

Hydrogeochemical Investigation of the Standard Mine Vicinity, Upper Elk Creek Basin, Colorado

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Background on USGS

- One of the missions of the USGS is to provide unbiased science information on natural resources to assist decision makers
- USGS has been working on water and mining resource issues for over 125 years
- USGS has been working in the Elk Mtns. for a long time:
 - Operated stream gages since 1905
 - Made several geologic 1:24,000 scale maps
 - Completed mineral assessments
 - Performed environmental geochemistry studies in Mt. Emmons area, focusing on Redwell Basin



Study Objectives



Characterize groundwater flow system:

- Where does ground-water flow occur?
- What are geological controls on flow?
- How does ground-water flow to and through the Standard Mine?
- What are characteristic ground-water residence times?

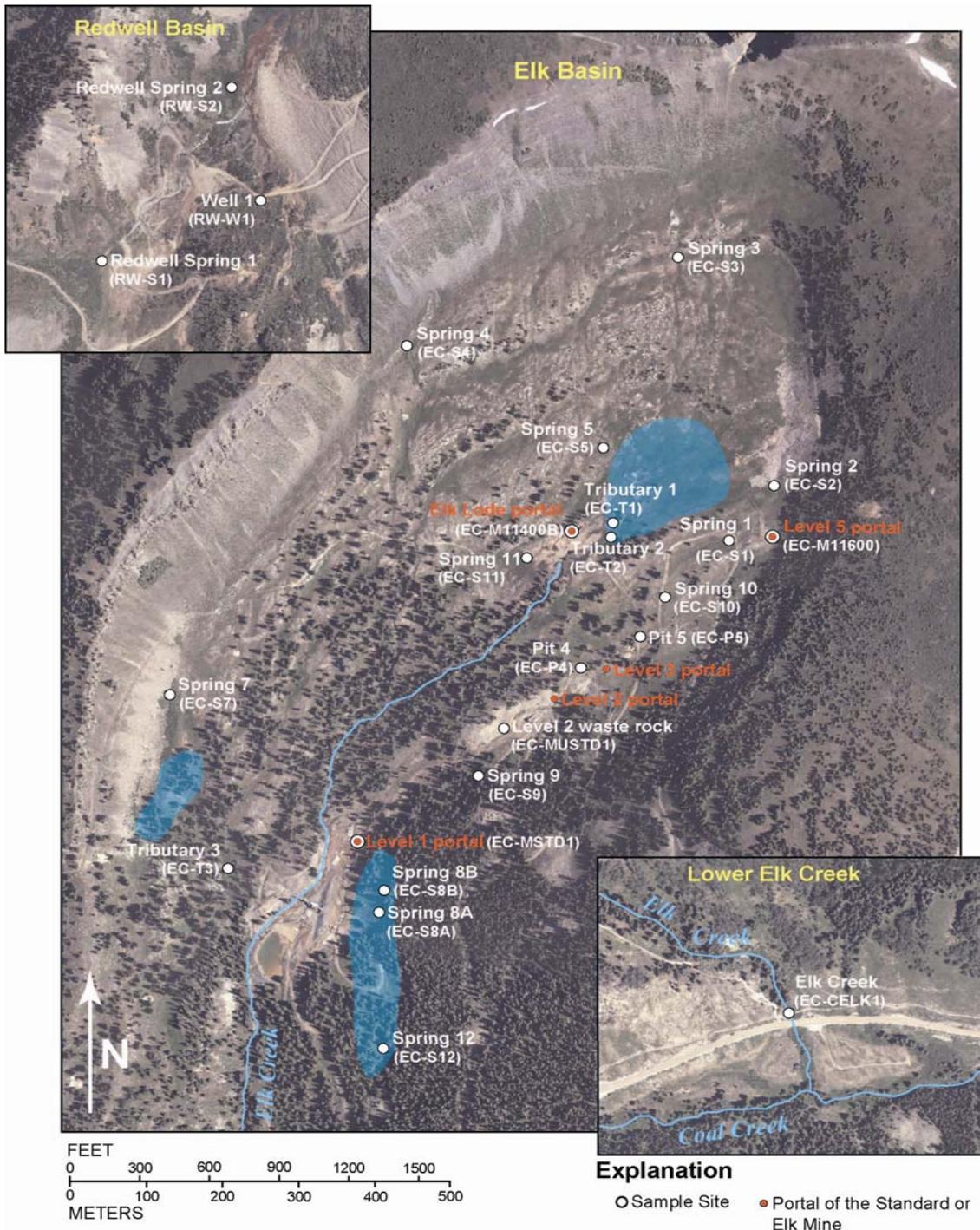


Characterize ground-water chemistry:

- How do metal concentrations in mine discharge compare to concentrations elsewhere in basin?
- What is the main source of the high metal concentrations?
- How do metal concentrations in mine discharge vary with time?

Characterize surface-water chemistry:

- How do metal concentrations in Elk Creek vary with time?
- What is the source of high metal concentrations in Elk Creek?



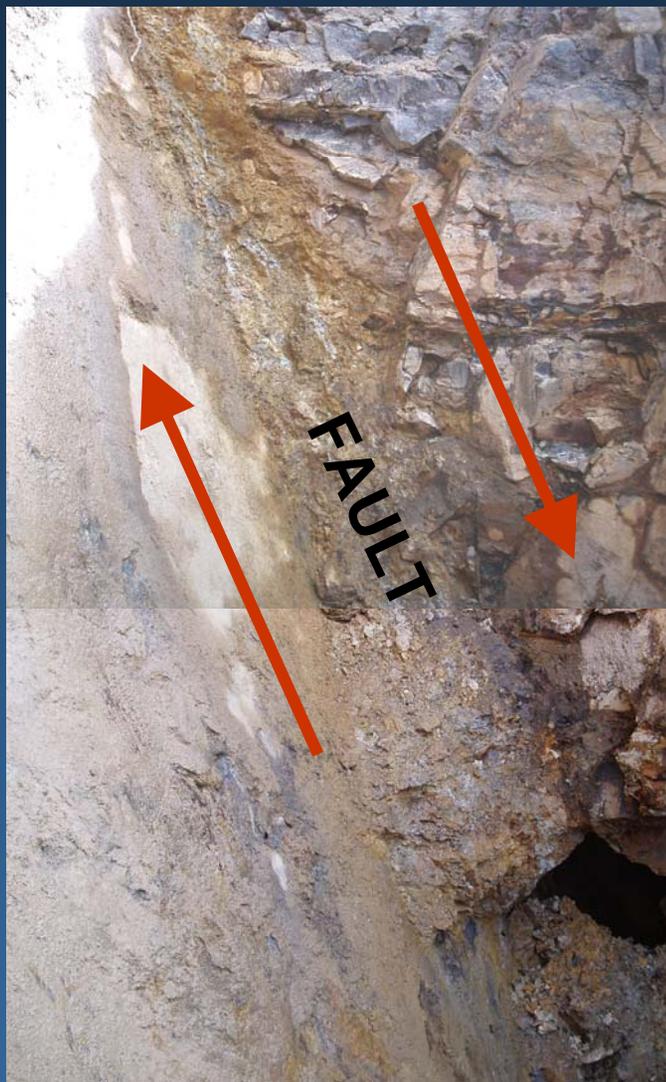
Methods

- Ground- and surface-water samples collected from summer 2006 through spring 2007
 - One-time sampling of above-ground sites in August 2007
 - One-time sampling of underground sites in the Standard mine in August 2007
 - Time-series sampling from summer 2006 through spring 2007 at the Standard Mine portal and Elk Creek
- Samples collected from springs, mine tunnel discharge, waste-rock pile discharge, exploration pits, underground workings of Standard Mine, and Elk Creek
- Samples were analyzed for:
 - Major ions and trace elements
 - Multiple isotopes
 - Tritium and dissolved gases

Results

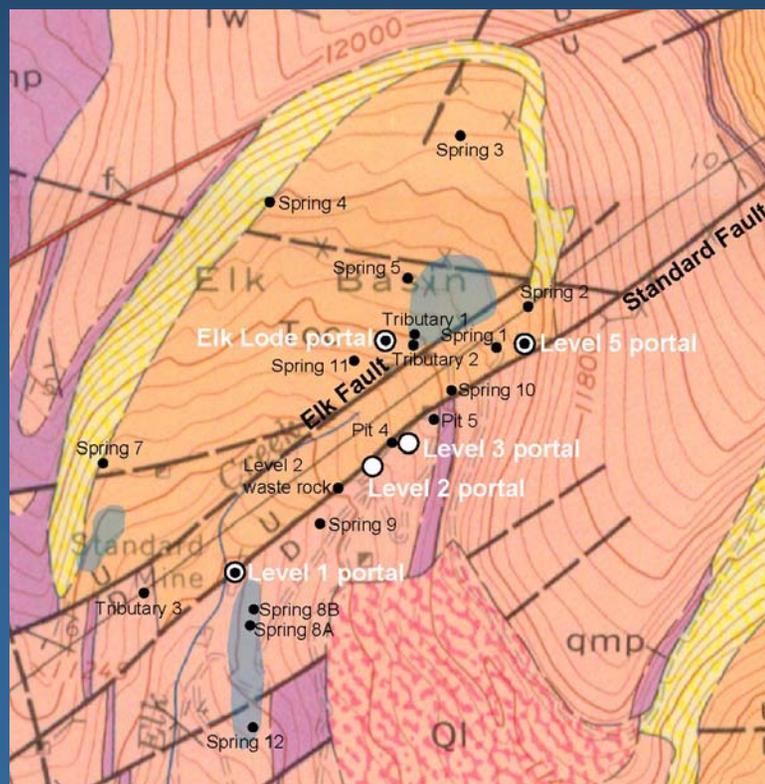
Ground-Water Flow

Controls on Shallow Ground-Water Flow



Simple topography, not geology, appears to mainly control shallow ground-water flow

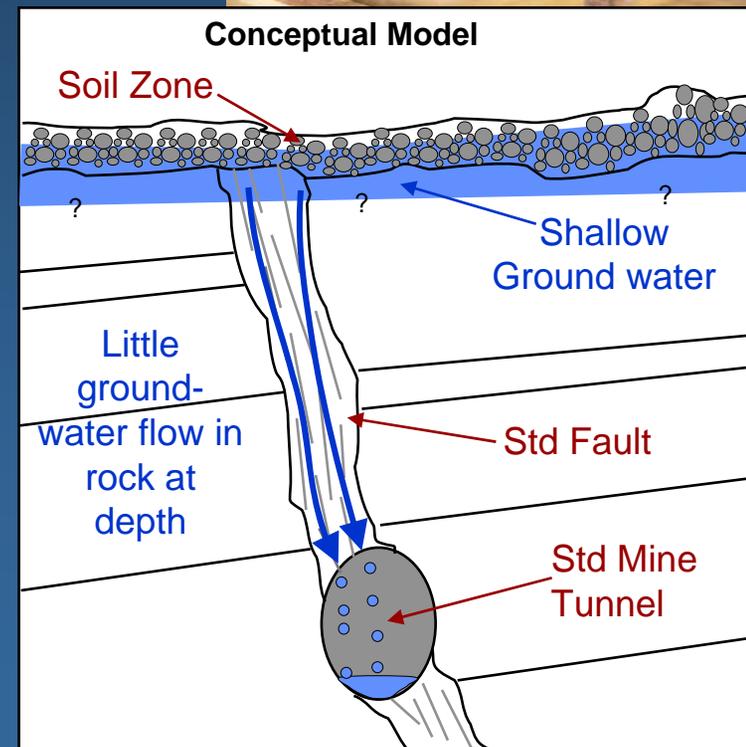
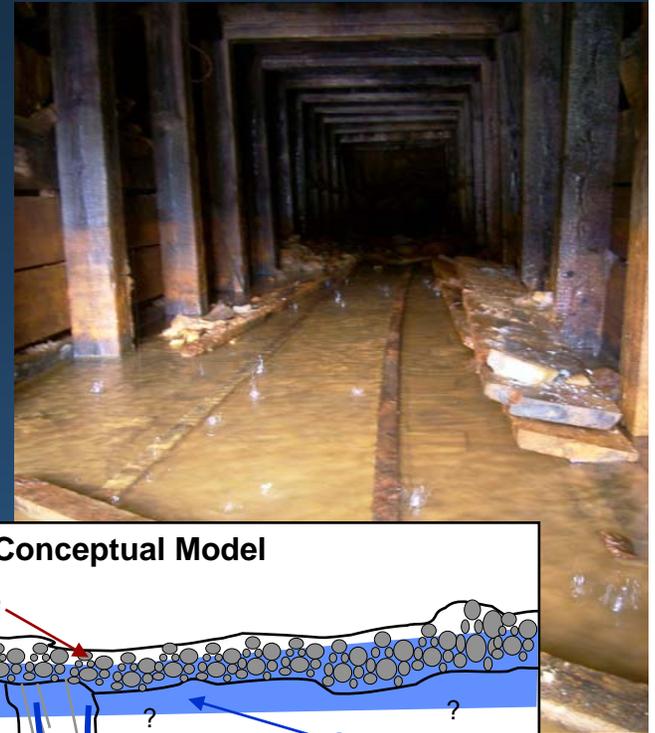
- Spring locations not correlated with map-scale faults
- Springs locations not correlated with geologic units
- Springs occur on basin floor



Ground-Water Flow to Standard Mine

Standard Fault itself probably main pathway of ground-water flow from shallow subsurface to the mine workings at depth

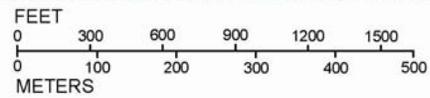
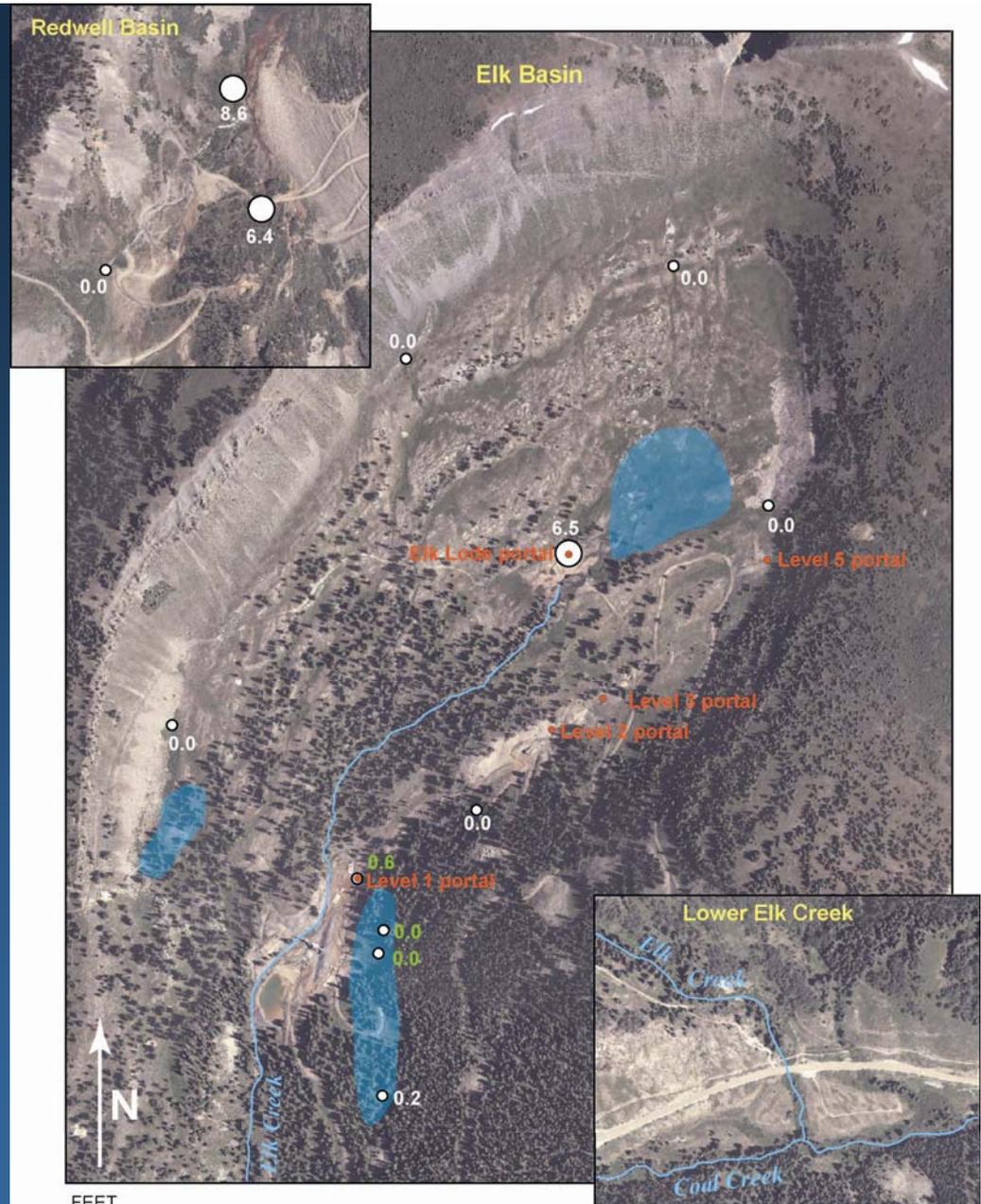
- Discrete inflows from cross-faults or other geologic features not observed
- Water enters Levels 3 and 5 as persistent dripping from standard fault zone material



Age of Shallow Ground Water

Shallow ground water in Upper Elk Creek Basin very young - dominantly weeks to months old rather than years old

- Tritium/helium-3 ground-water ages dominantly less than 1 year
- Tritium concentrations show effects of seasonal variations in precipitation tritium concentrations

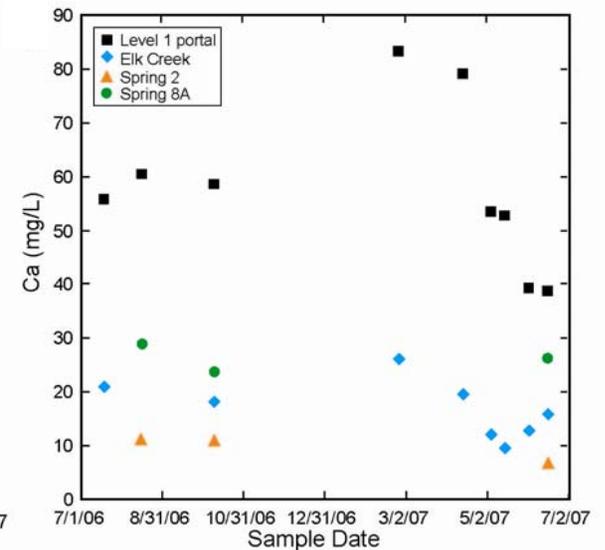
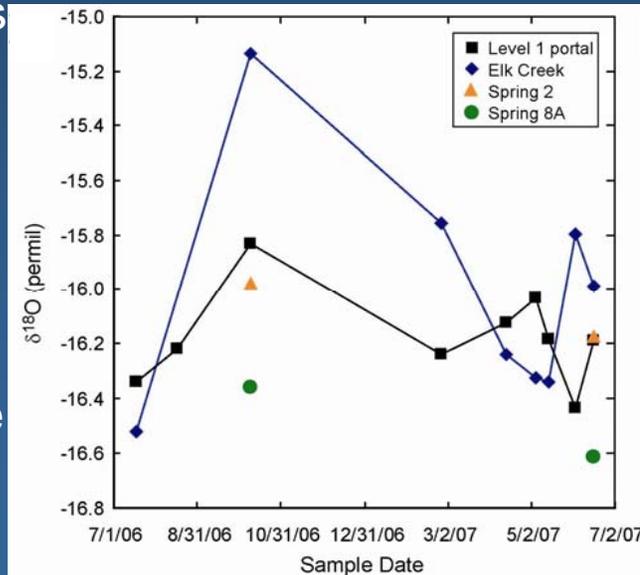
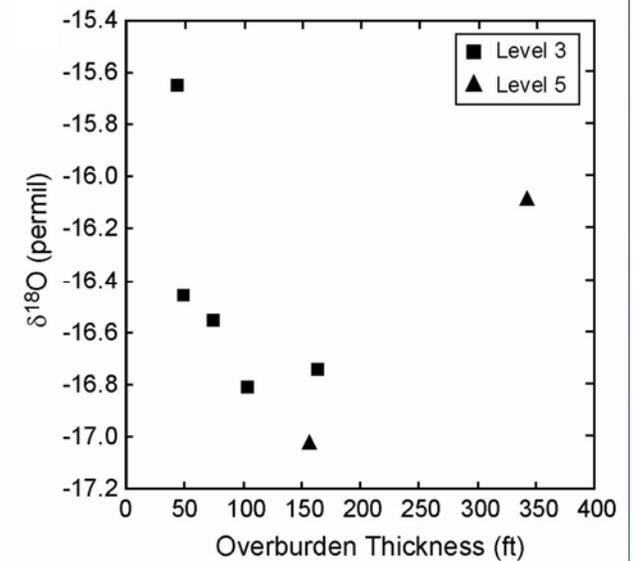
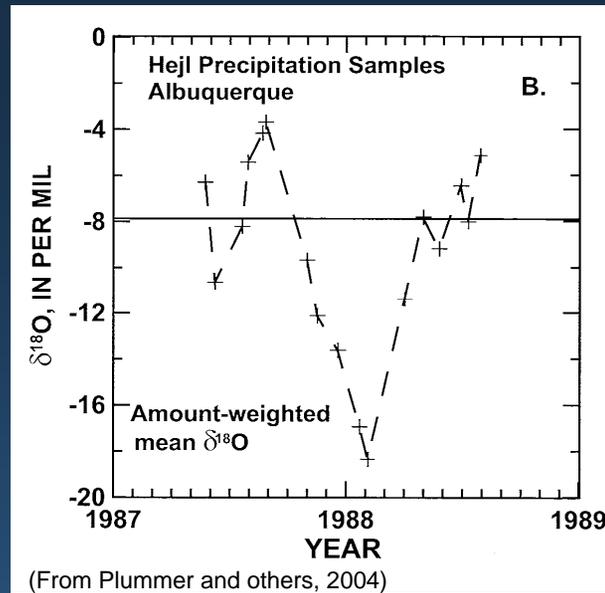


Explanation
Apparent $^3\text{H}/^3\text{He}$ Age (yr)
○ <1
○ >1

Age of Standard Mine Water

Ground water entering and discharging from the Standard Mine also largely less than 1 year old

- Two tritium/helium-3 ground-water ages less than 1 year
- Stable isotopes and tritium concentrations underground show effects of seasonal variations in precipitation
- Stable isotopes and chemistry of Level 1 discharge show large seasonal variations
- Young age inconsistent with large mine pool



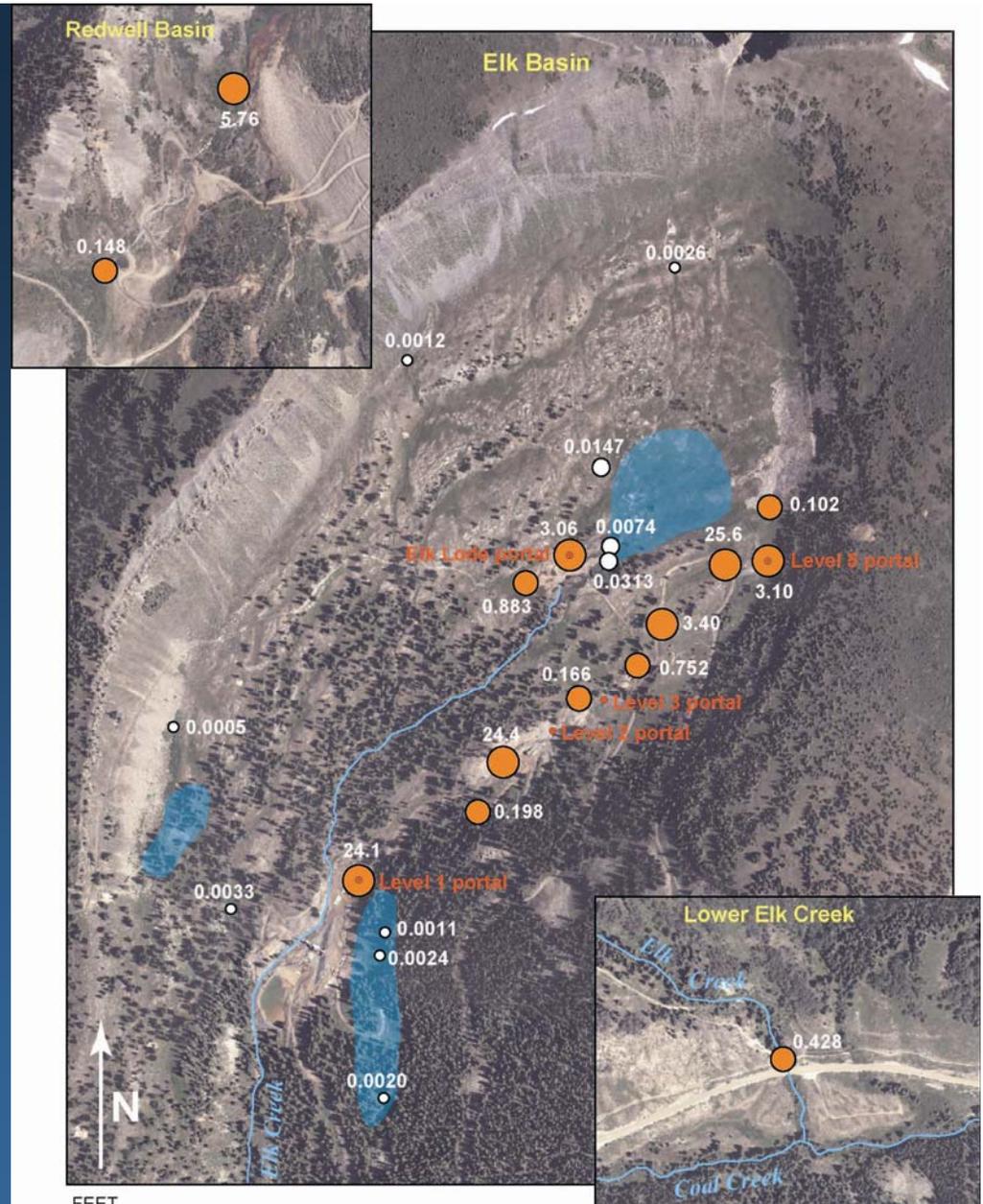
Plummer, L.N., Bexfield, L.M., Anderholm, S.K., Sanford, W.E., and Busenberg, E., 2004, Geochemical characterization of ground-water flow in the Santa Fe Group aquifer system, Middle Rio Grande Basin, New Mexico: U.S. Geological Survey Water Resources Investigations Report 03-4131, 395 p.

Findings: Ground-Water Chemistry

Controls on Ground-Water Metal Concentrations

Presence of sulfide-rich mineralized rock primary control

- Metal concentrations consistently elevated within or immediately down-gradient of areas where sulfides abundant
- Metal concentrations in Level 1 discharge among highest measured in Elk Basin



Explanation

Zn Concentration (mg/L)

- <0.005
- 0.005-0.066
- 0.066-1.0
- >1.0

Orange symbols exceed water quality standard

Controls on Ground-Water Metal Concentrations

Waste-rock piles can further elevate metal concentrations

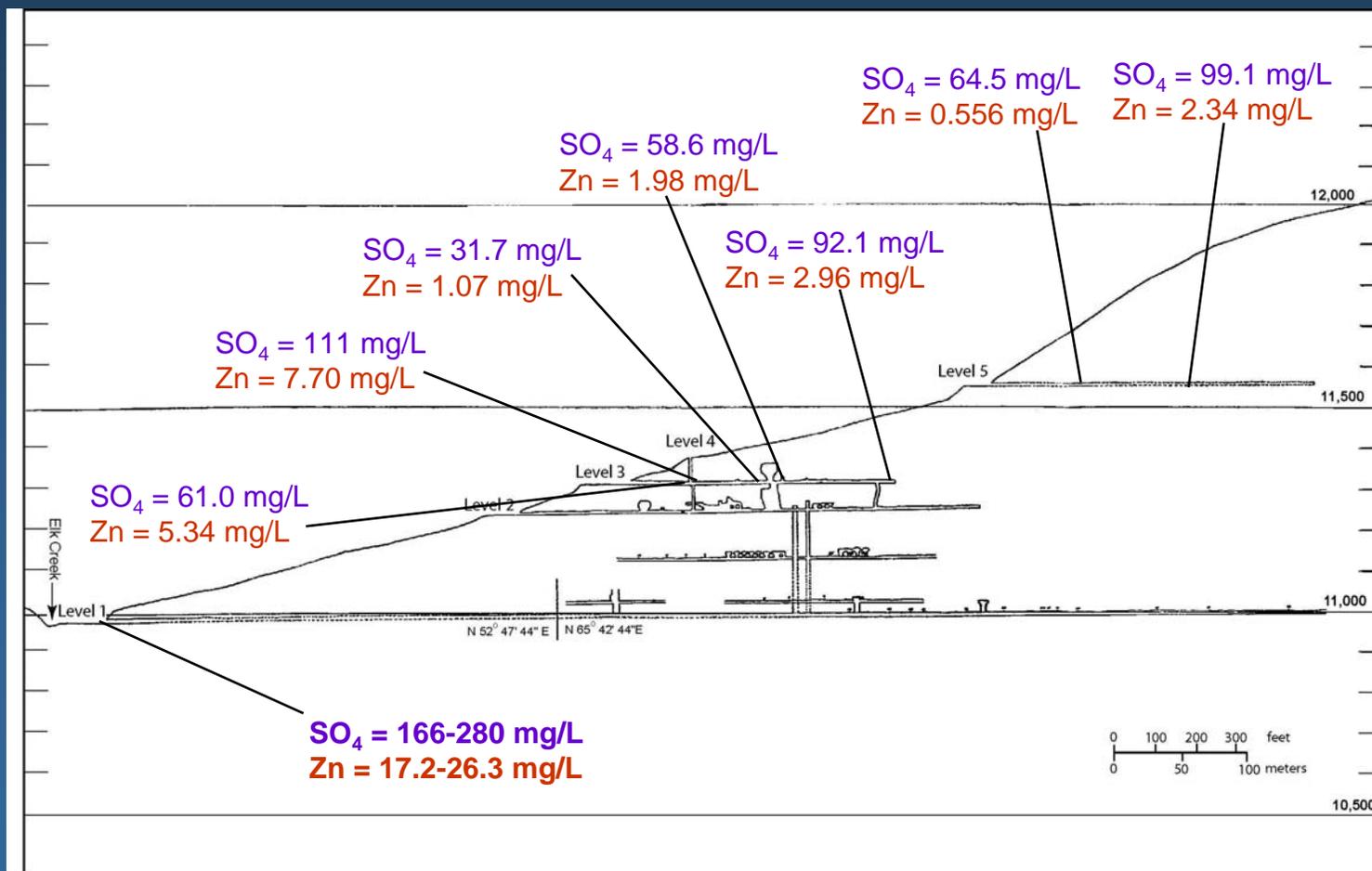
- Highest metal concentrations typically observed in ground water discharging from waste-rock piles
- Water discharging from waste-rock had higher metal concentrations than water infiltrating waste-rock



Source of Elevated Metal Concentrations In Level 1 Discharge

Primary source of elevated metal concentrations in Level 1 discharge water was not found

- Concentrations of many chemical constituents along with strontium isotope data indicate that sampled waters cannot be the source of metals in Level 1 discharge

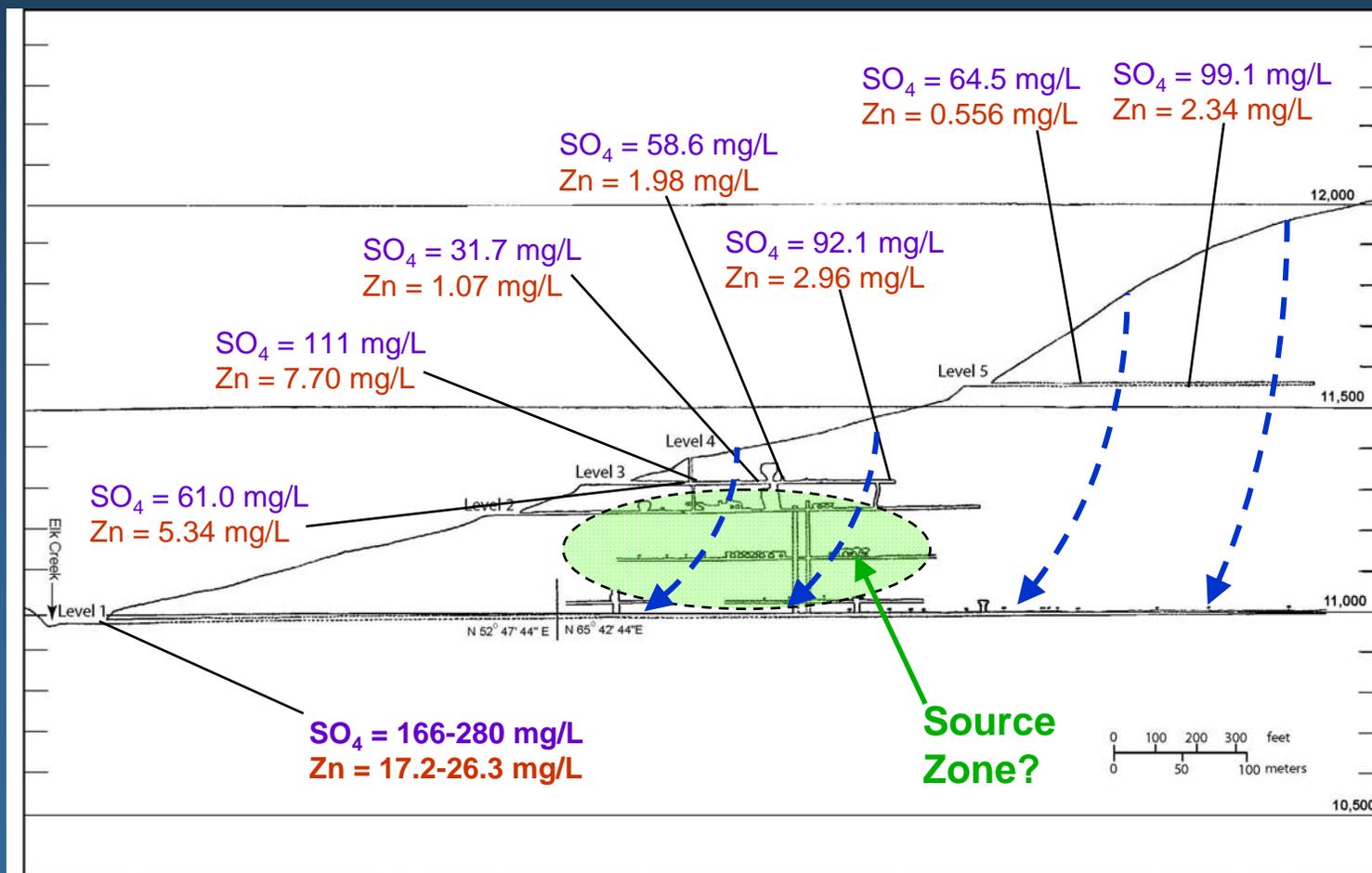


Redwell Basin
SO₄ < 81.5mg/L
Zn < 5.76 mg/L

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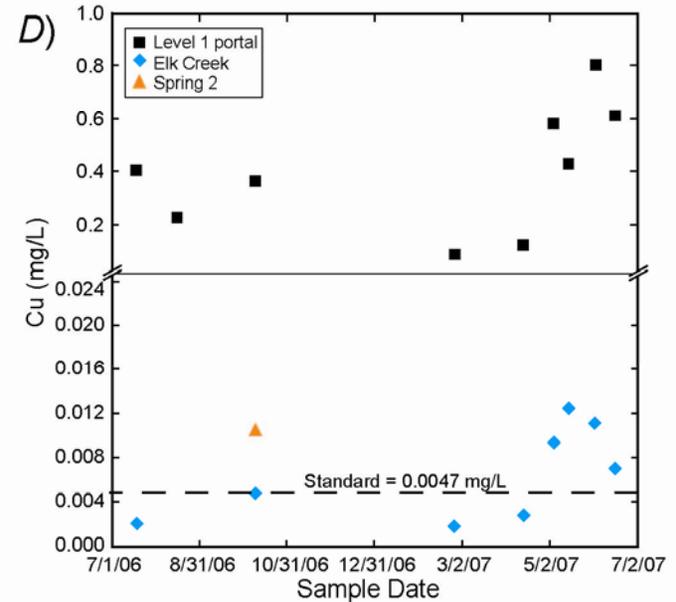
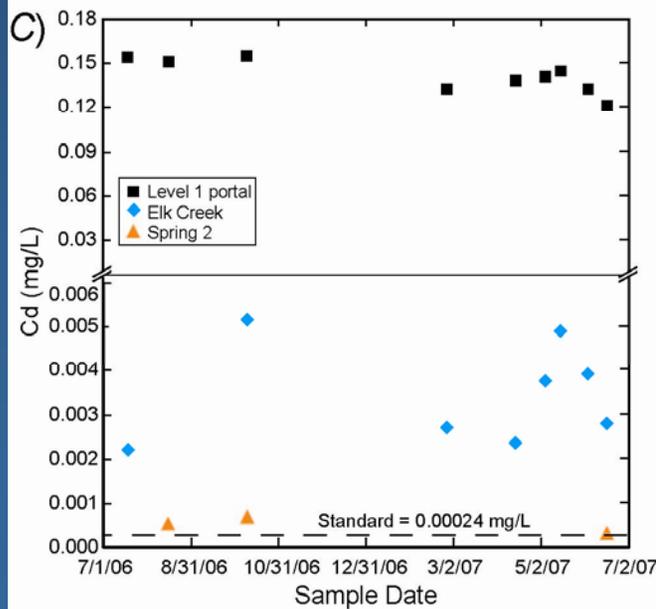
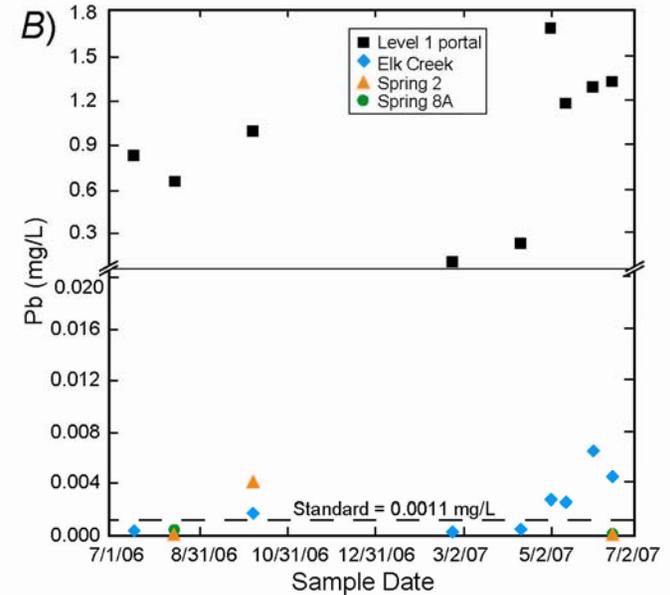
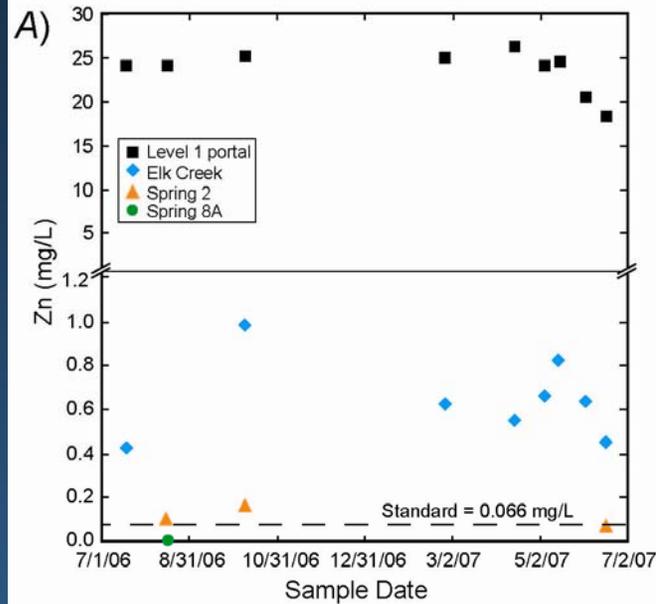


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Findings: Surface-Water Chemistry

Elk Creek Metal Concentrations

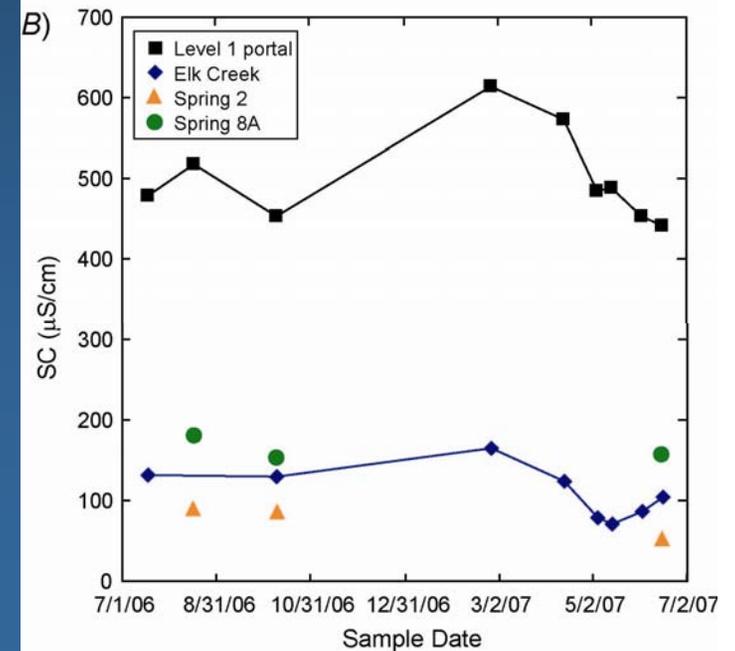
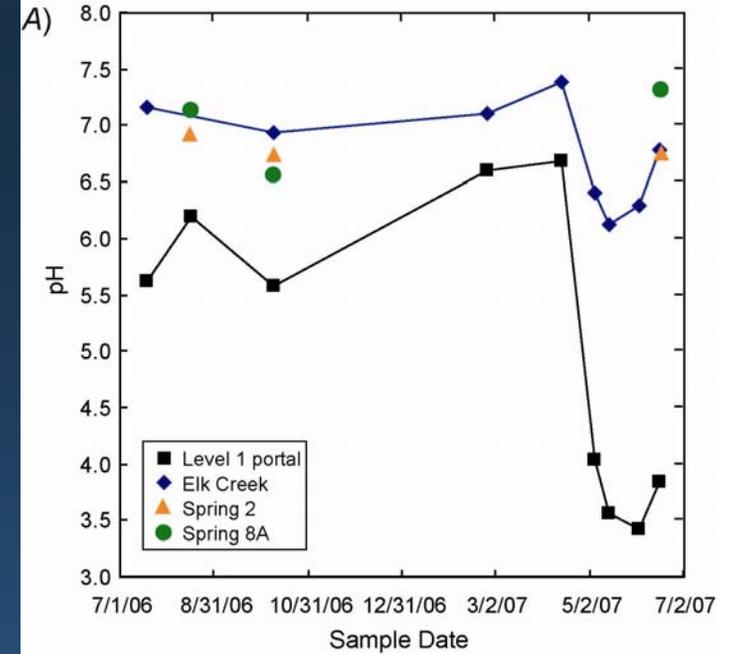
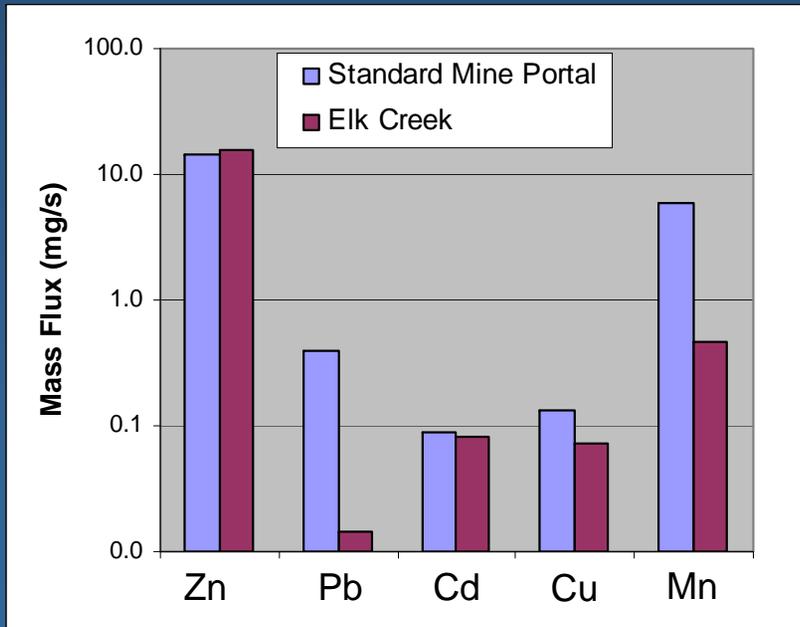
- Zn and Cd concentrations consistently exceed water quality standards
- Pb, Cu, and Mn concentrations exceed water quality standards in the spring
- All metal concentrations increase during spring runoff: “spring flush”



Source of Elevated Metal Concentrations

Level 1 discharge apparent source of elevated metal concentrations in Elk Creek

- Patterns of seasonal variations in stream chemistry in Level 1 discharge and Elk Creek very similar
- Estimated metal fluxes in Elk Creek in September 2006 similar to or less than those in Level 1 discharge





Questions?