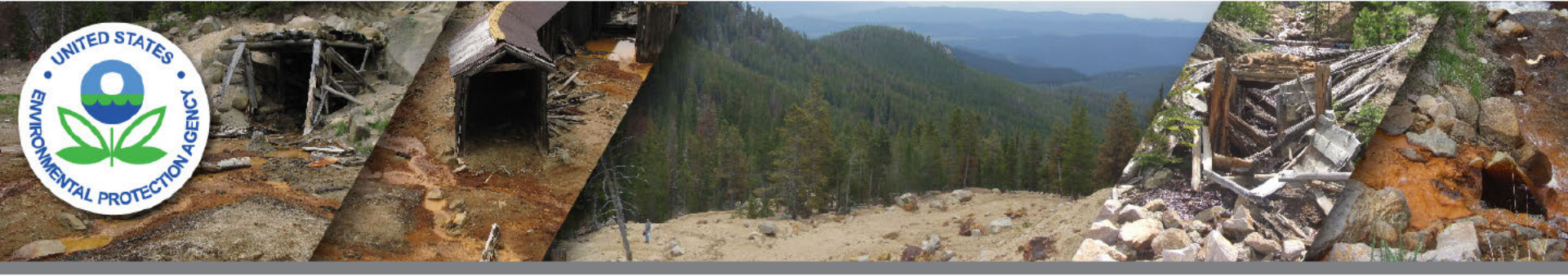


Priority Panel Presentation for Crystal and Bullion Mine Sites

Basin, Montana

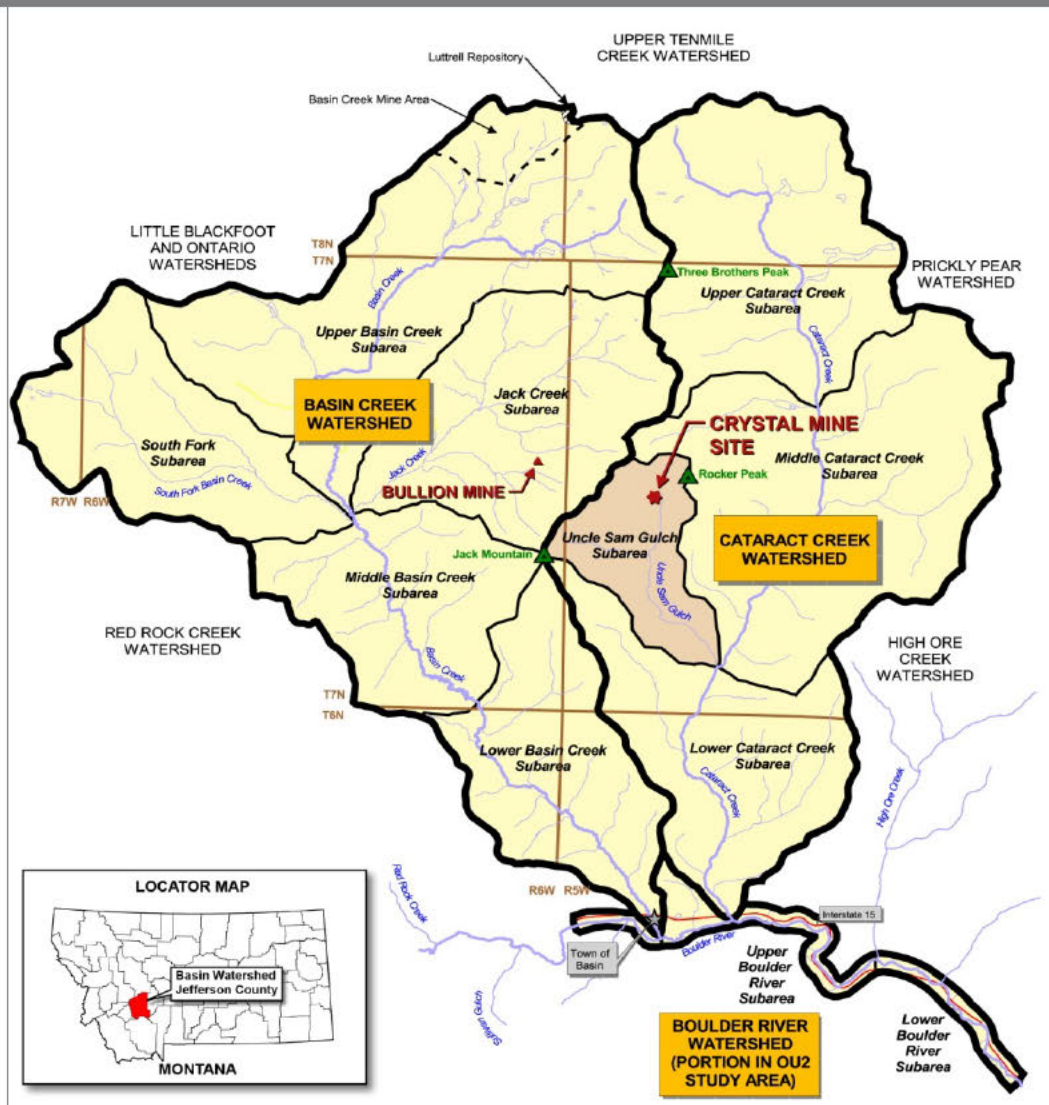
November 2015

General Information

- The historic Basin Mining District NPL site is located in west central Montana (Jefferson County), in the headwaters of the Boulder River.

- Much of the District falls w/in the Basin watershed (OU2)
  - Basin watershed consists of approximately 77 sq. miles of mountainous terrain (elevation ranges from 5,000 to 8,700 ft)
  - Encompasses 2 major sub watersheds: Basin Creek, and Cataract Creek, both drain into the Boulder River.
  - The Crystal mine (OU5) is located in the Basin Creek watershed
  - The Bullion mine (OU6) is located in the Cataract Creek watershed

Basin Watershed OU2



The site is located in west central Montana

General Information

- **Bullion and Crystal Mines**
  - The mines are located approximately 8 to 12 miles from the Town of Basin and are physically about 2 miles apart.
  - Both sites mine the same mineralized zone.
  - Access is by Forest Service Roads.
  - Bullion Mine is located in the Jack Creek Drainage w/in the Basin Creek Watershed.
  - Crystal Mine is located in Uncle Sam Gulch w/in the Cataract Creek Watershed.

BULLION MINE SITE

Basin, Montana

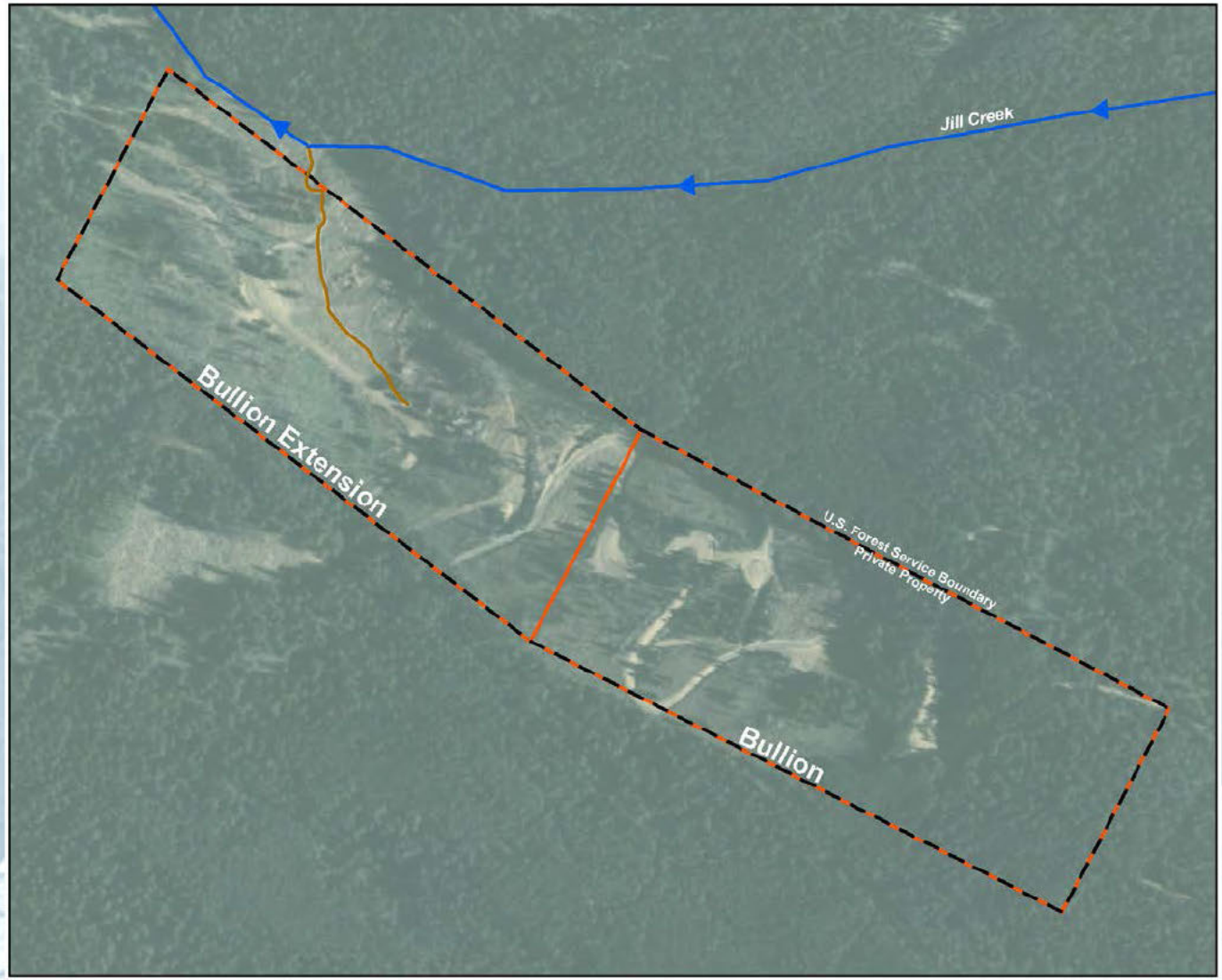
Bullion Mine

Background and Overview

- Multiple investigators including the USGS, MBMG, EPA and MDEQ consider the AMD from the Bullion Mine site to be the most significant contribution to water quality degradation in the Basin Creek Watershed
- The mine began operations in 1870s. Most active period 1897-1955 with final mining in the early 1970s.
- The mine was primarily underground with 3 portals separated by elevation. Processing activities included flotation mill, gravity concentrator and smelter.
- The site is approximately 40 acres in size.
- The Bullion Mine produced gold, silver, copper, lead, and zinc.

Overview – Mine Boundaries

Bullion Mine

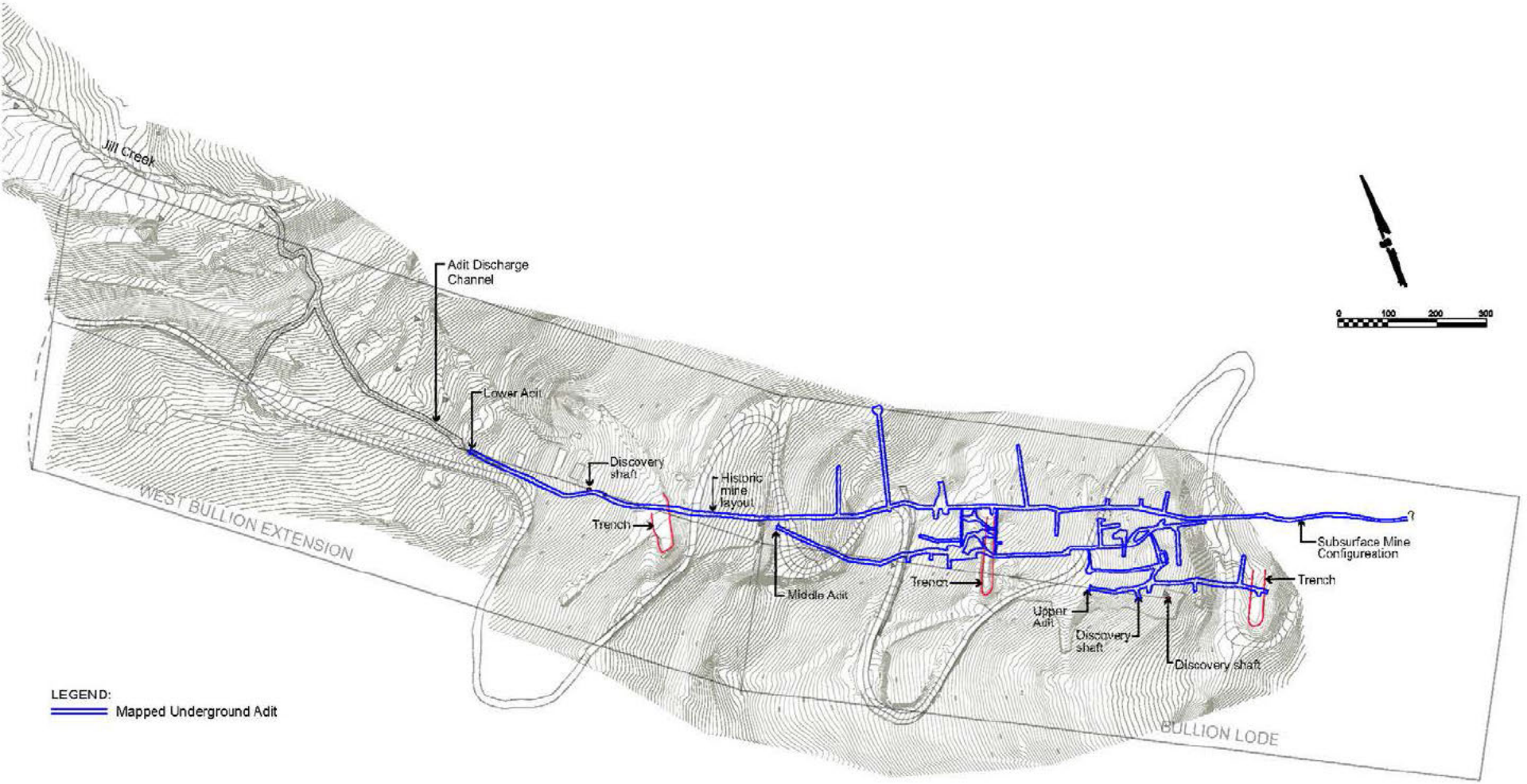


Overview – Prominent Site Features

Former waste rock dumps removed in 2002, adit plug removed in 2015; some mine structures remain in place.

Overview – Underground Workings

(Approximate location of Upper, Intermediate and Lower Mine Workings)



Bullion Mine

Overview – Site Description

- Mine wastes were removed and the site supports vegetation, although some areas need soil amendment and revegetation. Also the 2015 removal action involved extensive site disturbance, and some areas may need additional revegetation.

- Acid Mine Drainage (AMD) from the collapsed lower adit portal flows directly into Jill Creek. Discharge rate went from 5 to 9 gpm, to approximately 50 gpm after 2015 plug removal.

- Low pH AMD: 2.5 to 2.8 prior to plug removal, now 4.5.

- COCs that are risk drivers include arsenic, cadmium, copper, lead, and zinc

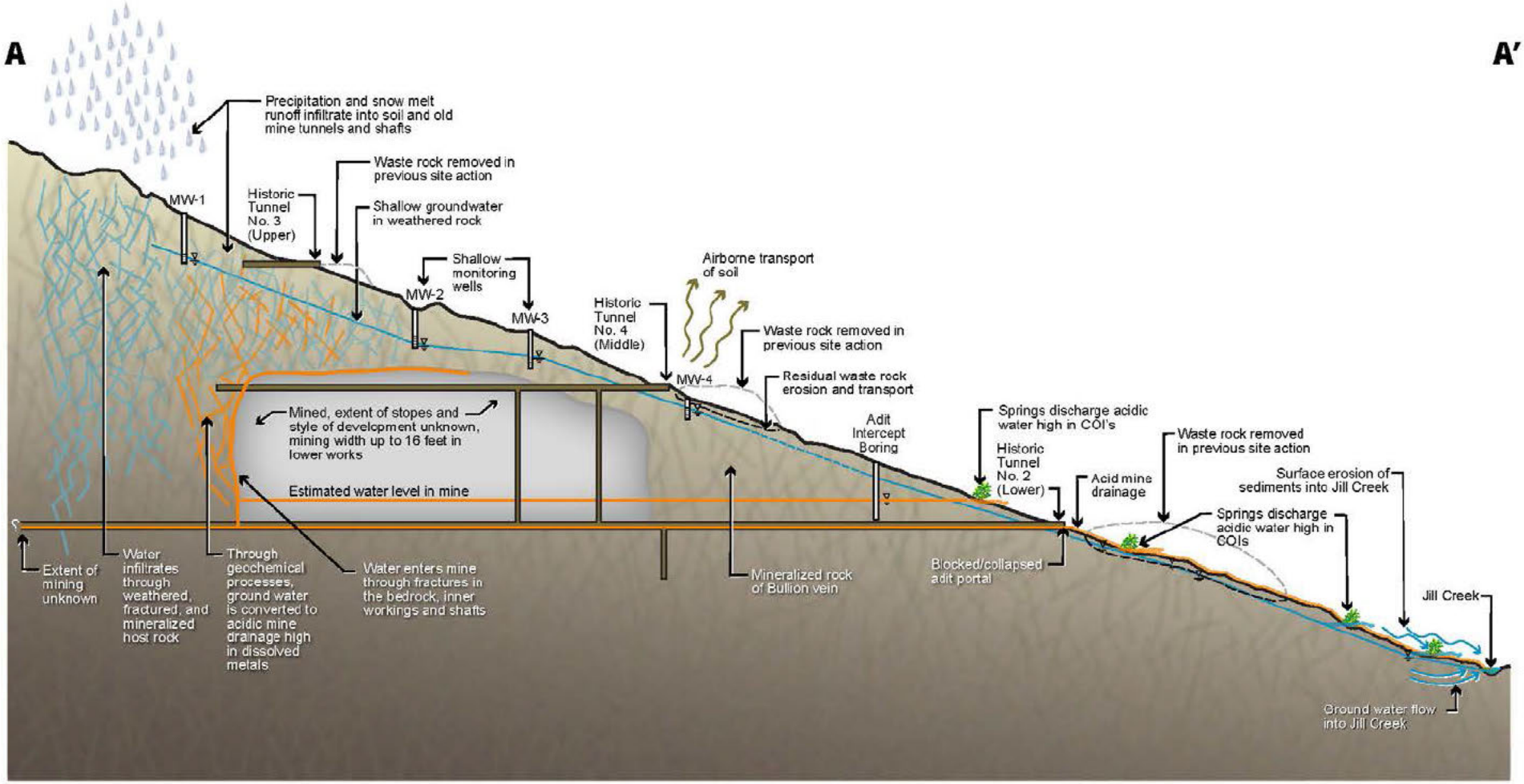
Overview – Previous Site Actions

Bullion Mine

- 1998-99. Preliminary Assessment/Site Investigation.
- 1999. National Priority Listing
  - ✓ The Bullion Mine was proposed for the Superfund NPL as part of the Basin Mining Area in October 1999
- 2000. Action Memorandum
  - ✓ Formal designation of the Bullion as OU6 occurred on April 12, 2000
- 2001 to 2002. Time Critical Removal Activities
  - ✓ In 2001 and 2002, a TCRA was completed through a joint USFS and EPA initiative
  - ✓ 27,238 cubic yards of mine waste rock and tailings removed to the Luttrell Repository in the headwaters of Basin Creek. Site capped w/ limestone gravel and clean fill (12-18 inches)
- 2005. Basin Watershed OU2 RI/FS Study
- 2010-2013. Remedial Investigation, Feasibility Study, Human Health and Ecological Risk Assessment. ROD signed in April 2015.
- 2015. Removal of debris plug, bulkhead and 140 feet of 24 inch diameter pipe installed.

Findings of Remedial Investigation

Bullion Mine



Development of Conceptual Site Model

Findings of RI: Nature and Extent of COPCs

Bullion Mine

- A perpetual point source of contaminated groundwater flows from the lower adit portal into Jill Creek. Flow rate went from 5 to 9 gpm prior to plug removal to 50+ gpm. New high flow rate will be measured spring of 2016.

- Elevated concentrations of aluminum, arsenic, cadmium, copper, lead, manganese, and zinc have been documented in Jill Creek.

- Elevated concentrations of aluminum, arsenic, cadmium, copper, lead, manganese, and zinc were documented extensively across the site in subsurface soils covered by previous reclamation activities.
  - ✓ Cover shows some localized wear, but most of it remains intact and vegetated.
  - ✓ 2015 removal areas were reseeded in October.

Findings of RI: Nature and Extent of COPCs (cont'd)

Bullion Mine

- Groundwater discharging from the lower adit carries significant concentrations of aluminum, arsenic, cadmium, copper, lead, and zinc that exceed the state and federal drinking water and aquatic life standards
  - ✓ Adit Discharge - Mean
  - ✓ As 3,885 µg/l; Cd 423 µg/l; Cu 8,739 µg/l; Pb 470 µg/l; Zn 49,029 µg/l; pH 3.02]
  - ✓ Adit discharge loading: Cd (9 lbs/yr), Cu (202 lbs/yr) and Zn (1113 lbs/yr) to Jill Creek

- Water quality in Jill Creek is unsuitable for aquatic organisms and cannot support benthic macroinvertebrates communities – entire reach to confluence w/ Jack Creek.

- The human and ecological risks are unacceptable.

Risk and Reuse

Bullion Mine

Current and Reasonably Anticipated Future Land Use:

- The majority of the land in the Basin watershed is managed by the USFS or BLM
- The watershed is sparsely populated, with residences located along the mainstem of Basin Creek, Cataract Creek, and the town of Basin
- Land uses within the vicinity of the Bullion Mine include historical mining, habitat for fish and wildlife, and recreational use including hiking, ATV riding, camping, fishing, and big-game hunting

Bullion Mine

ROD, Remedy Description

- EPA's remedy for the Bullion Mine consists of controlling surface water and groundwater infiltration into the mine workings, followed by capturing and semi-passively treating the contaminated discharge from the lower mine adit. Exposed, eroding, and contaminated soils will be covered with clean soil and revegetated. The remedy will be implemented primarily within the patented claim boundaries of the site.

- Depending on the performance of the bulkhead/drainage structure installed during the 2015 removal action, EPA may need to modify it to assure the free flowing condition of the adit in perpetuity.

- The preferred remedy addresses human health and ecological risks, and waives water quality standards until the Basin watershed OU2 remedy.

Bullion Mine

Sequence of Preferred Remedy

The proposed sequence of remedial actions starts in 2016 with:

- Road improvement to facilitate the safe movement of equipment to, and around, the site. Install stormwater BMPs and take actions to intercept water from entering the mine workings.
- Monitor AMD flow rate and chemistry, adjust and finish passive treatment system (PTS) design.
- Evaluation of the bulkhead and adjust the design to include modification if needed to maintain AMD flow to the PTS in perpetuity.
- 2016 costs are estimated at $3 million.

Bullion after 2015 Plug Removal

Bullion Bulkhead

Bullion Adit Flow October, 2015

Remedy Sequence, cont.

Bullion Mine

In 2017 the focus will be installation and start-up of the PTS

Adit discharge will be collected via a structure designed to provide continuous AMD flow to the PTS. The PTS will consist of two parallel treatment trains to allow for one to be out of service for maintenance or repairs while the other serves treatment needs.

The three stages of the treatment process are as follows:

- ✓ **Stage 1 pH Cell** - The pH adjustment cell will raise the pH of the adit discharge to greater than 5. The cell will consist of three layers including:
  - The top layer of adit discharge water to act as an insulator during the winter.
  - Below the water layer will be a mixed layer of limestone sand and compost or stable waste, sized to provide approximately 16 hours retention time.
  - Below the limestone compost layer will be a layer of drain-rock with 6-inch-diameter perforated collector pipes running through the layer. The perforated collector pipes will drain into a solid 6-inch-diameter collector pipe which will drain into the SRBR cells.
  - The entire pH adjustment cell will be lined with a high-density polyethylene liner.
  - Water from the pH adjustment cell then flows by gravity into the sulfate reducing bioreactor cells.

Remedy Sequence, cont.

Bullion Mine

Stage 2 Sulfate Reducing Bioreactor - The SRBR consists of a series of horizontal flow-through cells.

- Each cell will be comprised of limestone gravel and compost or stable waste.
- The SRBR cells will provide, at a minimum, 5 days retention time. Effluent from the pH adjustment cell will be evenly distributed to the SRBR cells at one end of each cell.
- At the opposite end of each cell, treated effluent will be collected in 6-inch-diameter perforated polyvinyl chloride (PVC) pipes, which will drain into a 6-inch solid PVC collector pipe that discharges into a clarification pond.
- For insulation purposes, earth backfill will be placed on top of the SRBR cells.
- The SRBR cells will need to be replaced approximately every 15 years.
- Between the SRBR cells and the clarification pond, the treated effluent will pass over a series of enclosed weirs or manholes to allow for aeration prior to discharging into a clarification pond.

Remedy Sequence, cont.

Bullion Mine

- **Stage 3 Clarification** - The clarification pond will allow settling of sludges and organic materials formed in the prior two stages.

  - ✓ Effluent from the SRBR cells will be discharged into the deep end of the pond which offers storage for settling sludges.
  - ✓ The bottom of the pond will gradually rise halfway through. At the shallow end of the pond, native aquatic vegetation will provide biological filtering, before the treated water discharges into a channel leading to Jill Creek.
  - ✓ Periodically, sludge that settles in the deep end of the clarification pond will be excavated, and dried on drying beds that will drain into the clarification pond. The dried waste will be transported to the Luttrell Repository for disposal.

Bullon, Final Steps

Bullion Mine

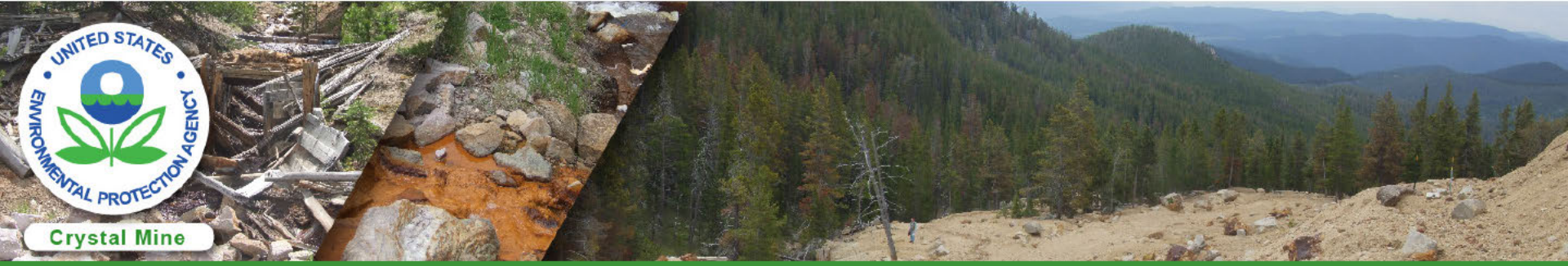
- Areas of contaminated soil exposed by erosion of the previous cap material will be identified, regraded, amended with topsoil, and revegetated. Debris will be strategically placed over the reclaimed areas to discourage ATV use. Cost of 2017 activities are estimated at $8 million.

- Land-use controls to prohibit residential use, prevent installation of drinking water wells, and to protect the remedy will be required throughout the mine site. Land-use controls will be tailored to the size, location, and complexity of the area.

- The EPA and MDEQ will work with adjacent landowner agencies (primarily USFS) on the specific application of this remedy. The agencies will work to ensure that land-use controls are protective of human health and compatible with existing and reasonably anticipated future land use in the area.

- Construction and post construction monitoring of water quality and other environmental parameters will be required.

- Total cost of Bullion remedy is estimated at $11 million over two years.



Priority Panel Meeting
November 2015

Crystal Mine Site
Basin, Montana

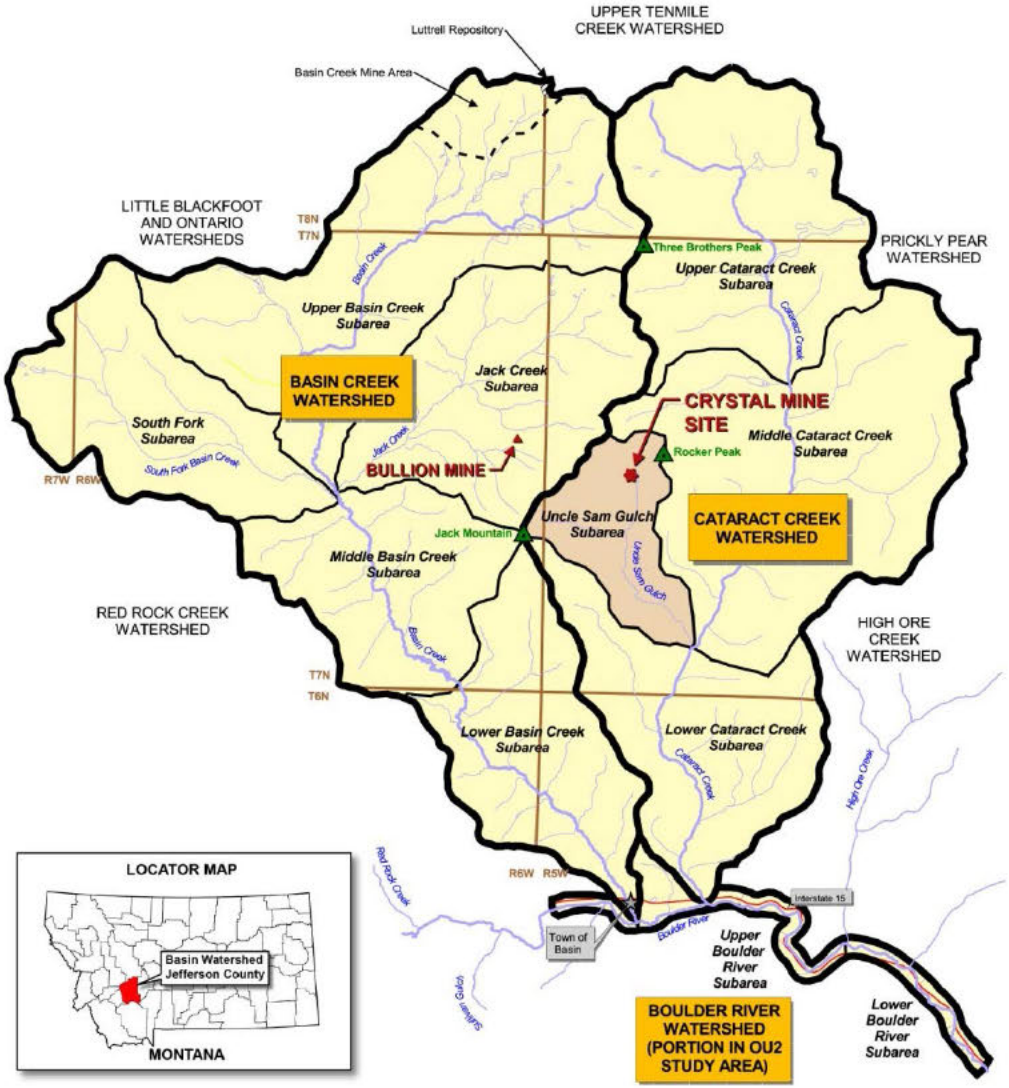
Background and Overview

- The Crystal Mine (OU5) is the primary source of contamination to Cataract Creek
- The mine began operations in 1883 and was mined intermittently until 1983
- Mineralized zone is 12 to 33 feet wide (aplite w/semi-continuous high-grade quartz-sulfide veins)
- The mine includes both surface mining (the Crystal Trench) and multiple underground workings (approx. 2,600 ft including 800 ft cross cut)
- Two historic portals (upper and lower)
- The Crystal Mine produced gold, silver, copper, lead, and zinc
- The site is approximately 22 acres in size (disturbed area)

Background and Overview

(Note Location of Crystal Mine in Uncle Sam Gulch)

Crystal Mine

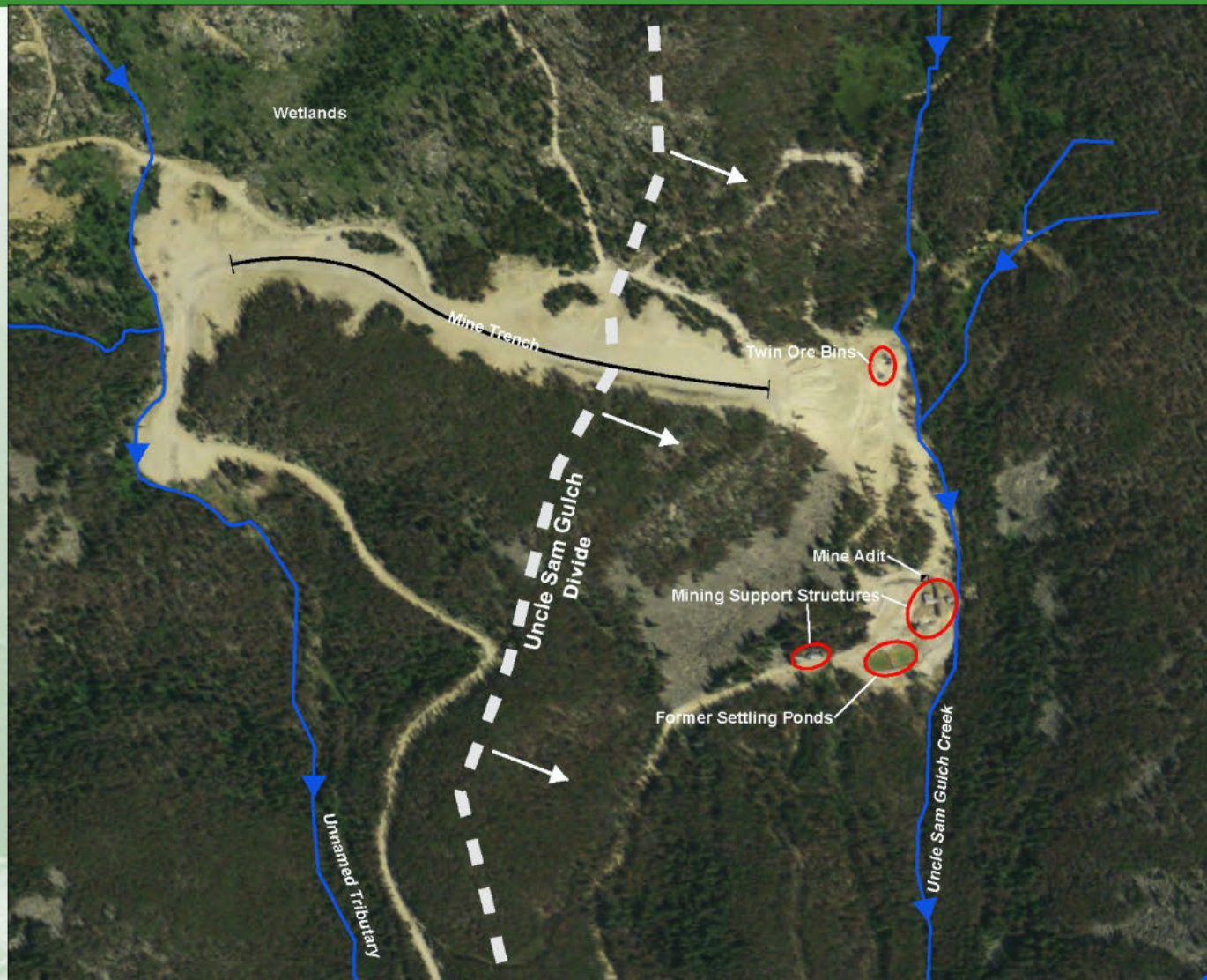


The site is located in west central Montana

Background and Overview

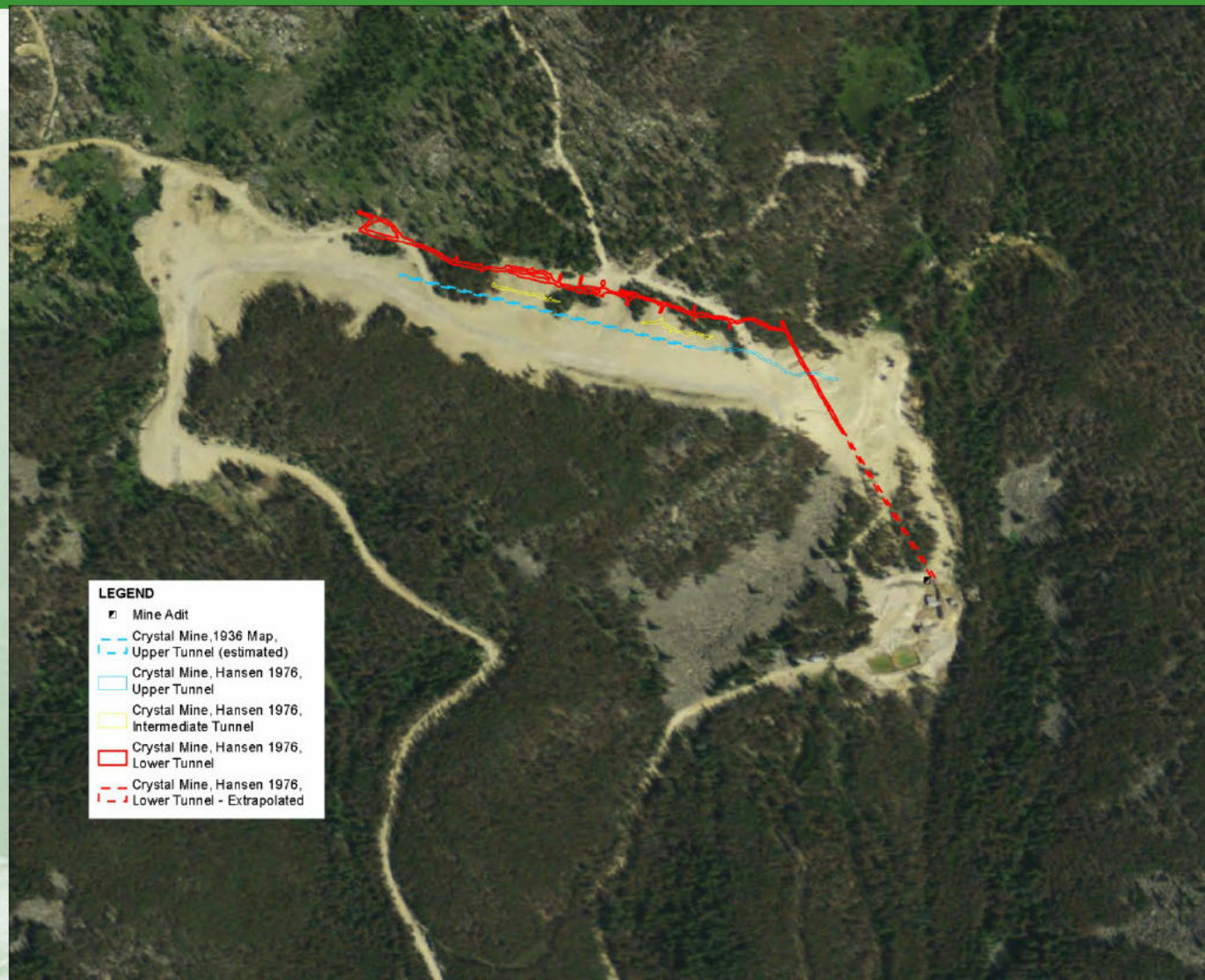
Crystal Mine

The site is remote, located between 7,400 and 8,000 feet in elevation, and only seasonally accessible (June thru October)



Background and Overview

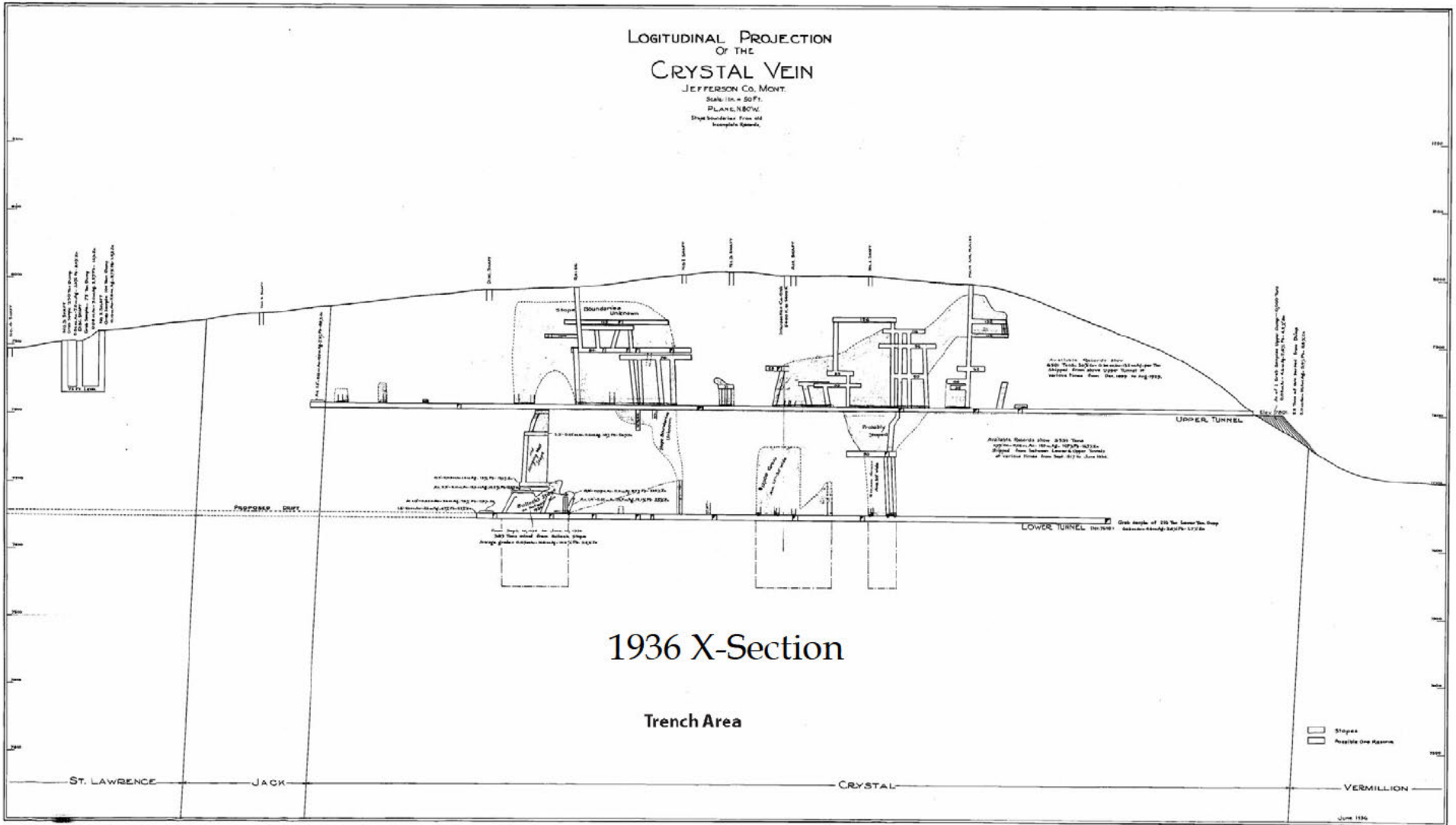
Crystal Mine



Approximate location of Upper, Intermediate and Lower Mine Workings

Background and Overview

Crystal Mine



1936 X-Section

Crystal Mine

Background and Overview

- Mine structures (buildings, ore bins), 3 waste rock dumps, and 1 haul road remain in place
- The waste dumps are unvegetated and actively eroding into Uncle Sam Gulch (USG) Creek
- AMD from the lower adit portal flows directly into USG Creek
- COPCs include aluminum, antimony, arsenic, cadmium, copper, lead, silver, and zinc

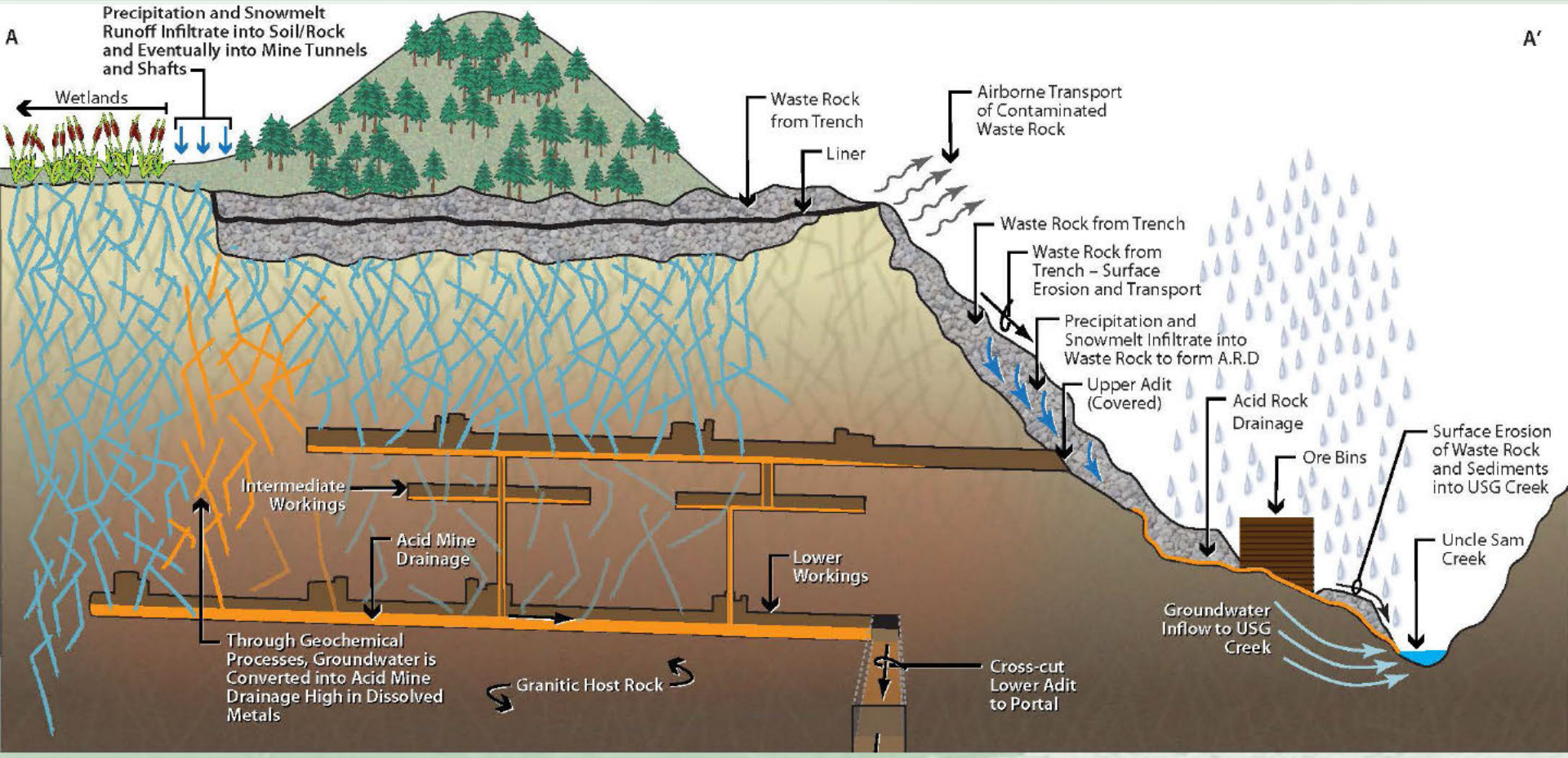
Background and Overview (cont'd)

Crystal Mine

- Previous Site Actions:
  - ✓ 1994 - 1996: Pilot Study by MSE - Lower adit AMD was temporarily treated with an Aqua-Fix® quicklime injection system
  - ✓ 2002: Time-Critical Removal Action - included partial backfill of the Crystal Trench, installing a geomembrane over the Trench, constructing a drainage channel, and grading the Crystal Trench area
  - ✓ 2010-12: Focused RI/FS, followed by 2015 Interim ROD
  - ✓ 2014: Removal of sediment retention ponds and sludges to Luttrell
  - ✓ 2014: On-site Treatability Study-Proof of Concept-Acid neutralization and sulfur reducing biochemical reactor (media = sugar cane bagasse).
  - ✓ 2015: Lab bench test to optimize treatment process and determine hydraulic retention times.

Findings of Remedial Investigation

Crystal Mine



Development of Conceptual Site Model

Findings of RI: Nature and Extent of COPCs

Crystal Mine

- USG Creek receives Acid Rock Drainage from 1,000 linear feet of stream banks covered by eroding waste rock.

- Approx. 85,000 yds^3 of waste rock covers the site. Much of this exceeds human health and ecological screening levels for arsenic and lead.
  - ✓ Surface soils Mean Values:
    - **As** 1,789 mg/kg;
    - **Pb** 1,393 mg/kg;
    - **pH** 3.4

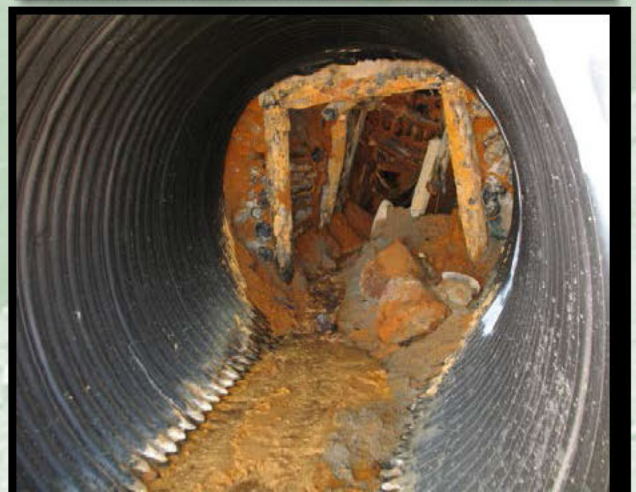
Findings of RI: Nature and Extent of COPCs (cont'd)

Crystal Mine

- Groundwater discharging from the lower adit carries significantly elevated concentrations of arsenic, cadmium, copper, lead, and zinc that exceed state and federal drinking water and aquatic life standards.
  - ✓ Adit Discharge [n=37; USGS 2003 to 2010]

    mean (Total recoverable):
    - **As** 247 ug/l; **Cd** 468 ug/l;
    - **Cu** 5,674 ug/l; **Pb** 48.2 ug/l;
    - **Zn** 36,642 ug/l; **pH** 3.7
  - ✓ **Crystal AMD loading to Uncle Sam Gulch Creek**:
    - As (28 lbs/yr); Cd (51 lbs/yr); Cu (650 lbs/yr); Zn (4046 lbs/yr)

- Water quality in USG Creek is unsuitable for aquatic organisms – to confluence w/ Cataract Creek



- Wetlands along USG Creek are significantly impacted

Human Health and Ecological Risk Assessment (HHRA/ERA)

Crystal Mine

- Human Health and Ecological Risk Assessments were conducted in accordance with applicable Montana DEQ and EPA guidance.

- Human health risks were evaluated for current and reasonably anticipated future uses, including:
  - ✓ Intermittent workers, recreational users (adult and adolescent), excavation workers, and industrial workers.

- Ecological risks were estimated for:
  - ✓ Endpoint species representative of the types that use the Crystal Mine site and surrounding areas, which include wildlife (birds and mammals), aquatic biota, benthic biota, and vegetation.

Crystal Mine

Conclusions of RI

- Based on weight-of-evidence approach that considers multiple lines of evidence collectively, the RI findings support the conclusion that unacceptable risk exists to human and ecological receptors.

- Multiple investigators including the USGS, MBMG, and MDEQ consider the Acid Mine Drainage from the Crystal Mine to be the most significant contribution to water quality degradation in the Cataract Creek Watershed.

Risk and Reuse

Crystal Mine

Current and Reasonably Anticipated Future Land Use:

- The majority of the land in the Basin watershed is managed by the USFS or BLM.
- The watershed is sparsely populated, with residences located along the mainstem of Basin Creek, Cataract Creek, and the town of Basin. New cabins and residences are increasing along Cataract Creek.
- Land uses in the vicinity of the Crystal Mine include mining, habitat for fish and wildlife, and recreational use including hiking, ATV riding, camping, fishing, and big-game hunting.

ROD, Remedy Description

Crystal Mine

- EPA's preferred remedy for the Crystal Mine OU5 is a combination of the removal and on-site disposal of contaminated mining waste and soils, intercepting/diverting surface water away from underground workings, and capturing and treating the discharge of AMD from the lower mine adit in a PTS.
- EPA will construct an on-site mine waste repository over a portion of the Crystal trench.
- Final design of the PTS will follow waste rock and soil removal, and survey of the new site topography. It will be similar to that described for the Bullion remedy.

Crystal Mine

Sequence of Preferred Remedy

Dependent on Funding, Contracting, & Construction Season Constraints:

- The first phase includes an upgrade of service roads and construction of the onsite repository (2016 if funding provided and contract mechanisms available). The 2016 costs are estimated at $6 million.
- The second phase of activity (2017) will be the removal of contaminated waste rock and soils to the onsite repository and construction of surface water conveyance features. This phase includes reclamation of the clean slopes with topsoil/vegetation, and reconstruction of USG Creek. The 2017 costs are estimated at $5 million.
- The third phase (2018) involves finalizing design of PTS, opening/stabilizing the mine portal, and construction of the PTS.
- The fourth phase (2018) involves treatment system start-up and reclamation of onsite service roads. The 2018 costs are estimated at $8 million.
- The fifth phase concludes with performance monitoring of the reclamation, maintenance of the treatment system, and development of land use controls.
- Total cost of Crystal remedy is estimated at $19 million over 3 years.

The End

Crystal Mine

Questions, Comments, or Concerns?