Fluorescent Dye Tracing in Abandoned Mines for Adit Discharge Source Control

Crystal and Bullion Mines

Basin Mining Area Site, Jefferson County, Montana

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Presentation Overview

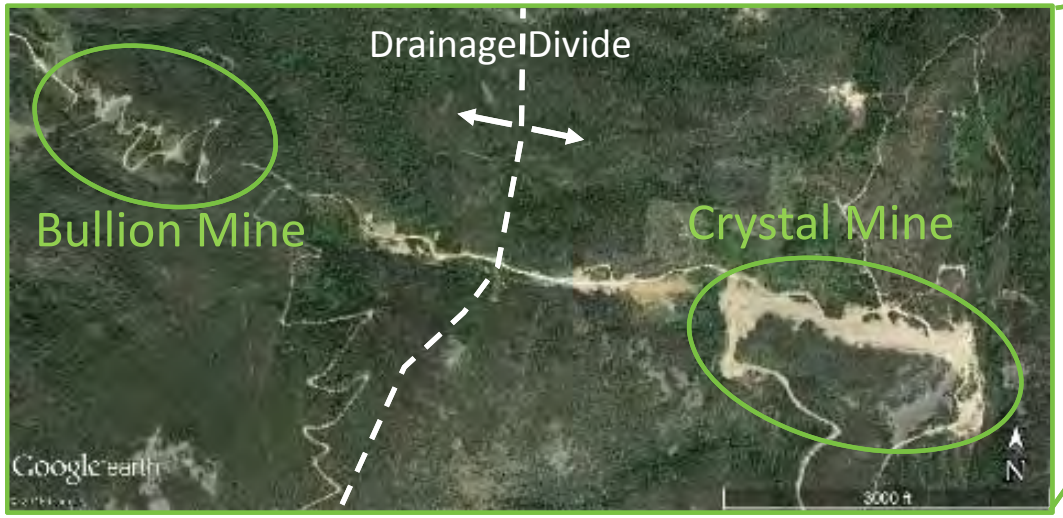
- Project introduction
- Site location and description
- Study goal and design
- Execution (dye deployment and monitoring)
- Results
- Lessons learned
- Potential future source identification
- Conclusions
- Questions

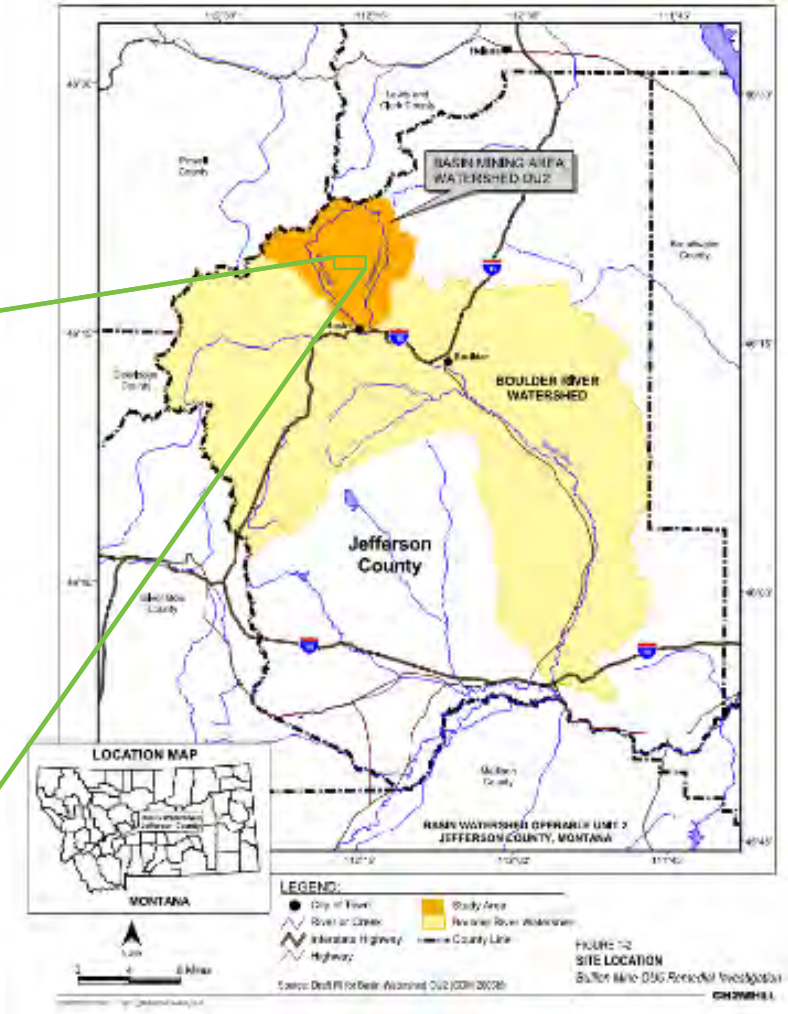
Project Introduction

- Why source control?
- Many mines with acid mine drainage (AMD) from historic mining activities
- Source investigation using fluorescent dye tracers

Site Location

- Located within Basin Mining Area NPL Site

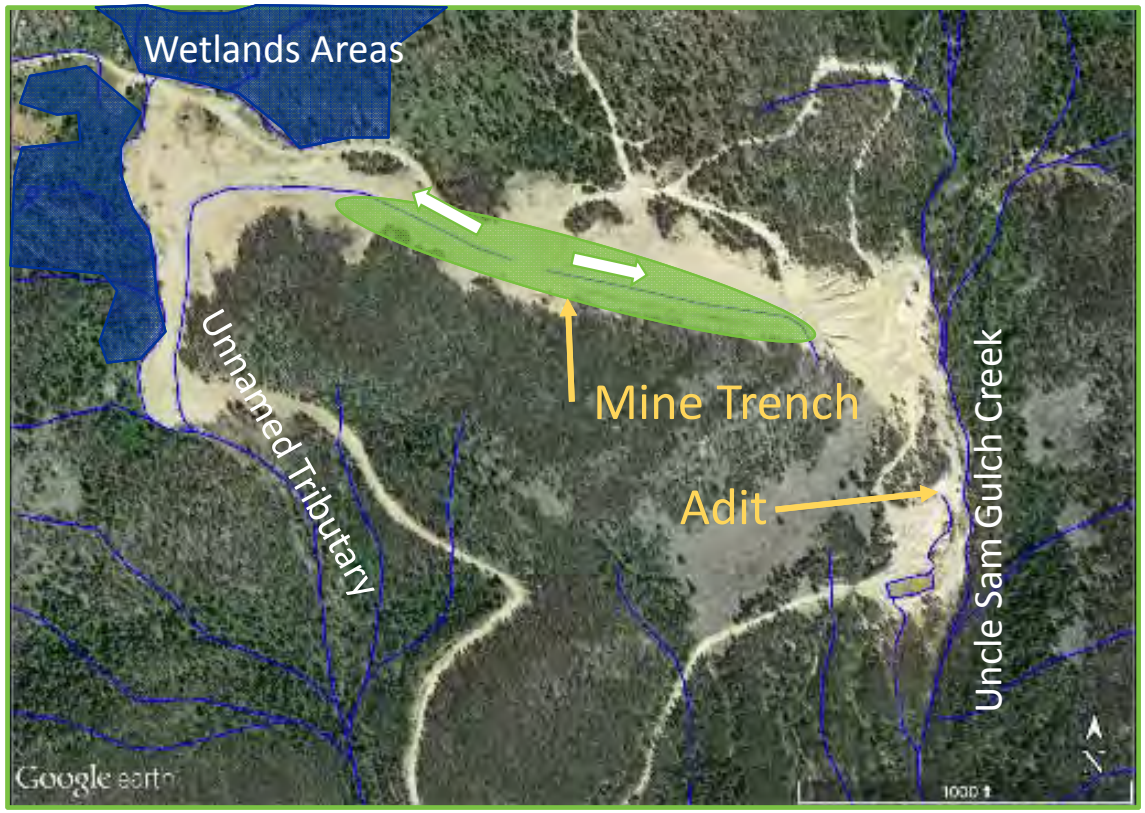




Source: Focused Remedial Investigation, Bullion Mine, OU6. US EPA. 2013

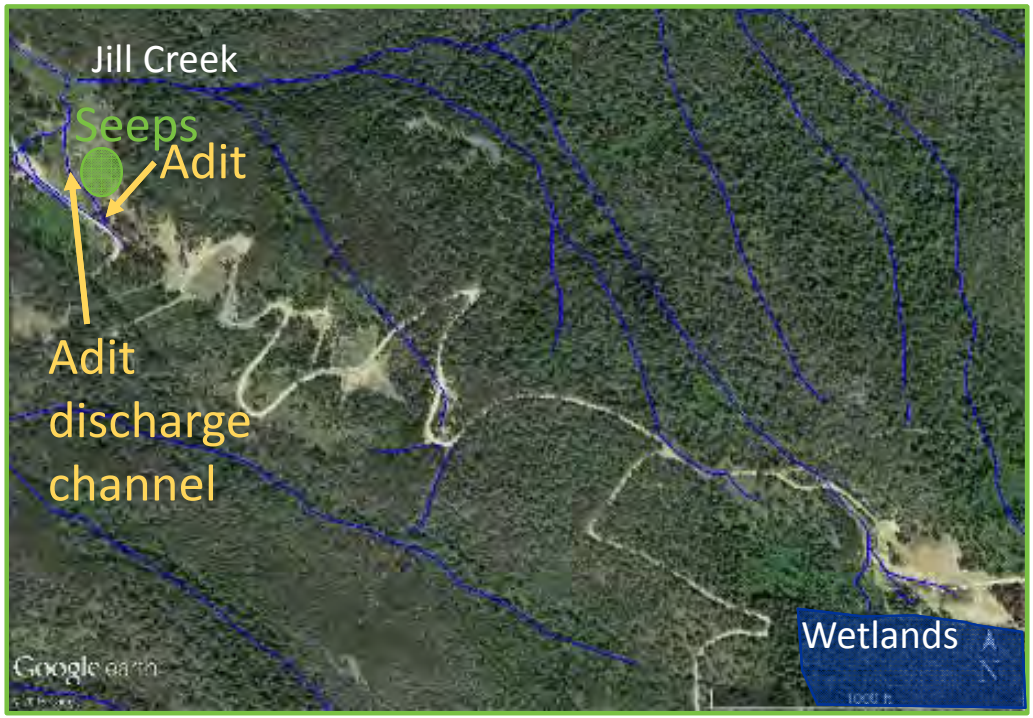
Crystal Mine (OU6)

- Adit discharge ~25 gpm
- pH = 3.9 - 4.5
- Contaminant concentrations
  - 400 ppb arsenic
  - 9,000 ppb copper
  - 43,000 ppb zinc
  - 90 ppb lead
- Focused RI/FS completed 2013
- Interim ROD completed April 2015



Bullion Mine (OU5)

- Adit discharge ~2-14 gpm
- pH = 2.5 - 2.9
- Contaminant concentrations
  - 5,000 ppb arsenic
  - 10,000 ppb copper
  - 63,000 ppb zinc
  - 650 ppb lead
- Several springs downslope of adit
- Interim ROD signed April 2015



Selected Interim Remedy Summary

- Crystal Mine
  - **Source control**
  - Semi-passive water treatment system
  - Waste rock removal and remediation
  - O&M
  - Institutional Controls
- Bullion Mine
  - **Source control**
  - Passive water treatment system
  - O&M
  - Institutional controls
  - Waste rock removal already completed

Study Goal and Design

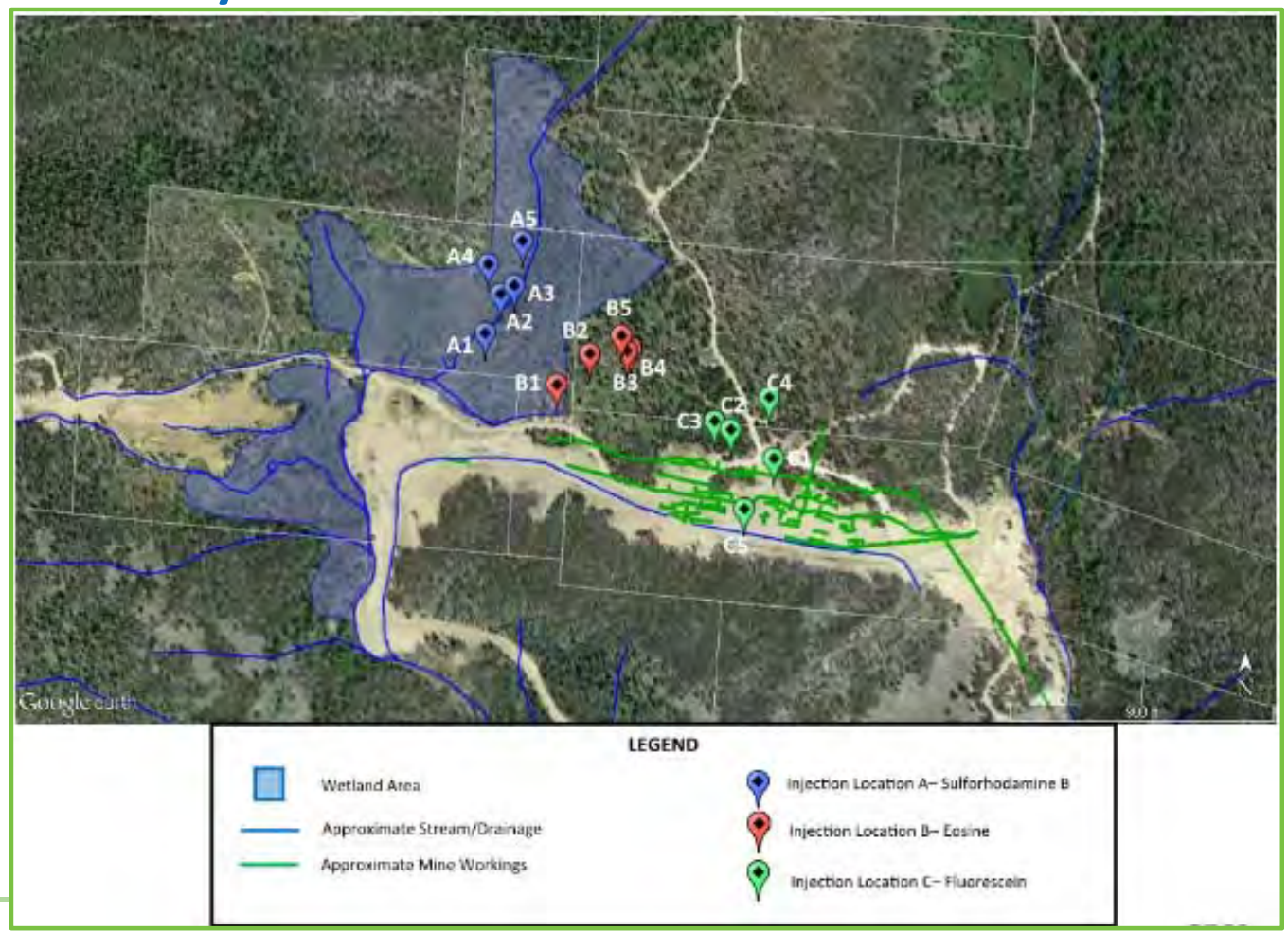
- Goal
  - Qualitatively determine sources of surface water that could be contributing to adit discharge at both mine sites
- Design & Methods
  - Only 3 fluorescent dyes available for use in acidic mine environments
  - Passive samplings – activated carbon
  - Detection limit – 0.005 ppb
  - Evaluating data from RI/FS at both mines
  - Dye deployment in late May
  - Dispersed dye deployment

Design – Monitoring Schedule

- Background samples
- 1st, 3rd, 5th, 7th days after dye deployment
- Weekly for 6 weeks
- Bi-weekly until end of study
- First sample June 1
- Last sample October 23

Dye Deployment – Crystal Mine

- Deployment locations focused at areas with surface water features
- Areas that drain towards possible “sinks”
- Focused in area over workings

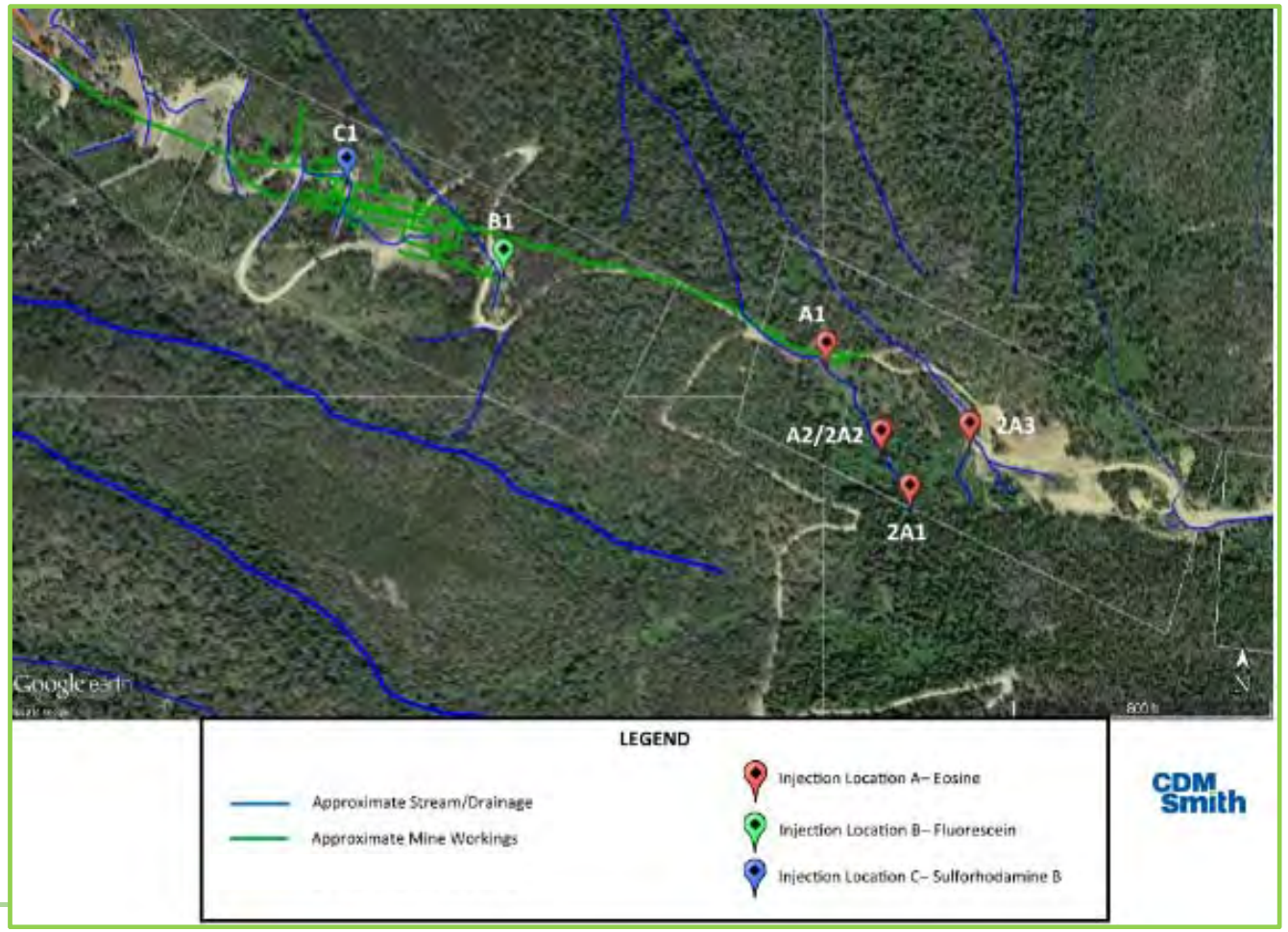


Monitoring Locations – Crystal Mine

- Mine adit, springs, and creek
- One spring (SP04) dried up during monitoring

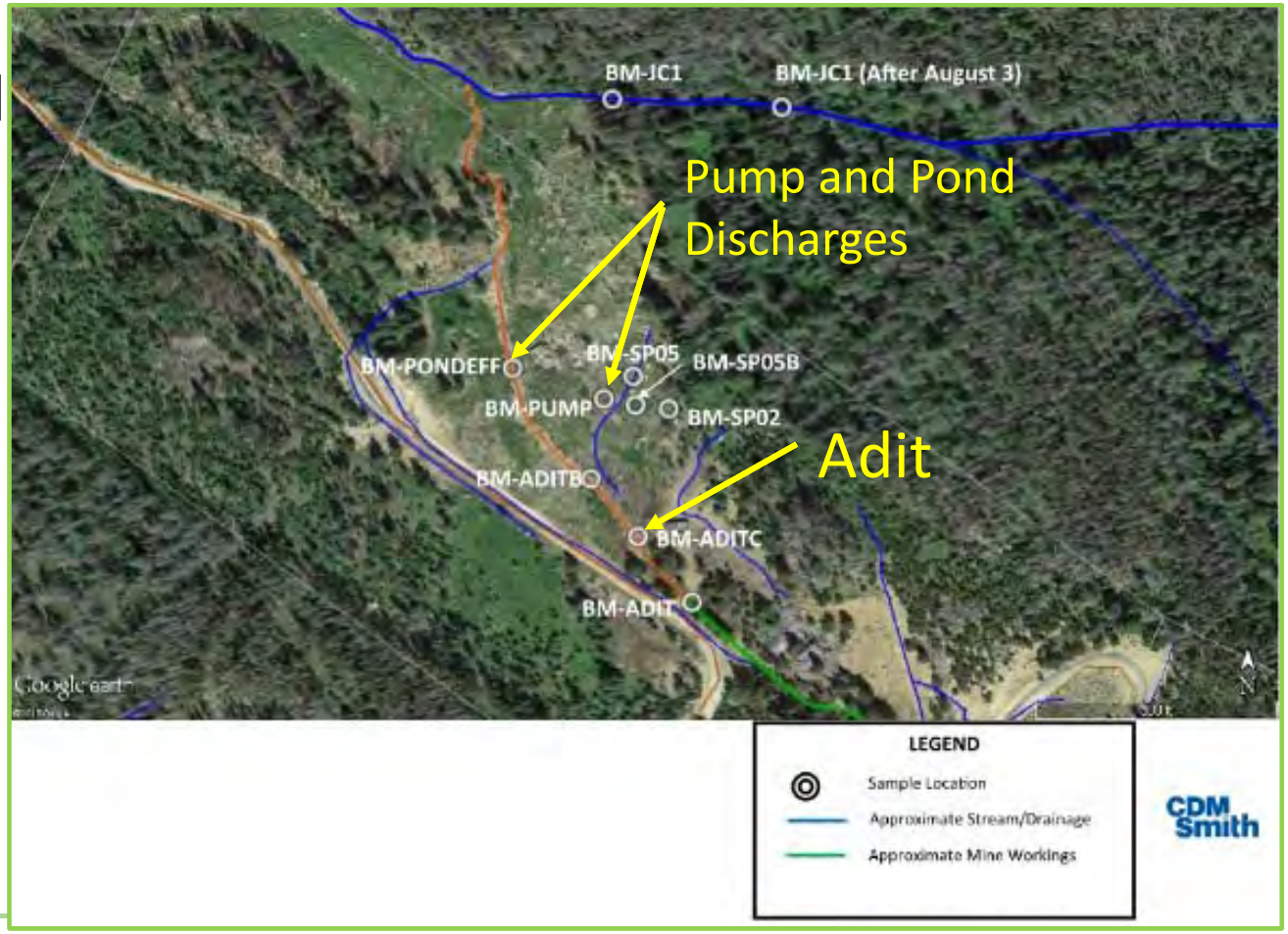
Dye Deployment – Bullion Mine

- 2 locations in local depressions with surface runoff
- 1 in wetland complex near top of mine workings
- Performed second dye deployment later in season



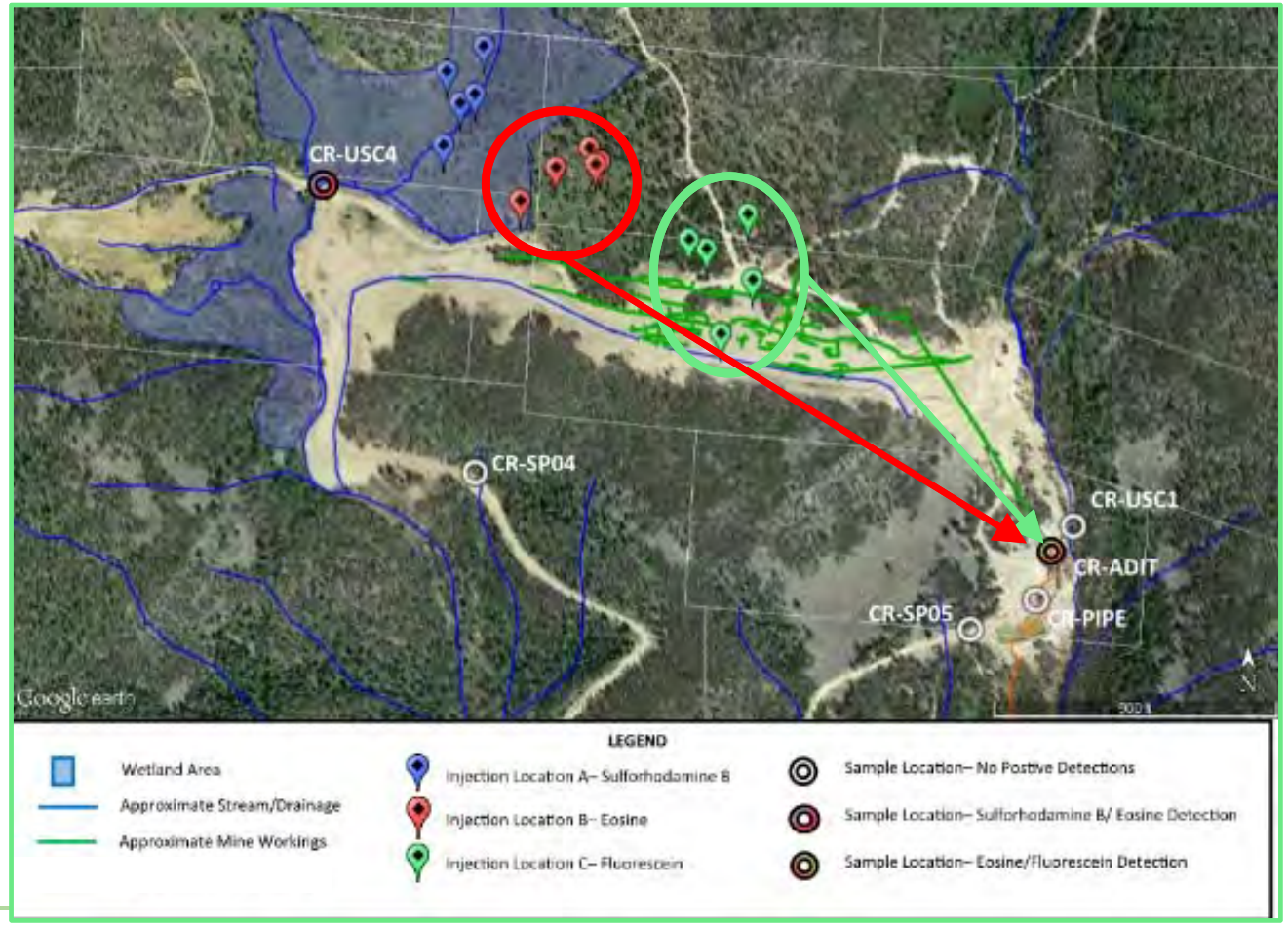
Monitoring Locations – Bullion Mine

- Adit, springs, and Jill Creek
- Adit dewatering work:
  - 1M+ gallons of water dammed inside mine
  - Potential effects on tracer study



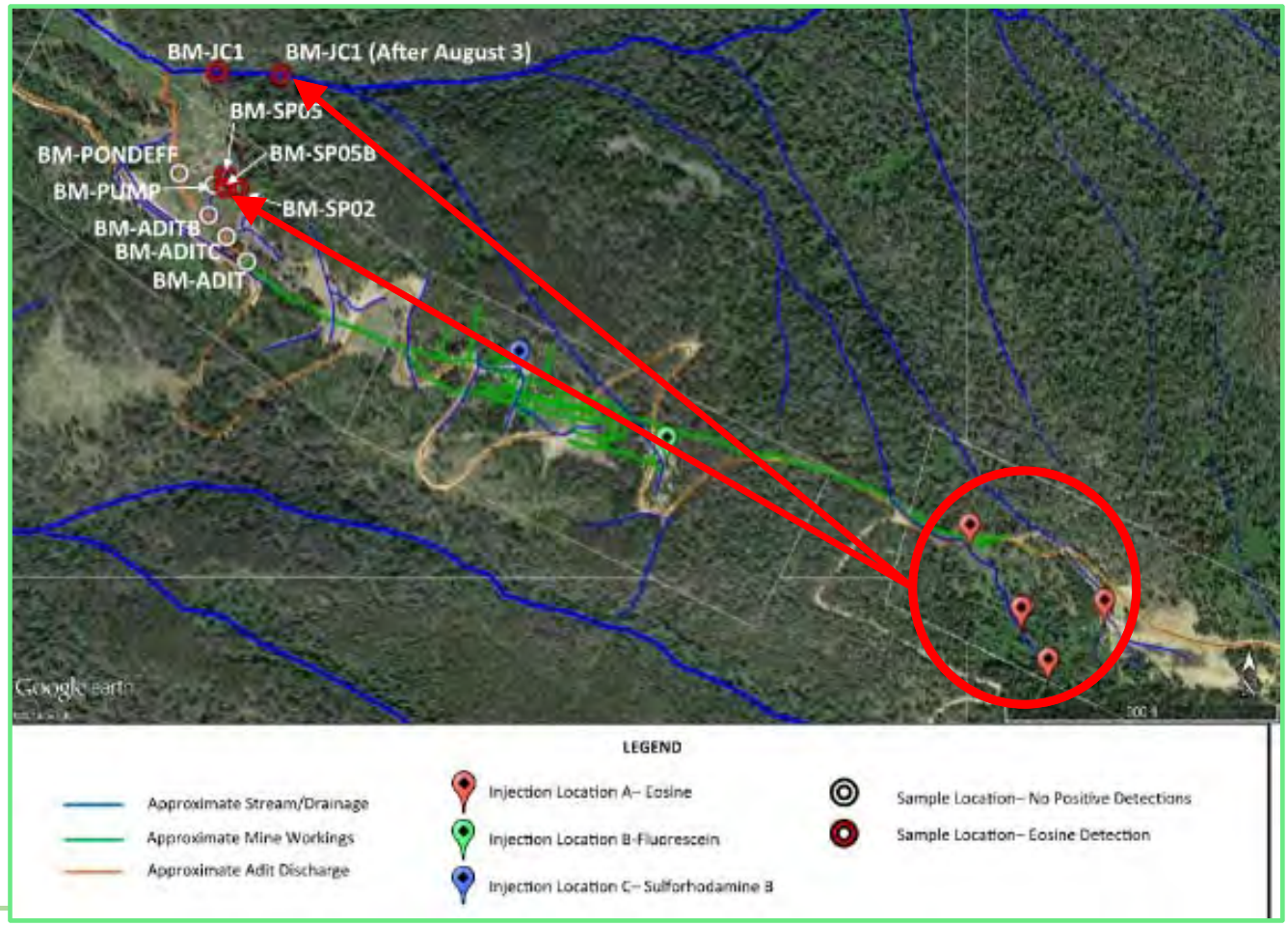
Results – Crystal Mine

- Positive dye detections in Crystal Adit
- Positive dye detections in creek – as expected



Results – Bullion Mine

- Positive dye detections in 2 springs from furthest injection location
- Very quick response time



Potential Future Source Identification

- Collection of samplers left over winter
- Further work to define and isolate flow pathways for positive detection samples
- Fluorescent tracers cannot be used for a couple of years
- Inorganic tracers

Challenges & Lessons Learned

- Only 3 dyes available – choose locations wisely
- Identifying workings locations is important
- Water to drive dye into workings is important
- Animals
- Qualitative indicator only
- Dye response times can vary drastically
  - Bullion – 1 day
  - Crystal – 1 month and 3 months

Conclusions

- Positive connections identified at both sites (not between the mines)
- Bullion adit may have been affected by water backed up in workings and dewatering efforts
- Dye tracing can be effective method for identifying surface water connections to adit discharge

Acknowledgements

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Questions?