locations in accordance with BPMD QAPP (EPA, 2021). The sample bottles were filled with water in immediate succession of one another. The sample bottles and filter apparatuses were new, certified clean, and not reused between sampling locations.

Surface water samples were collected by immersing an uncapped sample bottle completely beneath the water surface at approximately a 45-degree angle with the mouth of the sample bottle facing upstream. The sample bottles, except dissolved metals sample bottles, were rinsed three times using surface water before taking samples. If the water depth was too low or flow was insufficient to directly fill bottles, a new, certified-clean syringe was used to transfer water from the stream to the sample bottles. When collecting dissolved metals samples and other field filtered samples, an unused 60 mL syringe was triple rinsed with sample water, and water was collected directly from the source via syringe. A 0.45-micron filter was attached to the syringe, and the sample was filtered directly into the dissolved metals container. Nitric acid was added via dropper to both the total and dissolved metals containers immediately following sample collection.

2.2.3 Flow Measurement Collection

At most stream locations, flow measurements were made using aach 950 flowmeter in accordance with the manufacturer's operation manual. A few inflow locations with small flows were measured using a 2" throat cutthroat flume (manufacturer Baski). For surface water sampling locations where flow was too slow or small to be measured using the flowmeter or flume, other quantitative methods (e.g., bucket/stopwatch) were used to measure flow rates. If a quantitative flow measurement was not possible because of low-flow conditions (sources with less than 1 L/min), a visual estimate and photograph of flow was recorded.

At the time of sampling, no permanent flow measurement devices were in place to collect continuous streamflow measurements, so flow was measured at each sampling location immediately after samples were collected.

2.3 Habitat Restoration and Protection Activities

AWR conducted and monitored beaver wetland habitat restoration at the North Star Mine site on Mineral Creek and provided support monitoring of beaver habitat restoration on BLM lands in Cunningham Gulch. AWR also conducted follow up maintenance of beaver exclusion fencing for road infrastructure (culvert) protection on Highway 550 at Chattanooga turn. Additionally, AWR designed and constructed beaver exclusion fencing on County Road 2 near the Forest Queen Mine. A summary of each activity is provided below.

2.3.1 NorthStar Mine Revegetation and Community Engagement

At the North Star Mine, AWR launched a beaver habitat restoration project that not only aimed to expand wetland habitat on reclaimed mine lands but also brought the community together and provided a hands-on learning experience for the next generation. The project began with the careful harvesting of willow sprigs (cuttings) from downstream on the North Star property, with the landowner's permission. Willows are a critical food source for beavers and planting them around the manmade ponds at the mine was the next step in creating an environment where beavers could thrive. These efforts are part of a larger vision to use beaver habitats as a natural solution for cleaning up and restoring abandoned mine sites.

AWR used common revegetation techniques to restore beaver habitat and engage the community in conservation work. After confirming that willows were native to the area and assessing the site's hydrology and soil conditions, we harvested dormant willow cuttings from healthy willow clusters adjacent to the site. The cuttings, selected for optimal diameter (½ to 1 inch) and length (minimum 18 inches), were sealed, stored, and soaked prior to planting to maximize rooting success.

AWR ensured that planting followed best practices by inserting the cuttings deep into the soil, with several inches extending into the saturated soils to maintain consistent moisture contact. Soil was firmly packed around the cuttings to eliminate air pockets and ensure proper soil-to-cutting contact, crucial for adventitious root formation. The cuttings were strategically spaced along the banks of the manmade ponds, with placement optimized to match natural riparian zones.

A key highlight of this project was the enthusiastic involvement of 25 students from the PEAK Summer School Program at Silverton School. These young participants played a vital role in planting the willows along the banks of the ponds, turning the restoration work into an educational and empowering experience. Through their involvement, the students learned about the ecological importance of beavers, particularly their role as natural water filters and their ability to store water in the watershed. This hands-on activity not only taught the kids about the interconnectedness of ecosystems but also instilled a sense of stewardship and responsibility for the environment. For many of the students, this was their first exposure to ecological restoration work, sparking curiosity and pride in contributing to the health of their local landscape.

The project also served as a model for how abandoned mine sites can be revitalized in ways that benefit both nature and the community. By harnessing the natural abilities of beavers to filter water, stabilize ecosystems, and store water in drought-prone areas, we demonstrated an innovative and sustainable approach to environmental cleanup. Moreover, the involvement of the community, particularly the next generation, emphasized the importance of collaboration in addressing environmental challenges.

This restoration work at the North Star Mine is just the beginning of an ongoing commitment to creating a thriving habitat for beavers while engaging the local community in meaningful ways. Each year, we plan to build on this success, continuing to plant willows and monitor the habitat's growth. By combining education, community

engagement, and innovative ecological solutions, we hope this project will inspire similar efforts at other mine sites and beyond.

Over 250 willow sprigs were planted at North Star mine in 2024 and the re-growth success will be monitored in the future. The overall goal of the willow planting was to help stabilize the pond banks while enhancing wetland vegetation along the Mineral Creek riparian corridor. AWR plans to find future funding to continue monitoring the vegetation re-growth and hopes to engage more students in monitoring this area for beaver activity and increased wildlife diversity.



Figure 2.1 North Star Mine site habitat restoration. Silverton summer school students planting willow sprigs along the banks of the constructed wetland ponds that capture mine discharge.

2.3.2 Cunningham Gulch Beaver Dam Analogs and Post Assisted Log Structure BLM

In 2024 the BLM implemented low tech process-based restoration on public lands along Cunningham Creek in the Upper Animas Watershed. The project included building Beaver Dam Analogs and Post Assisted Log Structures along an upper reach to improve

floodplain connectivity and encourage adjacent beaver populations to actively maintain the constructed features.

AWR conducted baseline water quality sampling along Cunningham Creek in the fall of 2024, after completion of the restoration activities, and worked with BLM managers to develop a water quality sampling plan to assess the long-term impact of the BDA and PAL additions and beaver habitat expansion.

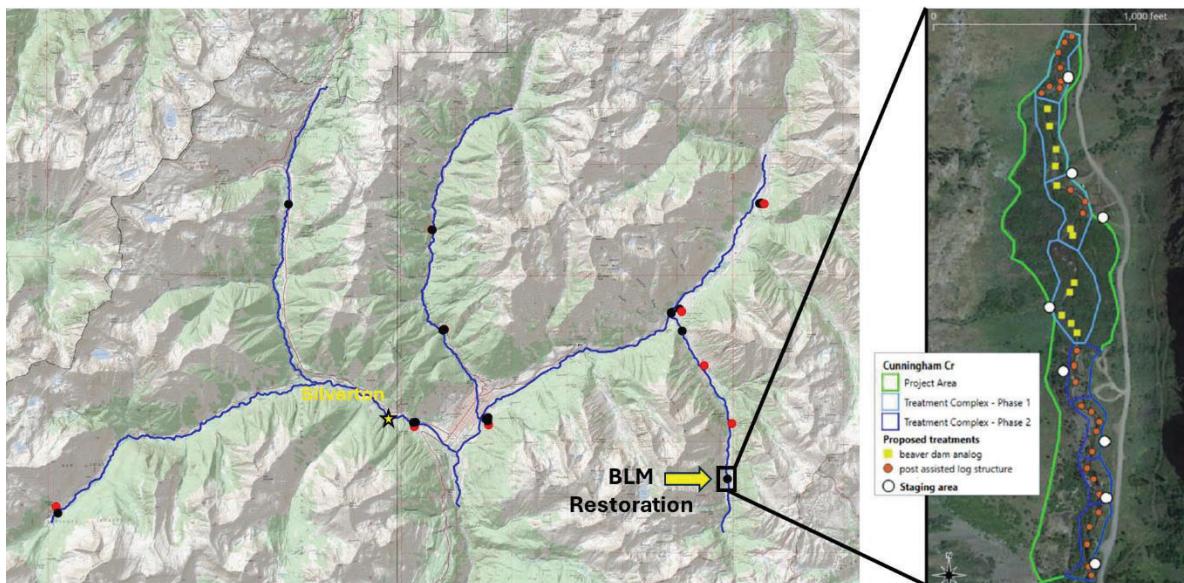


Figure 2-2: BLM beaver habitat restoration project in Cunningham Gulch



Figure 2-3: Examples of BDAs and PALs constructed by BLM for beaver habitat restoration in Cunningham Gulch.

2.3.3 Highway 550 Infrastructure Protection

A beaver exclusion fence was built by AWR for CDOT on highway 550 at Chattanooga turn in 2020 (Figure 2-4 left). The culvert was being constantly plugged by resident beavers which were causing water levels to compromise the highway road base infrastructure. The highway maintenance crews were having to repeatedly mobilize heavy equipment to remove debris from the culvert and lower ponded water levels. The installation of a low-tech beaver exclusion fence was performed to reduce the frequency and cost of culvert maintenance for CDOT.

Under this project the site was inspected in 2024 to assess the condition of the fence and the long-term maintenance requirements. The exclusion fence was still functioning after 4 years with no sign of culvert plugging by the area beavers. Due to the location of this fence infrastructure directly in a major highway avalanche path there is often extensive snow on top of the fence. After four winters the fence structure had become compromised and bent by the heavy snow loads each winter. In 2024 the AWR team performed stabilization of the existing posts and have made recommendations to CDOT on how to increase the long-term stability of this fence structure by using heavy duty post materials and more robust fence paneling. AWR intends to support long term monitoring and maintenance of this fence through future funding sources. The key takeaway from this project is that site specific characteristics, such as avalanches and snow loads, need to be taken into consideration when designing the low-tech defense structures.

As a second component to this project, AWR also constructed a BDA immediately upstream of the exclusion fence in 2023. The BDA was successful because in 2024 it was observed that beavers had taken over maintenance of the BDA and appeared to have put their focus on impounding water with the constructed dam and were no longer interested in damming at the culvert or around the exclusion fence (see BDA structure upstream of the fence in the right photo figure 2-4). This action demonstrated that while the exclusion fence prevented culvert clogging, the BDA also reduced beaver activity/damming along the exclusion fence which will ultimately reduce risks to the

highway infrastructure and reduce long term maintenance frequency and costs for CDOT.



Figure 2-4: Highway 550 culvert beaver exclusion fence construction in 2020 (left), and repair work in 2024 (right).

2.3.4 Country Road 2 Infrastructure Protection

San Juan County Road 2 culvert located near the Forest Queen Mine was being regularly plugged by beavers (left photo), requiring repeated maintenance to remove debris and prevent road damage. AWR received approval from the county to install a trapezoidal beaver exclusion fence (right photo). The fence excludes beaver access to the culvert and prevents flooding. The shape of the fence has been proven to discourage the beavers from damming along the entire fence due to the counter-intuitive flow direction of water across the fence walls. If beaver damming does occur an additional pipe and fence design can be extended off of the exclusion fence to permanently set a maximum water level of the ponded water and reduce risk to adjacent infrastructure and road.



Figure 2-5. Country Road 2 culvert beaver damming in summer 2024 (left) and construction of a trapezoidal beaver exclusion fence in December 2024 (right).

2.3.5 Identifying Suitable Locations for Future Beaver Habitat Enhancement and Restoration Activities

This study identified locations for additional Processed Based Restoration. This information can be used as a basis for identifying the best locations for future restoration and beaver habitat expansion when funding becomes available. A bullet list of locations and actions is provided below.

- Mineral Creek at Chattanooga – PALs to enhance new dams, connect flood plain
- Lower Cement Creek – PALs to expand flood plain and increase beaver habitat with potential of increasing removal of Fe and other metals in Cement Creek before it reaches the Animas River
- Cement Creek at Anglo Saxon – PALs and BDAs to reconnect floodplain and also provide additional tiered beaver ponds to further slow the mine discharge as it travels across the wetland area and towards the creek.

- Removal of Conifer vegetation in multiple locations along Cement Creek between Silverton and Gladstone in riparian areas where encroachment has occurred due to channel incision. Followed by BDAs and PALs to raise water tables and then promote deciduous vegetation regrowth.
- North Star mine: Continue revegetation of the reclaimed areas along Mineral Creek and around the constructed wetland ponds to provide wildlife refugia and beaver food sources and encourage beavers to utilize the perennial water source of the mine discharge to build additional habitat.
- Bandora Mine: Direct mine discharge to enter the beaver complex further upstream, providing more time for mixing and attenuation, reducing downstream impacts from metals



Section 3

Results

3.1 Watershed Water Quality Parameters and Flow

Water quality parameters obtained at focus area locations where water was observed include water temperature, pH, dissolved oxygen content, conductivity, oxidation-reduction potential, and discharge. Water quality parameter data is located in Appendix B. All water quality data can be used for baseline reference in future studies or actions. In general water quality across all sites varied from acid to neutral pH and medium to high specific conductivity. Water quality varied at individual sites based on natural variations in local geology and varying interactions with anthropogenic sources of mining contamination. Documenting water quality across the sites also showed that beavers are able to adapt to changing conditions and appear to be more tolerant to degraded water quality than the more sensitive aquatic species of invertebrates and fish. Specific highlights of water quality findings are presented on a site-by-site basis in section 3.3 below.

3.2 Analytical Chemistry Results

Analytical chemistry results for all focus area sites can be found in Appendix A with graphed data found in Appendix A1. A full analysis of each location where water chemistry was collected is beyond the scope of this report but was summarized in the final presentation (Appendix d). The presentation is available on YouTube at the link below.

<https://www.youtube.com/watch?v=wS43-Roa9cg>

Due to the wide variety of beaver habitat focus areas in relation to various draining mines and diverse background of geochemistry found in the different drainages in the Upper Animas River watershed there was a wide range of metals concentrations found in the surface waters. To summarize, healthy beaver populations in areas where

beavers have been active for many decades were documented across a wide range of metals concentrations that were often in exceedance of chronic standards for aquatic life (figure 3-1). Aluminum, Iron, and Zinc concentrations measured in beaver habitat were frequently above the aquatic life standards for the Animas River. The quantitative results provide a baseline database that begins to demonstrate the ability of beavers to live in degraded water quality.

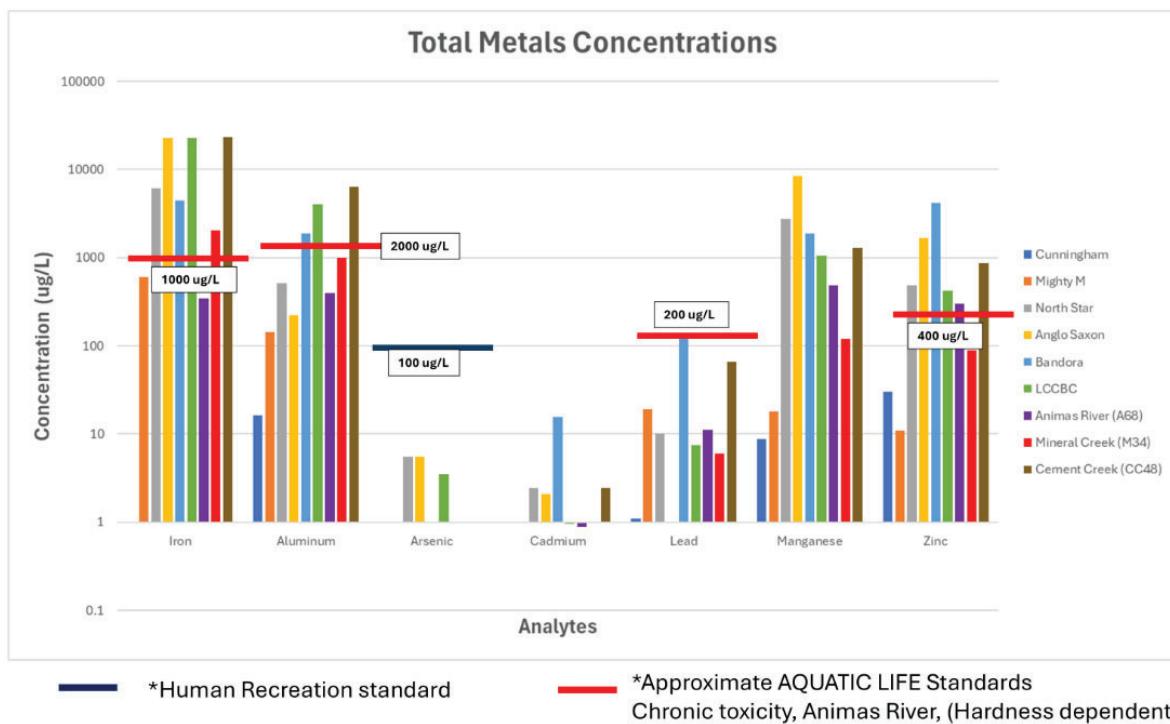


Figure 3-1. Graph of total metals concentrations at beaver habitat focus areas in relation to approximate Aquatic Life Water Quality standards for chronic toxicity in Animas River Watershed.

- Impacts of active beaver habitat (ponds, dams, and connections between surface waters and adjacent flood plains) were identified through the analytical chemistry results.
- Specifically, many of the focus study areas saw an improvement in water quality from upstream to downstream when beaver habitat was present.
- Reduction in total and dissolved metals concentrations was observed at nearly all monitored locations with individual focus areas results discussed in subsequent sections.

3.3 Focus Area Results and Discussions

To efficiently summarize the overall efforts and results of this study, a summary of bullet points is provided for each focus area below. The bulleted summary is indented to provide succinct and clear information about each location that can be utilized to develop future actions for beaver habitat enhancement and restoration either in conjunction with ongoing mine site remediation or for overall watershed management and ecosystem improvements.

3.3.1 Bandora Mine

- Bandora mine discharge enters the headwaters of South Mineral Creek at a location where beavers are present.
- Long standing beaver colony, living at 11,200 ft elevation.
- many decades of beaver existence which shows that the beavers are thriving in this location even with metals in the waters.
- Healthy ecosystem adjacent to BPMD listed mine site with mine drainage and extensive mine wastes.
- High use recreational area for camping and backcountry entry point.
- Beaver ponds receive mine discharge and allow mixing and retention time before that water moves downstream.
- The pH increases across the site from 4.92 upstream to 5.79 downstream, which increases metals precipitation, especially Al.
- Mine discharge pH is higher than the receiving stream at 7.41.
- Beaver ponds are blue in color due to high aluminum (Al) background concentrations entering the stream from natural background sources (limited mining upstream).
- Upstream total Al is 3.95 mg/l, significantly higher than the ~2 mg/l Aquatic Life standard for chronic toxicity for the Animas River.
- Downstream Al is 1.58 mg/l, demonstrating significant Al attenuation in the beaver habitat.

- Bandora Mine Discharge is high in total Fe (13.0 mg/l), Mn (5.02 mg/l) and Zn (12.4 mg/l), Pb (0.281 mg/l).
- Total metals downstream of the beaver complex all decrease with Fe down to 0.26 mg/l, Mn down to 0.2312 mg/l, and Zn down to 0.186.
- Total Pb decreases to 0.0026 mg/l.
- Mixing and attenuation of the mine discharge, and upstream inflows, in the naturally occurring beaver complex increases pH, reduces total metals and improves downstream water quality.

3.3.2 Chattanooga

- Located in Upper Mineral Creek, 10,200 ft elevation.
- Example of a location with a lot of beaver activity, not directly adjacent to mine features but there are several BPMD listed mine sites upstream which contribute metals to surface water (Kohler, Junction, Longfellow, Silver Ledge).
- Overall water quality at this site is good with neutral pH and low specific conductivity.
- Historic and current beavers in the area documented with aerial imagery.
- Unique location that was a former mining community where the landscape was dried out to provide habitable land and build the historic railroad.
- Drying of the valley reduced deciduous vegetation in proximity to the stream channel and likely reduced floodplain.
- Historic mining activity in the area also removed vegetation.
- Current highway infrastructure and the historic railroad location restricts stream channel in places, narrowing the historic floodplain and increasing stream velocities.
- There is a fen ecosystem that was impacted by historic activities where the ground water levels were lowered by ditches to make more flat dry land.

- Restoration of the fen ecosystem for the past 15+ years is restoring groundwater tables adjacent to the flood plain but still disconnected to surface waters due to stream channel incision.
- Located in an area with significant avalanche activity which produces large wood debris carried into and adjacent to the stream channel.
- In recent years beavers are using large wood debris to make channel spanning dams.
- New dams have widened the stream channel from less than 30 ft wide to over 90 ft wide in just 2 years.
- New channels spanning dams are beginning to reconnect the stream channel with the floodplain and fens ecosystem.
- New dams are slowing water velocities and increasing sediment deposition.
- New dams are increasing riparian area water tables which should increase deciduous vegetation growth, improving habitat for beavers and other wildlife.
- Continued monitoring of this re-connection is warranted.
- Due to the large high flows during spring runoff the new dams are subject to repeated blow out due to channel incision and high velocity discharge.
- This location is a prime candidate for the addition of Post Assisted Log Structures (PALs) to reinforce the natural beaver dams, increase the number of dams, and reduce likelihood of annual blow outs.
- The PALs would support deeper water channels and support beaver expansion in the area.
- An expanded beaver habitat would provide greater connectivity with other beaver complexes upstream in Mill Creek.
- USFS collaboration is encouraged at this site.

3.3.3 North Star

- Located immediately adjacent to the Town of Silverton.
- Site with large mine waste rock piles on the edge of Mineral Creek.

- Mine water discharge was flowing over the waste rock.
- Remediation of the site by EPA moved waste rock away from the surface waters and stabilized in place.
- Remediation also channelized mine discharge and eliminated contact with waste materials
- Prior to mine remediation, beavers had voluntarily moved into the mine and dammed the mine discharge at the portal, directly on top of exposed waste rock.
- Beaver activity demonstrated the ability of beavers to live directly in mine discharge.
- Beavers were removed prior to restoration activities.
- Restoration included the construction of 7 consecutive ponds in the reclaimed area with the objective of creating wetland habitat that could be used by the beavers living in Mineral Creek.
- Long term goal is to have the beavers move back in and take over Maintenance of the constructed ponds.
- Revegetation of the earthen berms with willows has been initiated to provide stability and eventual food and building materials for future beaver use.
- Successful Education and Outreach actions at the site were completed with a community volunteering effort from students in the Silverton School “Peak” summer program.
- Students planted over 200 willow sprigs, gaining hands on experience with restoration and learning about wetland ecosystems and beavers.
- Willow planting with the students will continue.
- AWR and volunteer groups will continue to monitor the vegetation regrowth and hope to monitor overall wildlife use of this rehabilitated wetland habitat after remediation.
- Long term goal of creating a healthy wetland area, used by beavers and other wildlife, adjacent to Mineral Creek in a location previously covered with mine

wastes, with a bonus of long-term metals removal from the mine discharge through passive treatment in beaver ponds maintained by beavers.

- Water quality impacts from the remediation was monitored in this study to show changes in metals concentrations.
- The greatest removal of metals was with Fe, going from 7.70 mg/l at the portal to 4.59 mg/l at the outflow to Mineral Creek.
- Total Al decreased from 0.643 mg/l to 0.391 mg/l.
- USGS Minni Sippers were installed by DRMS to monitor mine discharge and pond discharge at weekly intervals over a full year to see how metals concentrations change seasonally and how the constructed wetland habitat/ponds removed metals.
- Total Al showed up to 87% decrease over the system during high flow (mine discharge increases significantly during snowmelt at this site).
- Total Fe had up to 90% removal over much of the year.
- Total Zn levels decreased by 50% during spring discharge.
- Total Mn concentrations decreased by up to 30%.

3.3.4 Lower Cement Creek Beaver Complex

- Cement Creek has high metals concentrations due to both background geology and extensive mining in the upper watershed.
- Cement Creek does not currently support healthy aquatic life (benthic invertebrates or fish) due to degraded water quality but does support beaver populations.
- A goal is to document that beavers can live in degraded water and beaver habitat can provide passive water quality improvements through attenuation of metals, especially Fe.
- At LCCBC, beavers have been using a mine discharge to make habitat adjacent to the stream.

- Beavers at this site have also made several attempts to build channel spanning dams to flood the riparian area and connect their beaver lodge with surface waters.
- Channel dam only lasted during low flow conditions, but it was long enough to have significant iron settle out in the flooded areas, documented in this study with water quality data.
- Example of passive metals (esp. Fe) removal from Cement Creek which reduces metals loads entering the Animas River downstream.
- Historic removal/loss of beavers in Cement Creek, likely from trapping and mining activities has caused accelerated stream velocities, narrowing of stream channel and incision which has disconnected stream from historic flood plains.
- Drying of the flood plain has led to conifer encroachment over the past 100 years, and in place of aspen and other deciduous vegetation needed by the beavers.
- Observed behavior of beavers traveling long distances up the slope to source aspen trees for large debris to make dams and lodges and food source.
- Photos in photo log depict spruce trees dying in areas where the beaver managed to flood the area with the channel wide dam.
- Long term monitoring would help document this reversal of forest succession with beaver habitat expansion.
- This location is an example of where BDAs will encourage the beaver to maintain larger habitat, reconnect floodplain, and encourage forest succession by flooding out the spruce.
- Additional increases in beaver habitat along the entire Cement Creek corridor could have a cumulative effect of metals attenuation and removal (through deposition etc.) which may not bring aquatic life into Cement Creek but have positive impact by reducing overall water quality downstream of Cement Creek in the Animas River.

3.3.5 Anglo Saxon Mine

- Mine discharge traveling through a constructed pond and natural wetland before reaching Cement Creek

- Beaver activity present in the floodplain including attempts at channel spanning dams and floodplain reconnection.
- Spruce encroachment is evident due to stream channel incision. Areas where the water table has come back due to beaver dam expansion is littered with dying spruce and stand as an example of healthier floodplains without spruce.
- The water quality of the mine discharge was measured at the inflow to the pond/wetland complex and at the outflow to Cement Creek.
- Beaver activity observed near the settling pond and channel spanning dams (blown out) were observed in the area in 2023 and 2024.
- Drying of the flood plain has led to conifer encroachment over the past 100 years, and in place of aspen and other deciduous vegetation needed by the beavers.
- Water quality improvement of the Anglo Saxon mine discharge was measured across the pond and wetland complex.
- Total Fe in mine discharge decreased from 33.5 mg/l to 12/5 mg/l across the complex.
- Total Mn in mine discharge decreased from 8.57 mg/l to 8.19 mg/l across the complex.
- Total Zn in mine discharge decreased from 1.78 mg/l to 1.54 mg/l across the complex.
- Total Al, As, Cd, and Pb are low in the mine discharge, but all show measurable decreases in concentration across the site.
- This location is a good candidate for low tech restoration through BDAs and PALs to help reconnect the floodplain, increase deciduous vegetation and encourage beavers to build a complex that could help to filter mine discharge and improve water quality before entering Cement Creek.
- Reconnecting the floodplain would also reduce stream velocities and encourage more metals attenuation and removal at a location downstream of many of the largest metals contributing mines in the BPMD.

3.3.6 Mighty Monarch Mine and Kendall Beaver Ponds

- Beavers have a lodge and pond that has been active for many decades.

- The pond is fed by perennial mine drainage from the Mighty Monarch.
- The pond also likely receives GW related to the alluvial aquifer adjacent to the Animas River.
- Based on sampling results, the mine water is of better water quality than the alluvial GW which demonstrates where beavers are utilizing a stable and consistent tributary inflow (in the form of mine drainage) to create stable wetland habitat.
- The site is located at the edge of Kendal Mountain ski area and high recreational use due to high accessibility for a wide range of user groups.
- Site is a location where the local community has interests in improving natural ecosystems and enhancing recreational activities (wildlife viewing, fishing, etc.).
- Used in the wintertime as a hockey rink once frozen over and poses as opportunity to expand recreation.
- Maintaining and expanding beaver habitat at this location would allow for ADA Compliant recreation such as birdwatching and fishing.
- This site is currently not directly connected to the Animas River floodplain but could be good candidate for future ecosystem restoration that would benefit the local community and economy.

3.3.7 Cunningham Gulch

- Cunningham Gulch has historic mining activity (Old 100 and Pride of the West Mine).
- Documented beaver activity over the last several years.
- BLM targeted area for goal of expanding that habitat by doing process-based restoration (BDAs and PBRs).
- Cunningham Gulch has several BPMD listed mines, Old Hundred and Pride of the West and Little Nation which are impacting water quality and beaver activity has already been established downstream.

- Restoration was done in 2024 and initial monitoring was completed. A goal was to establish baseline conditions now that the BLM can use to do future monitoring of the PBR actions.
- Total Zn quantities decreased from 0.0384 mg/l to 0.216mg/l across the complex from above and below the existing beaver habitat.

3.3.8 Pride of the West Mill and Kittimac Sites

- These sites are along the Animas River above Silverton where there is extensive healthy beaver habitat adjacent to historic mine tailings and degraded areas with low or no ecosystem function.
- The primary objective was to document the extent of beaver activity in the Animas River valley in areas immediately adjacent to mining related contamination and impacts (tailings).
- The objective for studying this site was to document potential for greater beaver and wetland habitat connectivity by ecosystem restoration in areas where mine remediation is forthcoming.
- The sites have historic infrastructure impacts from the railroad and county road which currently constrict the river channel and reduce floodplain connectivity across the valley.
- Historic railroad grade and county roads have dissected the valley and limited lateral movement of water across the alluvial floodplain, resulting in over straightened river channels and isolated pockets of riparian habitat.
- Document how the river channel was modified into a single channel and moved to one side of the valley to make room for milling and mill tailings. Resulting in an incised channel and flood plain disconnect. The result is a significant reduction in the area beavers can use and a loss of riparian vegetation due to decreased alluvial groundwater tables.

3.3.9 Forrest Queen Mine Wetlands

- Mine discharge currently travels through a seasonal wetland with seasonal beaver activity before reaching the Animas River.

- Mine water from the Forest Queen enters the wetlands that beaver inhabit, Wetlands help remove metals and reduce metals transport to the river.
- County roads and historic railroad limits lateral movement of the river and groundwater during high flows and create.
- Beavers have been regularly damming the culvert under the country road to increase beaver habitat in the area directly below, and receiving of, the mine discharge from Forest Queen mine.
- The County roads department had to regularly unblock the culvert to prevent flooding and infrastructure damage, a reoccurring cost to the local community.
- A beaver exclusion fence was built around the culvert in 2024 to reduce maintenance costs and support co-existence of beaver habitat adjacent to public infrastructure in a location where expanding the habitat could have a double benefit of passively improving water quality of the Forest Queen mine discharge before reaching the Animas River.
- Forest Queen culvert. Then state that one idea would be to raise the country road and add large culverts etc. That would allow water to move back and forth and reconnect the east side of valley to the flood plain.

Section 4

Conclusions and Recommendations

Below is a list of concluding remarks and recommendations intended to encourage and inspire future efforts

- Integrate mapping efforts into large mapping database with other stakeholders (currently utilizing Cal-Topo platform, potential to integrate into a GIS database that can be shared across stakeholders).
- Continue monitoring changes to beaver habitat in relation to ongoing mine remediation or other land use changes such as infrastructure development.
- Build a more robust dataset to examine impacts of beaver habitat on metals concentrations and load reductions at reach and watershed scales.
- Continue education and outreach on the importance of beavers and how the community can participate in low tech PBR to enhance the ecosystem.
- Coordinate with partners to develop multiple phases of beaver habitat enhancements (stacking funding cycles/sources with understanding that the cumulative process will take decades to reach watershed scale goals for healthy ecosystems and habitat connectivity etc.)
- Understand and quantify any potential chronic impacts to beavers from living in waters with elevated metals concentrations. Identify biologist researchers who could provide beaver toxicology data through tissue sampling or other methods.
- Examine terrestrial impacts to beaver health (Pb in soil/sediment) and any impacts to beavers (beavers were not specifically identified or studied in the 2016 BPMD BERA).

- Better understand how beavers avoid aquatic contaminates through a terrestrial diet.
- Enhance interagency (local, state, federal governments) communication on ongoing funding and actions related to mine remediation and watershed improvement to increase likelihood of mutual benefits from coordinated efforts.
- Continue to monitor natural beaver population growth and habitat expansion through repeated photography and aerial imagery.
- Promote concepts of utilizing low tech process-based restoration to improve watershed function while also encouraging beaver recruitment and as a low-cost technique to perform passive remediation of mine sites.
- Further document how beaver habitat enhancement can be combined with other mine remediation techniques and practices to reach water quality and ecosystem improvements over reach to watershed scales.

Other Observations

While beaver habitat enhancement of metals impacted water is site dependent, monitoring sites in this study showed incremental improvements. With respect to the BPMD, beaver habitat enhancement should be considered supplementary to other remedial actions pursued at the BPMD site. Maintaining current information on beaver activity and habitat conditions in proximity to mine sites where remediation is planned or intended will support feasibility studies and planning.

Section 5

References

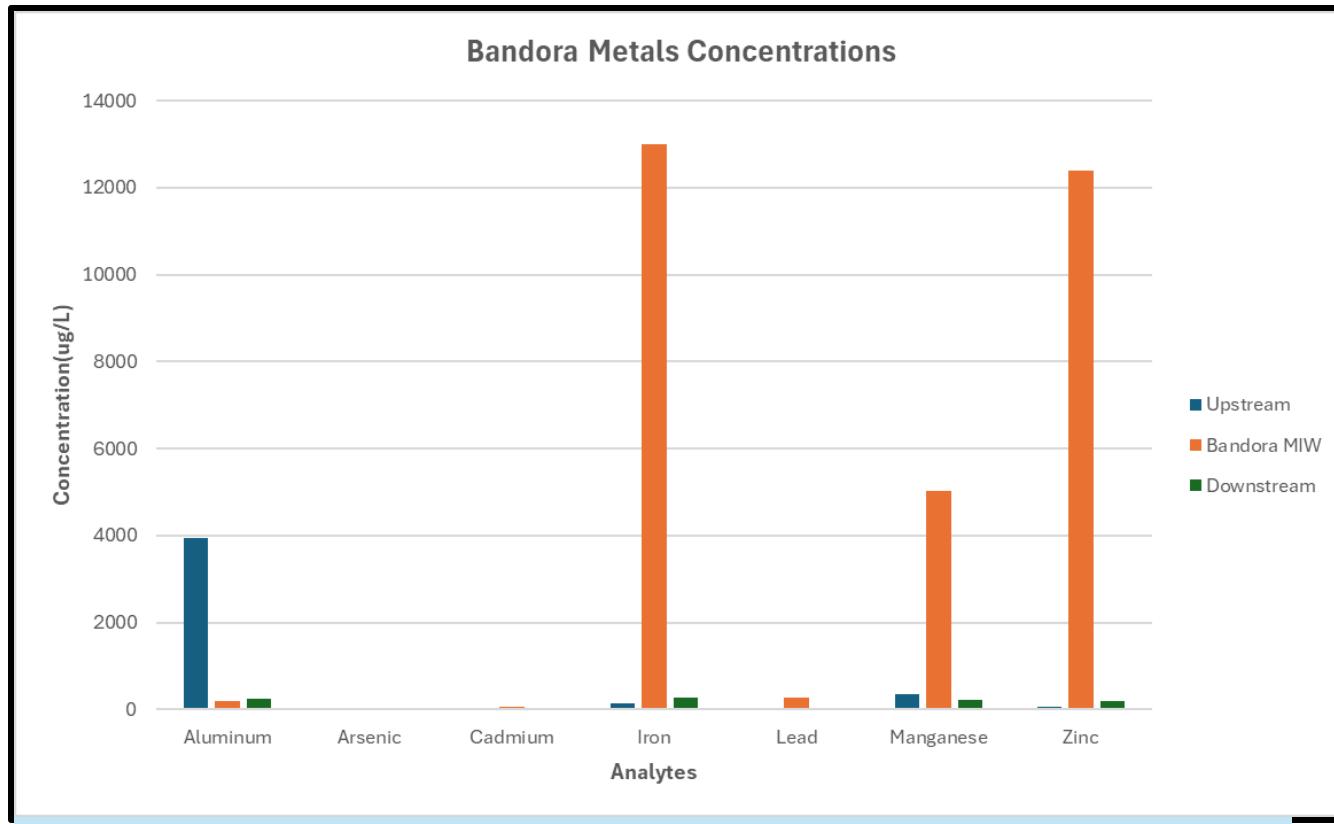
EPA. 2021. *Bonita Peak Mining District Quality Assurance Project Plan*. Prepared for U.S. Environmental Protection Agency by CDM Smith. Revision 5, August.

Appendix A Analytical Data Results

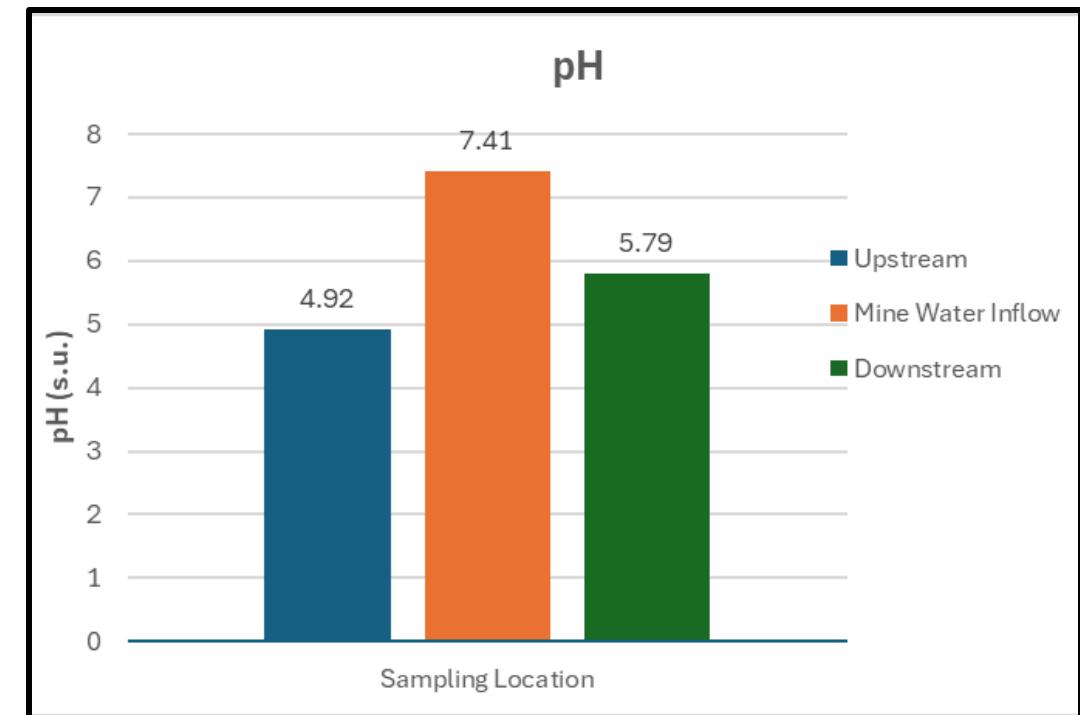
Data Under Separate Cover XLS Spreadsheet

Appendix A1 Water Quality Graphs

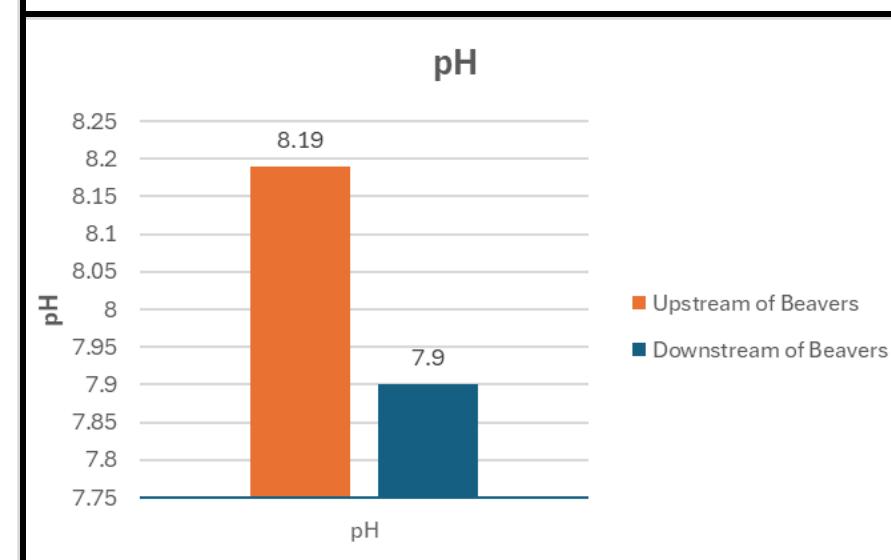
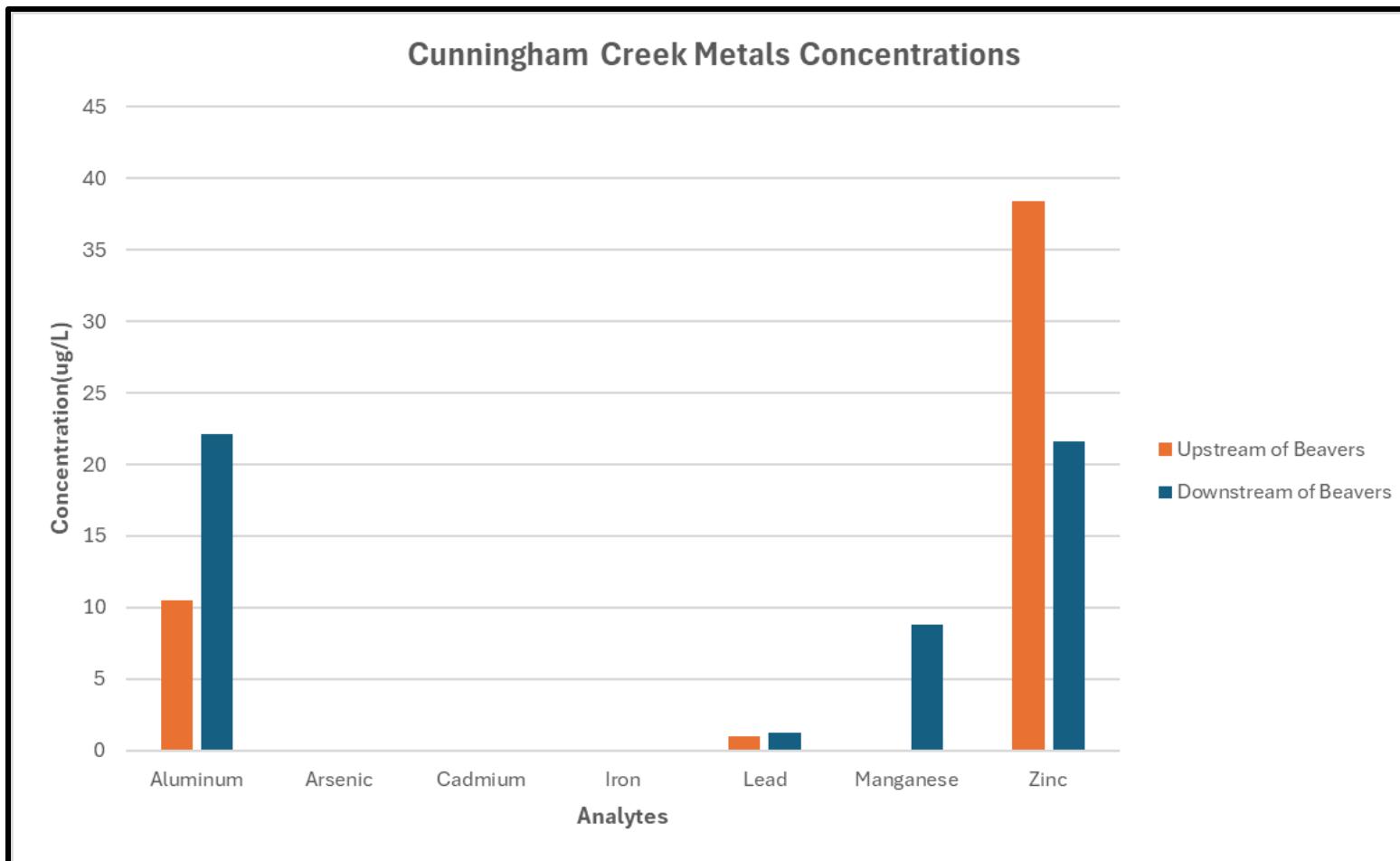
Bandora Mine Site Water Quality



- Al decreases significantly across beaver habitat (pH dep.)
- MIW inflows higher pH & high Fe, Mn, Zn, minimal load

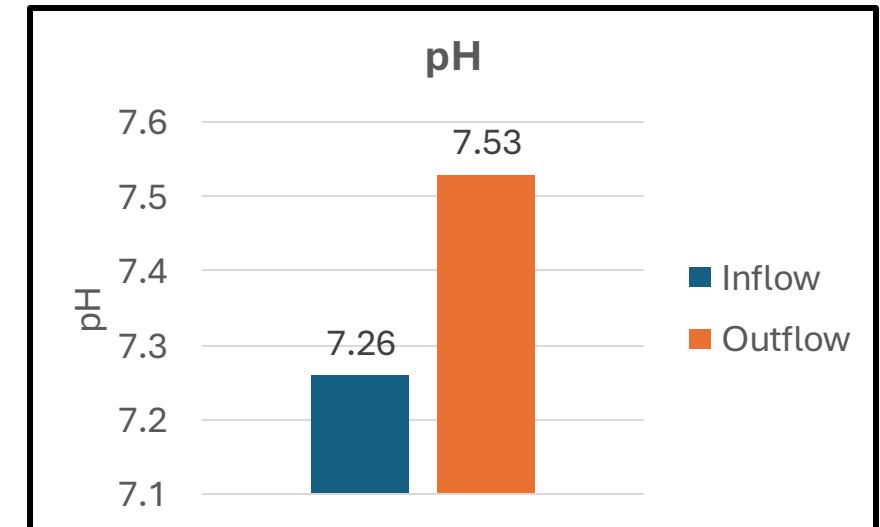
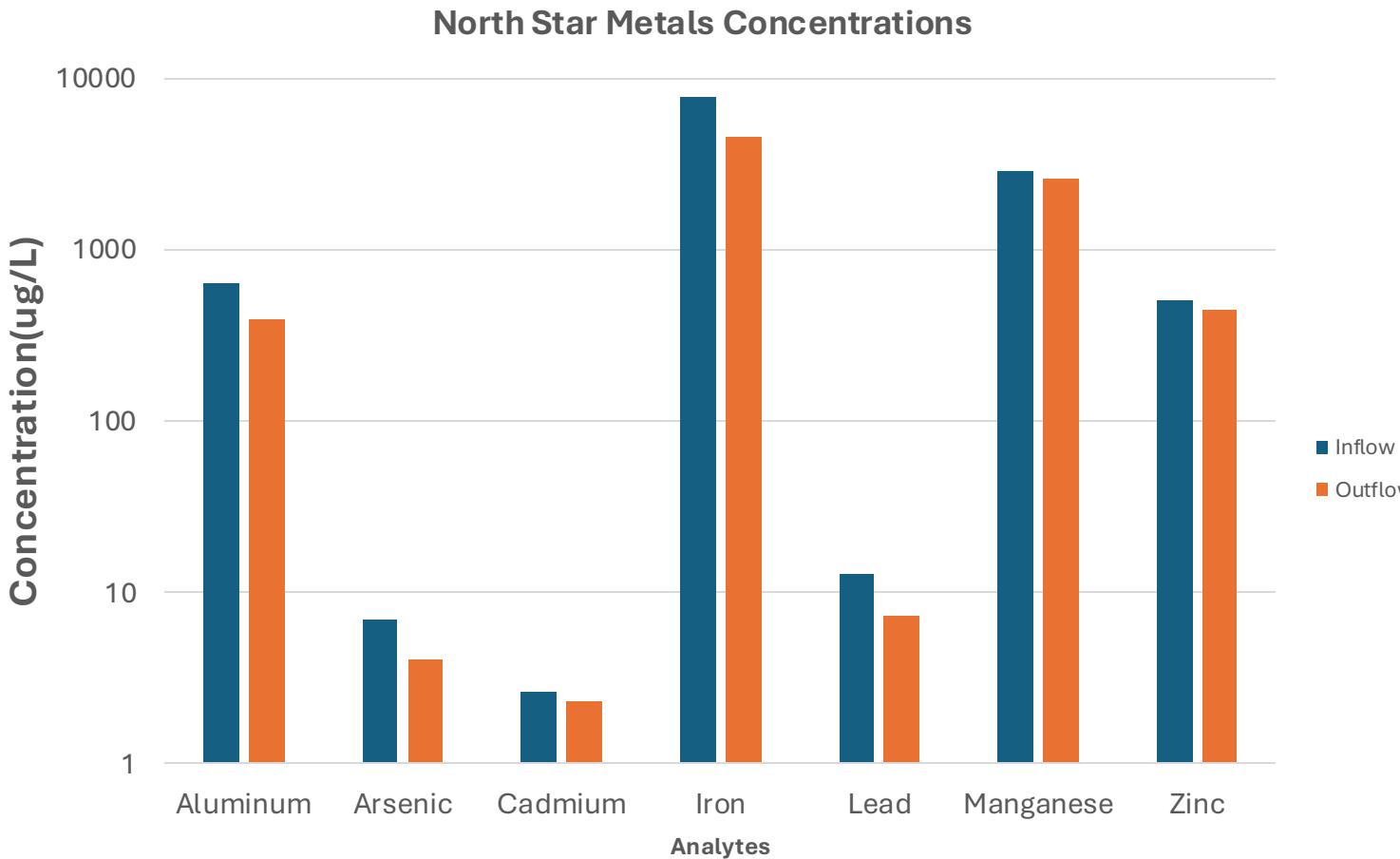


Cunningham Creek Water Quality Upstream and Downstream of Beaver Activity and Mine Water inflows

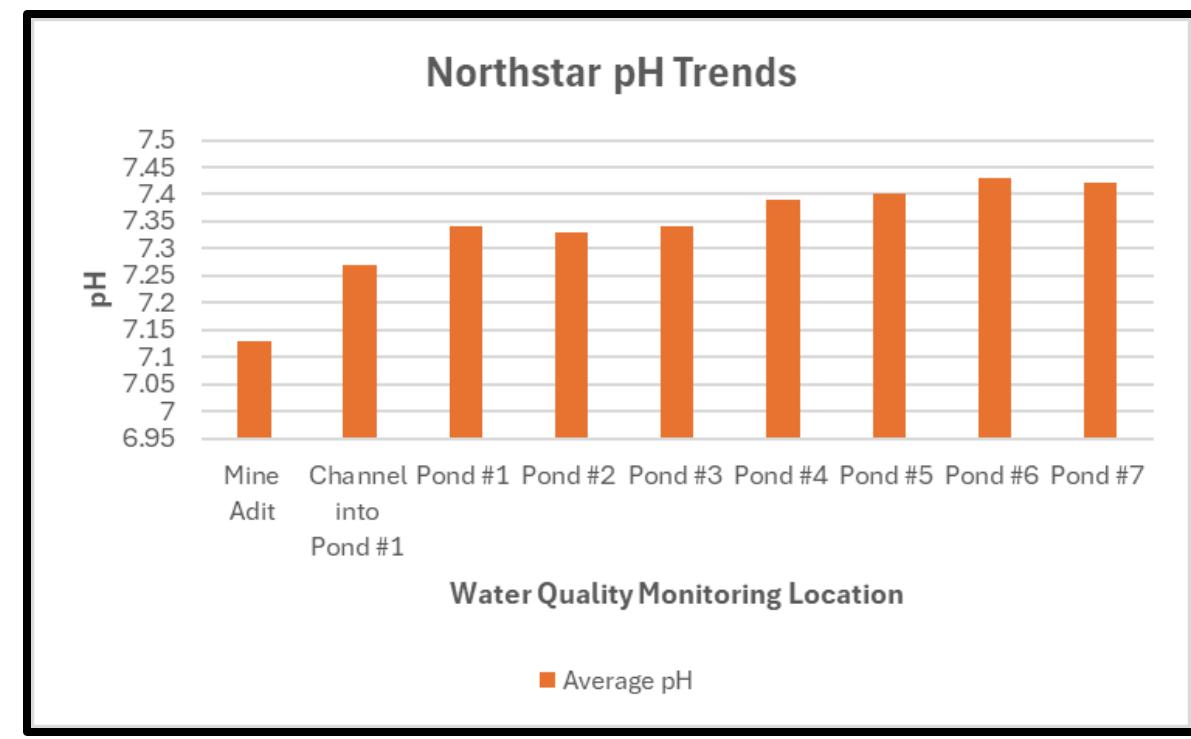
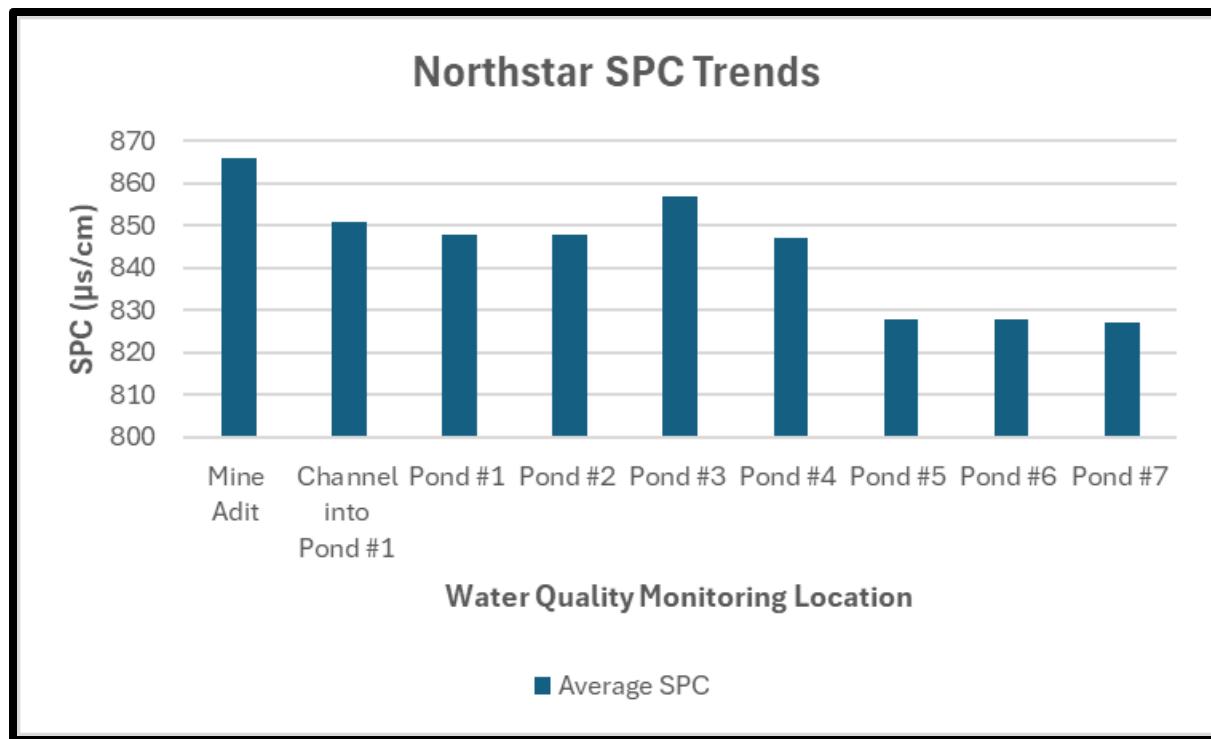


North Star Mine Impacted Water Quality

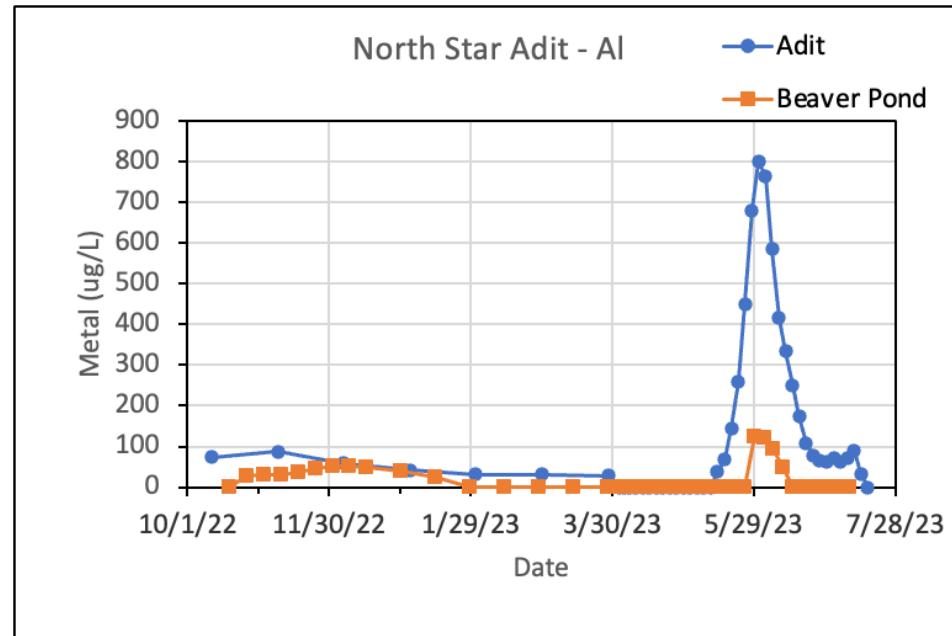
Upstream and Downstream of Ponds



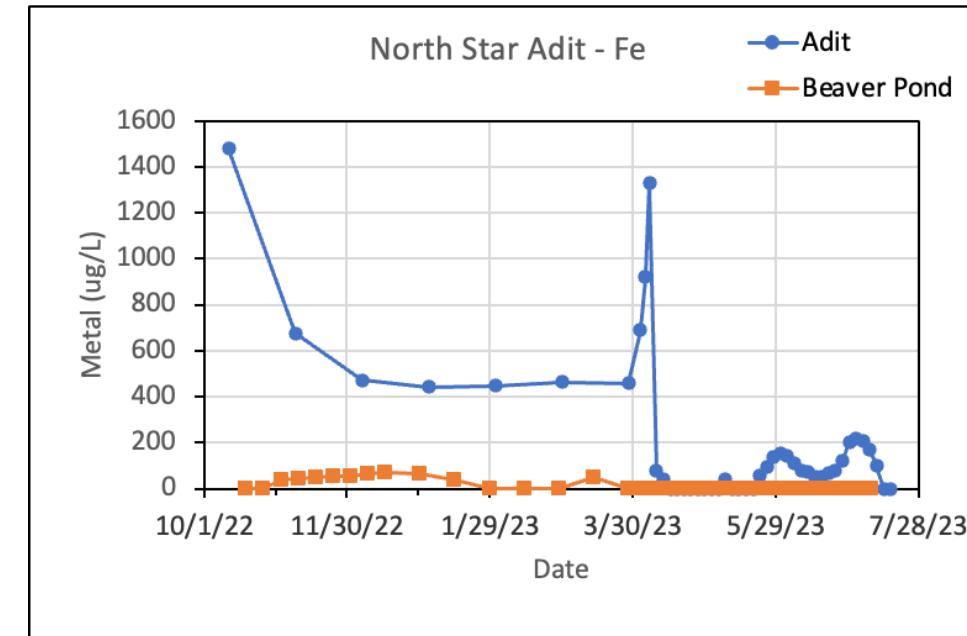
North Star Mine Average Water Quality from Four Site Visits (May 2024- October 2024)



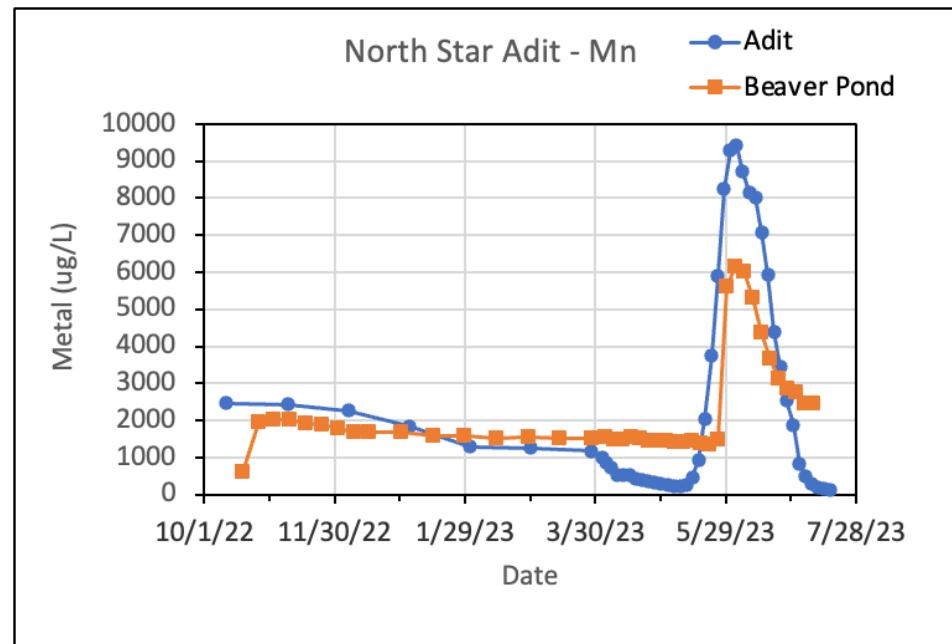
North Star Mine: DRMS/USGS Continuous Monitoring Data 2022-23



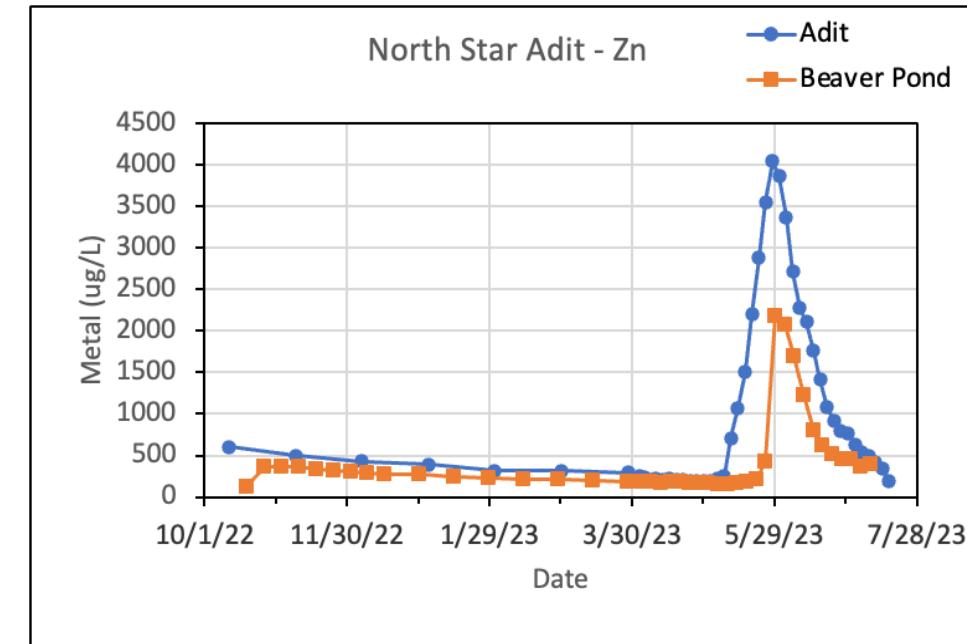
87%
Decrease



Up to
>90%
Decrease



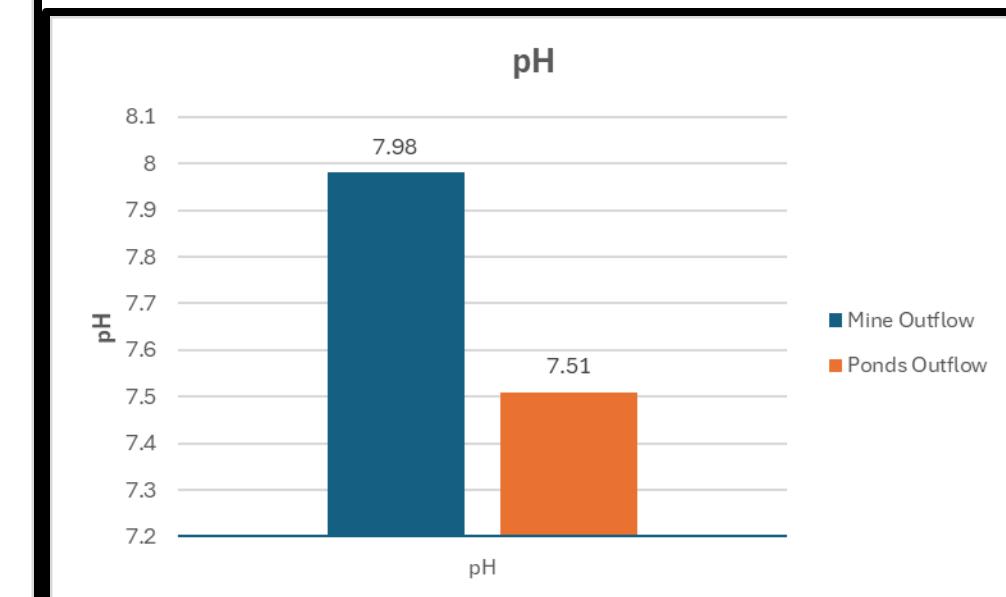
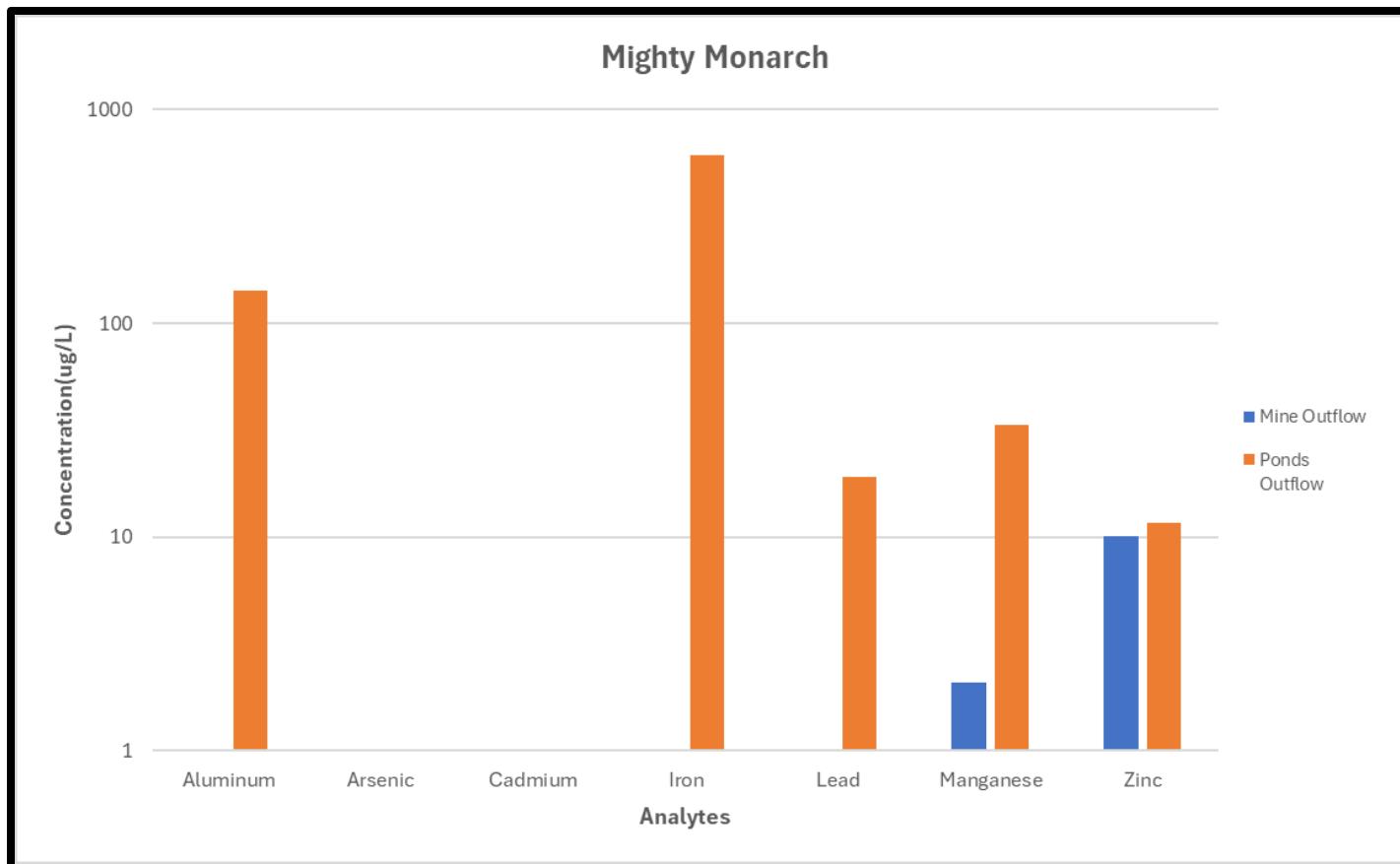
30%
Decrease



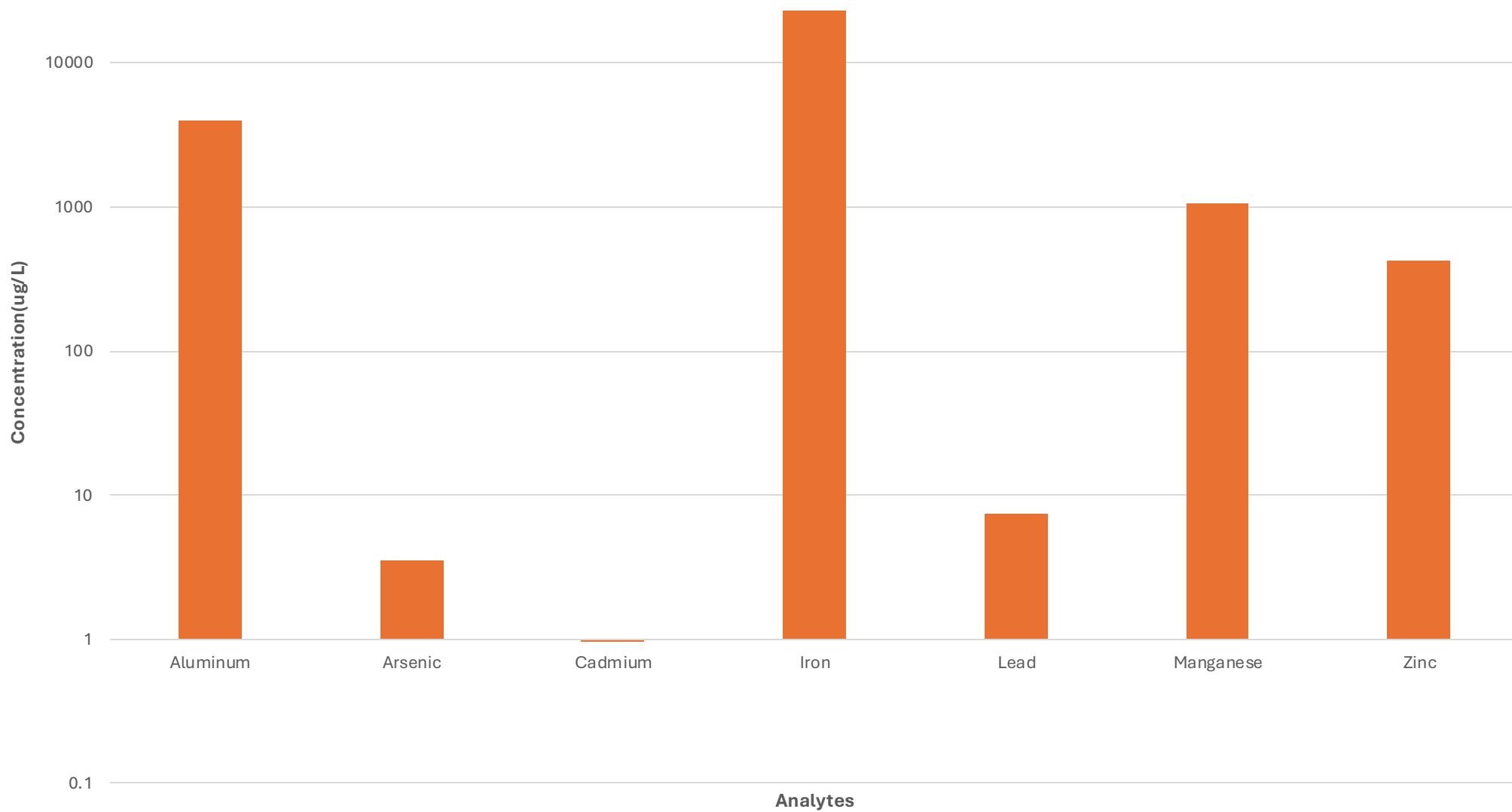
50%
Decrease

Mighty Monarch Mine

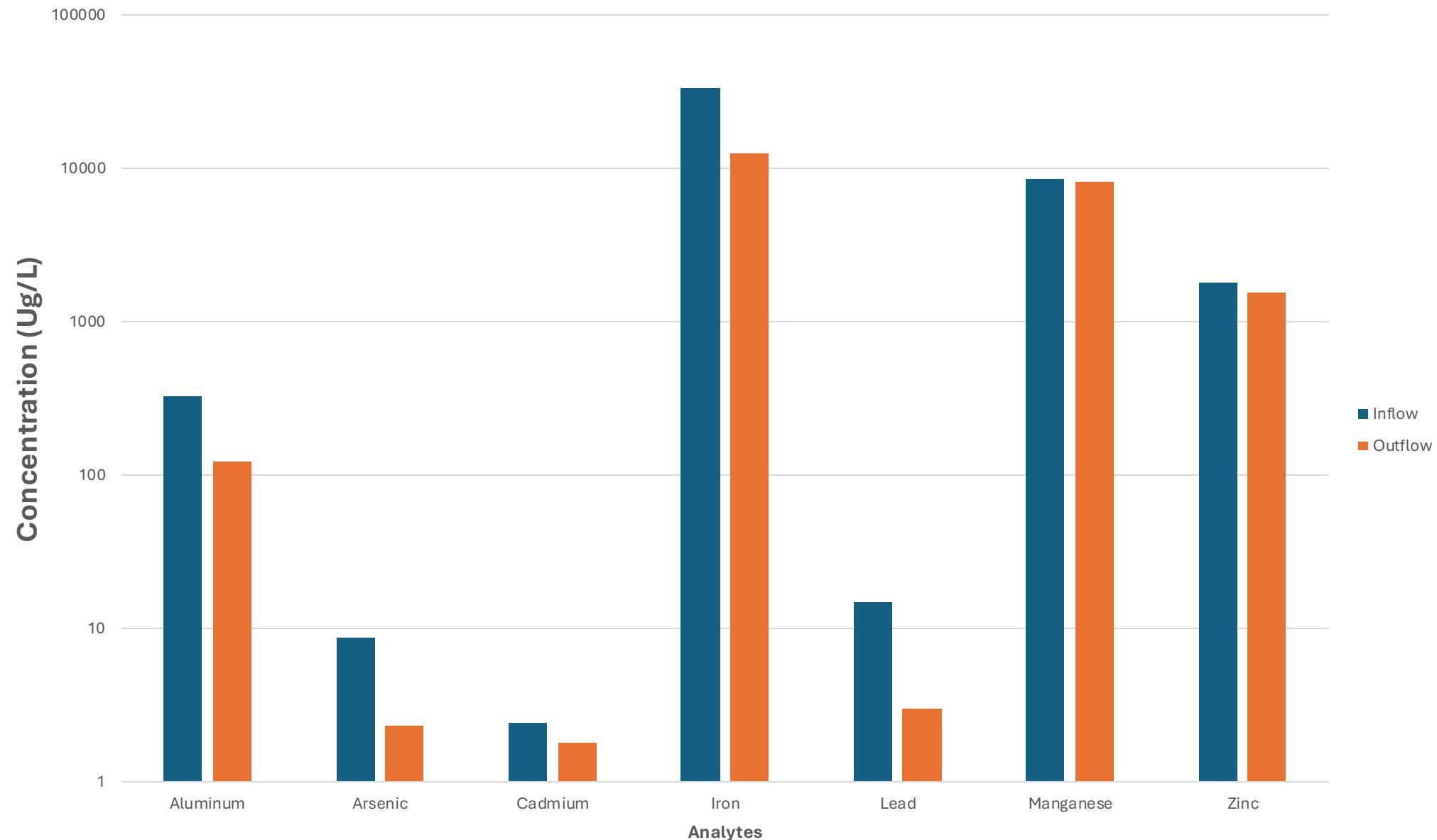
- Many decades of occupancy, utilizing mine discharge which is actually of better WQ than alluvial GW inputs



LCCBC (Lower Cement Creek Beaver Complex) Total Metals Concentrations



Anglo Saxon Mine Metals Concentrations



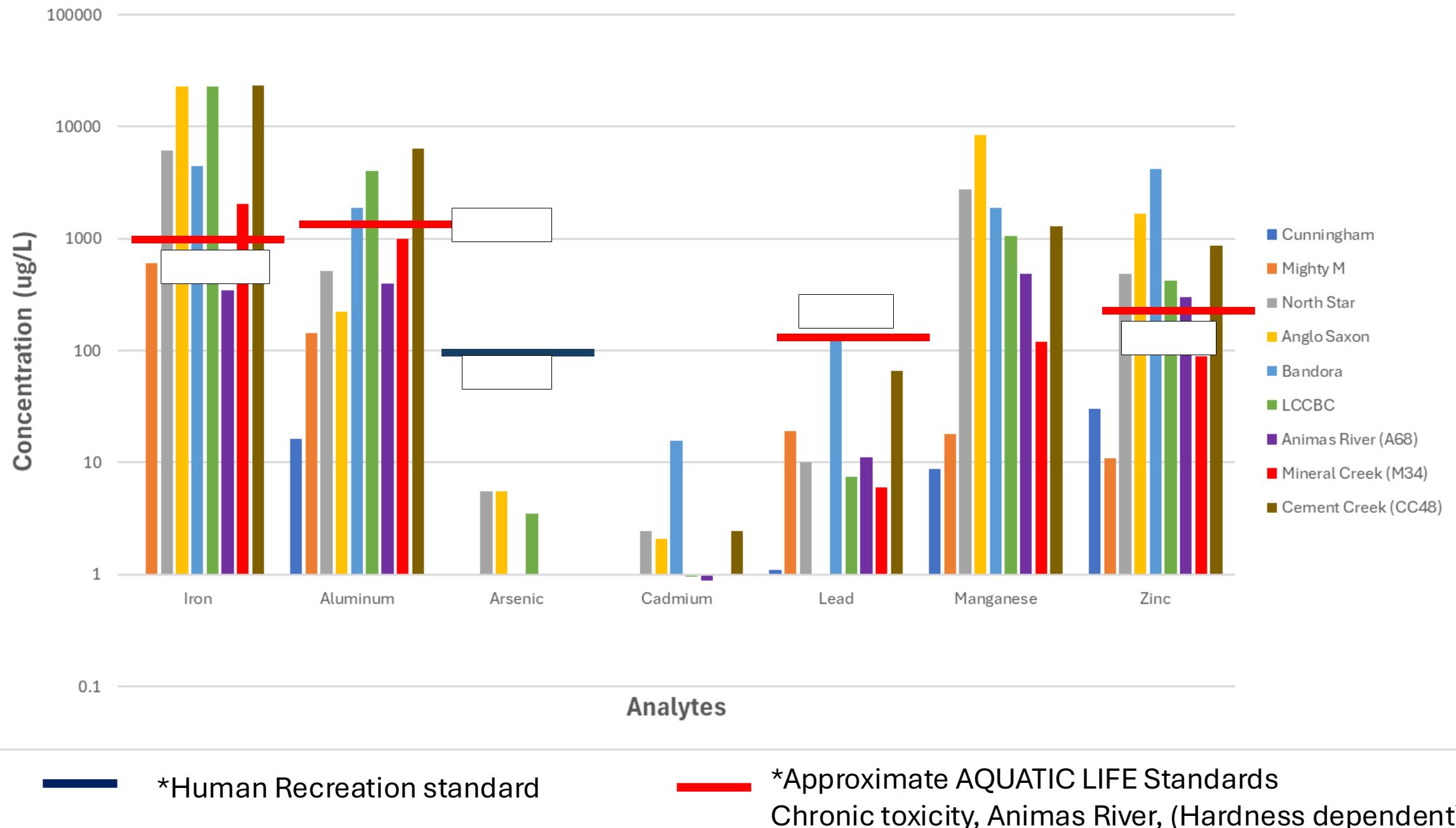
Min/ Max Metals Concentrations Across Active Beaver Sites in the Animas Watershed

Total Metals Summary Table

	<i>Min (ug/L)</i>	<i>Max (ug/L)</i>	<i>***</i>	
Iron	145	33500	1000 ug/L	Chronic
Aluminum	10.5	3950	2000 ug/L	Chronic
Arsenic	2.3	8.7		
Cadmium	0.5	54.2		
Lead	1	281	200 ug/L	Recreational
Manganese	2.1	8570		
Zinc	10.1	12400	400 ug/L	Chronic

***** Animas River Approximate Metals Standards for Aquatic Life**

Total Metals Concentrations



Appendix B: Water Quality Parameter and Flow Data

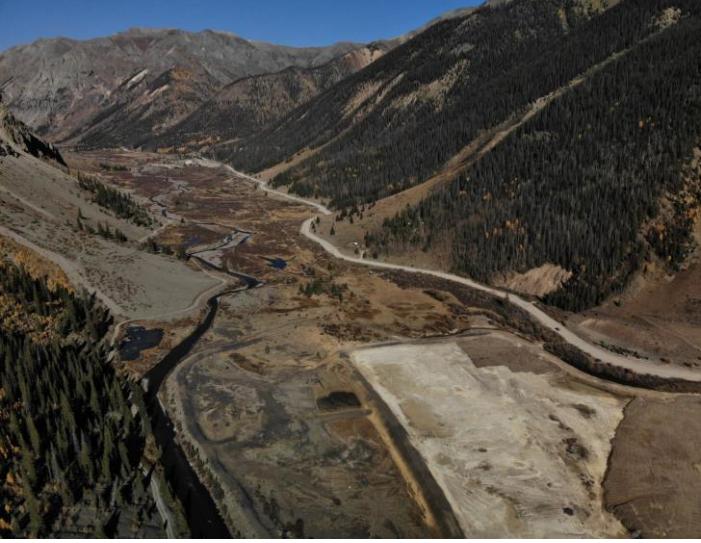
Data Under Separate Cover XLS Spreadsheet

Appendix C Photo Log

Appendix C
Photographic Documentation
Animas River Sites

	<p>Location: Animas River Drainage –Forest Queen Mine site</p> <p>Description: Flood plain along the animas river drainage from beavers clogging a culvert beneath County Road 2</p>
	<p>Location: Animas River Drainage –Forest Queen Mine site</p> <p>Description: Clogged culvert from beavers on County Road 2</p>
	<p>Location: Animas River Drainage –Forest Queen Mine site</p> <p>Description: Beaver dam construction near the Forest Queen Mine.</p>

Appendix C
Photographic Documentation
Animas River Sites

		<p>Location: Animas River Drainage –Pride of the West Mill site</p> <p>Description: Aerial photograph of the Animas River flood plane looking North before the influence of the Pride of the West Mill</p>
		<p>Location: Animas River Drainage –Pride of the West Mill site</p> <p>Description: Beaver lodge above the Pride of the West Mill</p>
		<p>Location: Animas River Drainage –Pride of the West Mill site</p> <p>Description: Aerial photograph of the Pride of the West Mill influencing the Natural Flow of the Animas River</p>

Appendix C
Photographic Documentation
Animas River Sites

	<p>Location: Animas River Drainage –Pride of the West Mill site</p> <p>Description: Mill influenced water before entering the Animas River</p>
	<p>Location: Animas River Drainage – Silverton, CO – Mighty Monarch Mine site</p> <p>Description: Aerial view of the beaver ponds below the Mighty Monarch mine site</p>
	<p>Location: Animas River Drainage – Silverton, CO – Mighty Monarch Mine site</p> <p>Description: Looking back at the beaver ponds below the mighty monarch mine site pictured on the hill side in the slide path above the beaver ponds</p>

Appendix C
Photographic Documentation
Animas River Sites



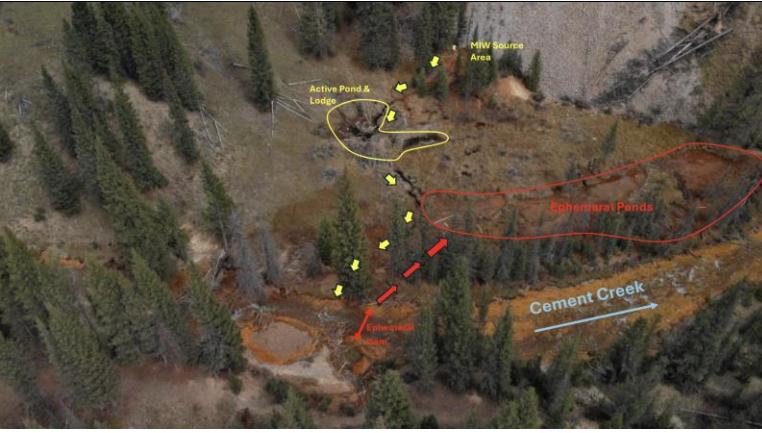
Location: Animas River
Drainage – Silverton, CO –
Mighty Monarch Mine site

Description: Overhead view of
the beaver ponds below the
Mighty Monarch mine site

Appendix C
Photographic Documentation
Cement Creek Sites

	<p>Location: Cement Creek – Anglo Saxon Mine site</p> <p>Description: Aerial View of Anglo Saxon looking south</p>
	<p>Location: Cement Creek – Anglo Saxon Mine site</p> <p>Description: Beaver dam that had been blown out by high flows during spring runoff at the Anglo Saxon Mine site. Also pictured is confiner encroachment along the banks of Cement Creek</p>
	<p>Location: Cement Creek – Chatanooga Corner</p> <p>Description: Flood plain along Cement creek below the Anglo Saxon mine</p>

Appendix C
Photographic Documentation
Cement Creek Sites

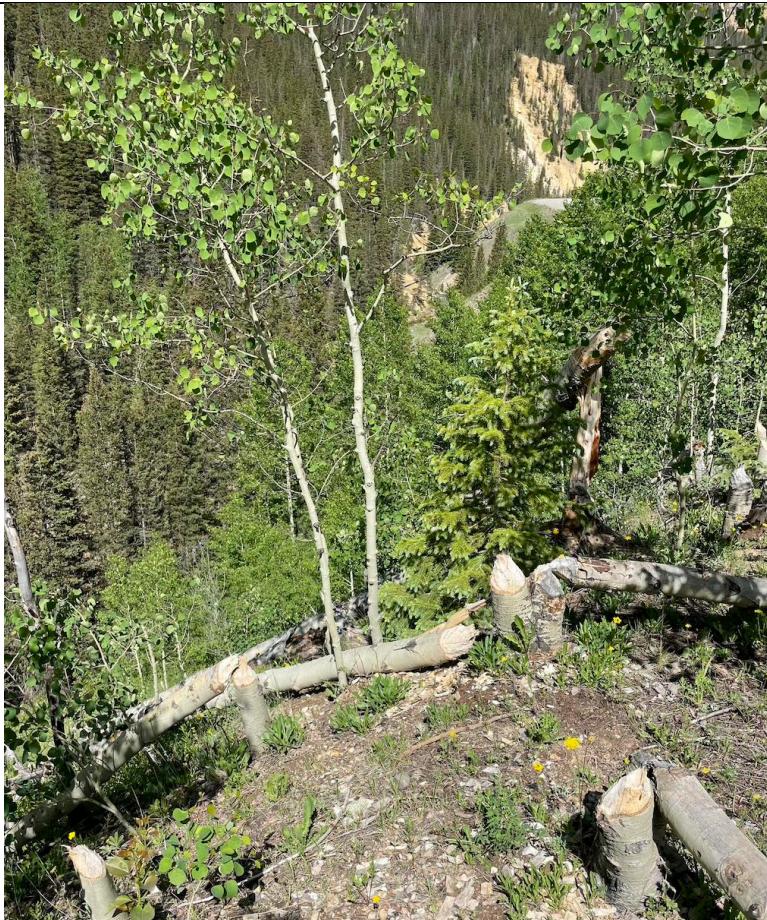
	<p>Location: Cement Creek – Lower Cement Creek Beaver Complex</p> <p>Description: Aerial view looking south with Kendal Mountain in the background.</p>
	<p>Location: Cement Creek – Lower Cement Creek Beaver Complex</p> <p>Description: Aerial view with annotations mapping the beaver complex</p>
	<p>Location: Cement Creek – Lower Cement Creek Beaver Complex</p> <p>Description: Mine influenced water before entering Cement Creek</p>

Appendix C
Photographic Documentation
Cement Creek Sites



Location: Cement Creek – Lower Cement Creek Beaver Complex

Description: Mine influenced water before entering Cement Creek



Location: Cement Creek – Lower Cement Creek Beaver Complex

Description: Beavers are traveling hundreds of ft uphill for building materials out of aspens

Appendix C
Photographic Documentation
Cement Creek Sites



Location: Cement Creek – Lower Cement Creek Beaver Complex

Description: Beaver dam blown out at the Lower Cement Creek Beaver Complex from spring runoff

Appendix C
Photographic Documentation
Cunningham Gulch

	<p>Location: Cunningham Creek</p> <p>Description: BLM X Eco metrics efforts to reinforce beaver constructed dams</p>
	<p>Location: Cunningham Creek</p> <p>Description: Beaver habitat below the Old 100 Mine</p>
	<p>Location: Cunningham Creek-Pride of the West Mine site</p> <p>Description: Mine water from Old 100 Mine flowing into Cunningham Creek above successful beaver dam development and habitat</p>

Appendix C
Photographic Documentation
Mineral Creek Sites

	<p>Location: South Mineral - Bandora Mine Site</p> <p>Description: Aerial view of the Bandora Mine. Mine in the right of the photo. Beaver pond and headwaters of South Mineral on the left</p>
	<p>Location: South Mineral – Bandora Mine Site</p> <p>Description: A Series of beaver dams at the Bandora Mine</p>
	<p>Location: South Mineral – Bandora Mine Site</p> <p>Description: Measuring the flow at the influence from the draining mine of the Bandora into South Mineral Creek</p>

Appendix C
Photographic Documentation
Mineral Creek Sites

	<p>Location: Mineral Creek – Chatanooga Corner</p> <p>Description: Highway at the Chatanooga corner pictured with beaver habitat development below the road</p>
	<p>Location: Mineral Creek – Chatanooga Corner</p> <p>Description: A beaver deceiver is installed to keep the culvert underneath the highway from clogging</p>
	<p>Location: Mineral Creek – Chatanooga Corner</p> <p>Description: Chatanooga corner beaver deceiver installed</p>

Appendix C
Photographic Documentation
Mineral Creek Sites

	<p>Location: Mineral Creek – Chatanooga Fend</p> <p>Description: Aerial view of Chatanooga Fend beaver complex</p>
	<p>Location: Mineral Creek – Chatanooga Fend</p> <p>Description: Water quality monitoring above the main beaver dam construction in the Chatanooga fend</p>
	<p>Location: Mineral Creek – Chatanooga Fend</p> <p>Description: A series of beaver dams along the Mineral Creek in the Chatanooga fend</p>

Appendix C
Photographic Documentation
Mineral Creek Sites

	<p>Location: Mineral Creek – North Star Mine site</p> <p>Description: Aerial View of the North Star Mine</p>
	<p>Location: Mineral Creek – North Star Mine site</p> <p>Description: Community Engagement with the Silverton School at the North Star Mine</p>
	<p>Location: Mineral Creek – North Star Mine site</p> <p>Description: Willow Planting at the North Star Mine</p>

**Appendix C
Photographic Documentation
Mineral Creek Sites**

Appendix D Final Presentation



State of the Beaver *Silverton and San Juan County*

Rory Cowie, PhD
Jack Klim
Matthew Cecil
Kylie Krivis



**ALPINE WATER
RESOURCES**

Project Goals

- Study relationship between beaver and mine impacted water (MIW) and mine impacted landscapes in the San Juan Mountains.
- Work with collaborators to explore possible solutions at the intersection between beaver and areas affected by legacy mining
- Explore the role of beaver in mountain ecosystem restoration through diverse stakeholder and financial avenues

Participating Partners and Funding Sources

- Water Infrastructure Improvements for the Nation (WIIN ACT) grants
- Colorado Department of Public Health and Environment
- BLM (Abandoned Mine Lands Program), USFS, EPA
- Colorado Division Of Reclamation and Mining Safety
- Mountain Studies Institute (MSI)
- Colorado Department of Transportation
- Local Town and County Governments
- Ski Areas, Private Land Owners
- Trout Unlimited, EcoMetrics, Pinon Land Design
- Natural Resource Damages funds
- Bureau of Reclamation (Water SMART Drought Response Program)



Castor Canadensis

Ecology

- ~200 million beaver in N. America before European arrival
- Nearly every stream was trapped from CO to CA between 1820-1840
- reduced to just 100,00 at start of 20th century
- Around 15 million today (<10% historic population)
- Found in every watershed in Western US
- Up to 52 beaver dams per km of stream in Wyoming
- Shaped entire landscapes (from arroyos to valleys)





“Before the emigrant's wagon ever rolled a mile, before the miner found his first color, before the government authorized a single road or trail, this inhospitable land had been traversed and mapped.” –Ross Tolle, 1959

“it was the persistent search for beaver that familiarized the white man with the western wilds, and eased the way for official explorers and settlers”. (LeRoy Hafen, 1933)

We went from coexistence to commodification about 200 years ago!

Castor Canadensis

Ecological Benefits

- Improve water quality
- Reduce sediment and turbidity
- Removal of metals and contamination
- Slow release of snowmelt for downstream agriculture uses
- Reduce spread of wildfires
- Mitigate flooding
- **Reduce transport of mining contamination?**
- **Increased Resiliency to changing climate?**



Beavers and Landscape Ecology



Two sections of Sevenmile Creek, Utah — where beavers have been active (left) and where heavy grazing is allowed [photo credit: Stacy Passmore]

Structurally Forced Resilience to Fire?



Credit:
Joe Wheaton, USU

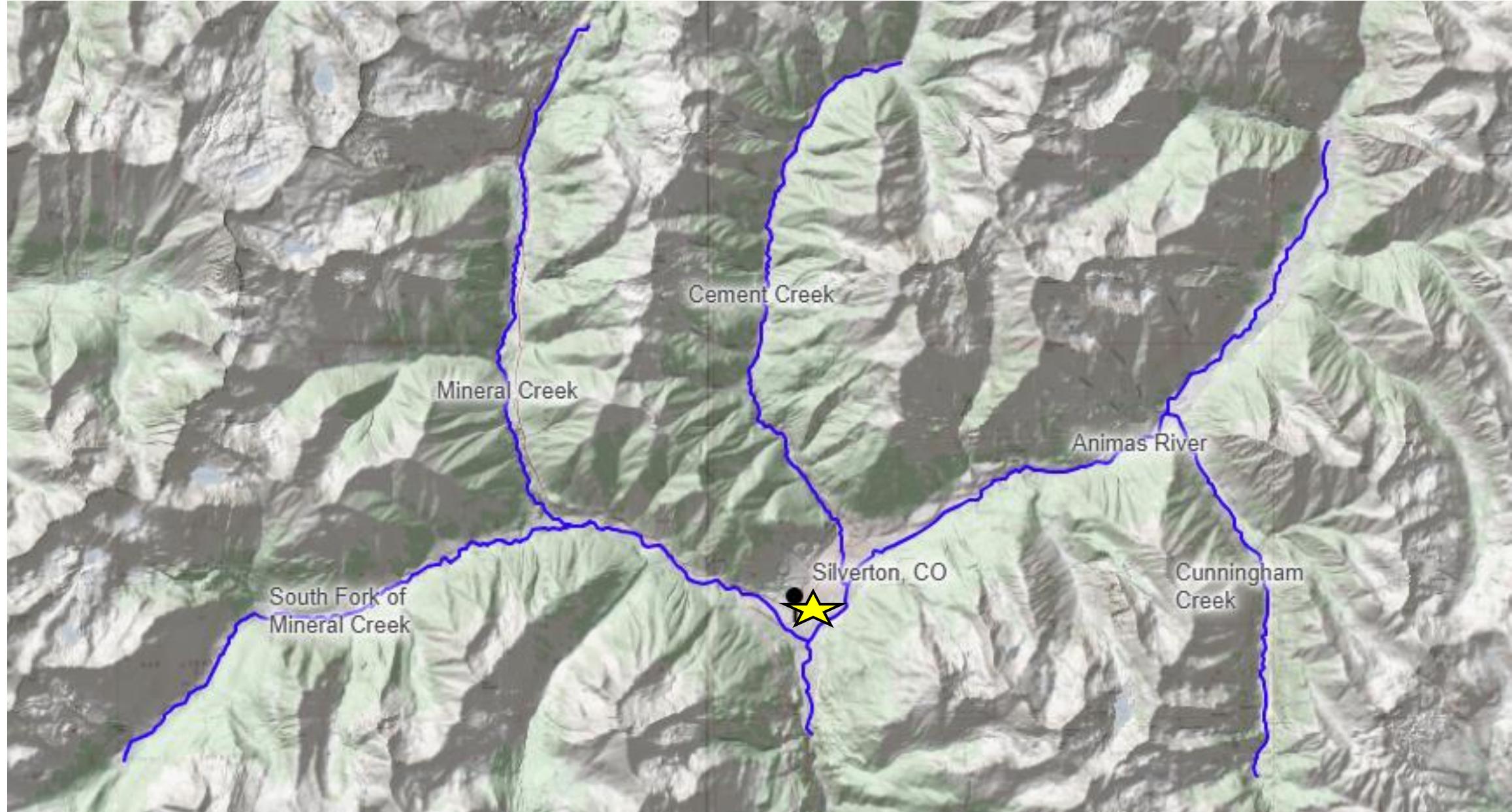


Beavers are not just an animal, they are an ecosystem!

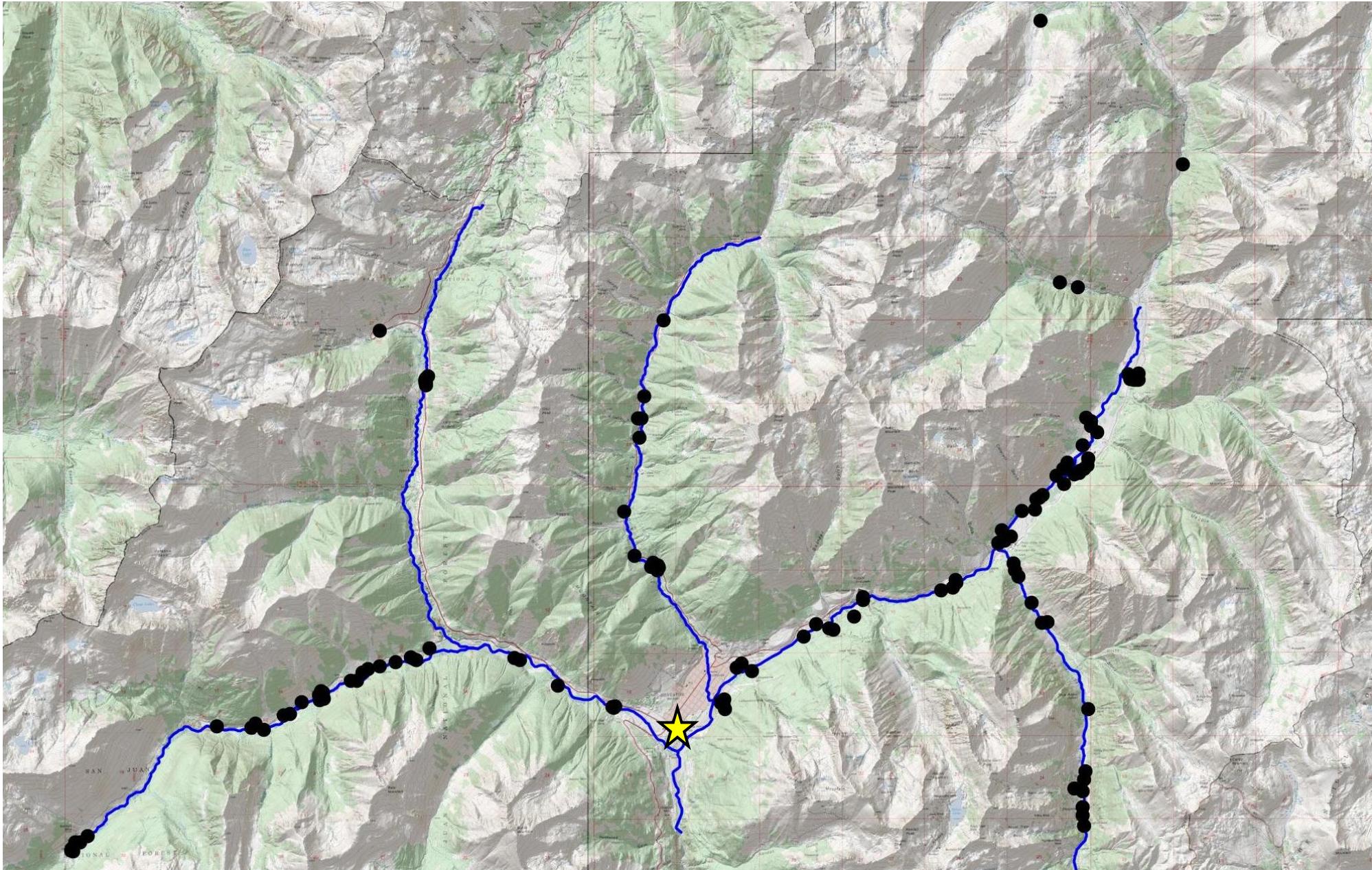
Habitat diversity
leads to
species biodiversity

Slide Credit: Torrey Ritter
Montana Dept Fish & Wildlife

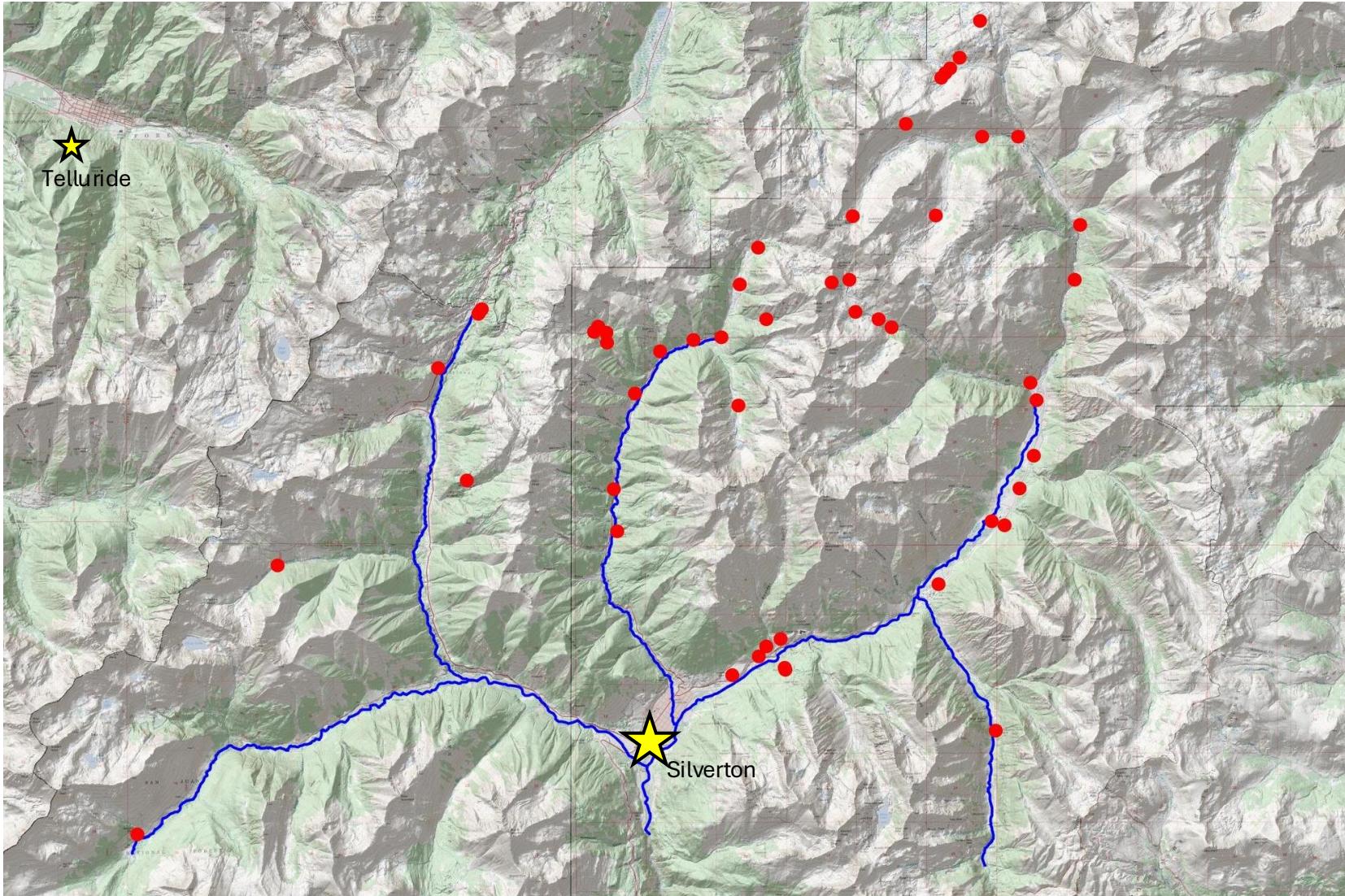
Focus Areas: Animas River Tributaries



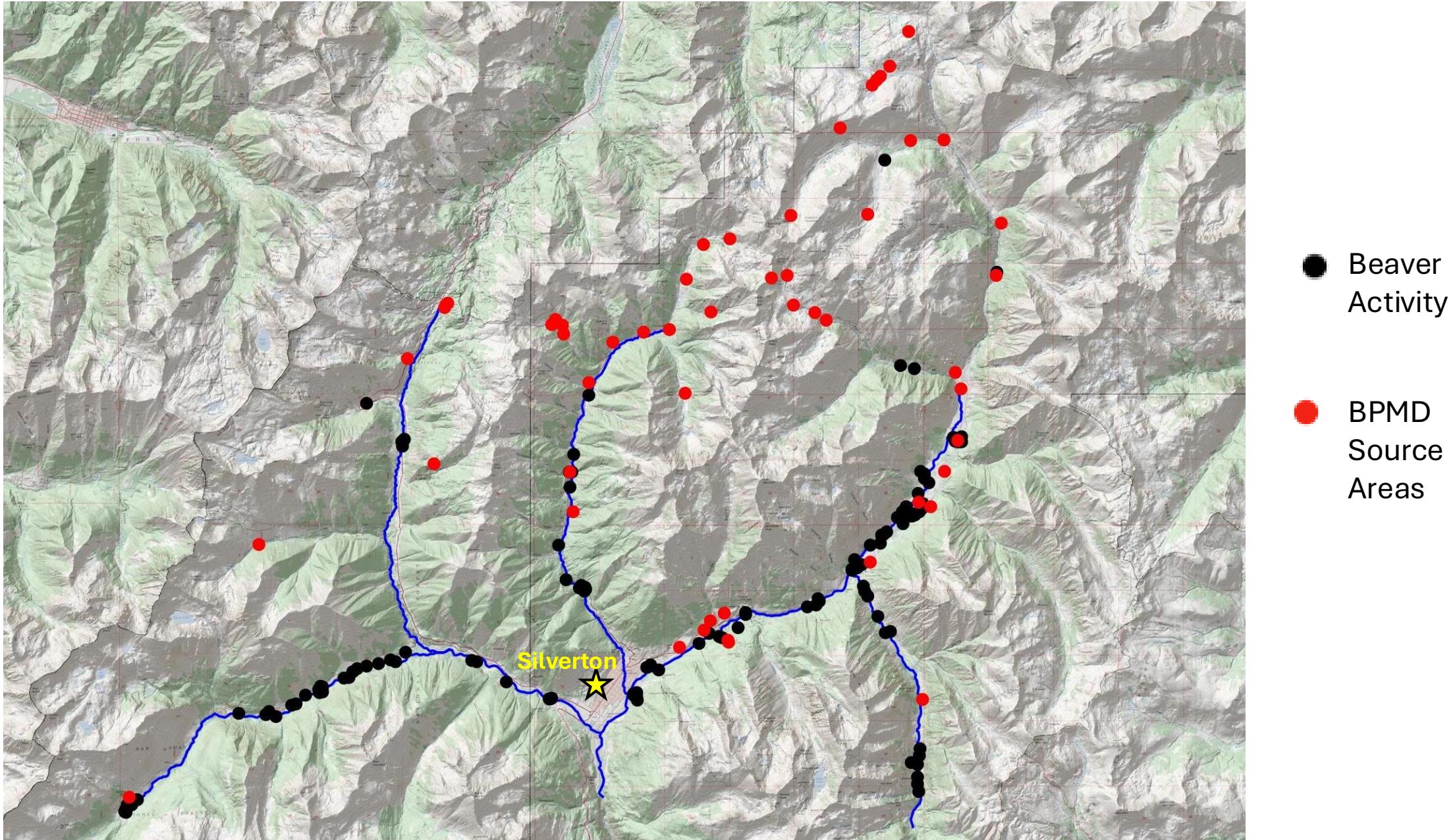
Current and Recent Beaver Activity

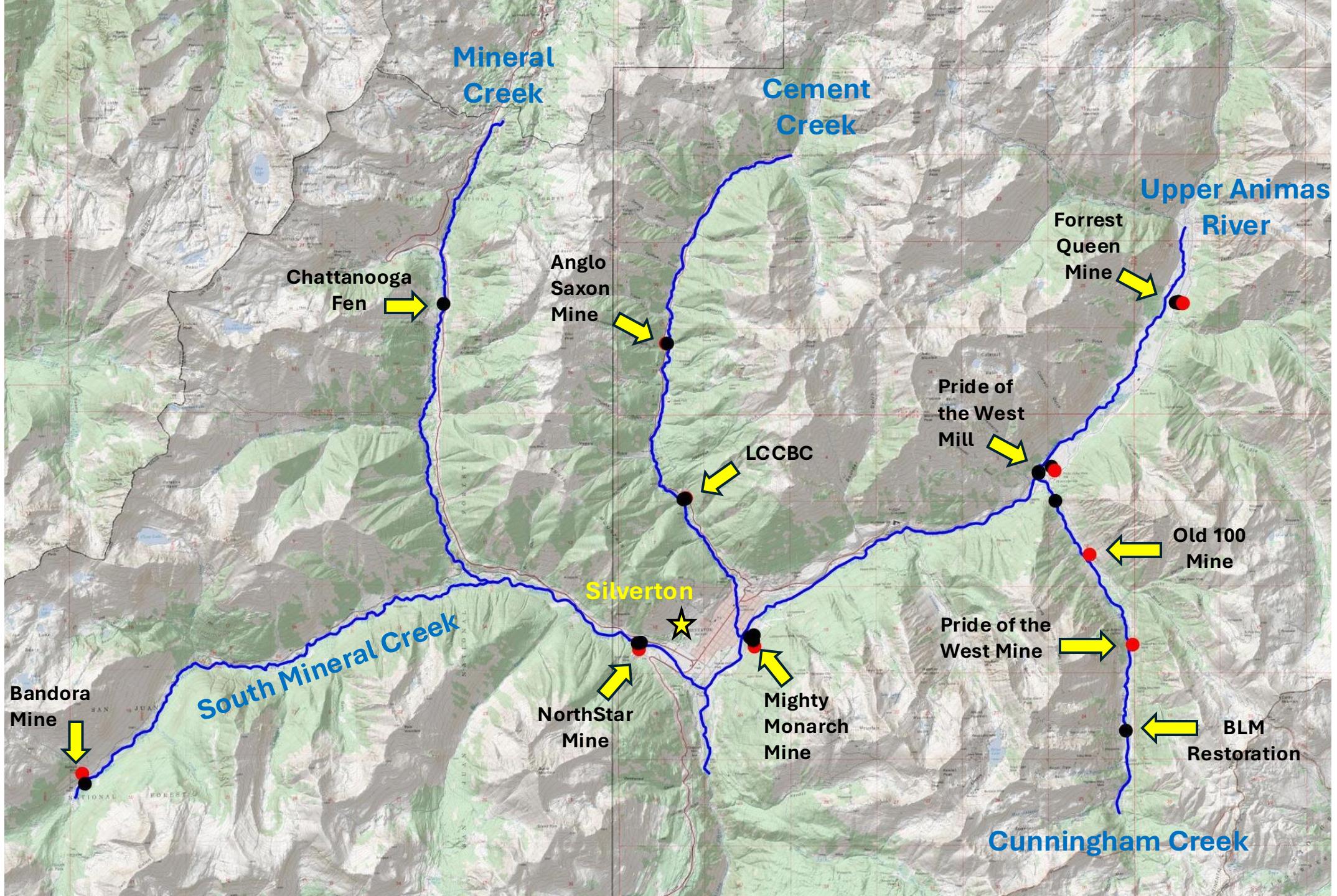


BPMD Contaminant Source Areas



BPMD Source Areas and Beaver Activity







Chattanooga Fen



Brooklyn Avalanche Paths



A scenic mountain landscape featuring a winding river flowing through a valley. The valley floor is covered in green grass and some brown, dry vegetation. In the foreground, there are several beaver dams, with one prominent one in the center foreground. The background consists of steep, rocky mountains covered in dense evergreen forests under a blue sky with white clouds.

New Beaver Dams 2024:

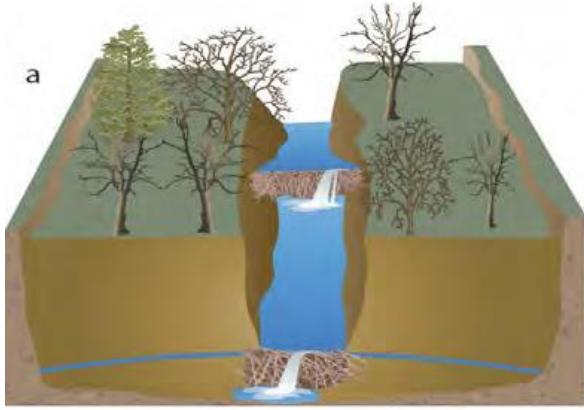
*Opportunity to add Post Assisted Log Structures
To reinforce dams



~90ft

~70ft

~50ft



- A) beaver attempting to build dams within narrow incision trenches
- B) high stream power often results in blowouts, widen the incision trench, allowing an inset floodplain to form
- C) widened channel = lower power → allows beaver to build more stable dams
- D) High sediment loads fill behind dams which are temporarily abandoned and creates riparian vegetation growth
- E) Step D repeats until dams raise the water table enough to reconnect to former flood plain
- F) Highly complex stream ecosystem with high groundwater levels that create multithread channels connected to off channel wetlands that span the entire valley bottom!

CDOT: Highway Infrastructure Protection Hwy 550 road culvert @ Chattanooga Turn

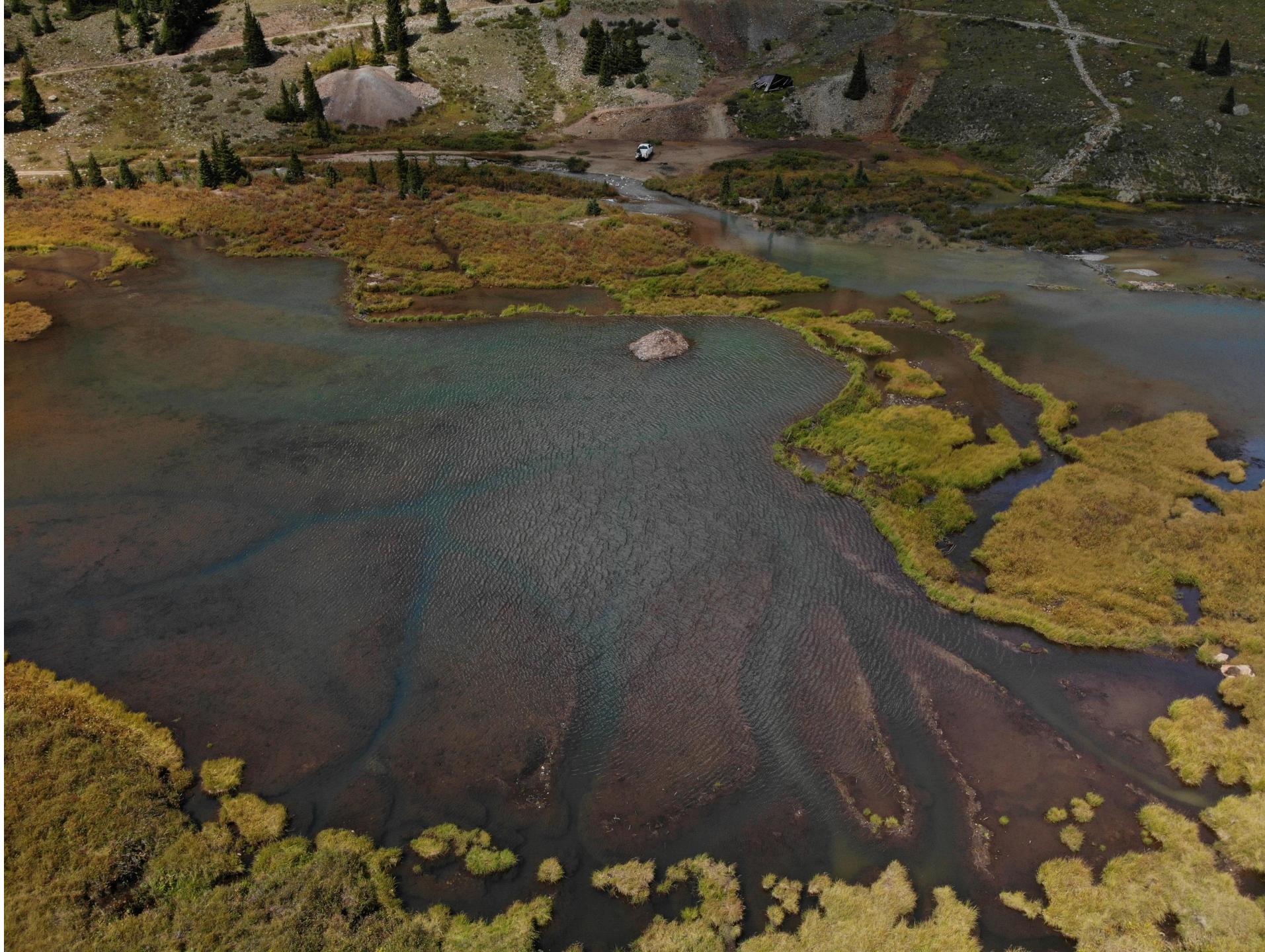




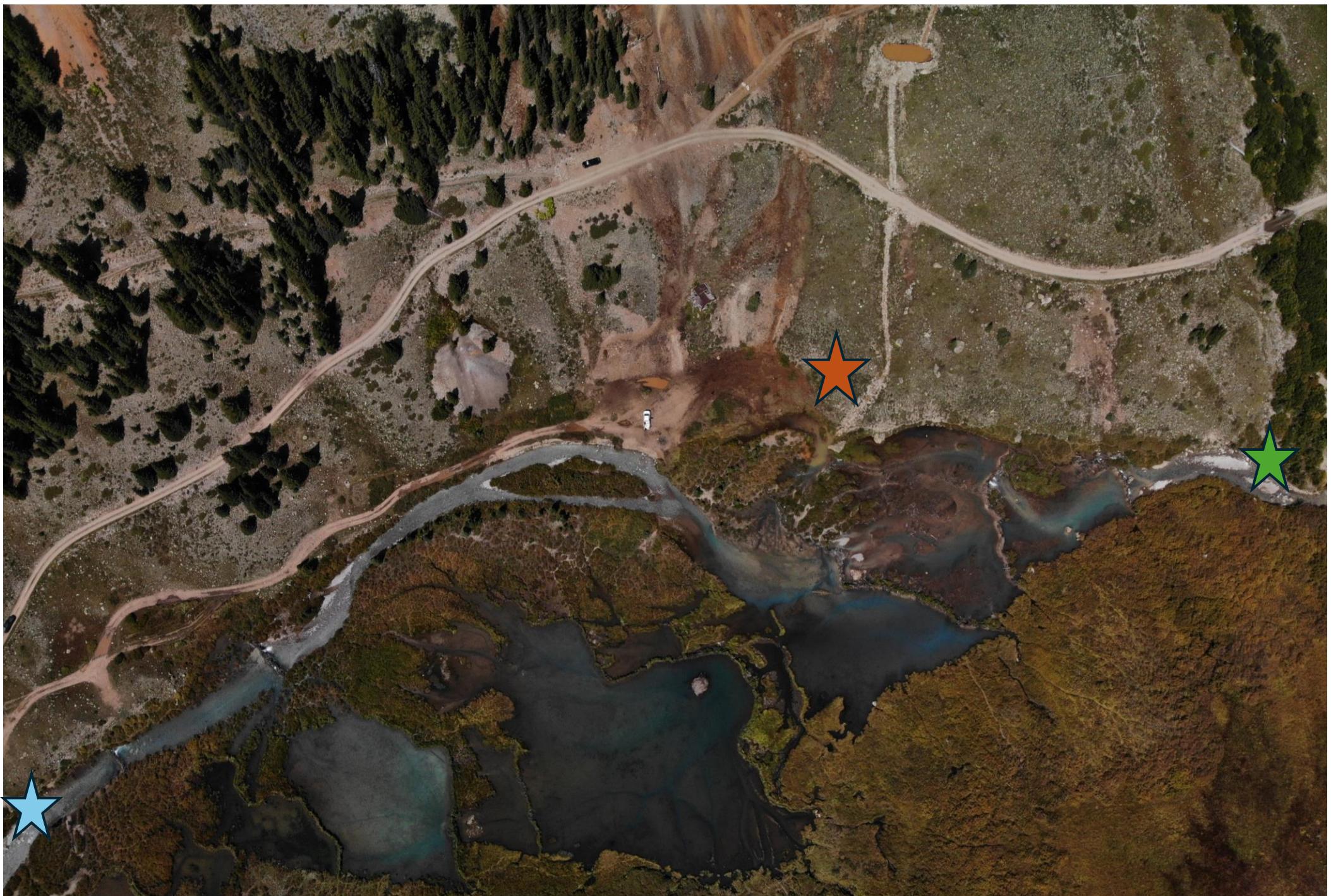


Bandora Mine

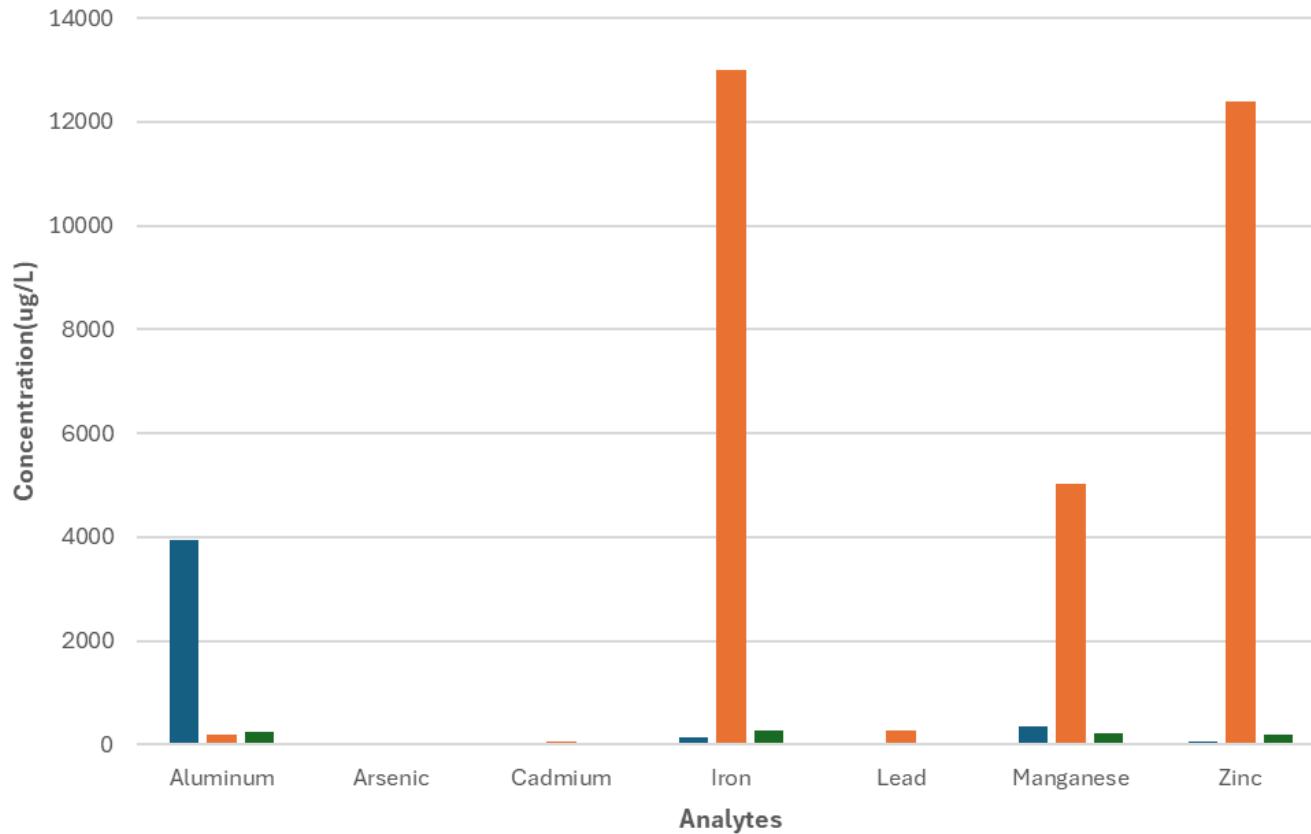




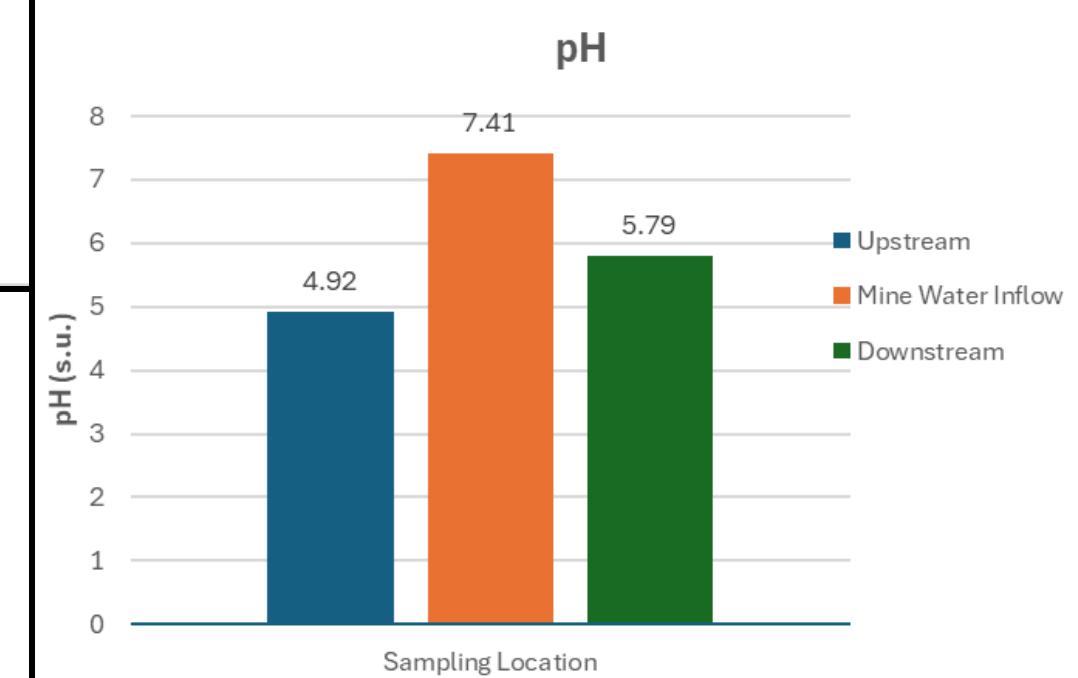




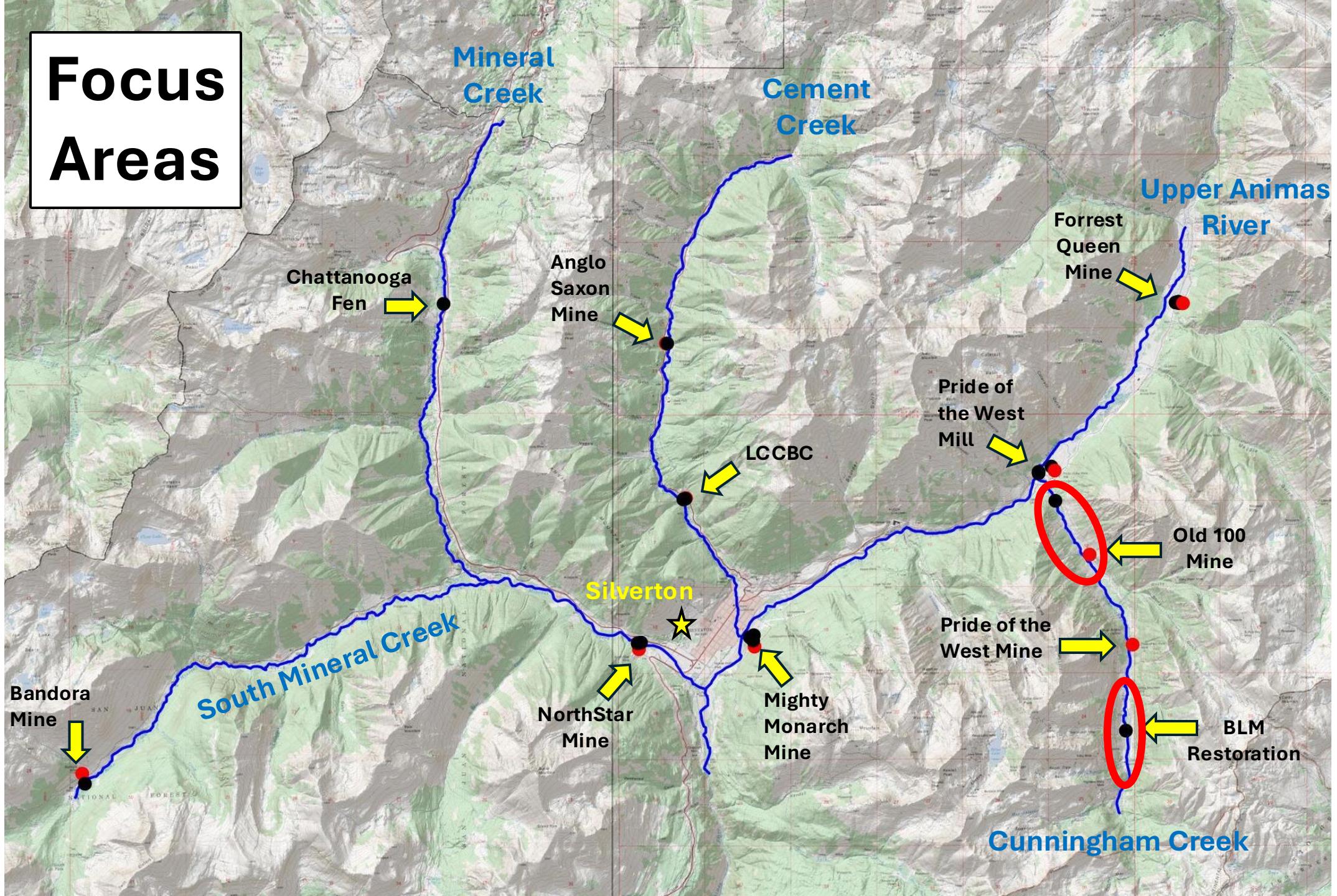
Bandora Metals Concentrations



- Al decreases significantly across beaver habitat (pH dep.)
- MIW inflows higher pH & high Fe, Mn, Zn, minimal load



Focus Areas



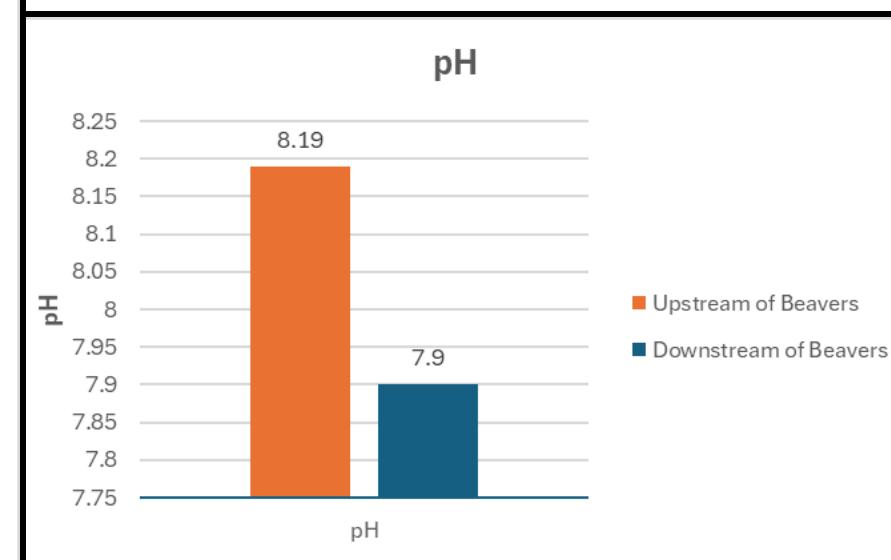
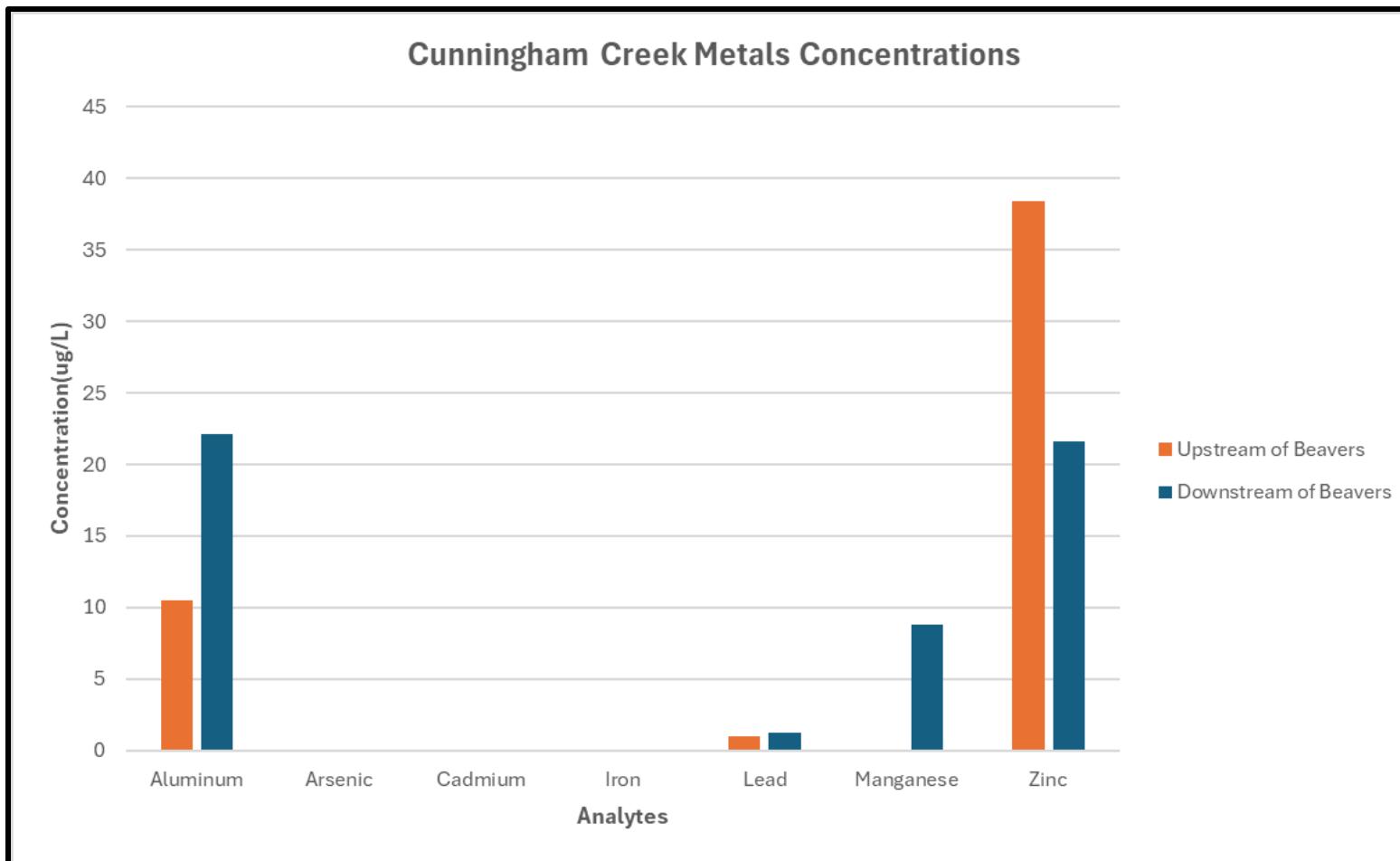
Cunningham Creek



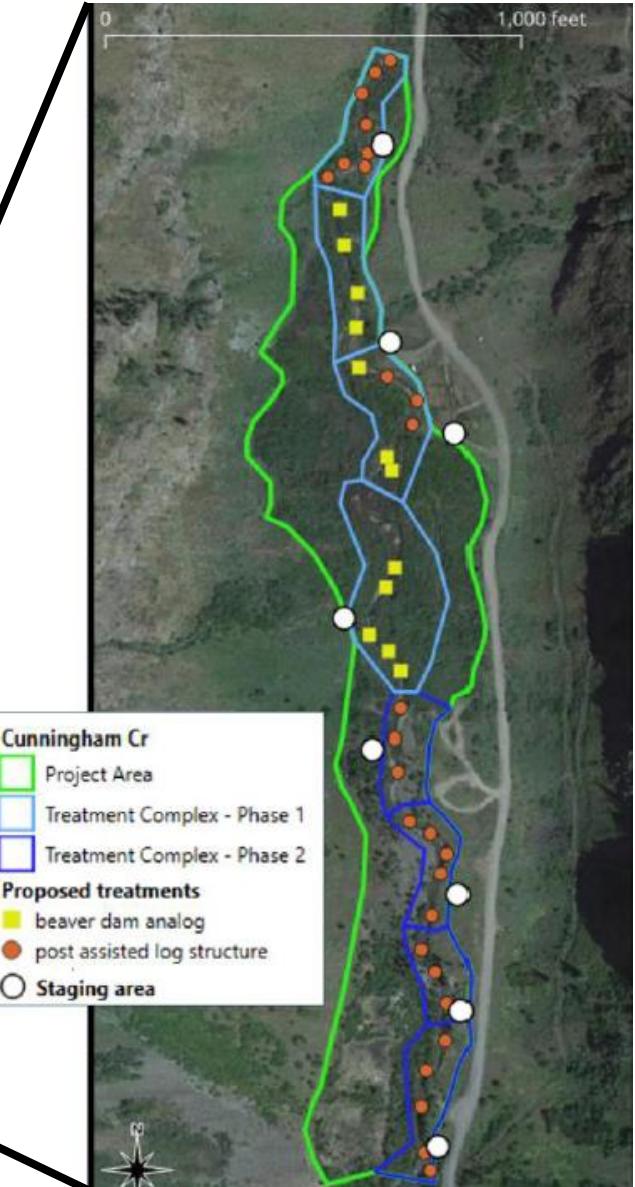
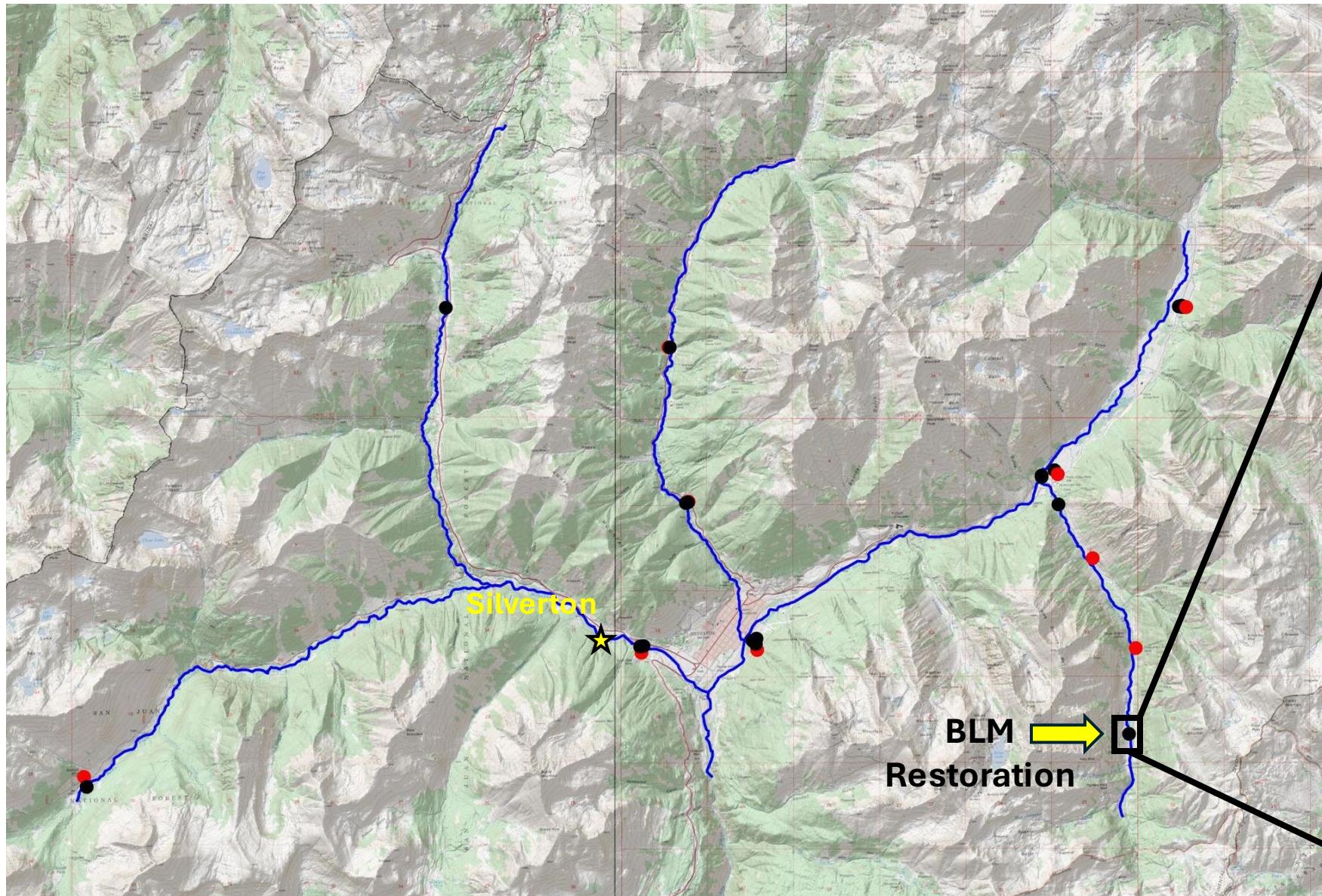




Cunningham Creek Water Quality Upstream and Downstream of Beaver Activity and Mine Water inflows



Cunningham Creek BDA & PAL Restoration





BLM x EcoMetrics

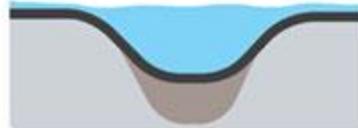


A stream comes back to life

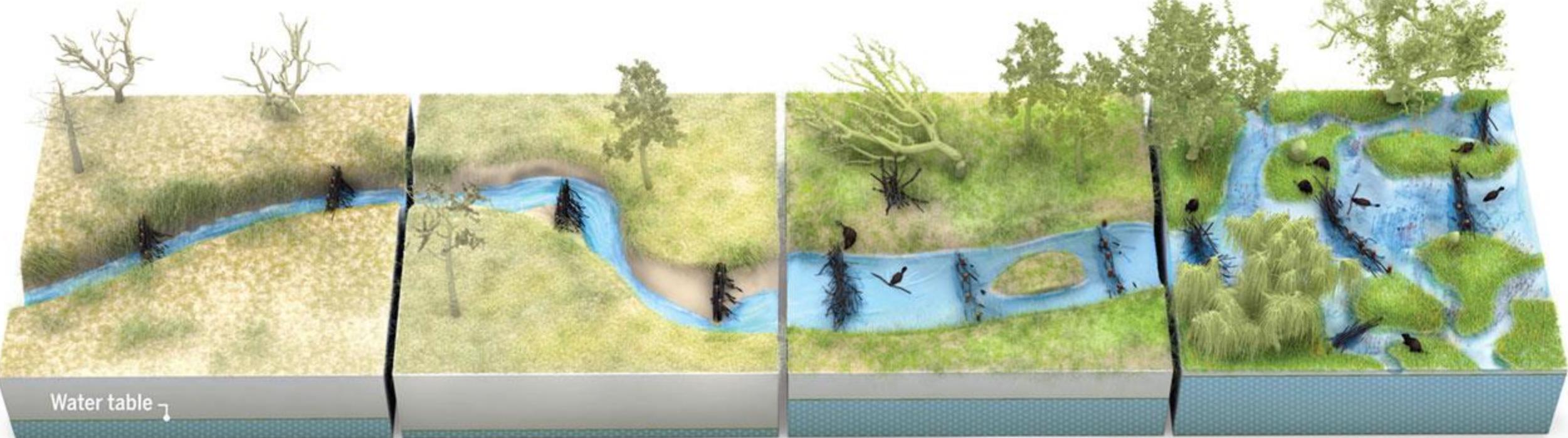
Across the U.S. West, scientists and land managers are using beaver dam analogs (BDAs) to heal damaged streams, re-establish beaver populations, and aid wildlife. In some cases, researchers have seen positive changes in just 1 to 3 years.



Incised stream



Restored stream



Adding dams

Beaver trapping and overgrazing have caused countless creeks to cut deep trenches and water tables to drop, drying floodplains. Installing BDAs can help.

Widening the trench

BDAs divert flows, causing streams to cut into banks, widening the incised channel, and creating a supply of sediment that helps raise the stream bed.

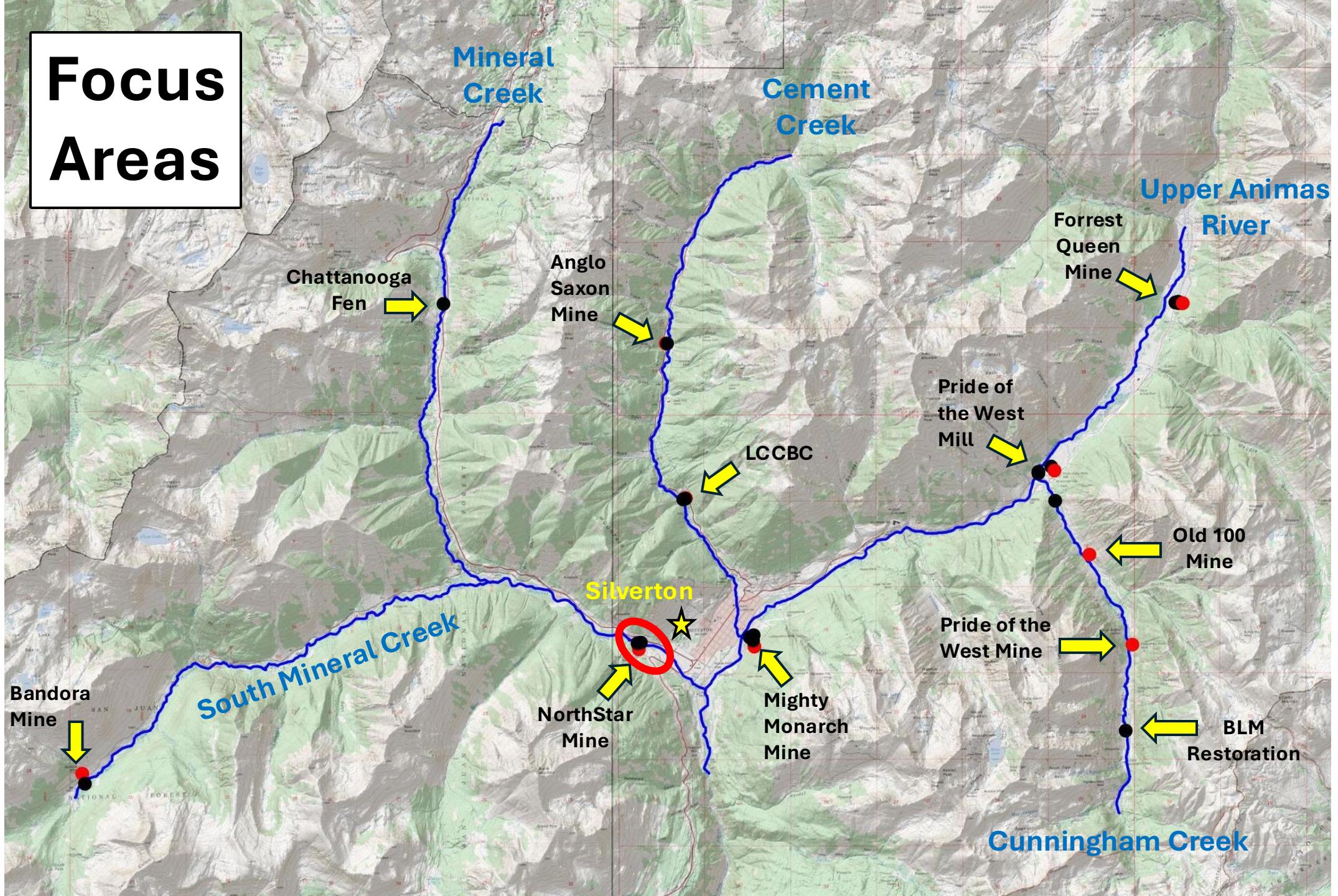
Beavers return

As BDAs trap sediment, the stream bed rebuilds and forces water onto the floodplain, recharging groundwater. Slower flows allow beavers to recolonize.

A complex haven

Re-established beavers raise water tables, irrigate new stands of willow and alder, and create a maze of pools and side channels for fish and wildlife.

Focus Areas





North Star Mine: Before Restoration

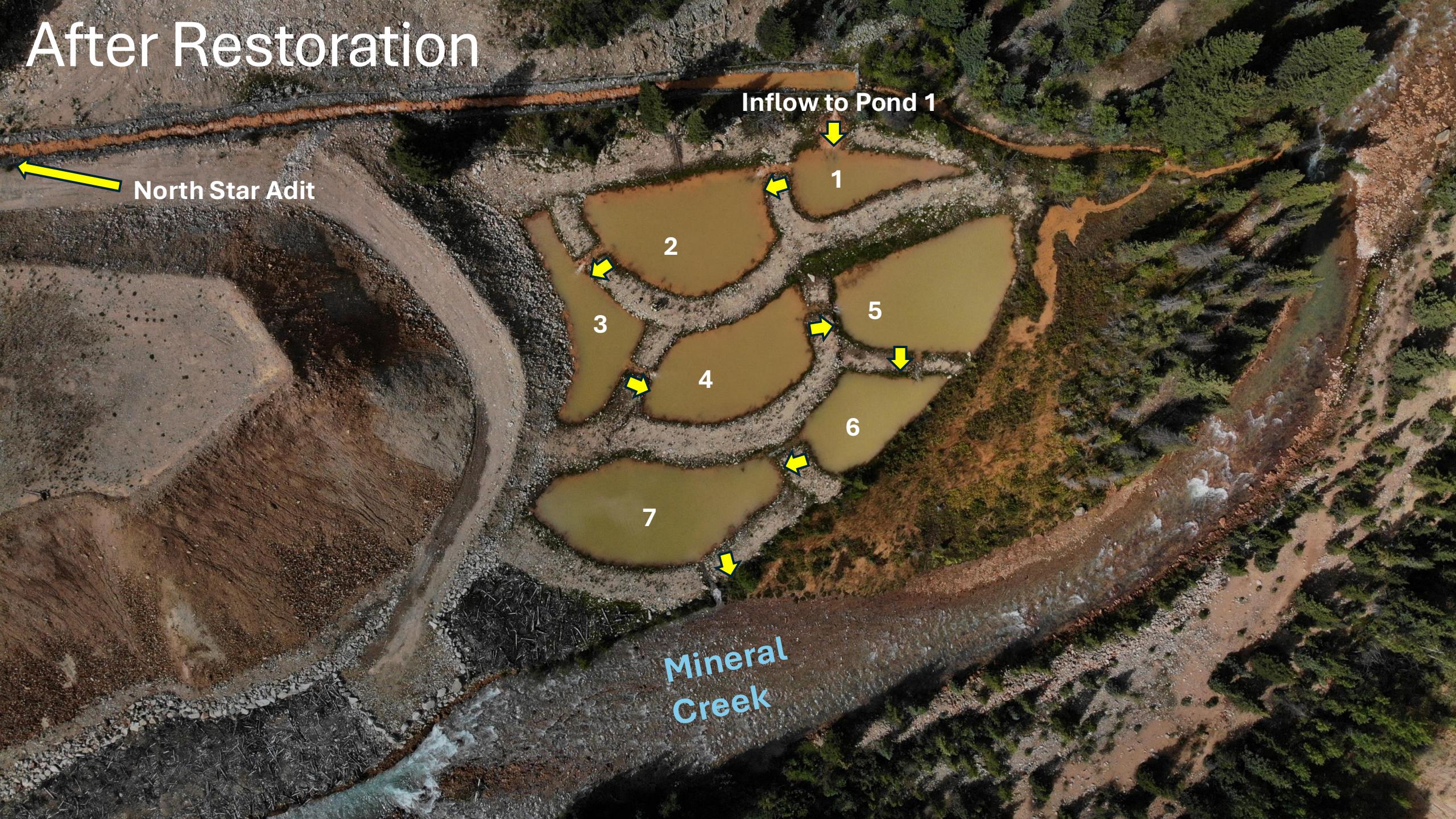
2020: Beaver dam at North Star Mine Portal



North Star Mine

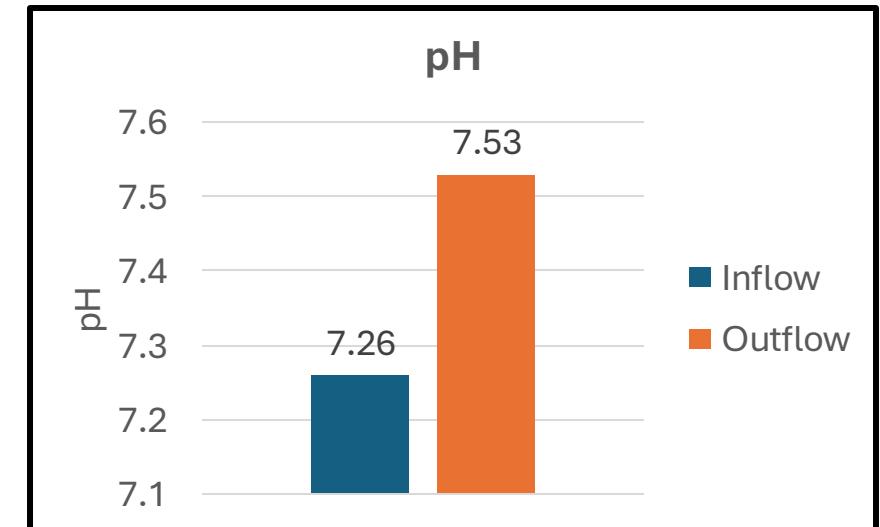
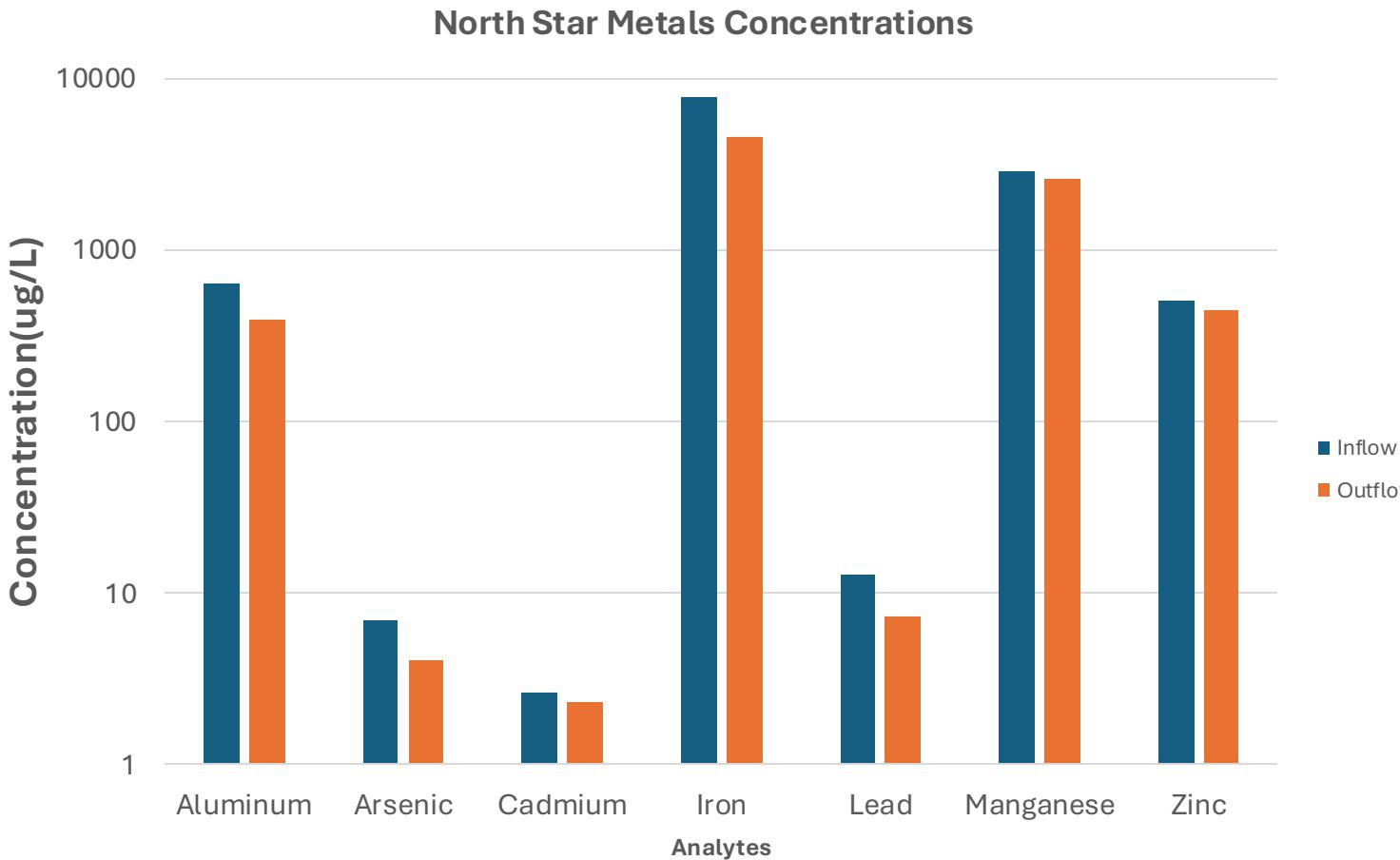


After Restoration



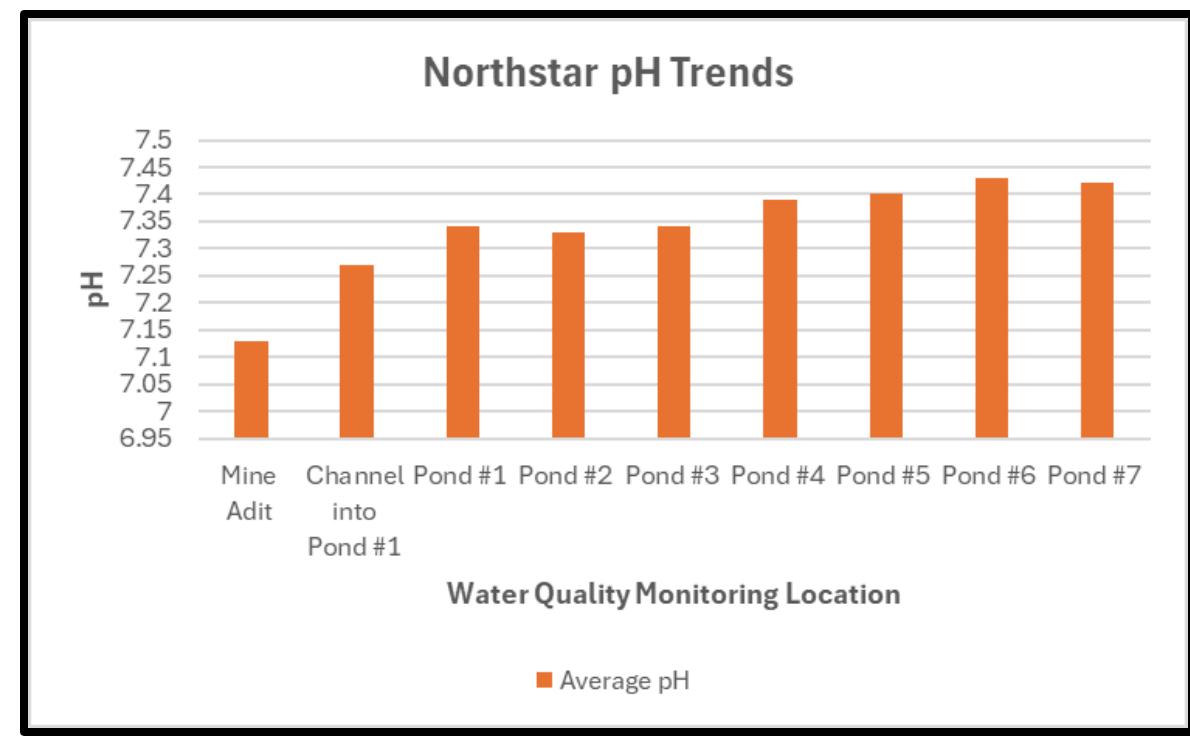
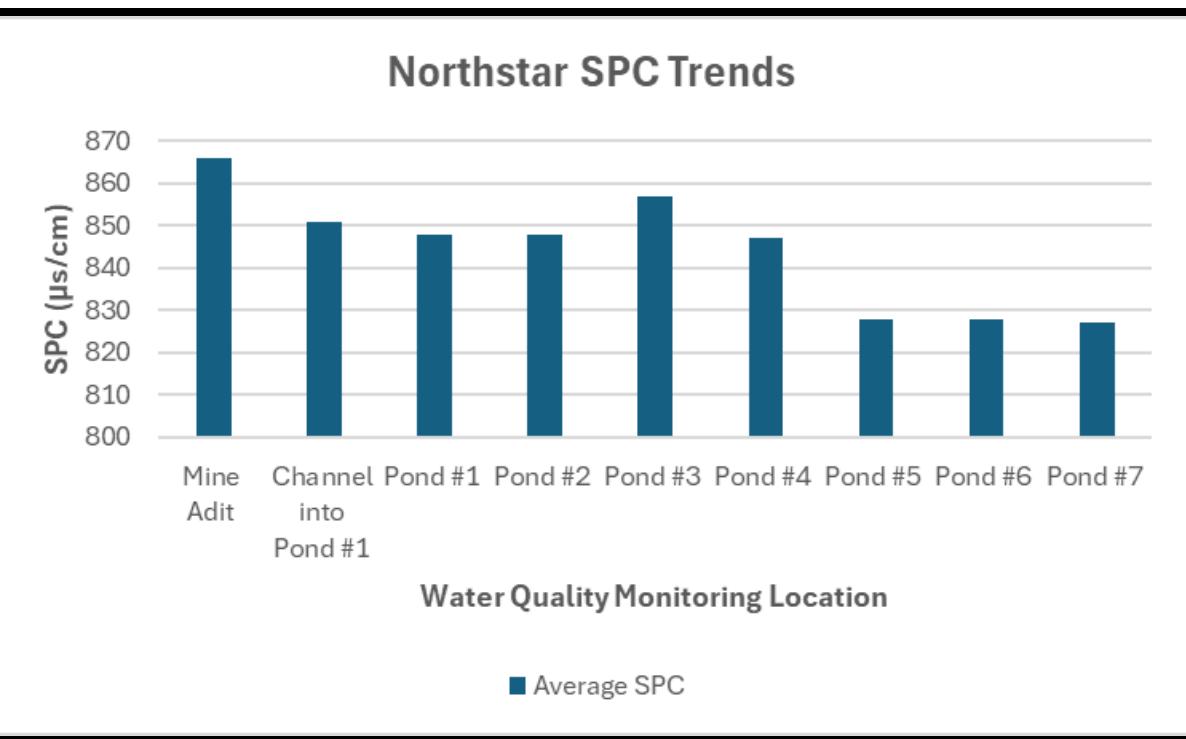
North Star Mine Impacted Water Quality

Upstream and Downstream of Ponds

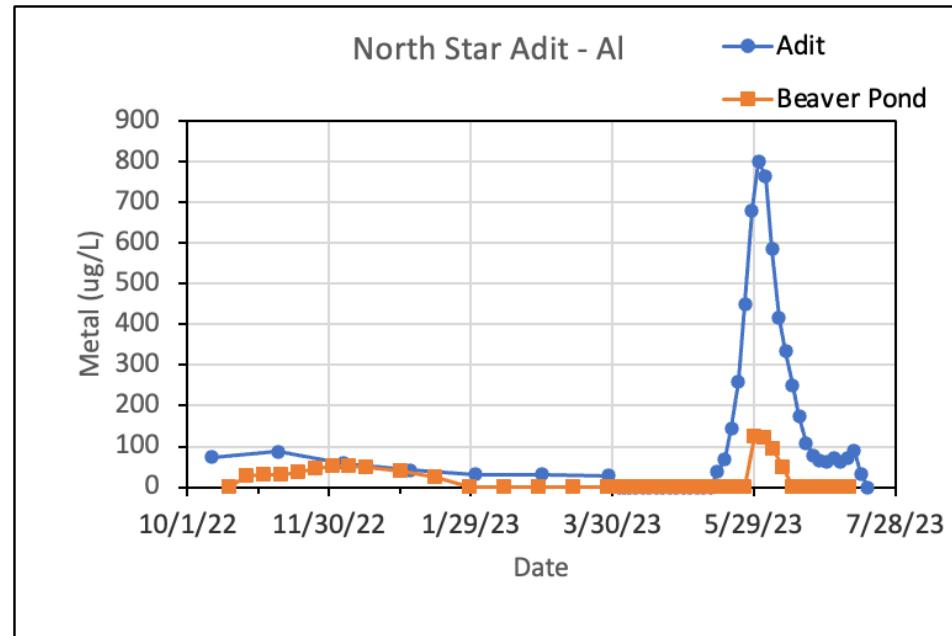


Average Water Quality from Four Site Visits

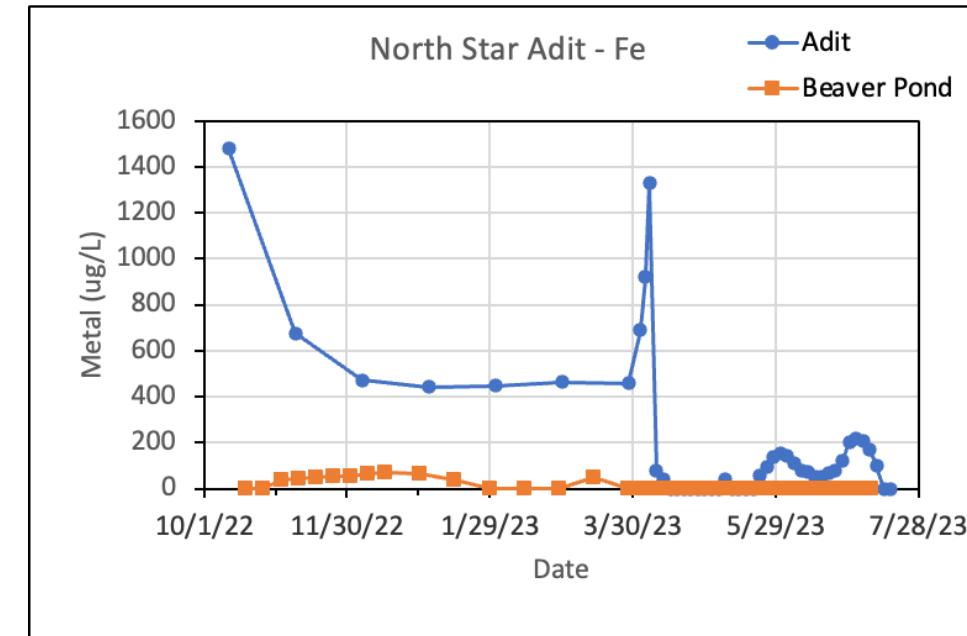
(May 2024- October 2024)



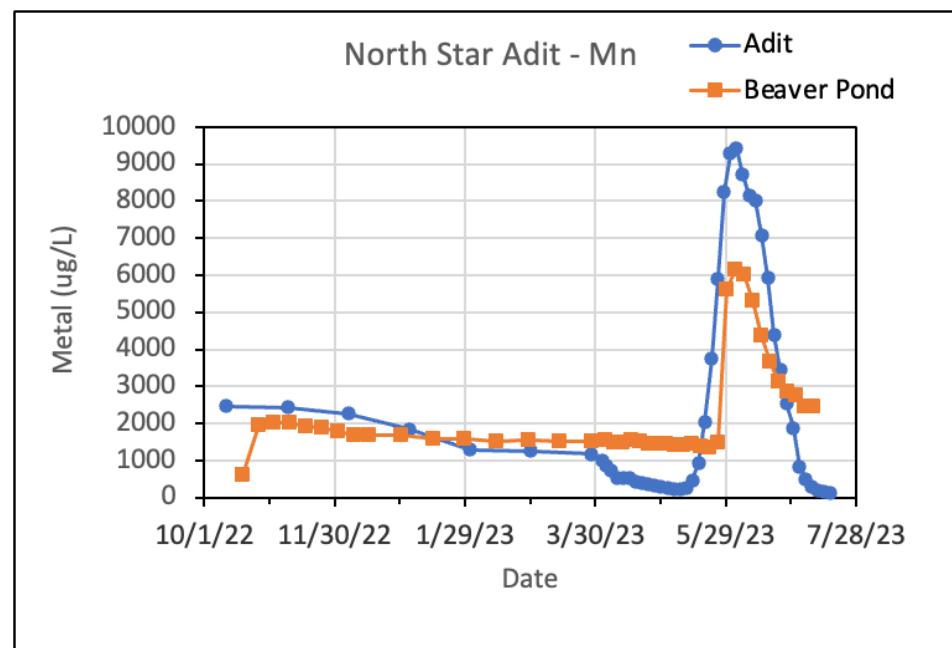
North Star Mine: DRMS/USGS Continuous Monitoring Data 2022-23



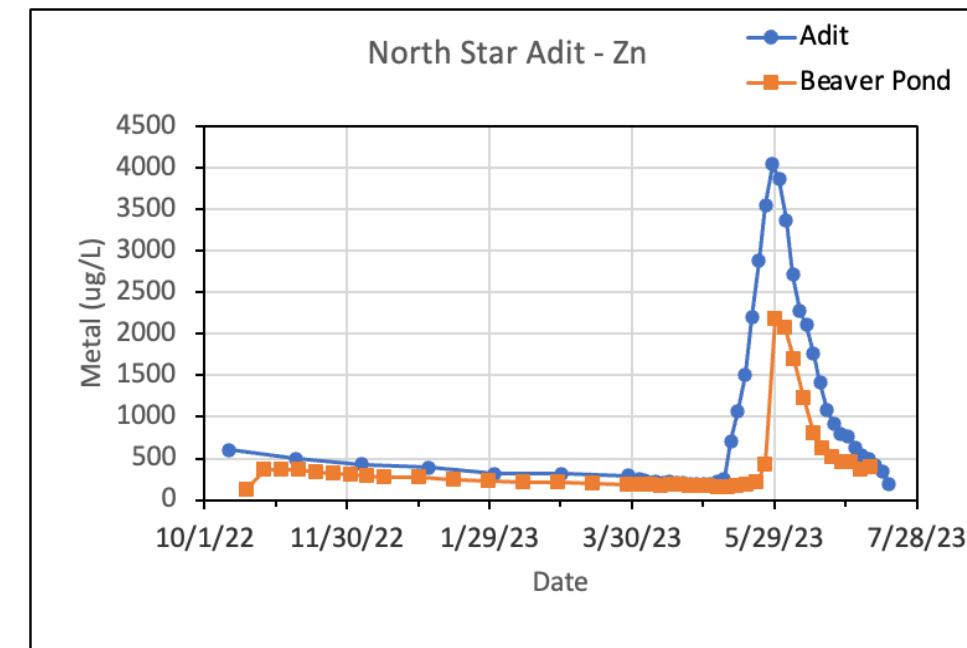
87%
Decrease



Up to
>90%
Decrease



30%
Decrease



50%
Decrease

North Star: Willow planting with Silverton Students

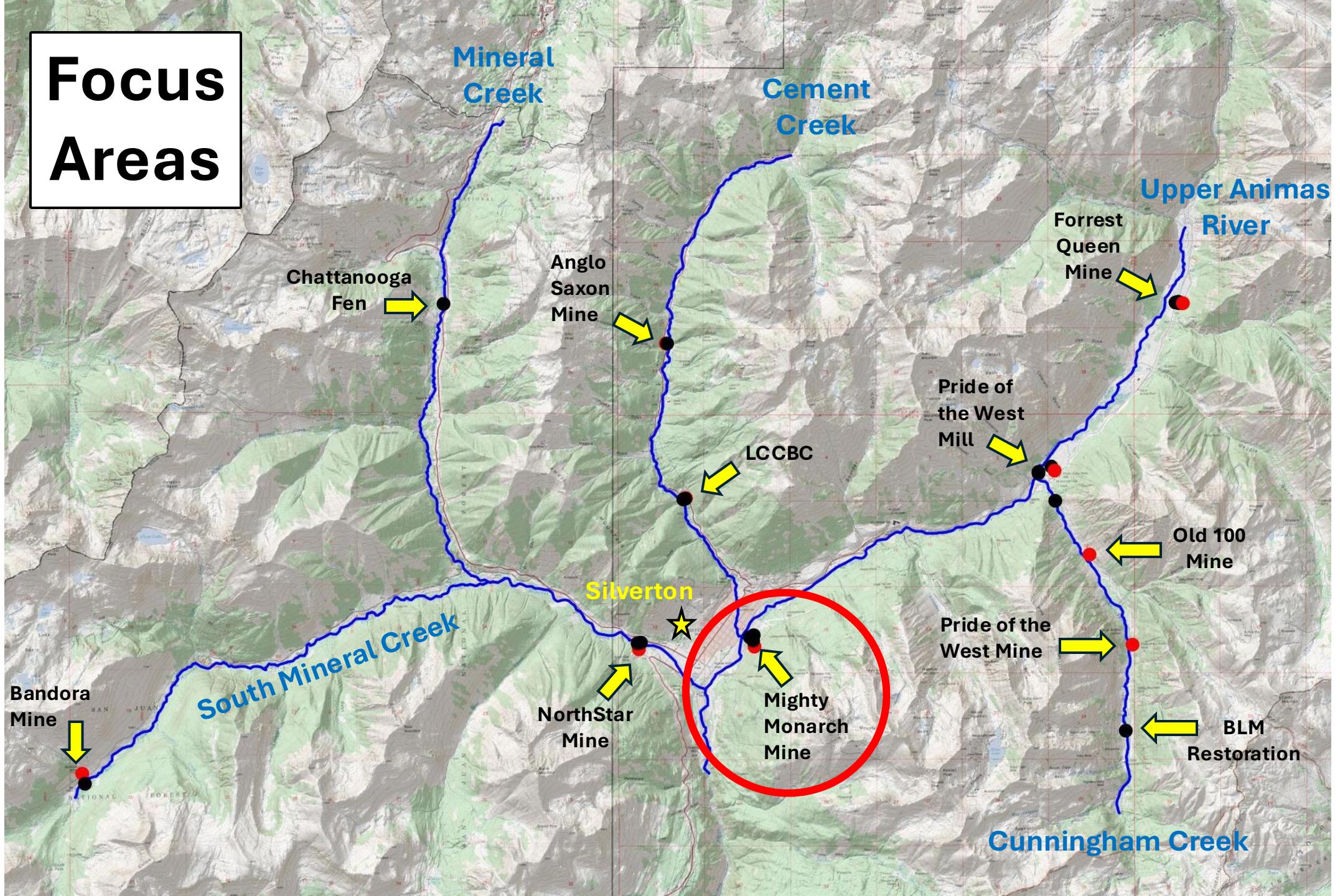
- Volunteer day with Summer School program
- Revegetation of wetland habitat
- Provide forage for beavers
- Creates wetland habitat for many animas
- Root structures reinforce earthen berms



Willow Transplanting with Silverton Public School

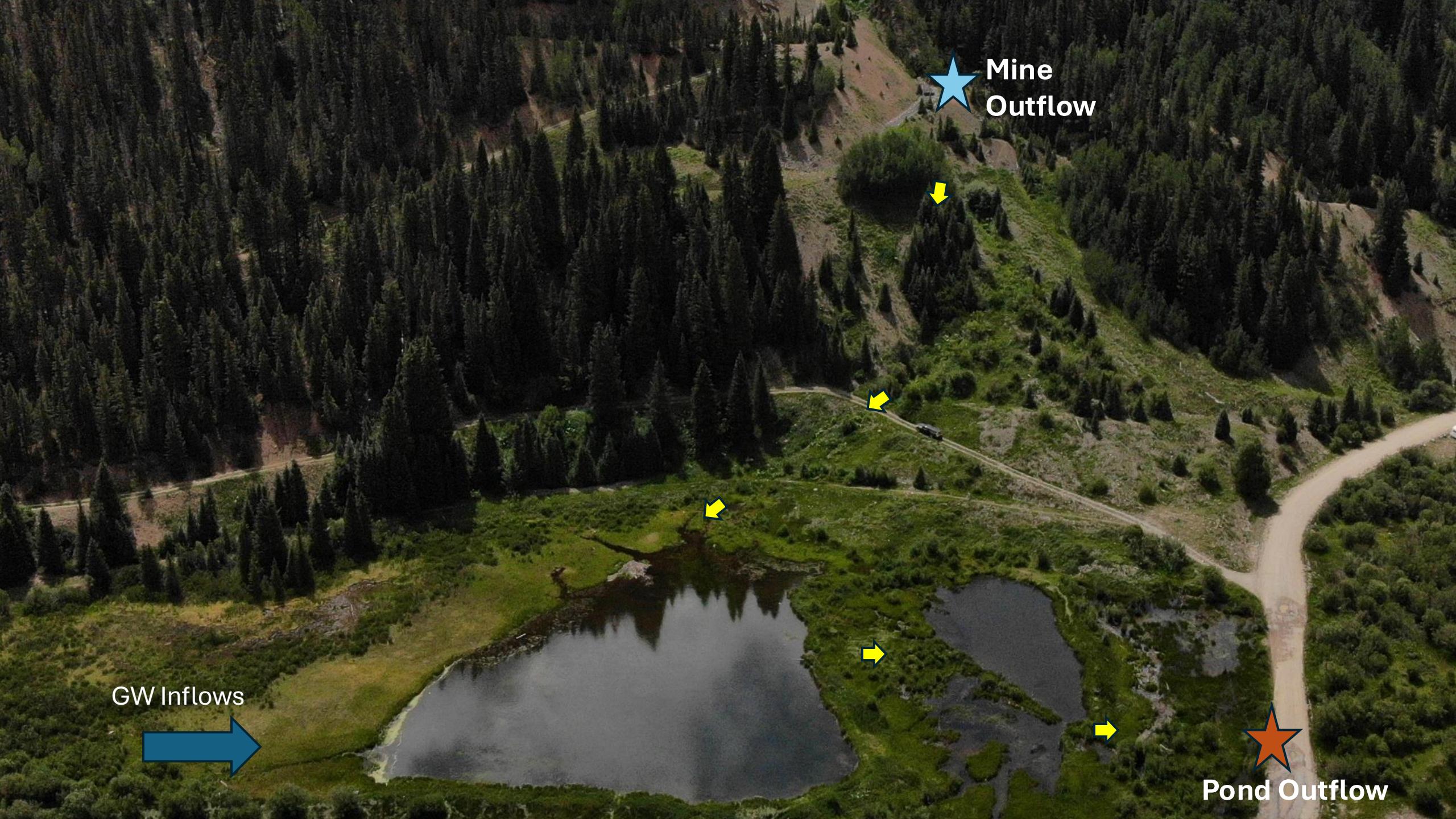


Focus Areas

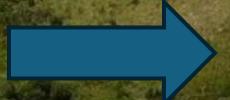


Mighty Monarch Mine & Kendall Beaver Ponds





GW Inflows



Mine
Outflow

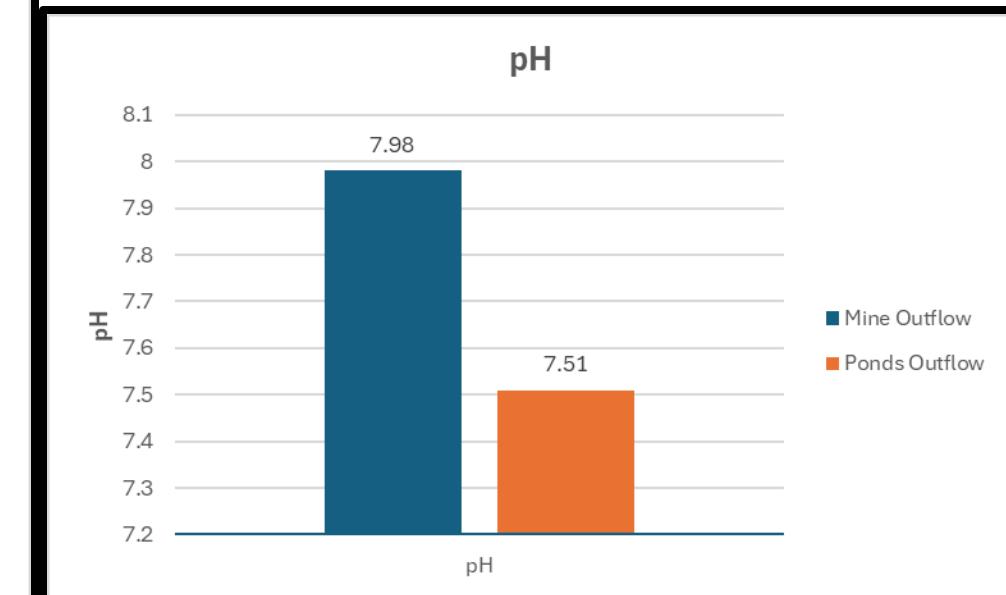
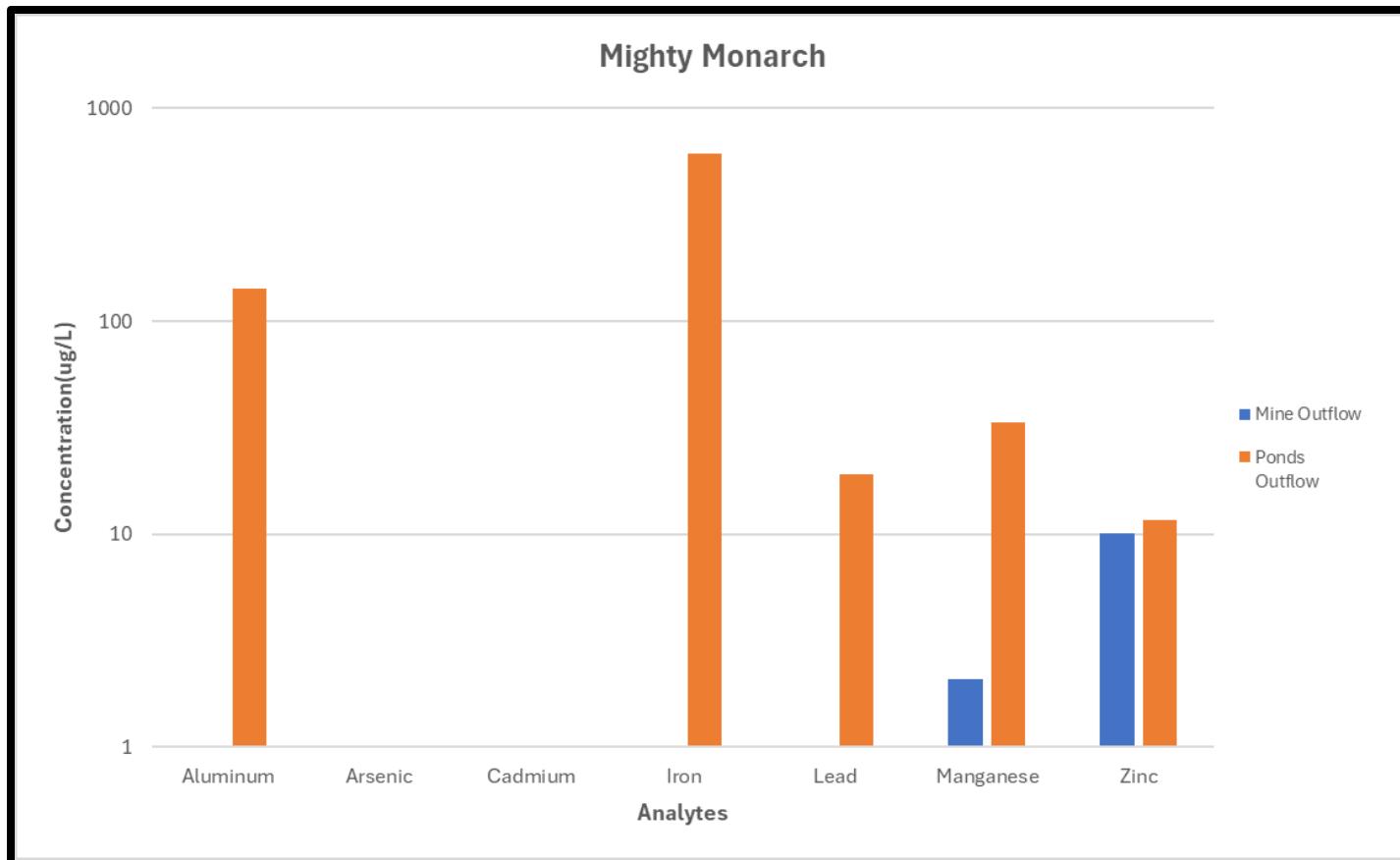


Pond Outflow



Mighty Monarch Mine

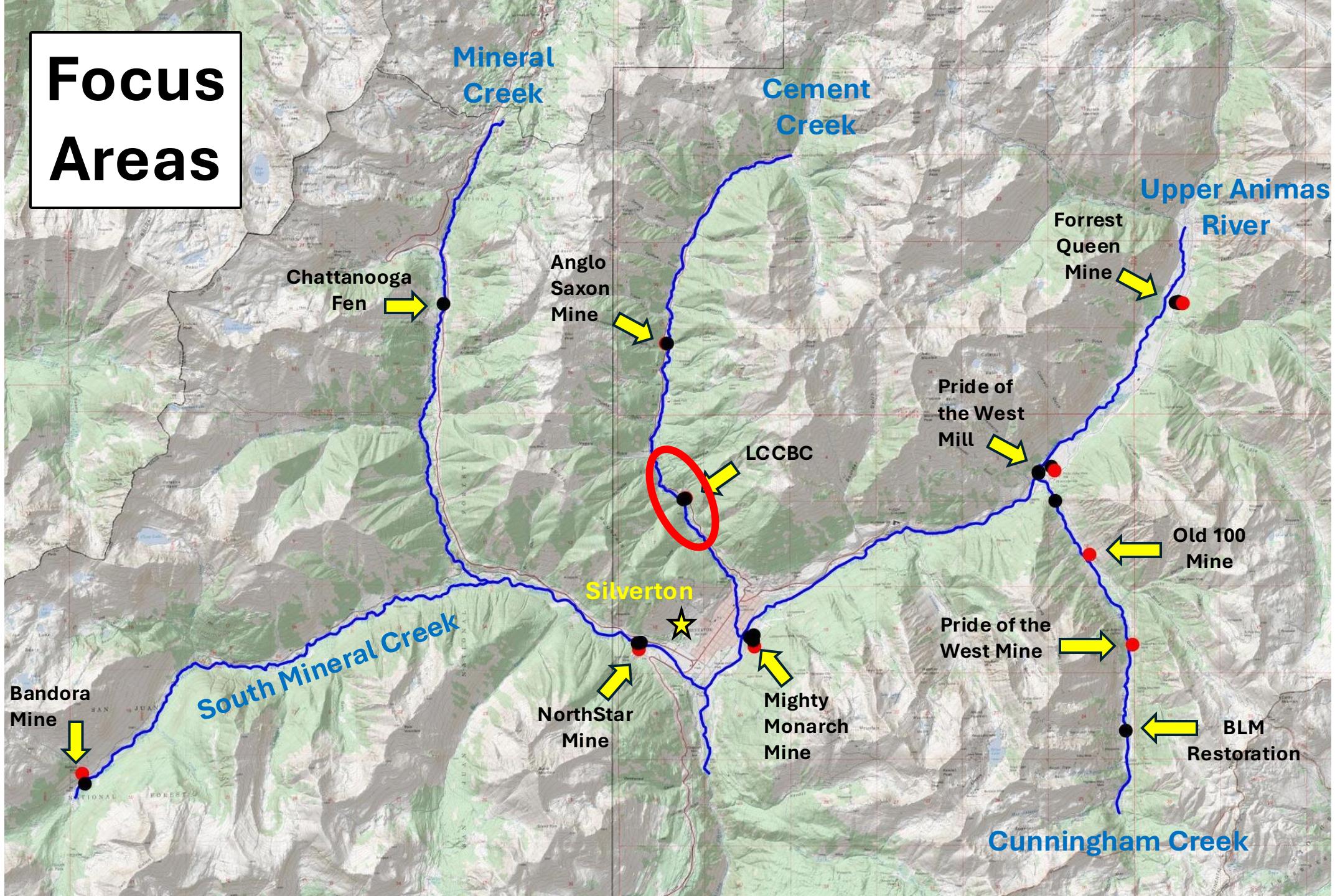
- Many decades of occupancy, utilizing mine discharge which is actually of better WQ than alluvial GW inputs



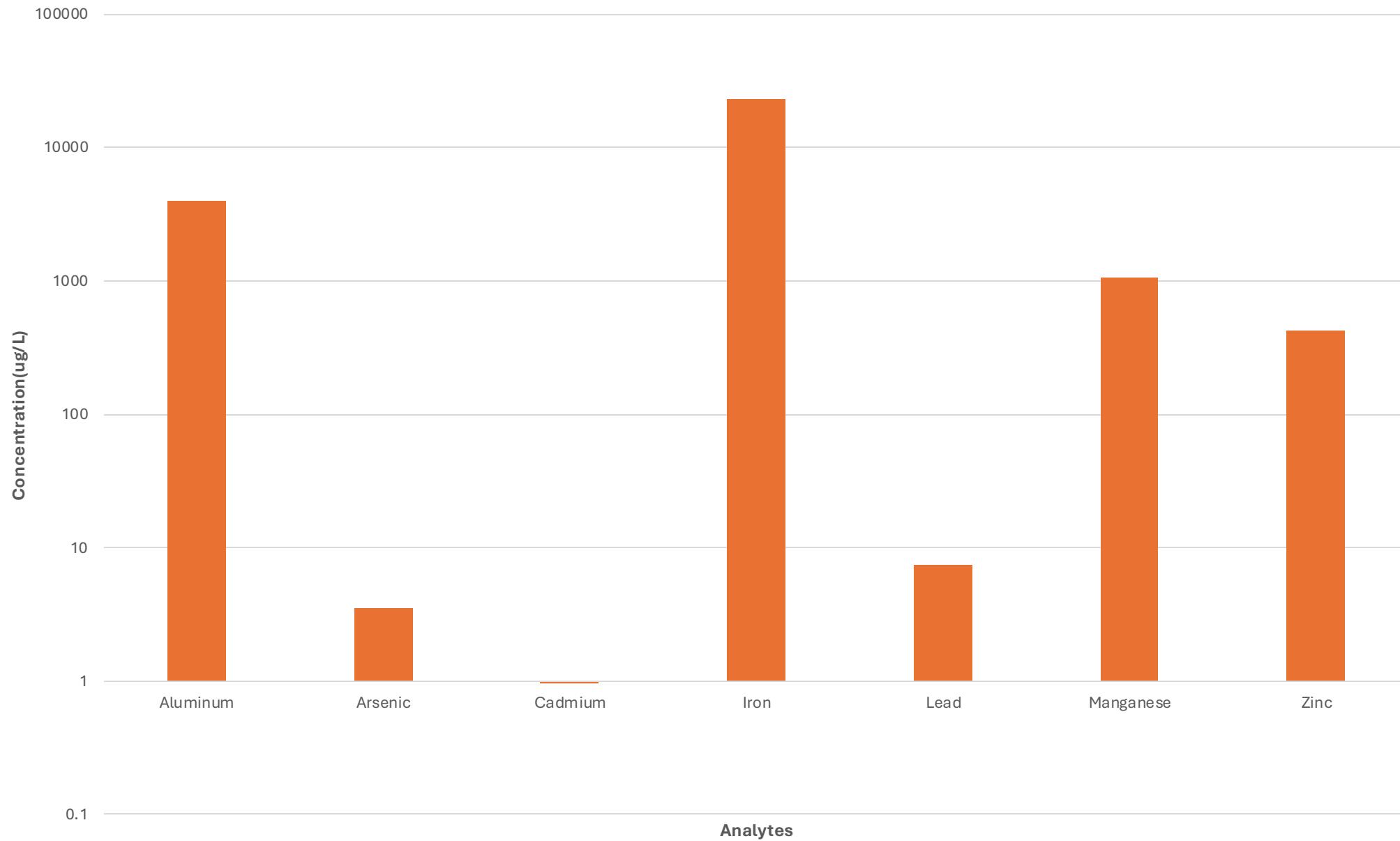
An aerial photograph of a mountainous forest area. A large, winding stream or creek bed cuts through the center of the image, its banks and surrounding ground appearing significantly lighter in color, likely due to soil erosion or mineral runoff. The terrain is rugged with many fallen trees and logs scattered across the ground. In the upper left, a steep slope shows extensive signs of deforestation or landslides. A few small, bright-colored markers (yellow and white) are visible on the ground, possibly indicating survey points or specific study sites. The surrounding forest is composed primarily of tall, dark green coniferous trees.

Lower Cement Creek Beaver Complex

Focus Areas

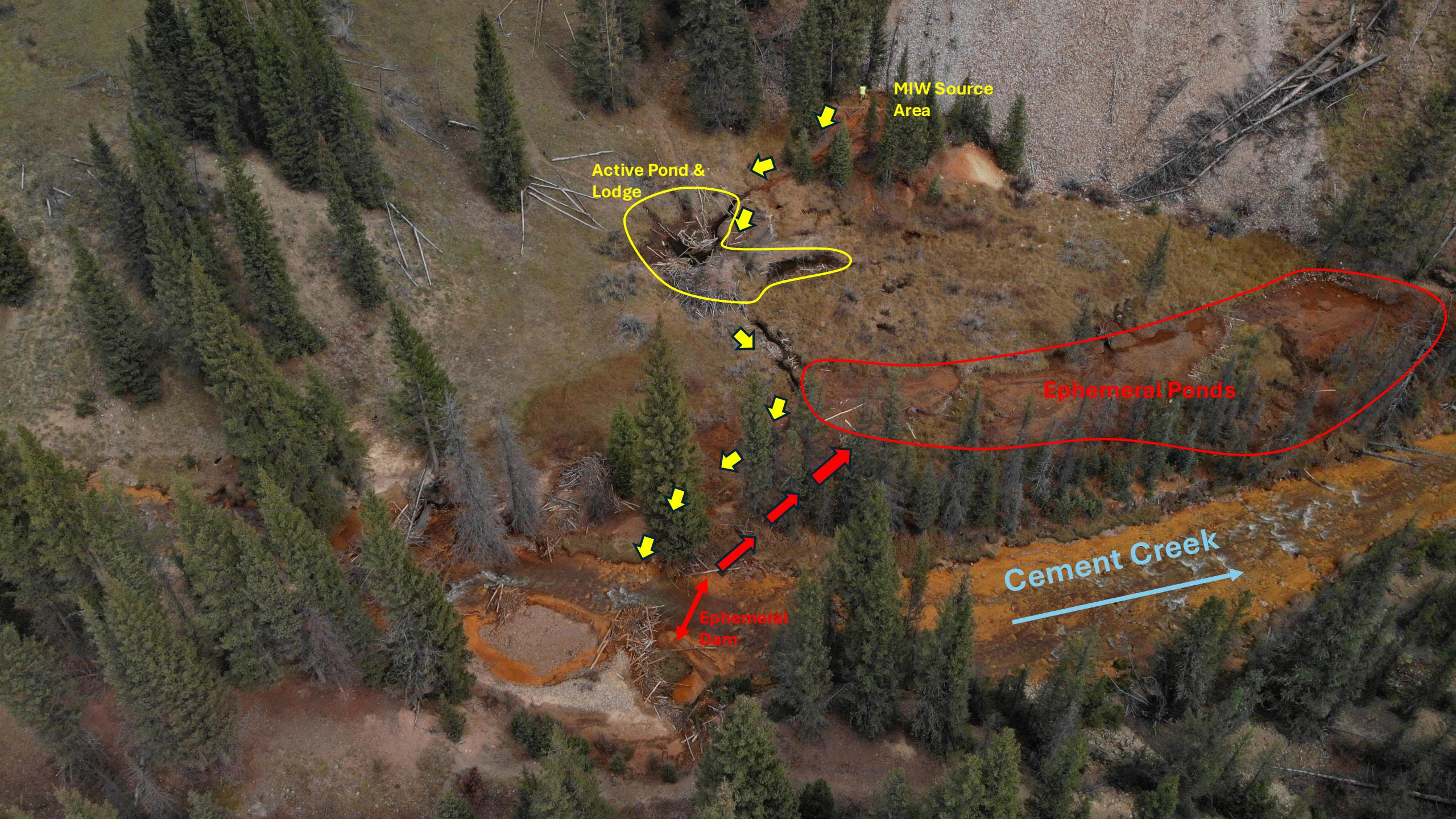


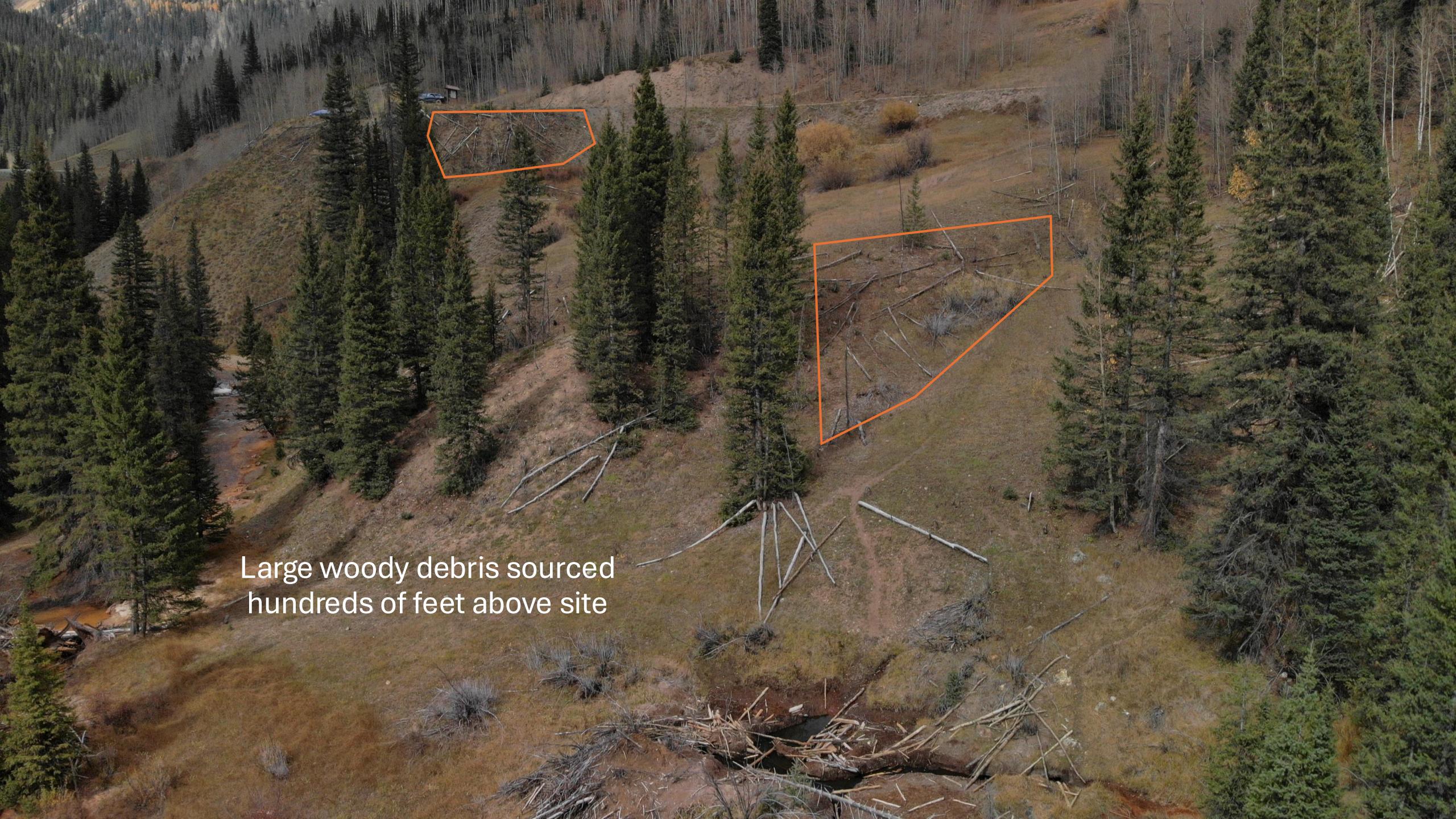
LCCBC Average Metals Concentrations



MIW Discharge to Beaver Pond Before Entering Cement Creek





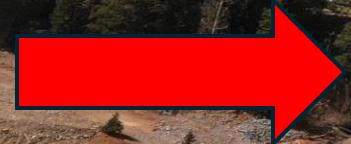


Large woody debris sourced
hundreds of feet above site



Cement Creek: Mine Drainage with active beaver habitat

Anglo Saxon
Mine Adit



County Road 110

Angle Saxon Mine Adit

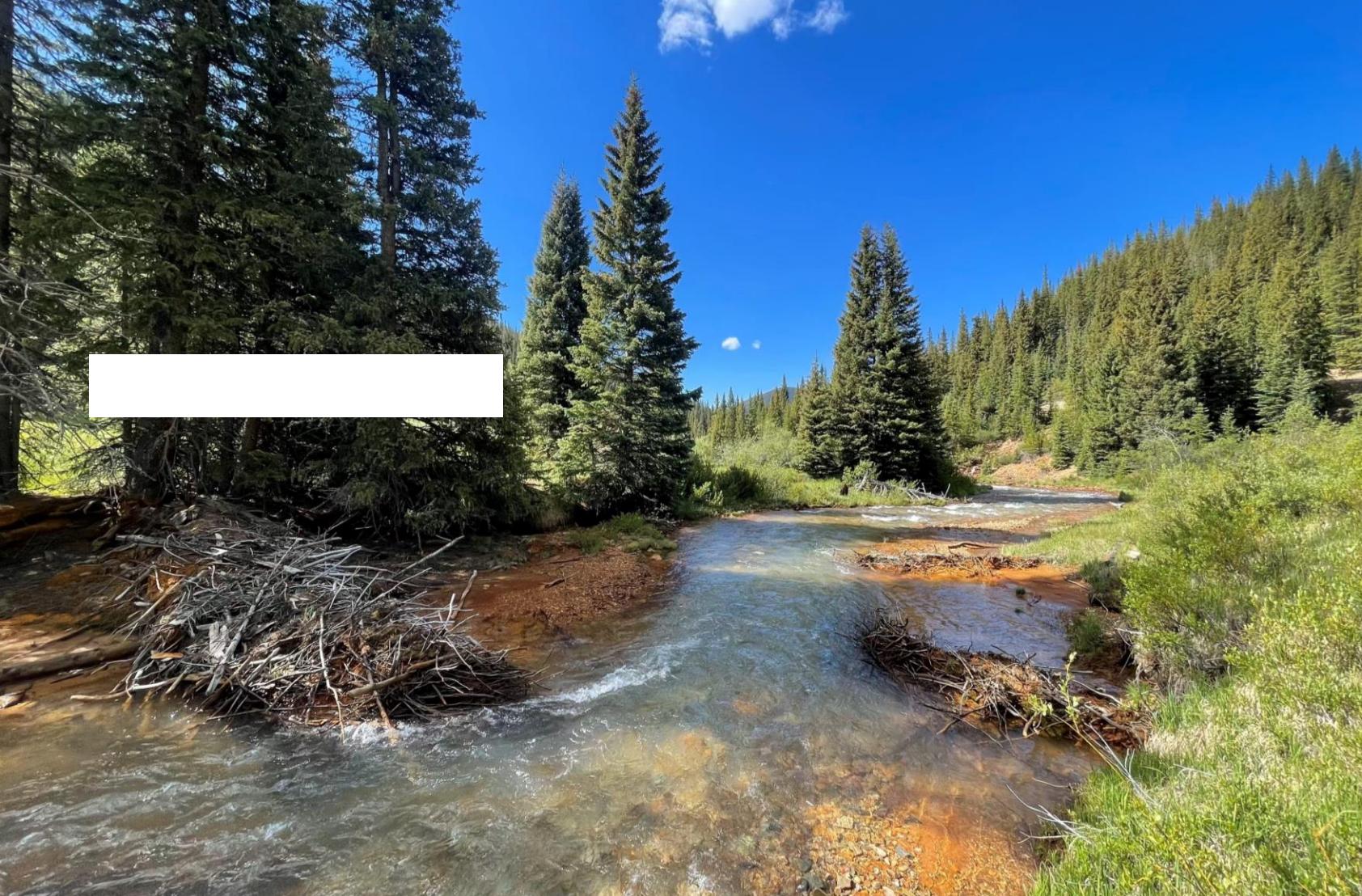


Beaver Dam
construction

CR 110

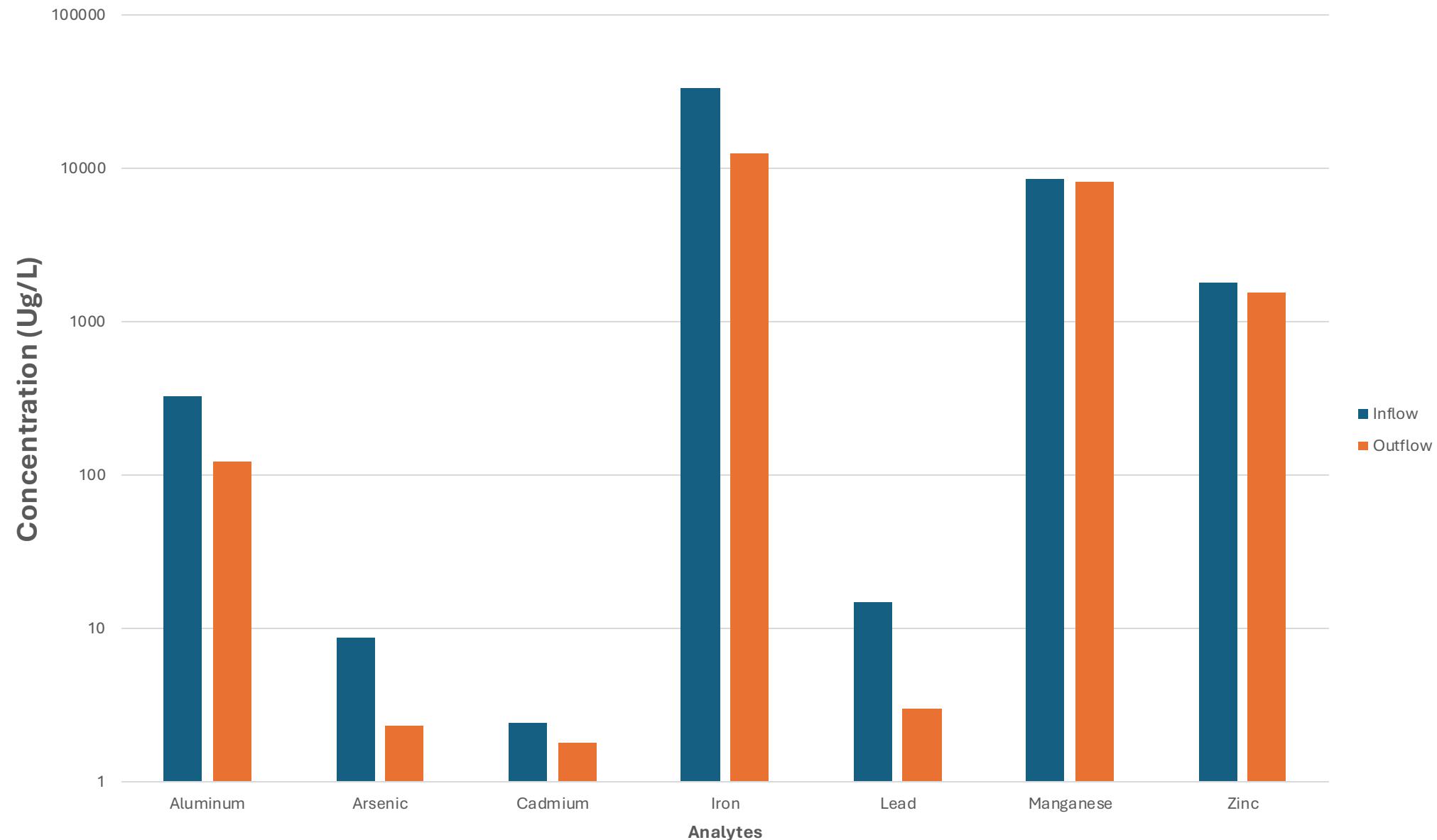


Silverton Mtn. 2 Miles North

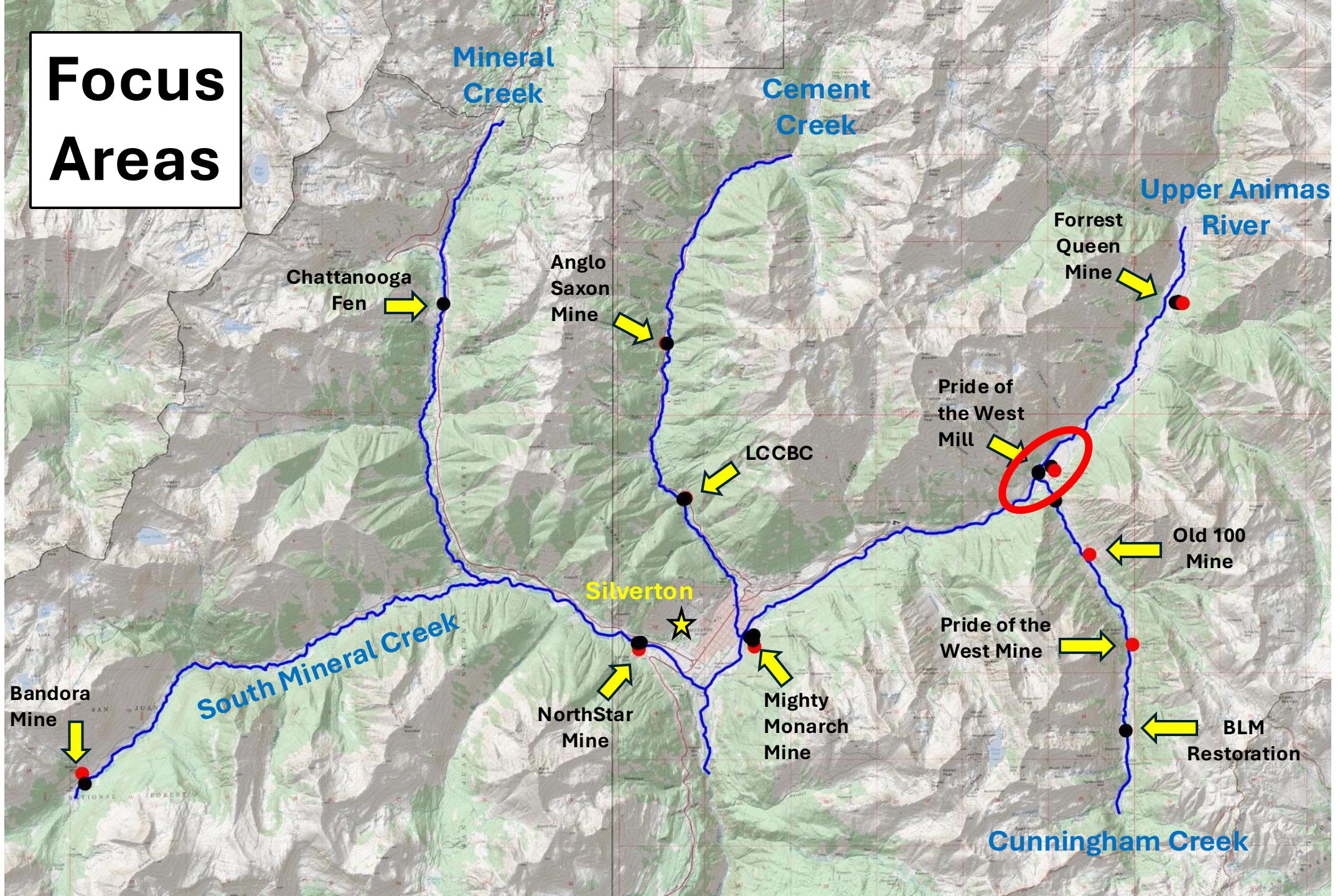


Other Evidence of Beaver Activity in Cement Creek (Anglo Saxon Mine)

Anglo Saxon Mine Metals Concentrations



Focus Areas



Pride of the West Mill



Mining Impacts: Animas River; mine tailings, channelization, and beaver habitat







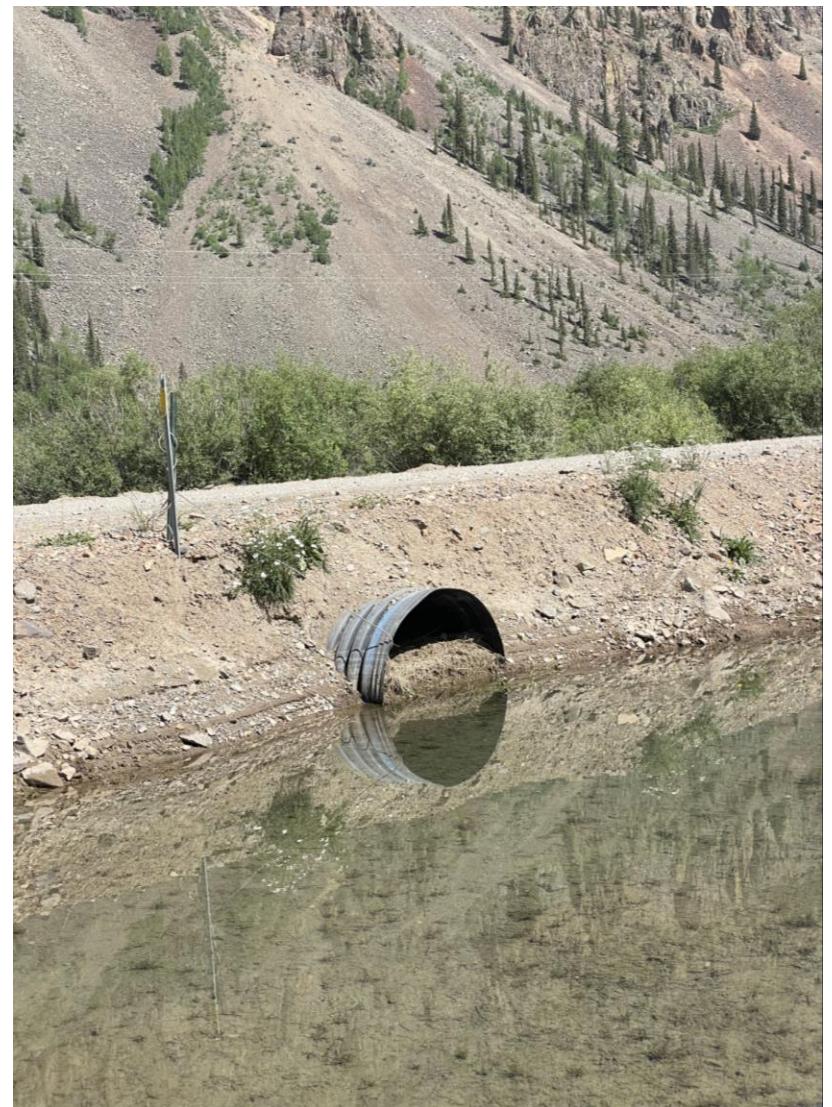
Mining Impacts: Animas River beaver habitat and mine tailings, Kittimac



CR 2 Infrastructure Protection: Culvert @ Forest Queen



CR 2 Infrastructure Protection: Culvert at Forest Queen Mine



Exclusion Fence Installation December 2024



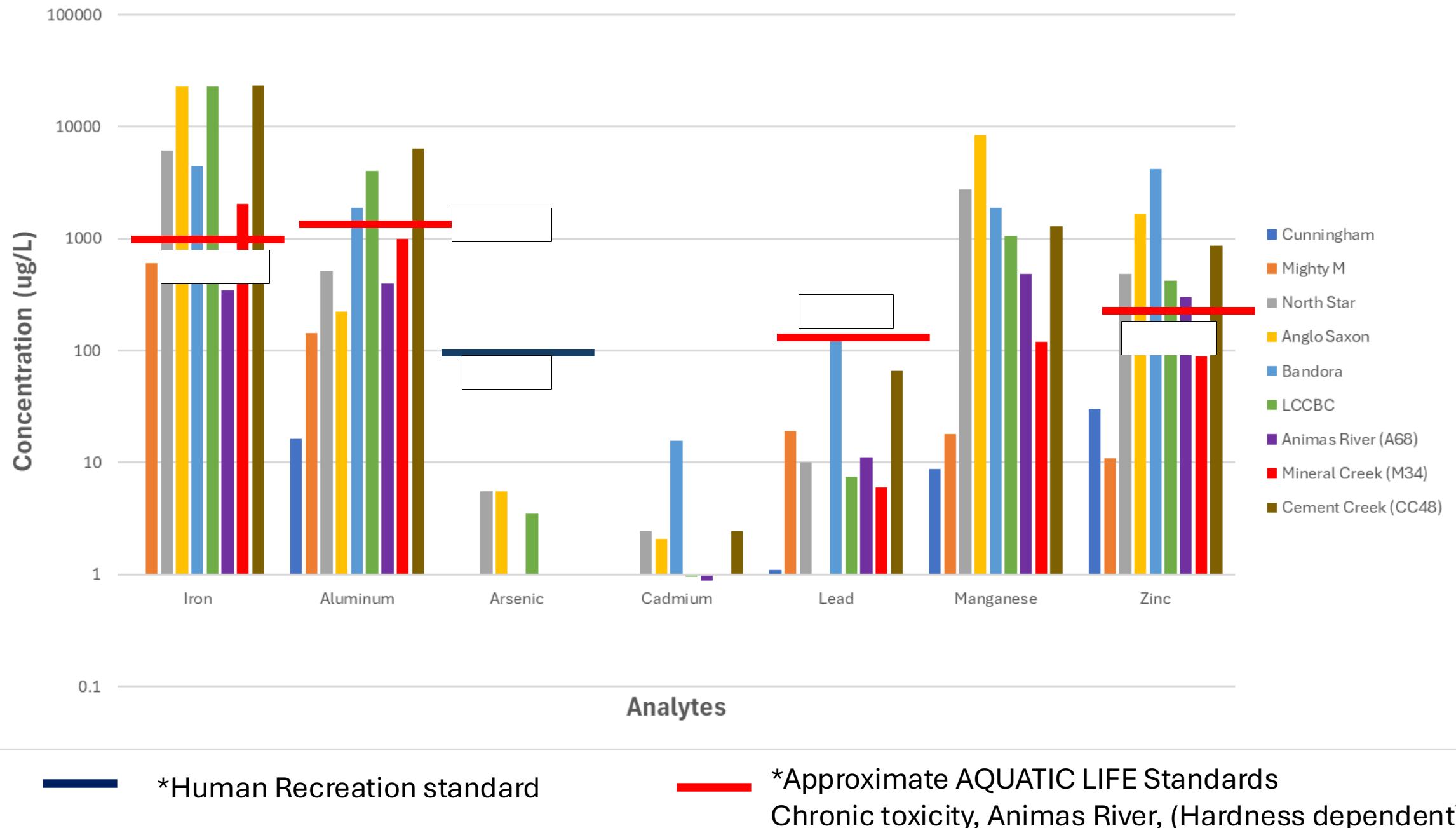
Min/ Max Metals Concentrations Across Active Beaver Sites in the Animas Watershed

Total Metals Summary Table

	<i>Min (ug/L)</i>	<i>Max (ug/L)</i>	<i>***</i>	
Iron	145	33500	1000 ug/L	Chronic
Aluminum	10.5	3950	2000 ug/L	Chronic
Arsenic	2.3	8.7		
Cadmium	0.5	54.2		
Lead	1	281	200 ug/L	Recreational
Manganese	2.1	8570		
Zinc	10.1	12400	400 ug/L	Chronic

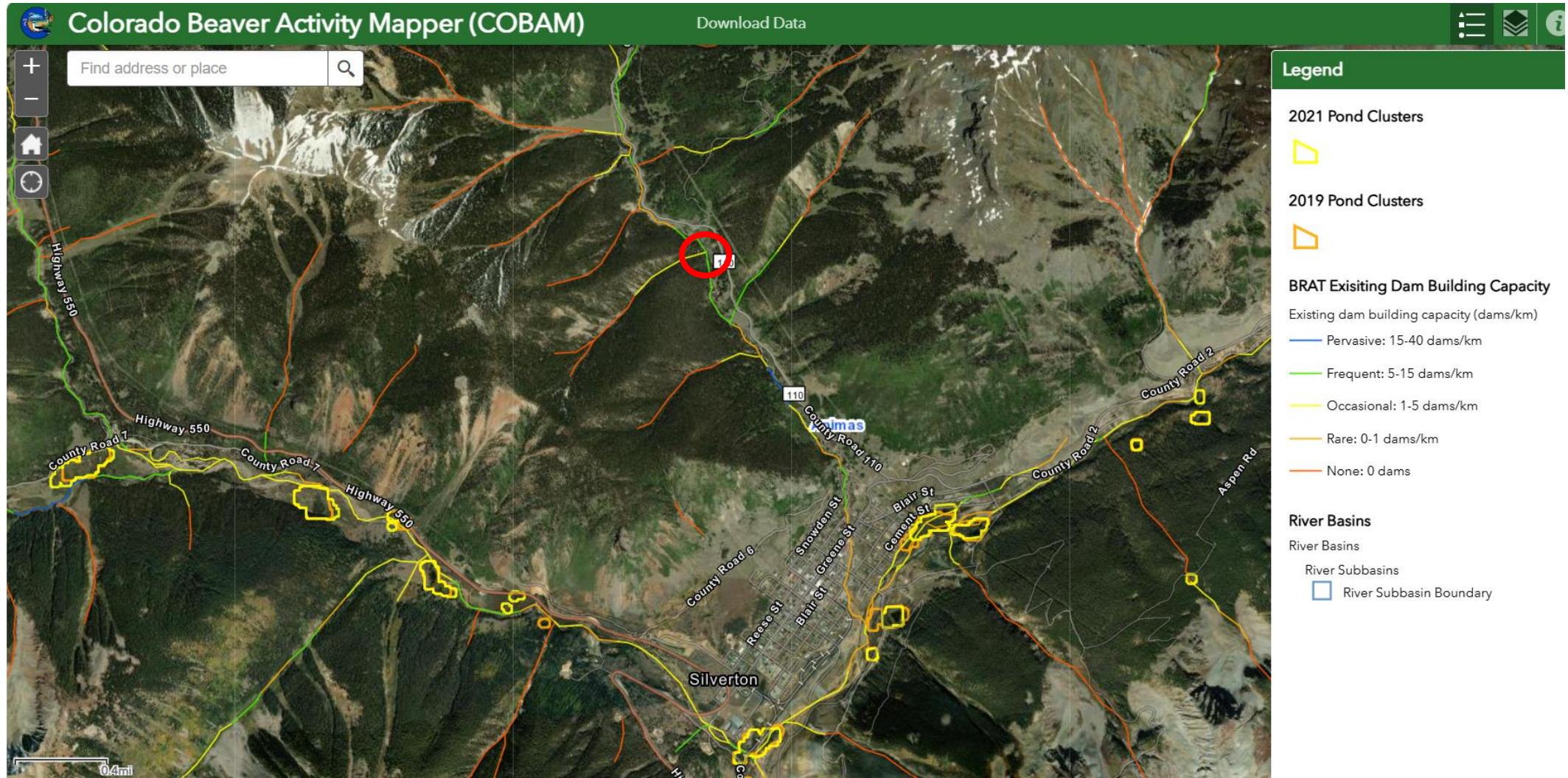
***** Animas River Approximate Metals Standards for Aquatic Life**

Total Metals Concentrations



Colorado Beaver Activity Mapper (COBAM)

Artificial Intelligence based tool for watershed managers, ecologists, restoration practitioners to explore recent & historical beaver activity alongside potential habitat suitability to identify opportunities for conservation and riverscape restoration.



Next steps and call for collaboration

- Build a more robust dataset to examine impacts of beaver habitat on metals concentrations and load reductions at reach and watershed scales
- Examine Impacts of chronic exposure to MIW on beaver health
- Examine Terrestrial impacts to beaver health (Pb in soil/sediment)
- Coordinate with partners to develop multiple phases of beaver habitat enhancements (Stacking funding cycles/sources)
- Continued Education and Outreach → succinct articulation of beaver benefits to diverse user groups/resource values



Silverton Beaver Pond Ice Hockey Facilities



"Hobgood-Drew Wetland above the beaver dam behind 299 Spruce Street, a building whose foundation is continuously threatened when beavers back up water too high" (10/11/2005)





Hobgood-Drew Wetland above the beaver dam that is behind 299 South Spruce Street, a building whose foundation is continuously threatened when beavers back up water levels too high. Man-hours required to lower this dam each day is 1 hour. If the beaver deceiver continues to work as it has for over 1 month now, approximately 150 hours of labor can be used doing other important tasks during the busy field season. (10/11/05)



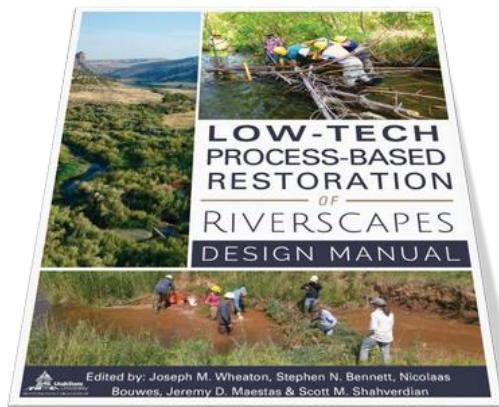
5 months after install

- No activity around the inflow fence
- Some activity over the dam section but no damming of outflow

Outflow pipe

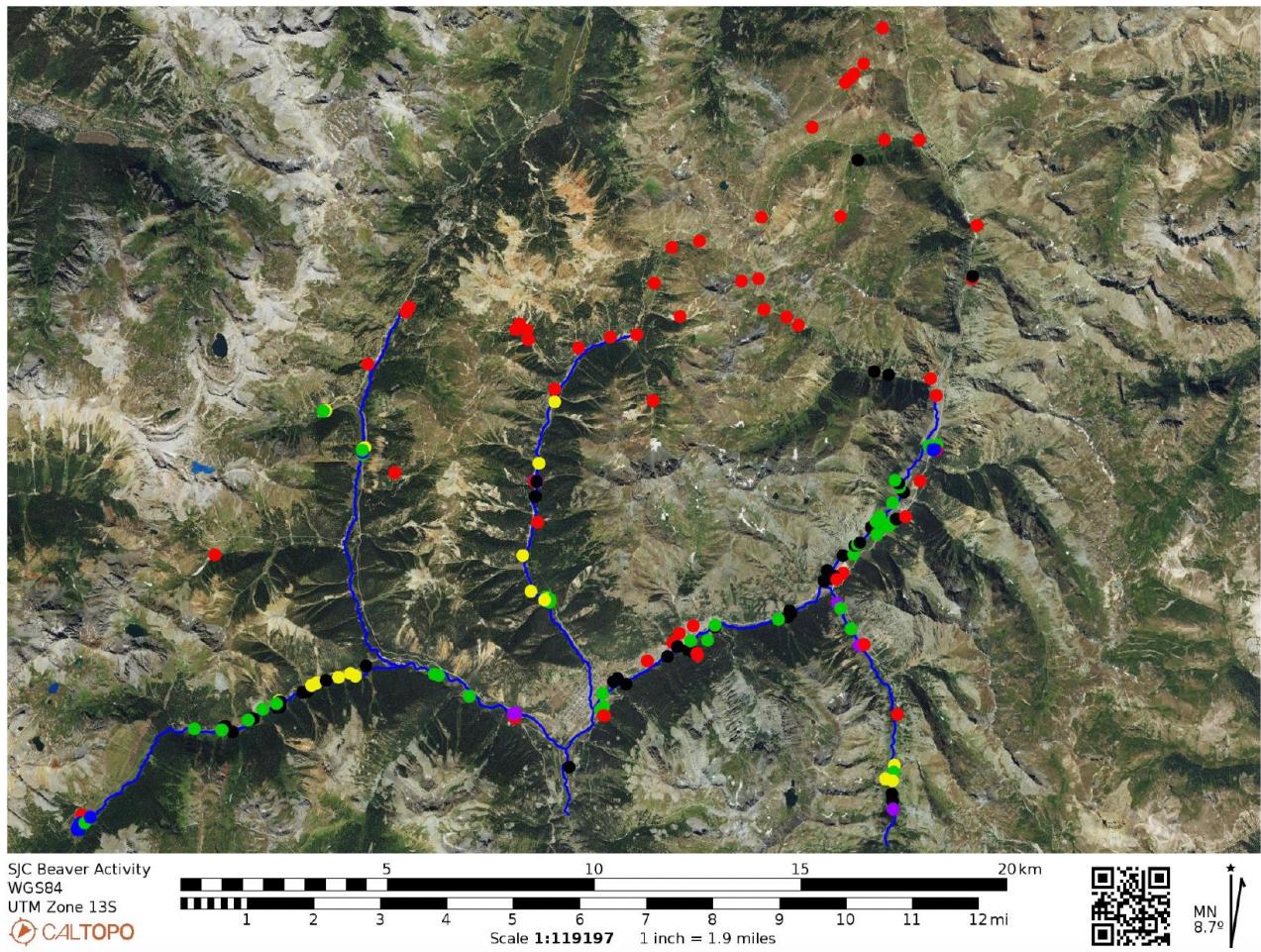
- Minimal maintenance
- 150 hrs per year x 17 years = 2,550 hours of labor saved





Appendix E Site Maps

San Juan County Beaver Activity



Legend:

Green: Evidence of Recent Activity

Black: Evidence of Past Activity or undetermined historical presence

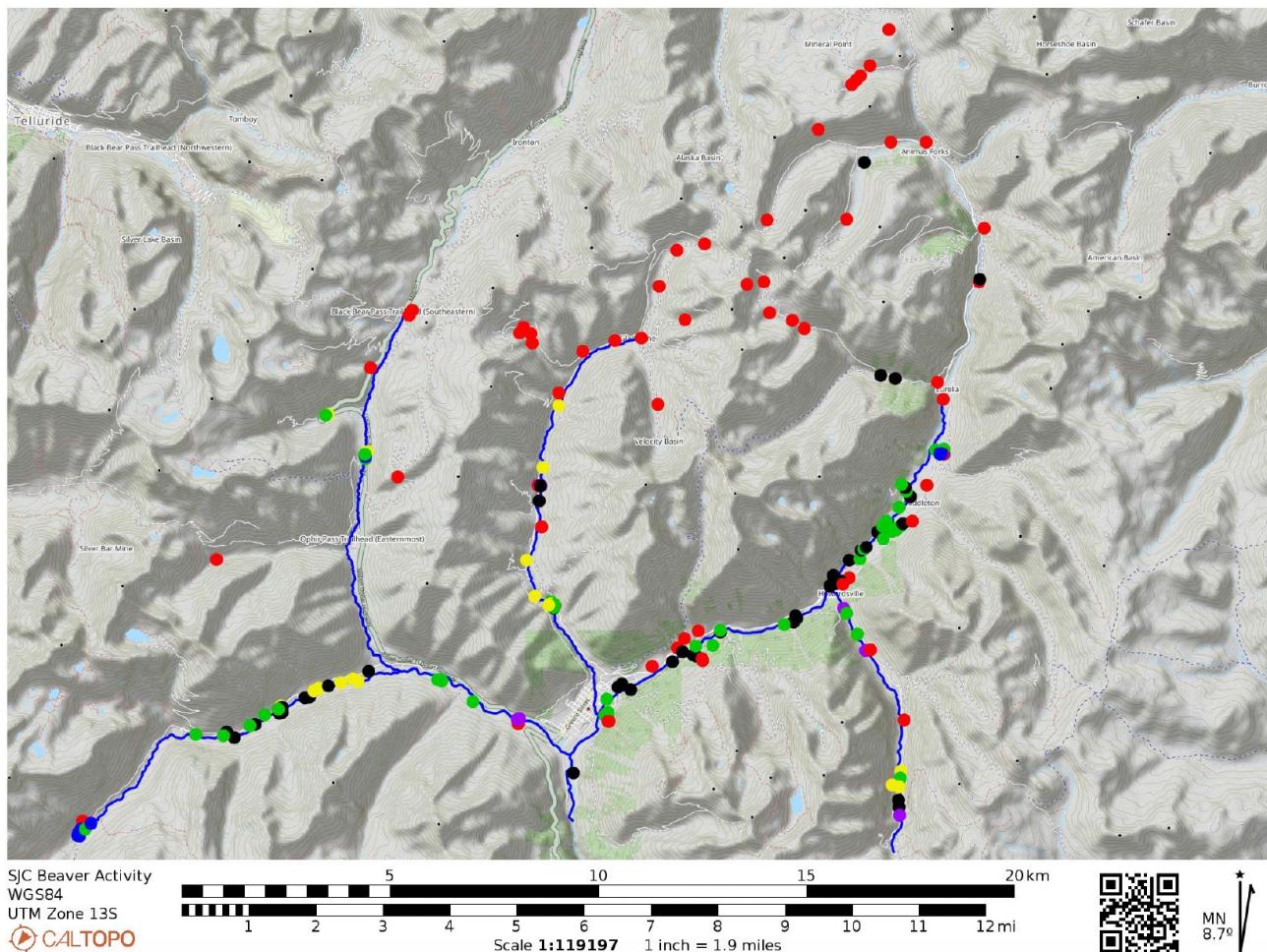
Blue: Water Quality Parameters Collected

Purple: Sampling Location

Red: BPMD Source Area

Yellow: Other Feature

San Juan County Beaver Activity



Legend:

- Green: Evidence of Recent Activity
- Black: Evidence of Past Activity or undetermined historical presence
- Blue: Water Quality Parameters Collected
- Purple: Sampling Location
- Red: BPMD Source Area
- Yellow: Other Feature