# Study of Metals and Rare-Earth Elements in Lincoln Creek

University of Colorado Boulder

# Meet the CU-INSTAAR Team

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Diane M. McKnight, PhD
Distinguished Professor

Tom Marchitto, PhD
Professor

# Let's set the Stage. Where is Lincoln Creek?

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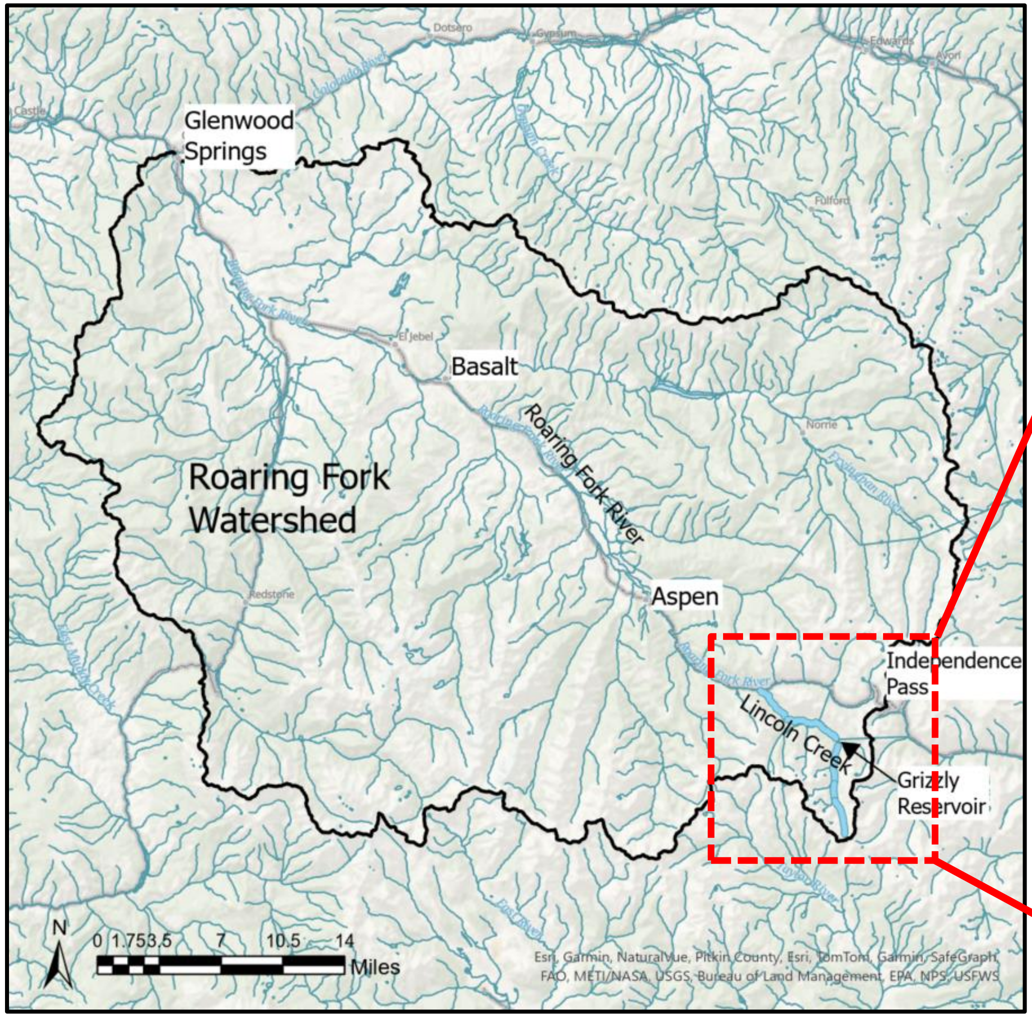
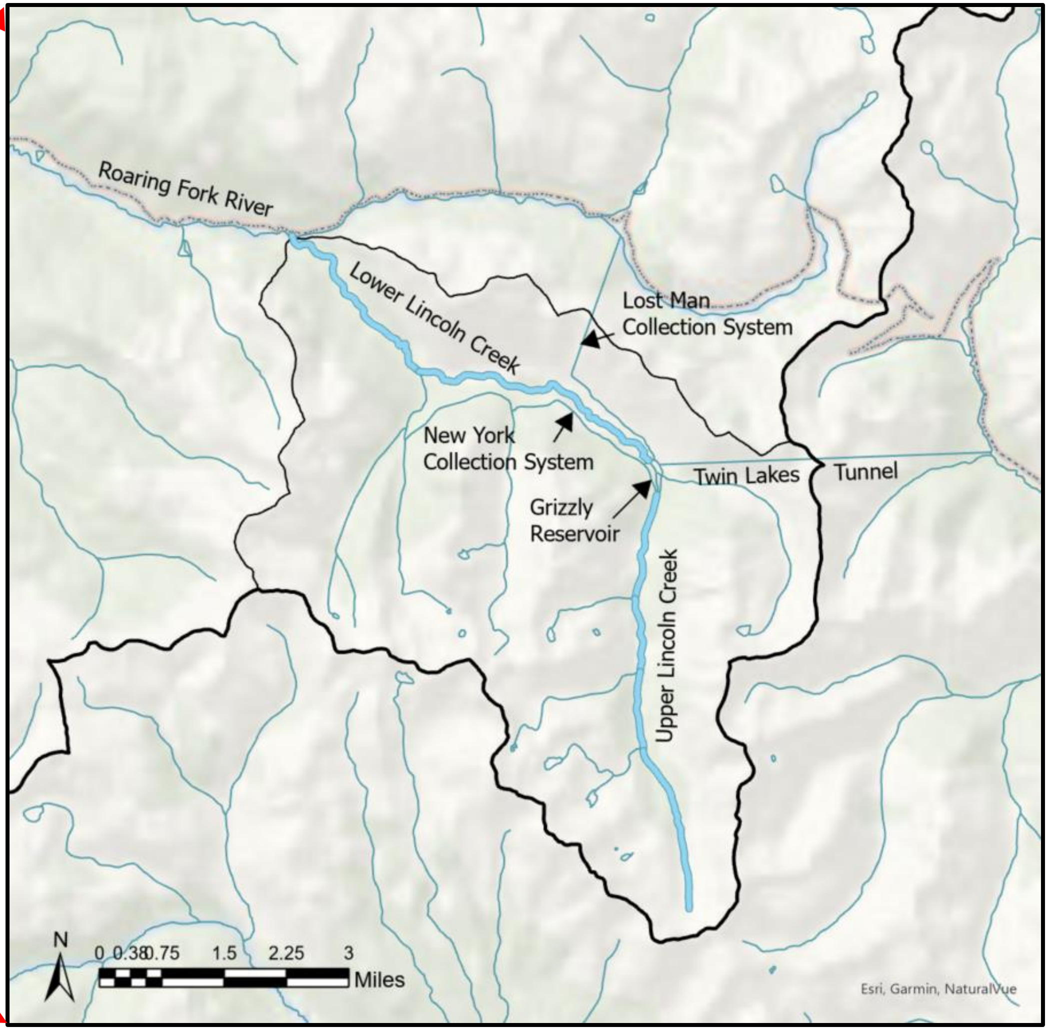


# Why is Lincoln Creek being Studied?

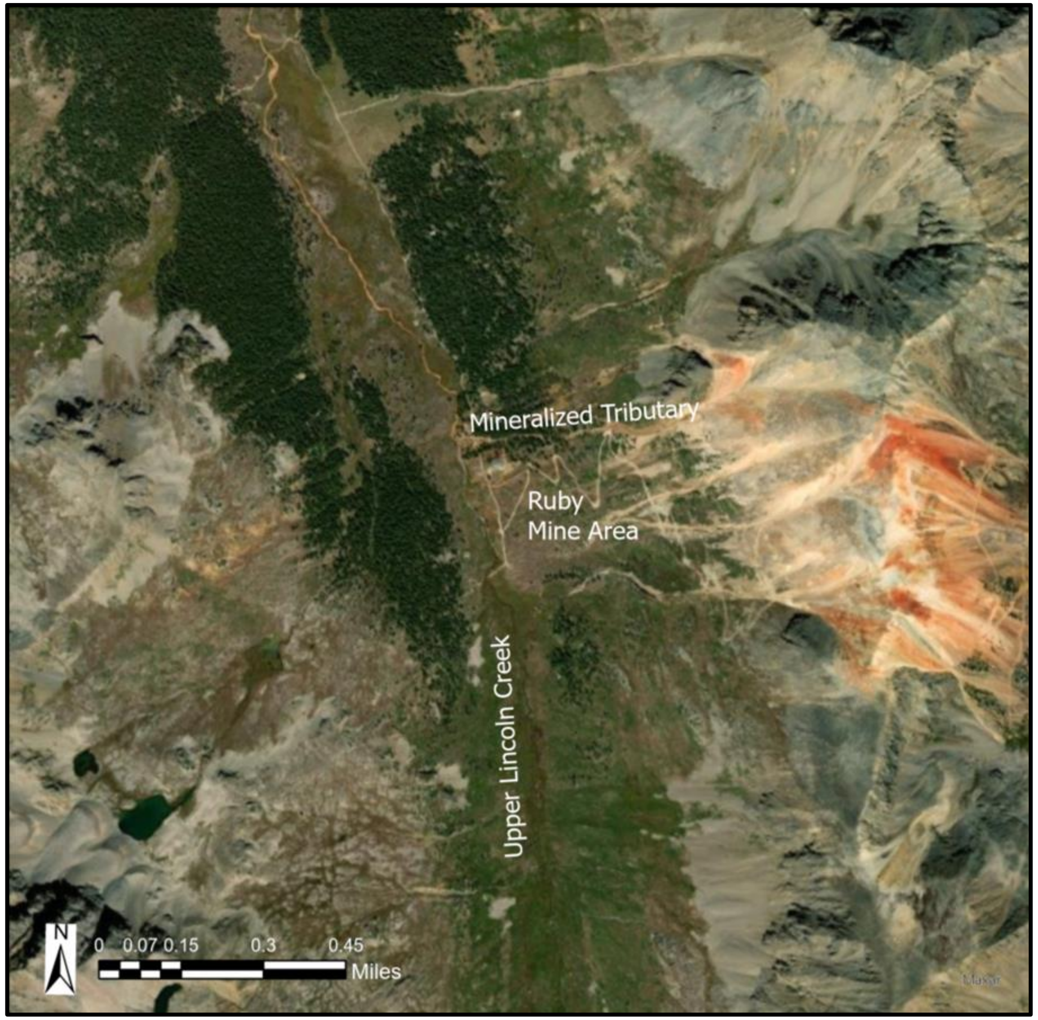
- Fish Kill Observed in Grizzly Reservoir August 2021
- Sampling revealed high amounts of **copper** originating near the Ruby Mine
- These findings prompted Colorado Parks and Wildlife to contact the EPA

# Why is Lincoln Creek being Studied?

- The **EPA** organized and funded two sampling efforts in July and September of 2022
- A Combined Assessment Report (CAR) was produced in November of 2023

# Primary Findings of the EPA's CAR

- Two primary sources of metal loading exist:
  - **Ruby Mine** Adits and Legacy Mining Activity (~ 2% of the copper)
  - The **Mineralized Tributary**, downstream of Ruby Mine (~98% of the copper)



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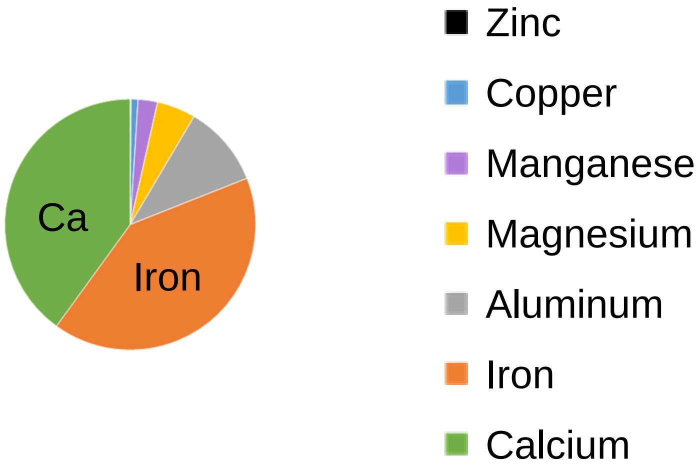
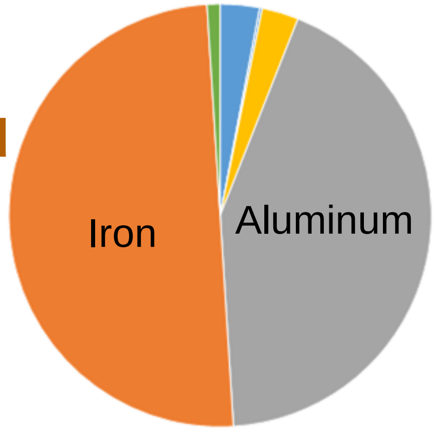
  - **Ruby Mine** Adits and Legacy Mining Activity (~ 2% of the copper)
  - The **Mineralized Tributary**, downstream of Ruby Mine (~98% of the copper)
- <u>Unique</u> chemical signatures:

**Ruby Mine Source Area:**




**Mineralized Tributary:**




Because the majority of contamination is natural, EPA **does not have the authority to conduct clean-up actions**

# This issue is now in the hands of the Lincoln Creek Workgroup

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TROUT UNLIMITED FERDINAND HAYDEN CHAPTER 009

TROUT UNLIMITED ABANDONED MINE LAND PROGRAM

INSTAAR
University of Colorado Boulder

COLORADO
Water Quality Control Division
Department of Public Health & Environment
CDPHE

PITKIN COUNTY
EMERGENCY MANAGEMENT

**Twin Lakes Reservoir & Canal Company**

# How did CU-INSTAAR get involved?

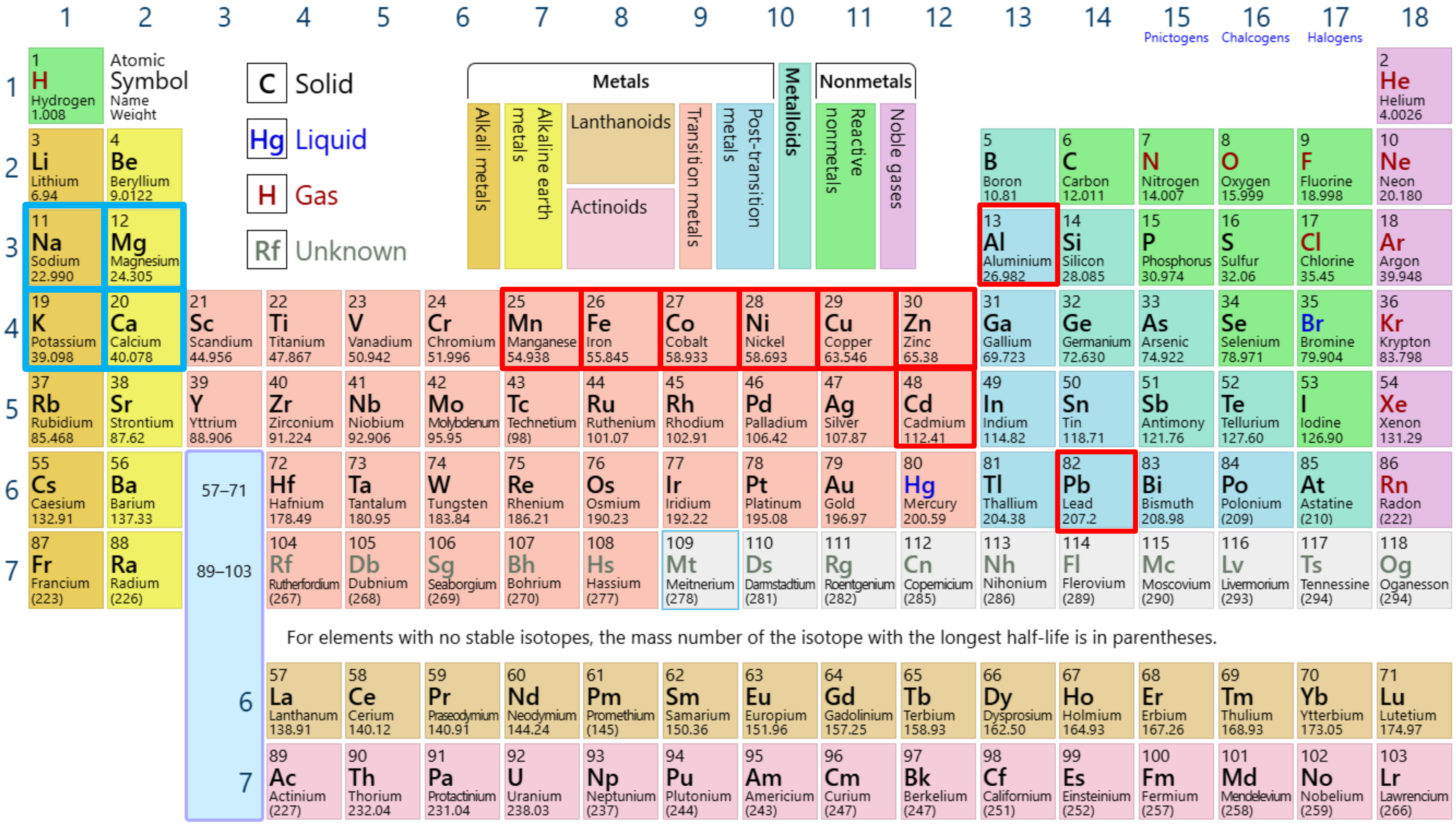
**March 2024** - Our group became aware of a need for additional research efforts
**May 2024** - Funding of our efforts was provided by **Pitkin County Healthy Rivers**
**June 2024** - First CU sampling trip alongside Pitkin County EH, RFC, and USFS

# What are we studying and why?

- Many entities in the Lincoln Creek Workgroup are studying the metals within Lincoln Creek. Each has their own distinct interests and responsibilities

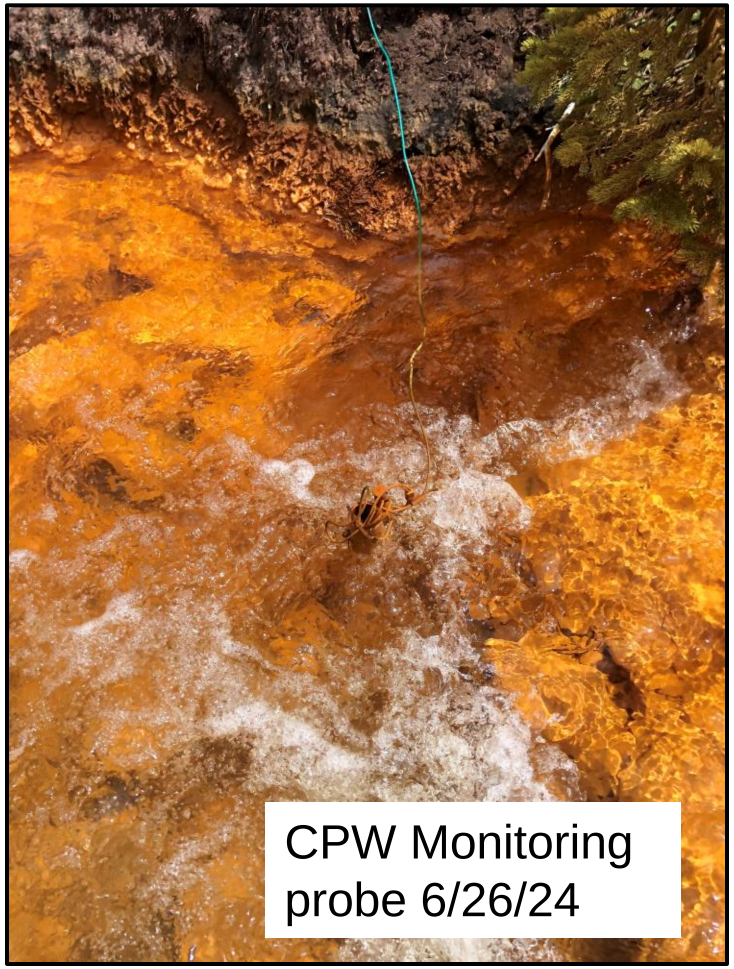
- CU Team is focused on studying **Rare Earth Elements**, **Major Cations**, and **Trace Metals**

# Major Cations and Trace Metals

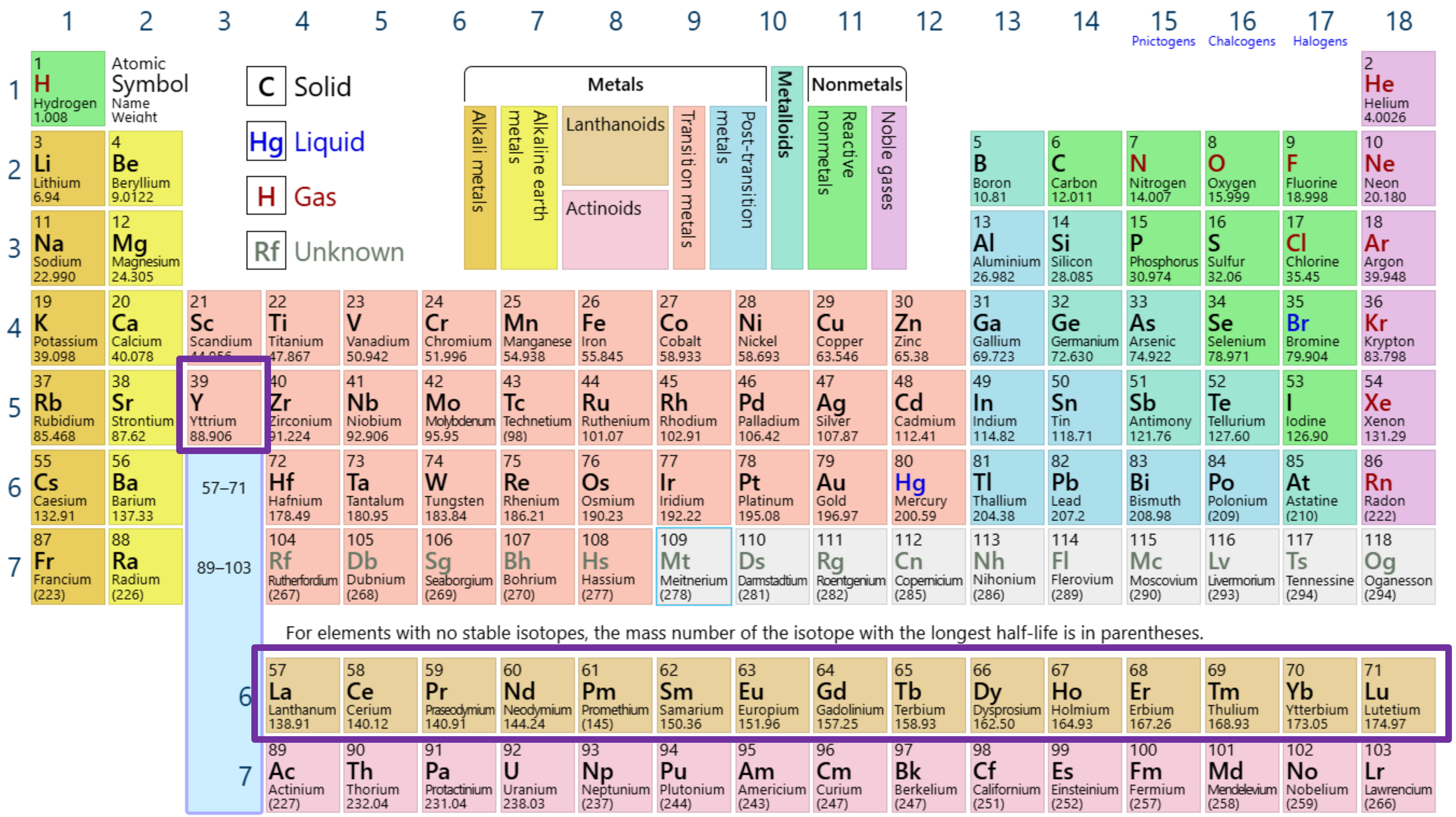


# Major Cations and Trace Metals

- Pyrite weathering inherently adds sulfuric acid to natural waters
- Acid leaches trace metals from rocks
- Negative effects on aquatic biota
  - Irritating fish gills could lead to suffocation
  - Precipitating metal oxides can smother aquatic plants and algae



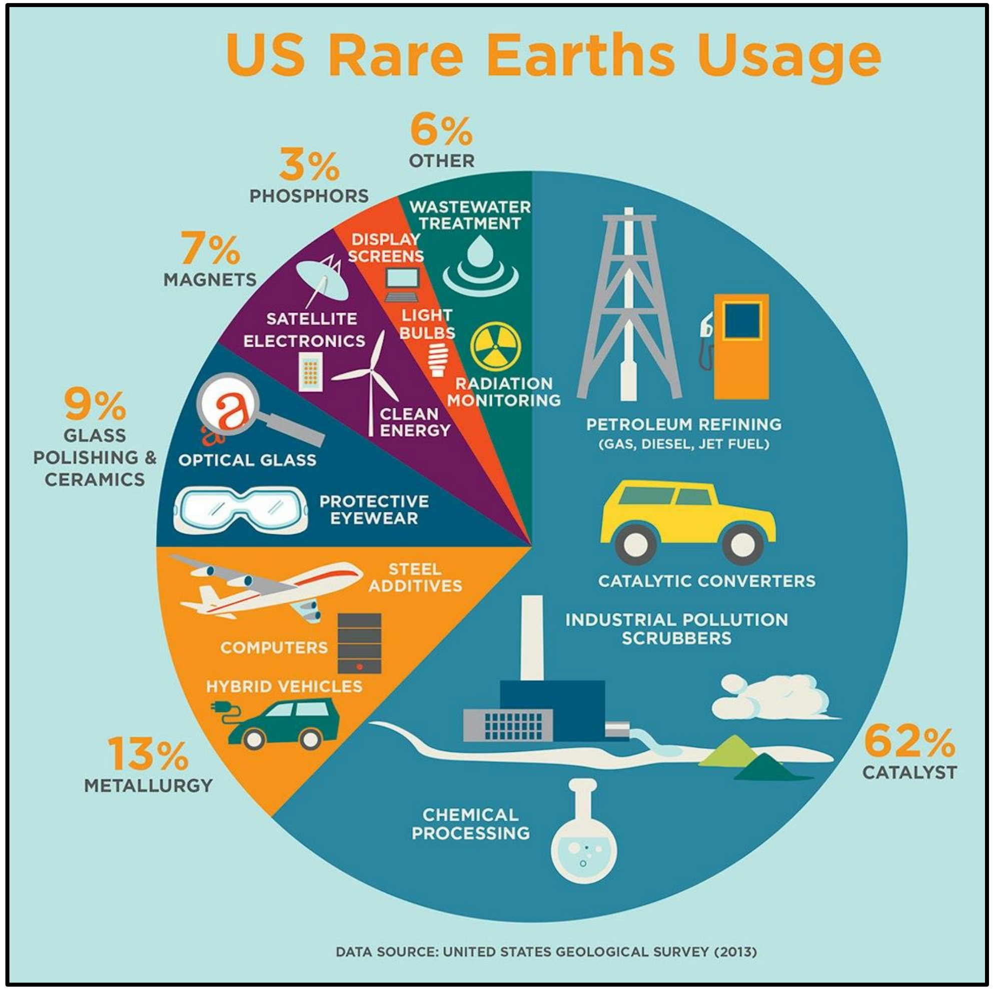
# Rare Earth Elements



# Rare Earth Elements

- Valuable to humans due to their unique electrical properties

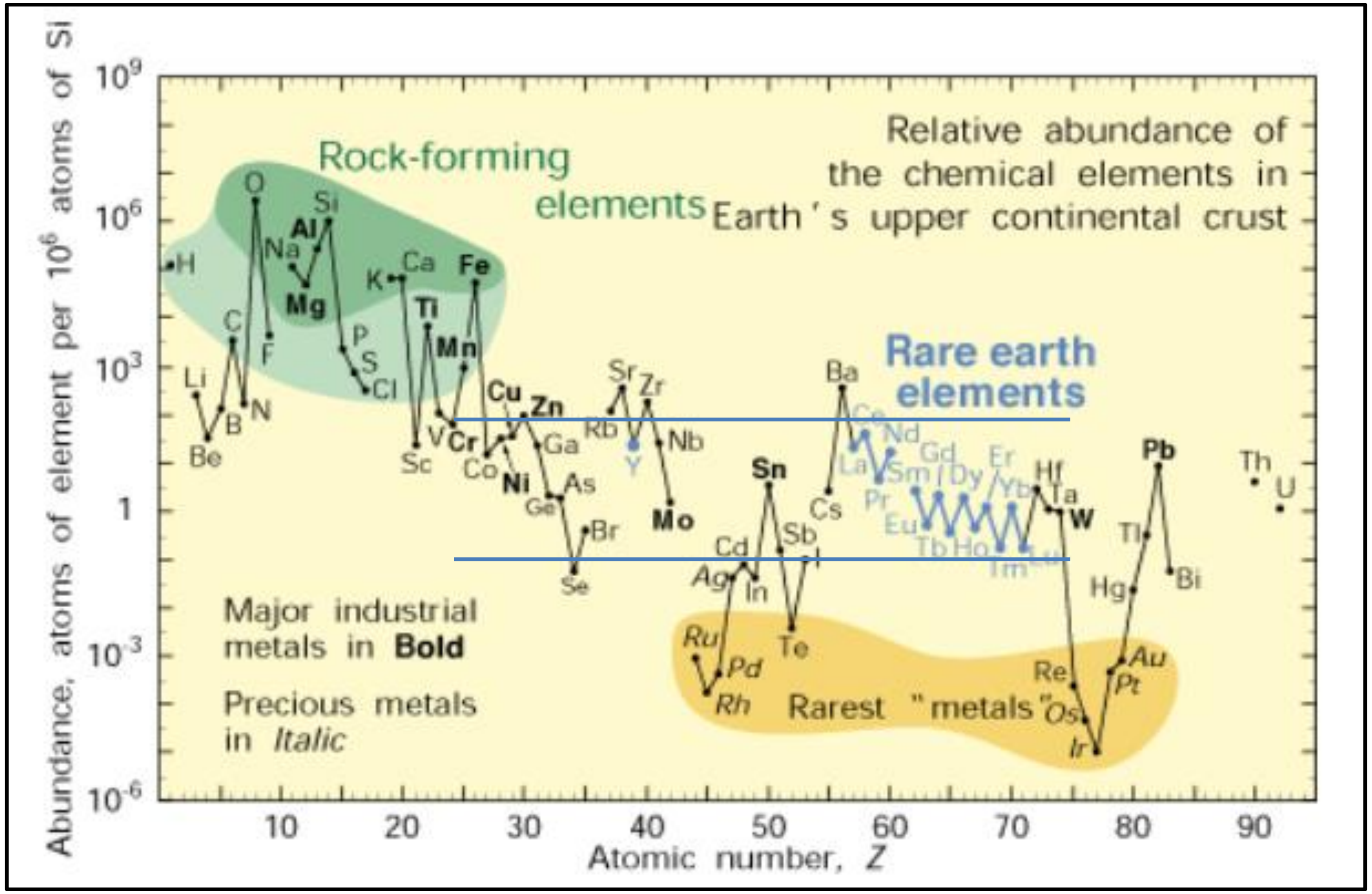
- Used heavily in computer manufacturing




https://massivesci.com/articles/rare-earth-elements-metals-not-really-that-rare/

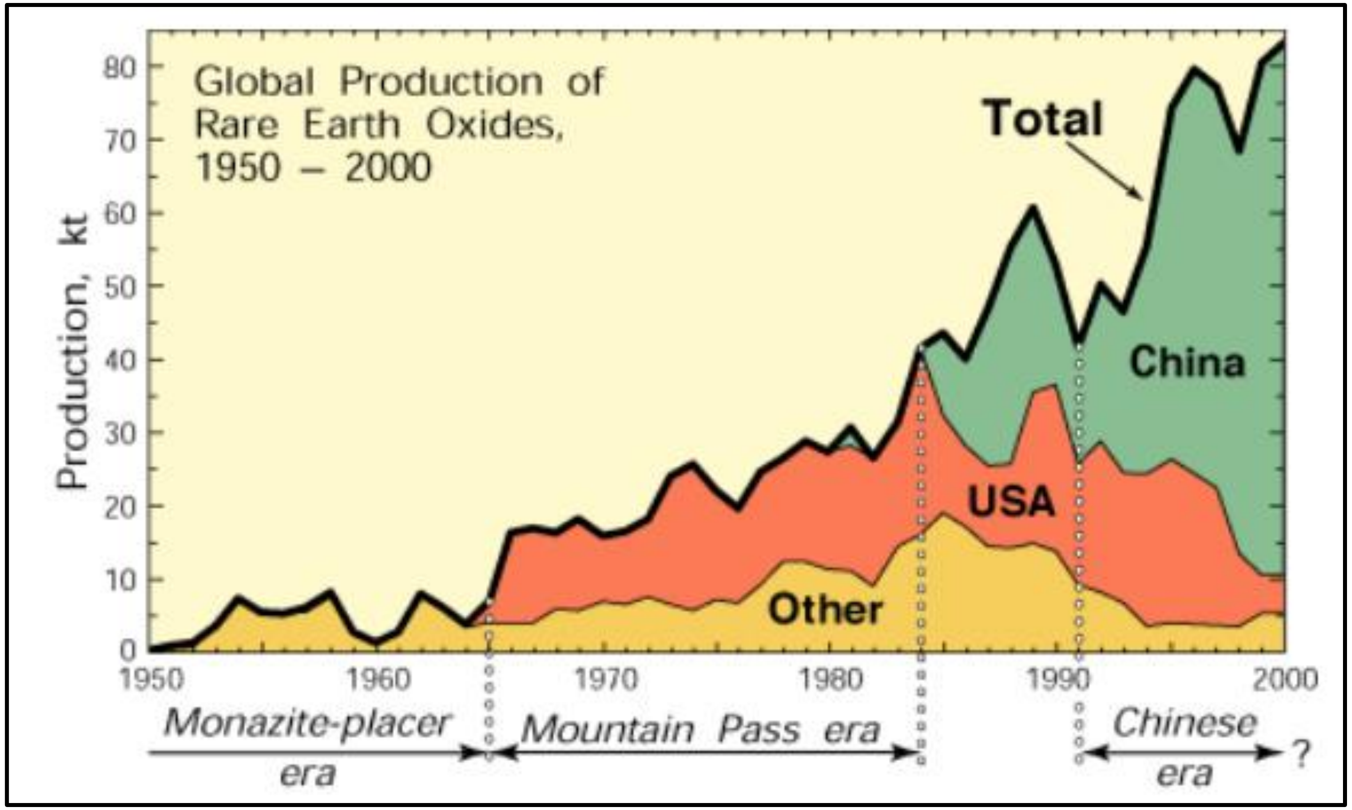
# Rare Earth Elements

- “Rare” Earth Elements is a bit of a misnomer
- Relatively high crustal abundance
- Difficult to mine and many waste products created



# Rare Earth Elements

- The U.S. is becoming increasingly dependent on REEs
- China is currently the largest supplier of REEs
- With shifting geopolitical landscapes, there is an interest in finding novel domestic sources of Rare Earth Elements



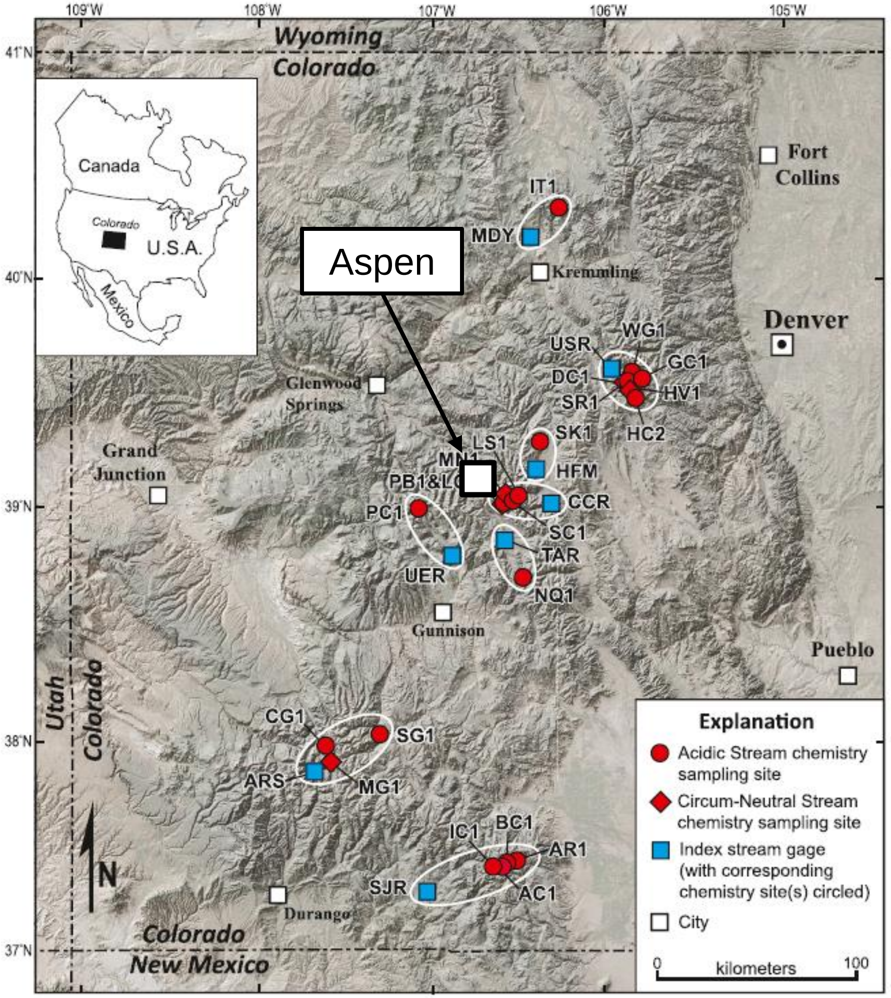
# Rare Earth Elements

- Acid Mine Drainage tributaries in the Colorado Mineral Belt are known to input REEs into aquatic systems
  - **A novel source?**

- Scientists across the U.S. are researching extraction methods to collect REEs from water

- **To extract aquatic REEs we must also identify where they can be found**

- No water quality standards for REEs for public health or aquatic life



# CU’s research goals

1. How **abundant** are REEs in Lincoln Creek?
   - Fluctuate seasonally?

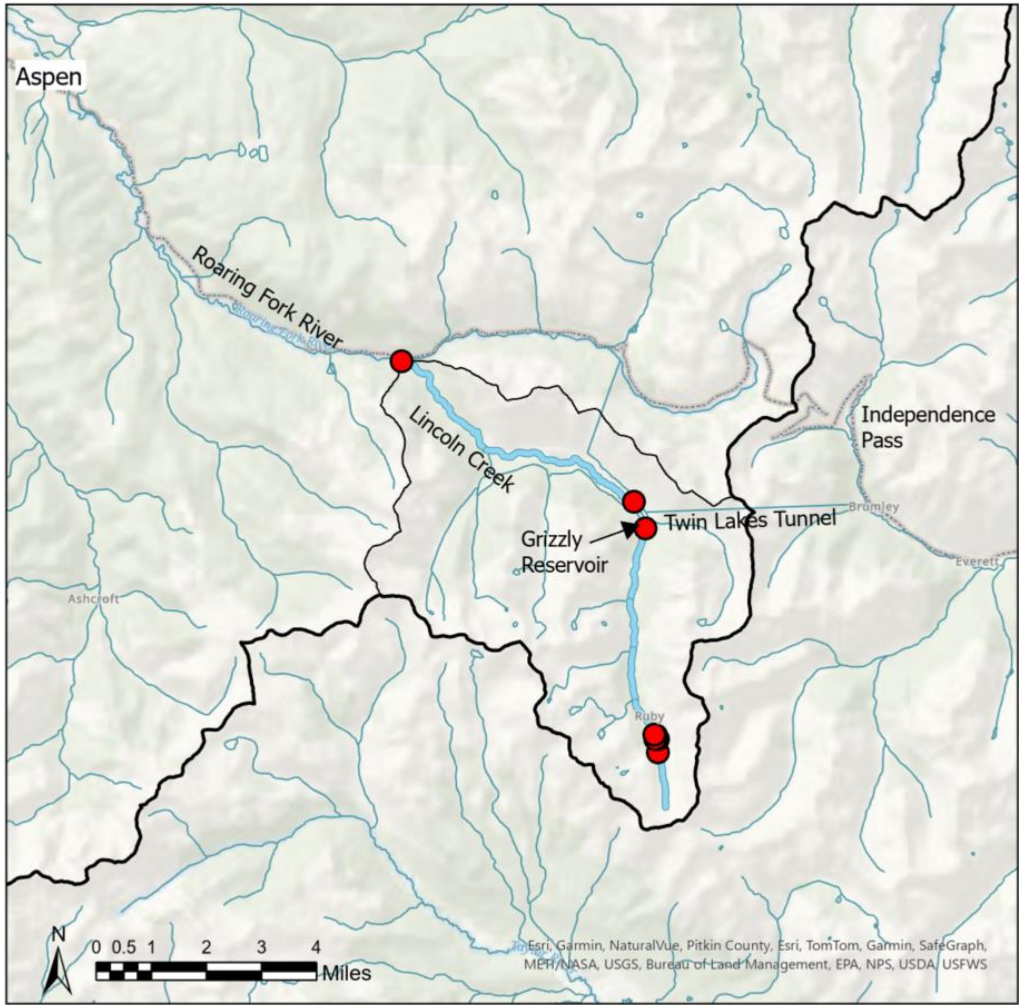
2. What is the **fate** of REE’s in Lincoln Creek?
   - Assimilated by the aquatic biota?
   - Adsorbing to sediment?
   - Precipitating out of the aquatic system as a solid?

3. How do REEs **interact** with Major Cations and Trace Metals?

# How will we answer these questions?

- Collect samples for one season
  - Water
  - Precipitated flocculent scrapings
  - Benthic Macroinvertebrate (BMI) Collection
  - Sediment core samples

- Analyze samples
  - Ion Coupled Plasma Mass Spectrometry - concentration
  - Microwave Digest BMIs - biota assimilation
  - sediment core - adsorption



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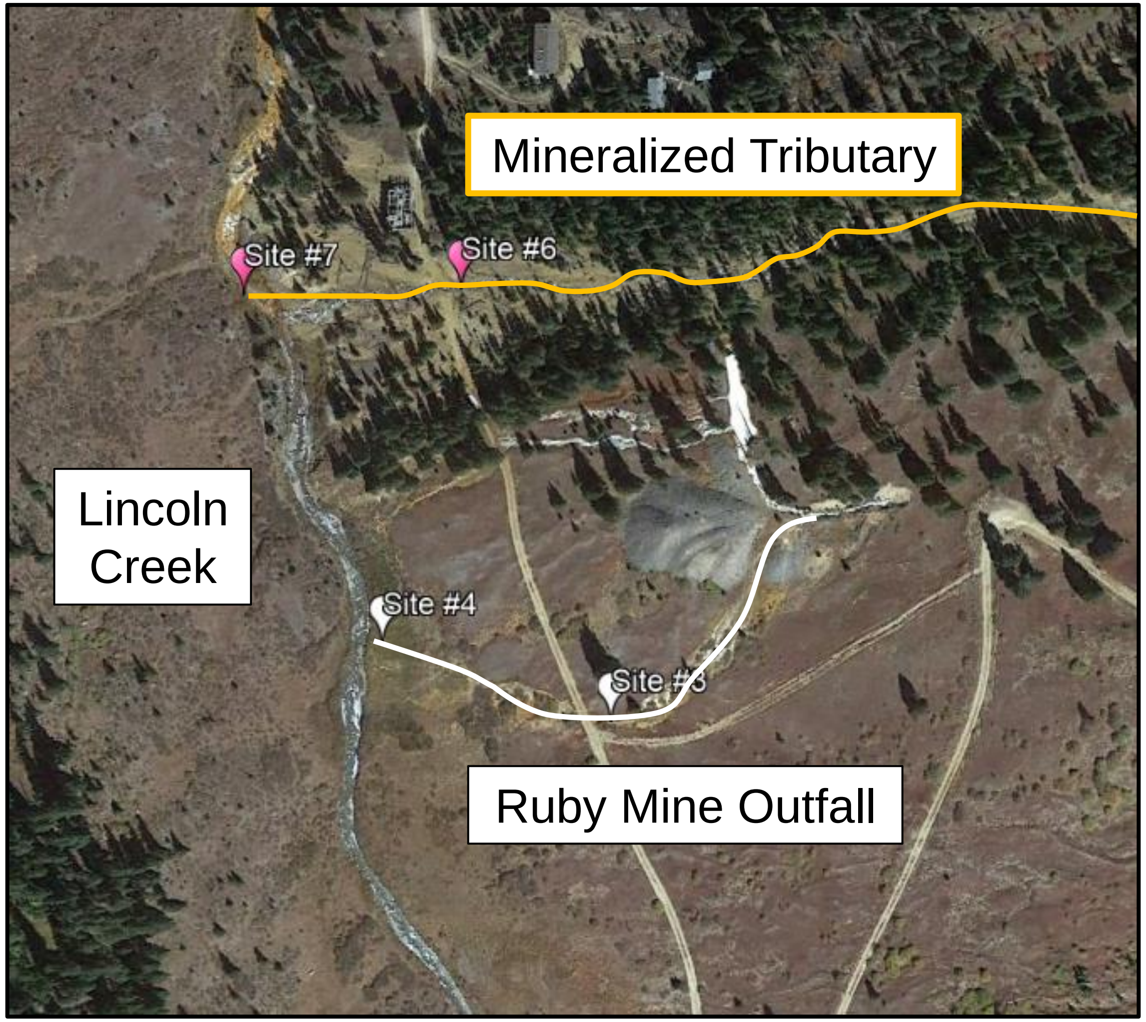
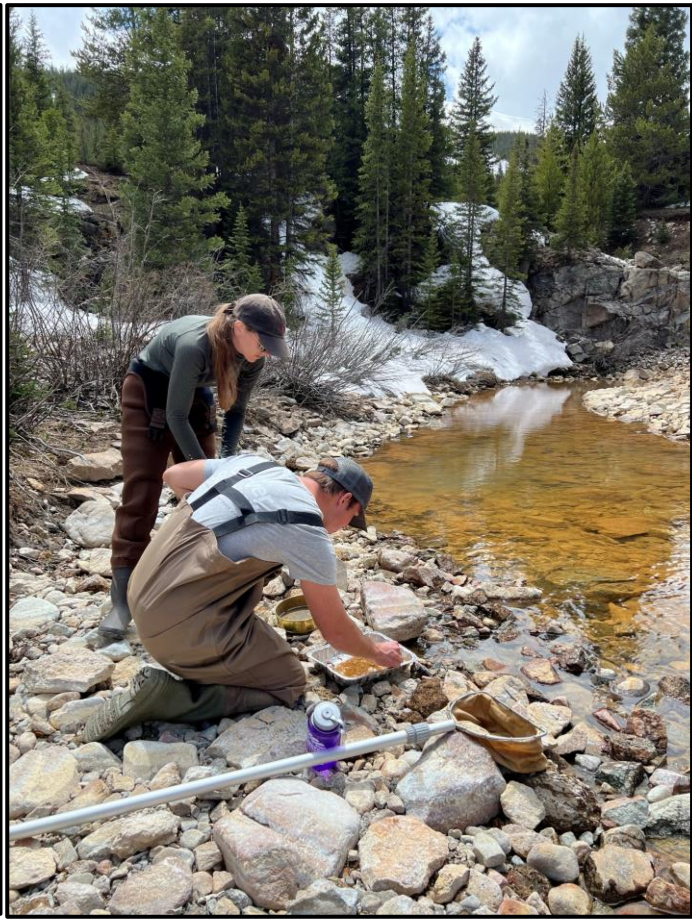


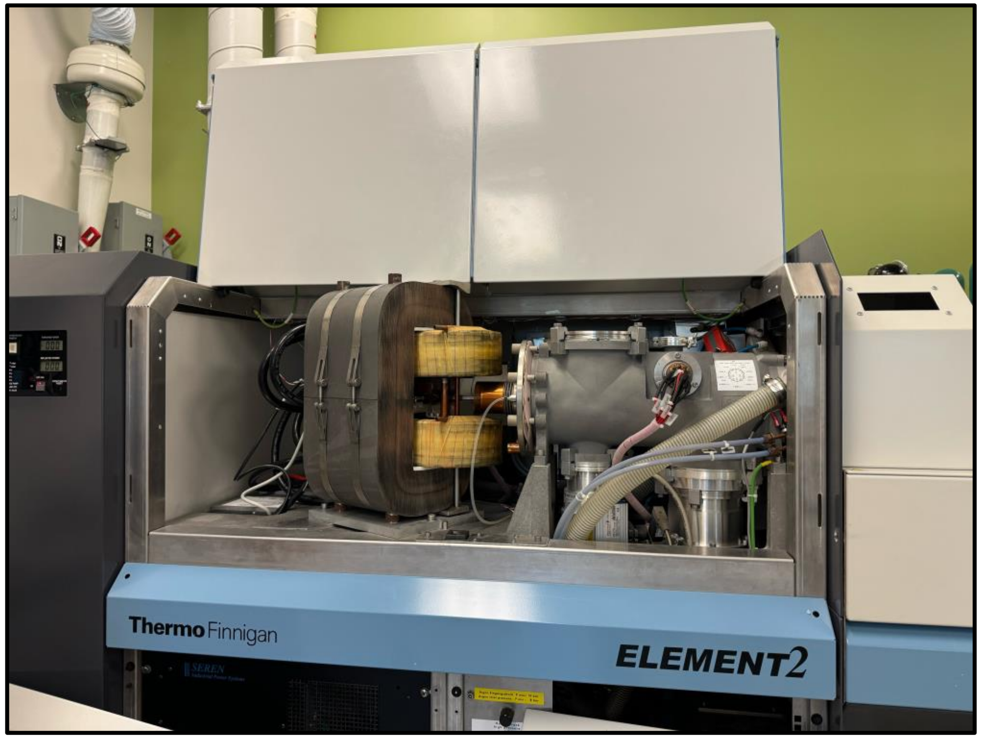
# Sample collection was completed June – October 2024





# We are now in the analysis phase

- Most water samples have been run through ICP-MS
- Now analyzing flocculent scrapings
- Sediment cores up next

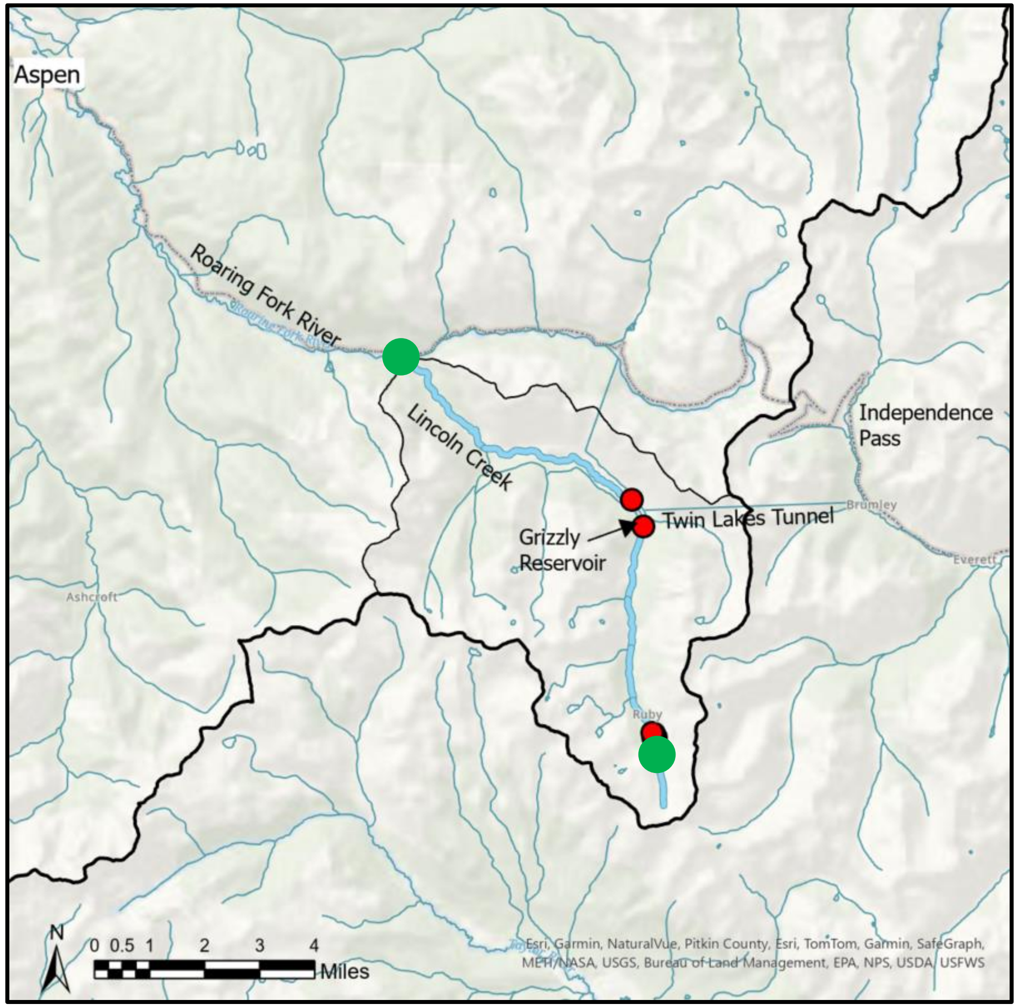



# Preliminary findings – Benthic Macroinvertebrates

- Unfortunately, none found in upper Lincoln Creek between tributaries and inlet to Grizzly Reservoir
  - **Why?**

- Observation of families present indicate healthy spread of BMIs above mine sources and at confluence with the Roaring Fork River

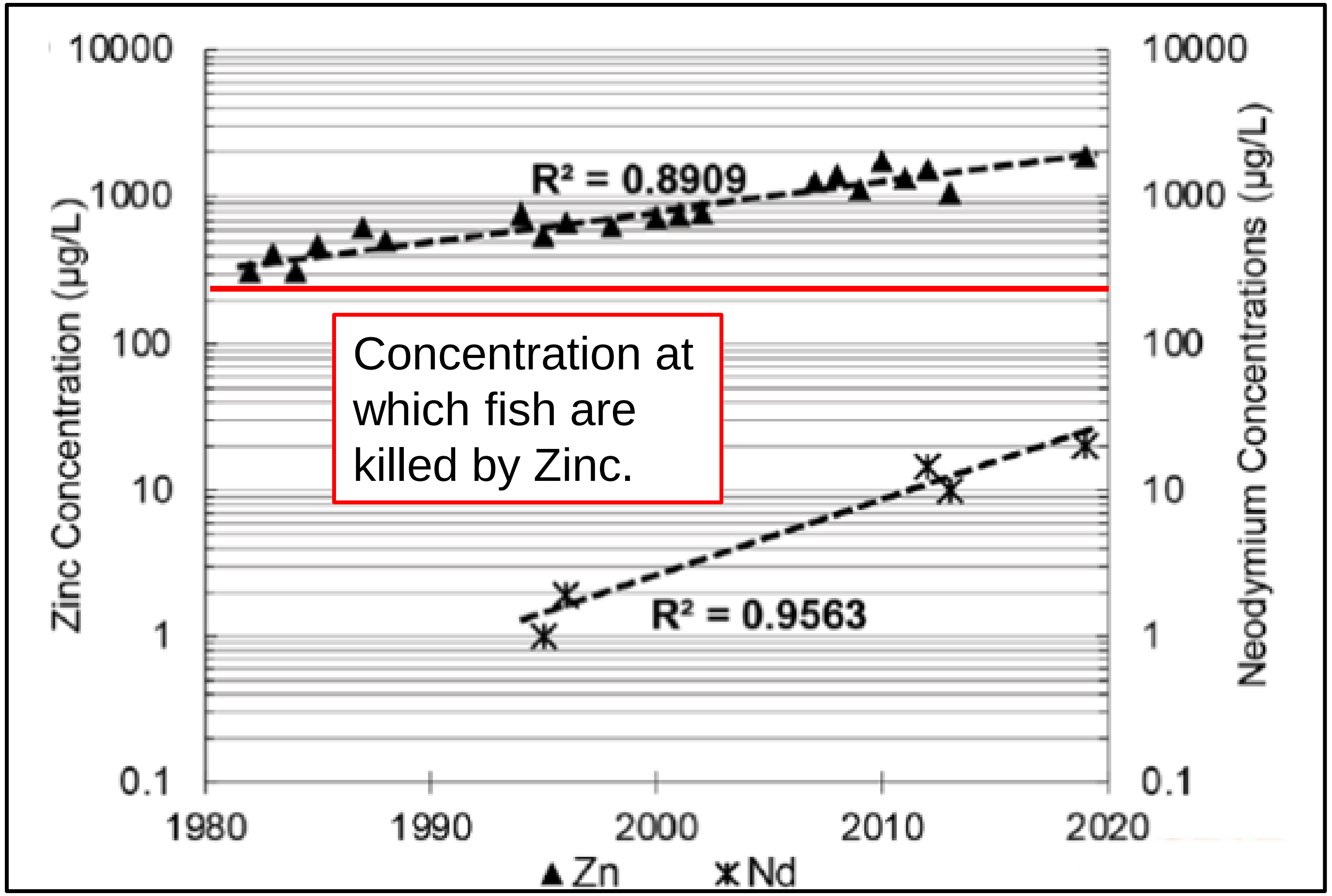
Perlodidae (stripe tail stonefly)



# Preliminary findings – Benthic Macroinvertebrates

- Snake River (near Dillion, CO)
  - High REE Concentrations
  - Lower trace metal concentrations
  - **Plenty of BMIs**
  - No fish

*Zapada Haysi* stonefly nymph

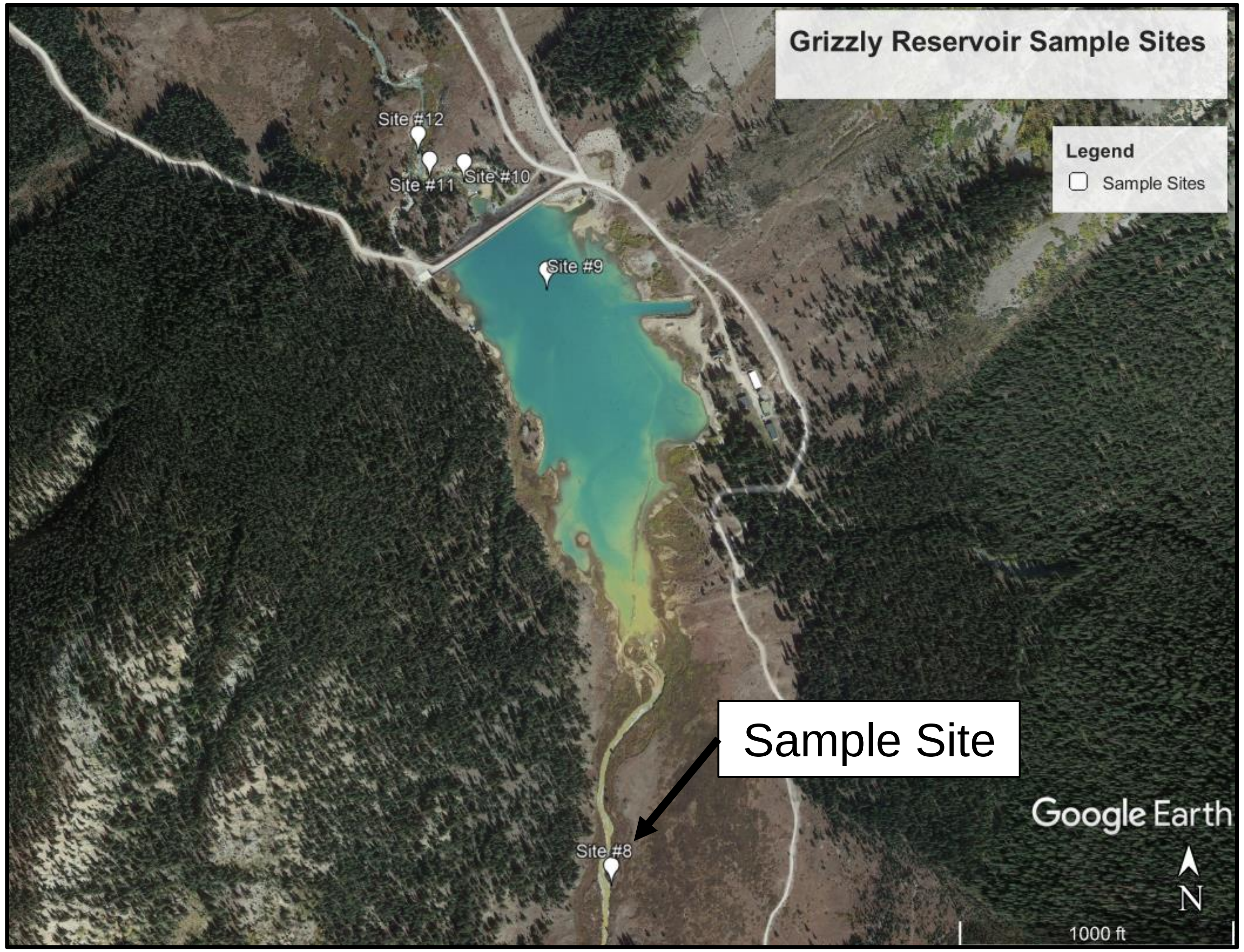


# Preliminary findings – Benthic Macroinvertebrates

- Something else must be harming the aquatic biota in Lincoln Creek
- We will analyze BMI collections from above the mine and below the reservoir for REE assimilation



# Preliminary Findings – Grizzly Reservoir Inlet



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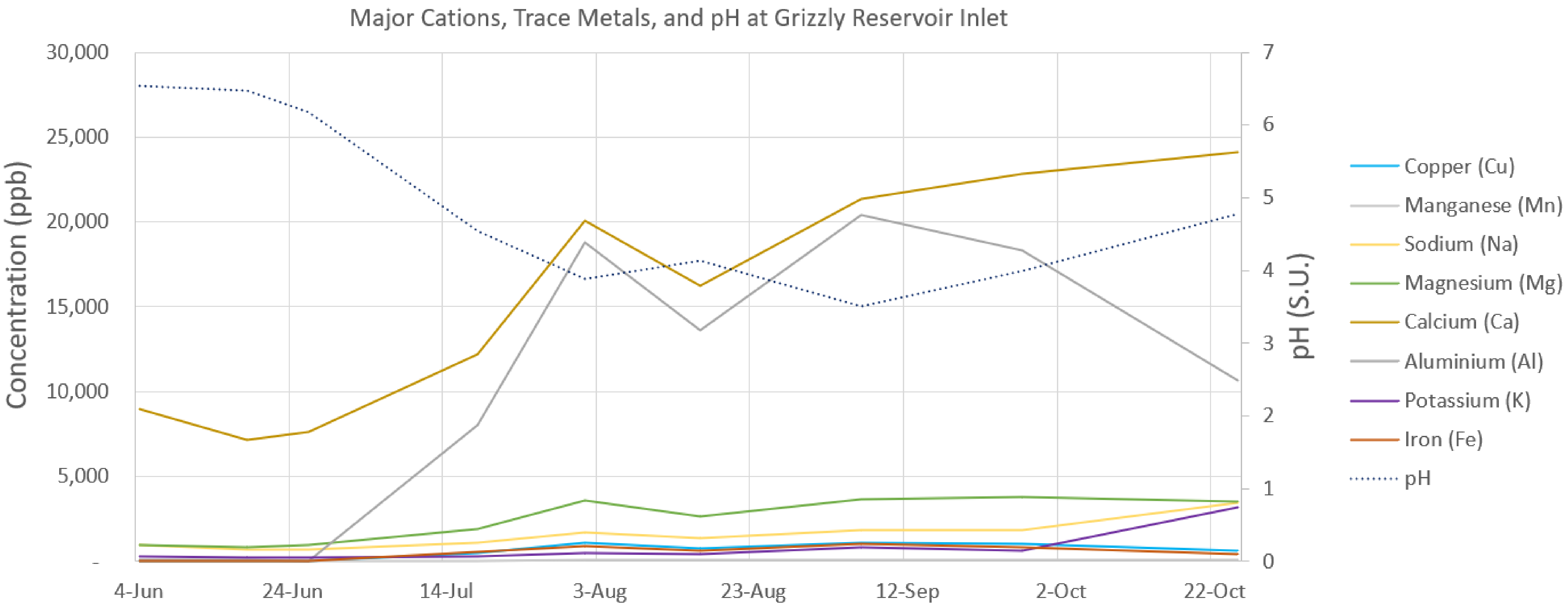

# What does “ppb” mean?

- Parts Per Billion
  - 1 ppb = 1 part element per 1 billion parts of water

- Think of this as one ounce of gold dissolved in one Olympic sized swimming pool
  - 1 pool = 2.5 million liters
  - 1 ounce of gold is approximately the mass of one large wedding ring

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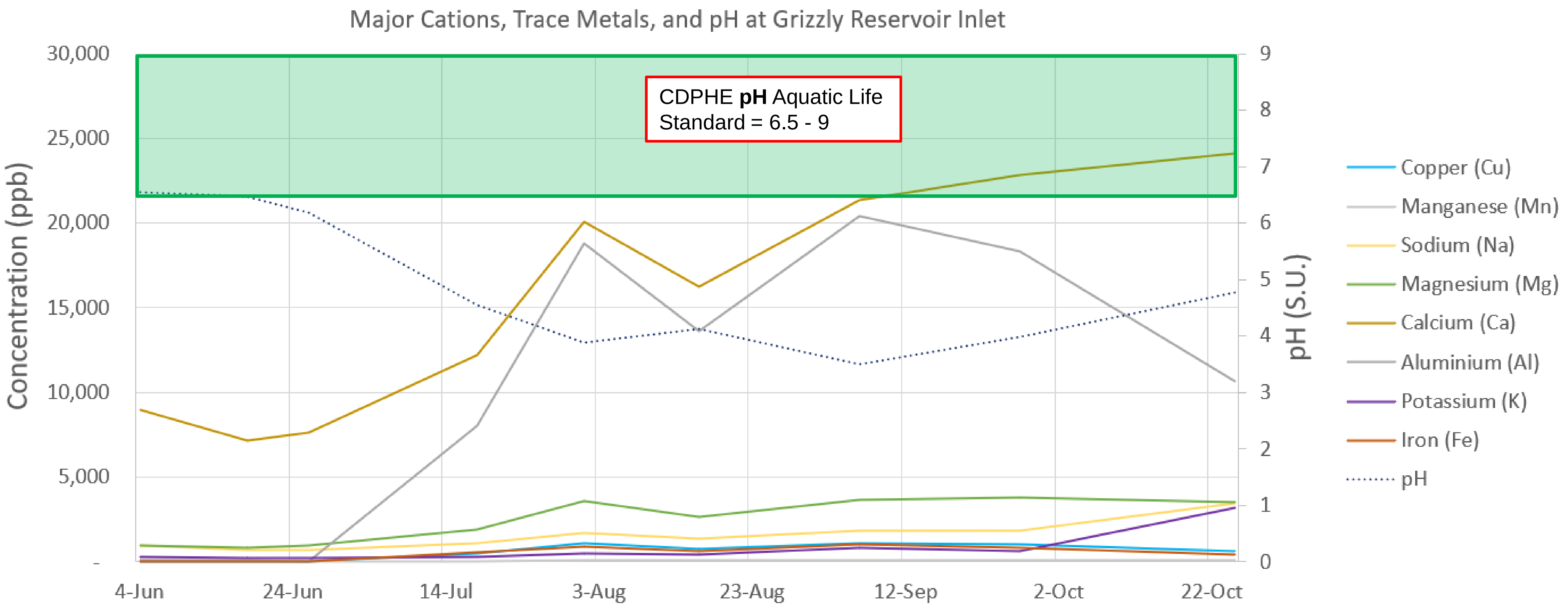

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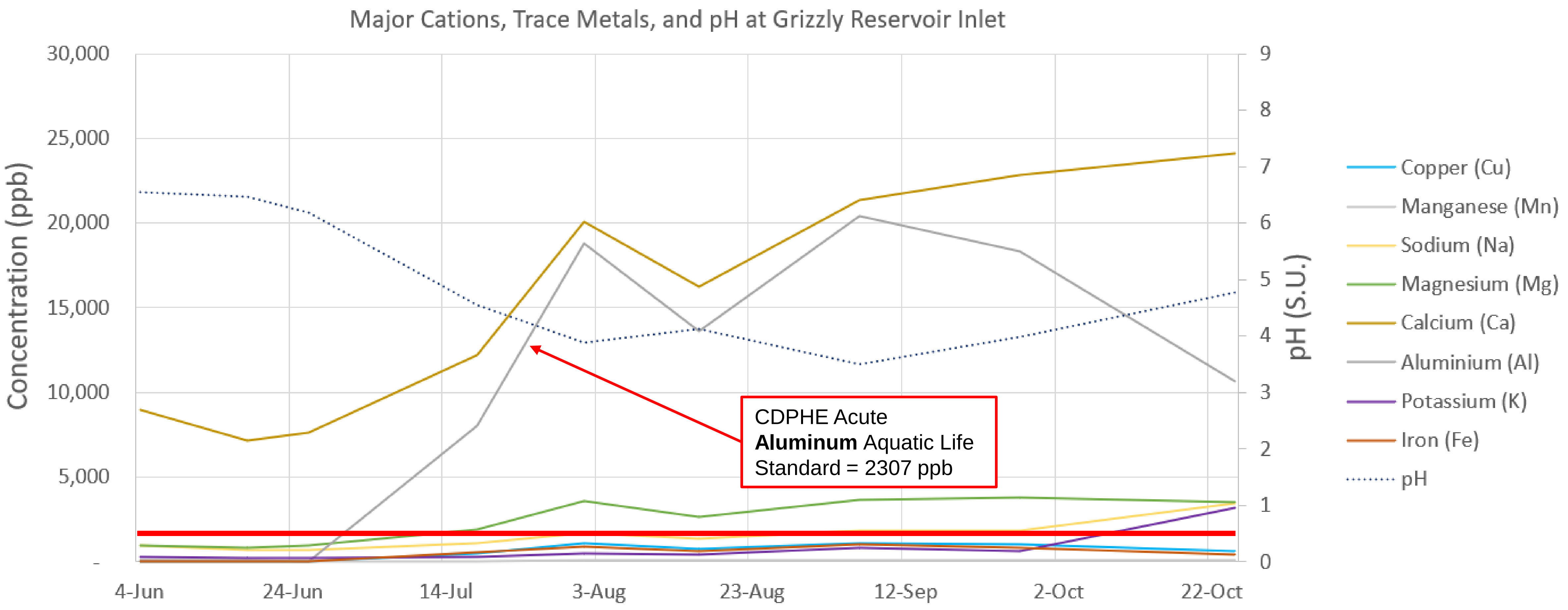

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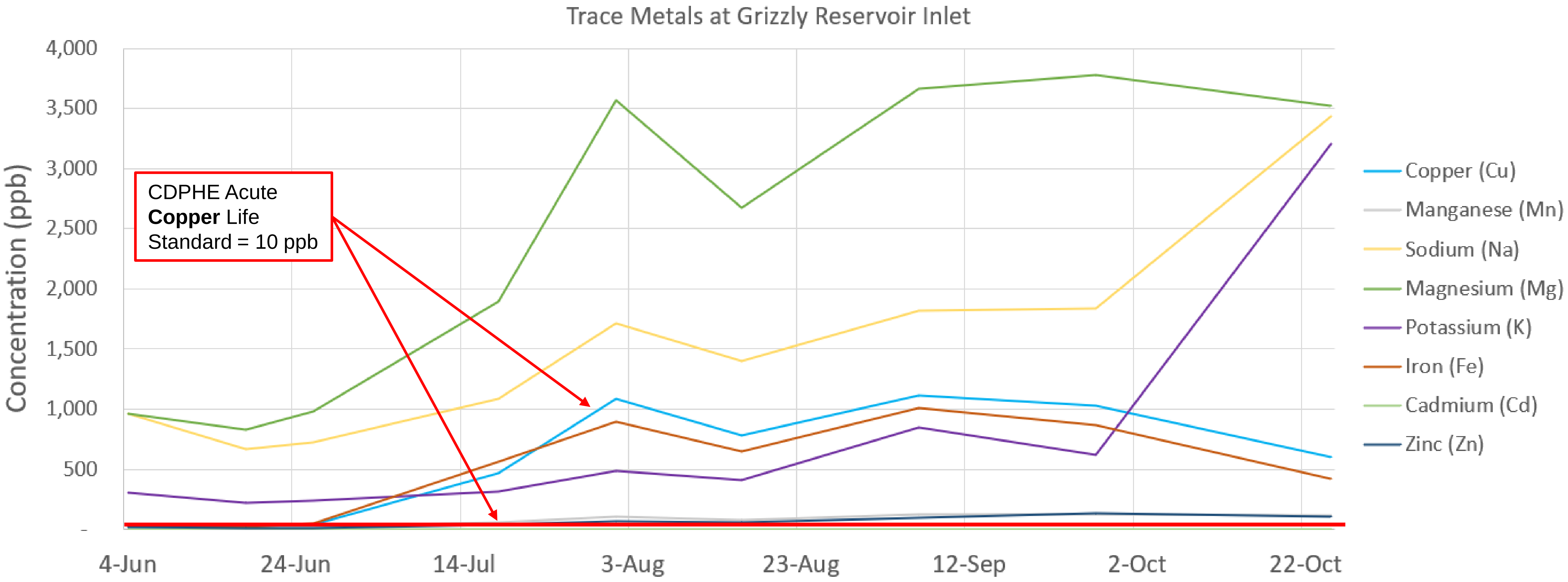


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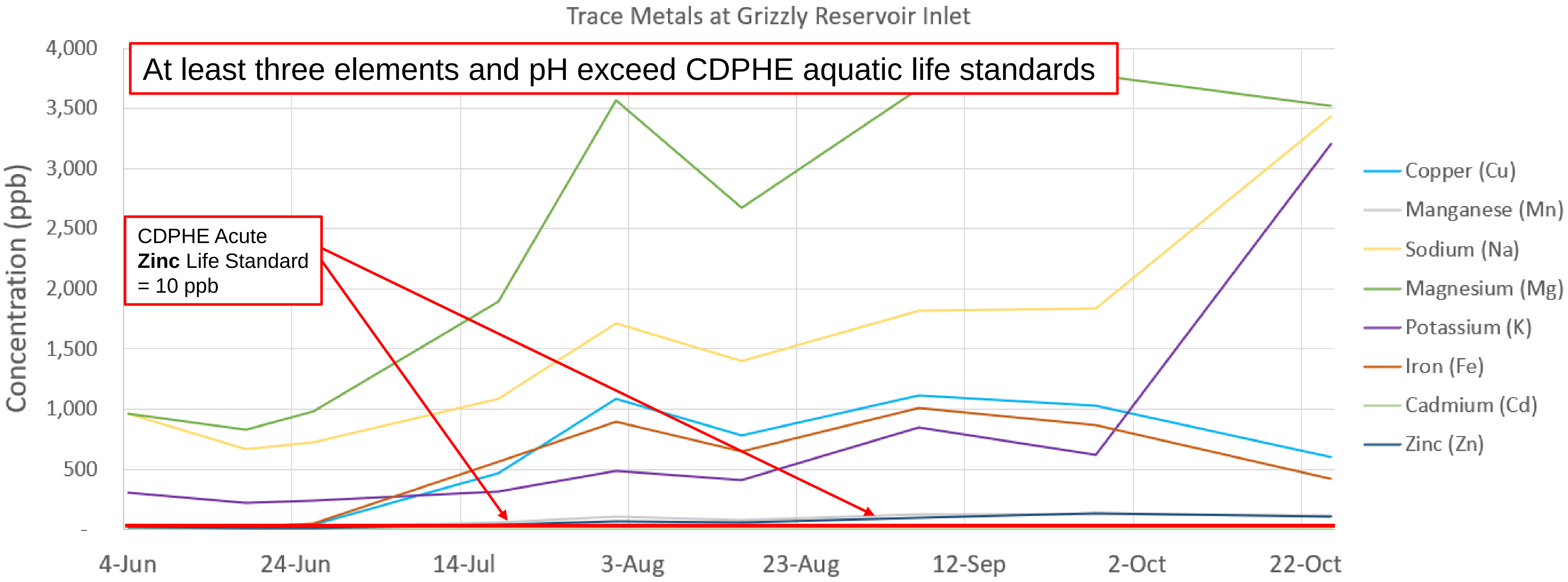

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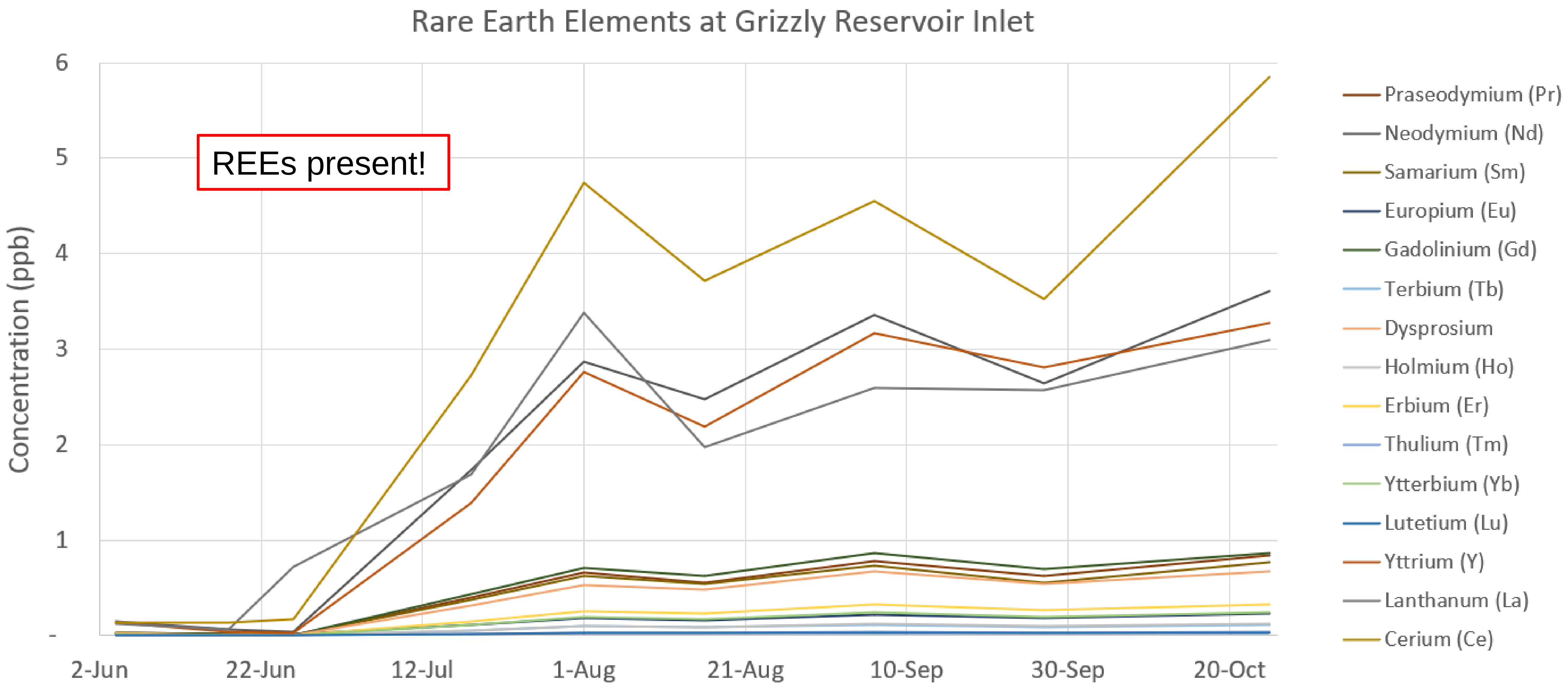

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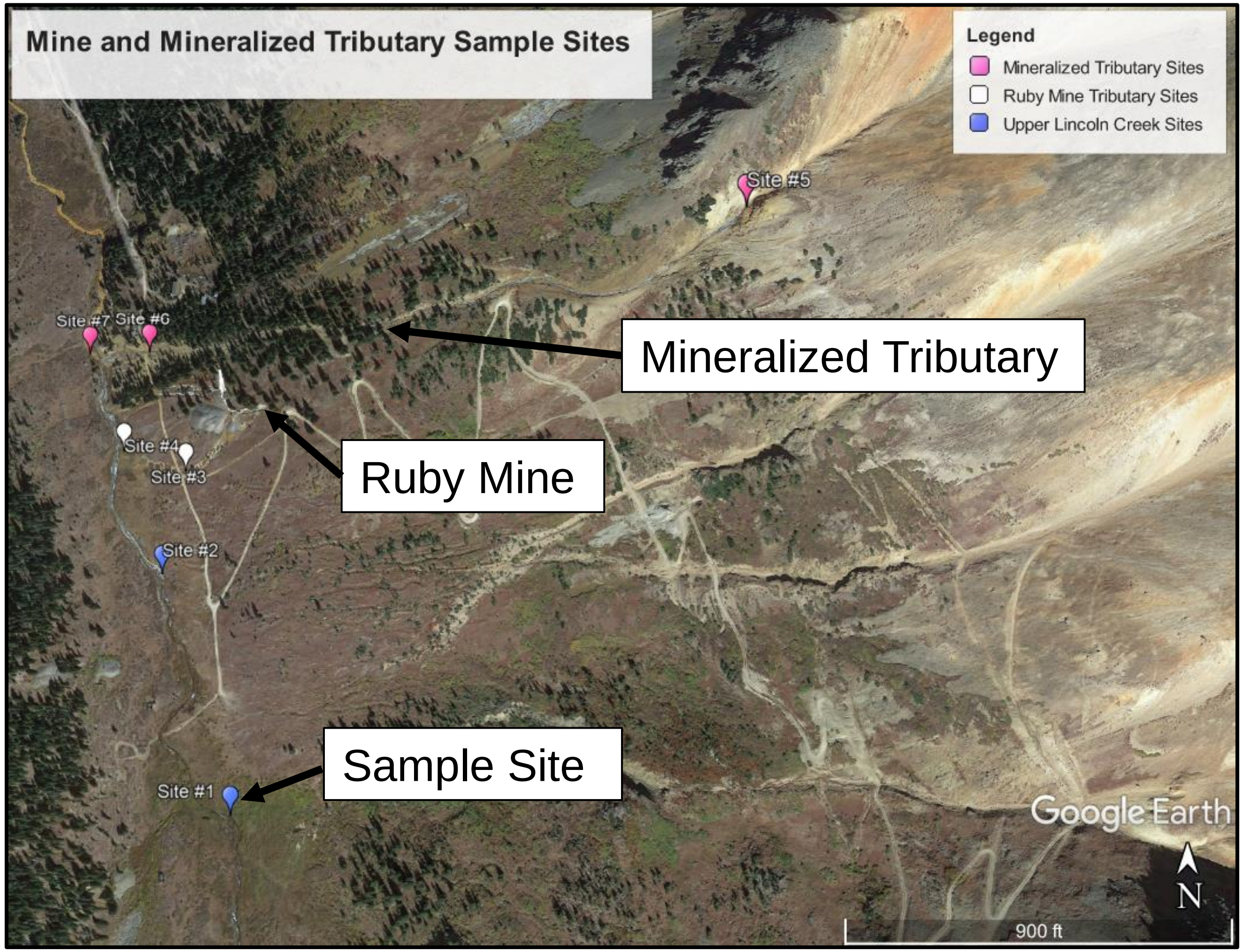

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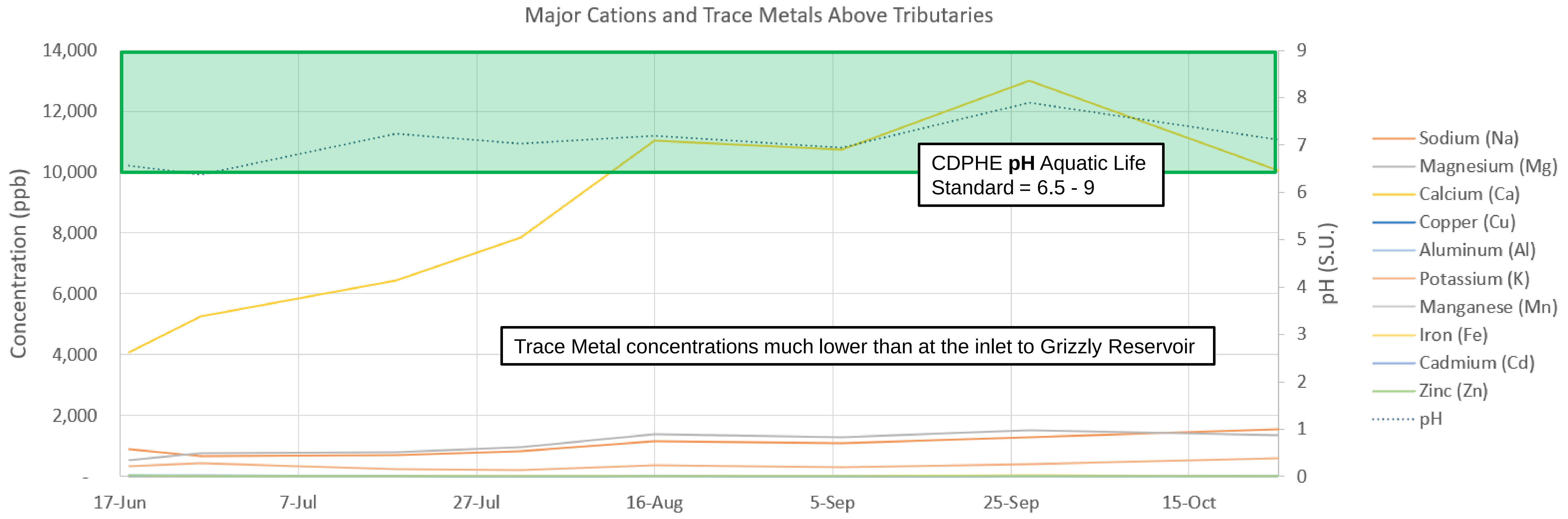

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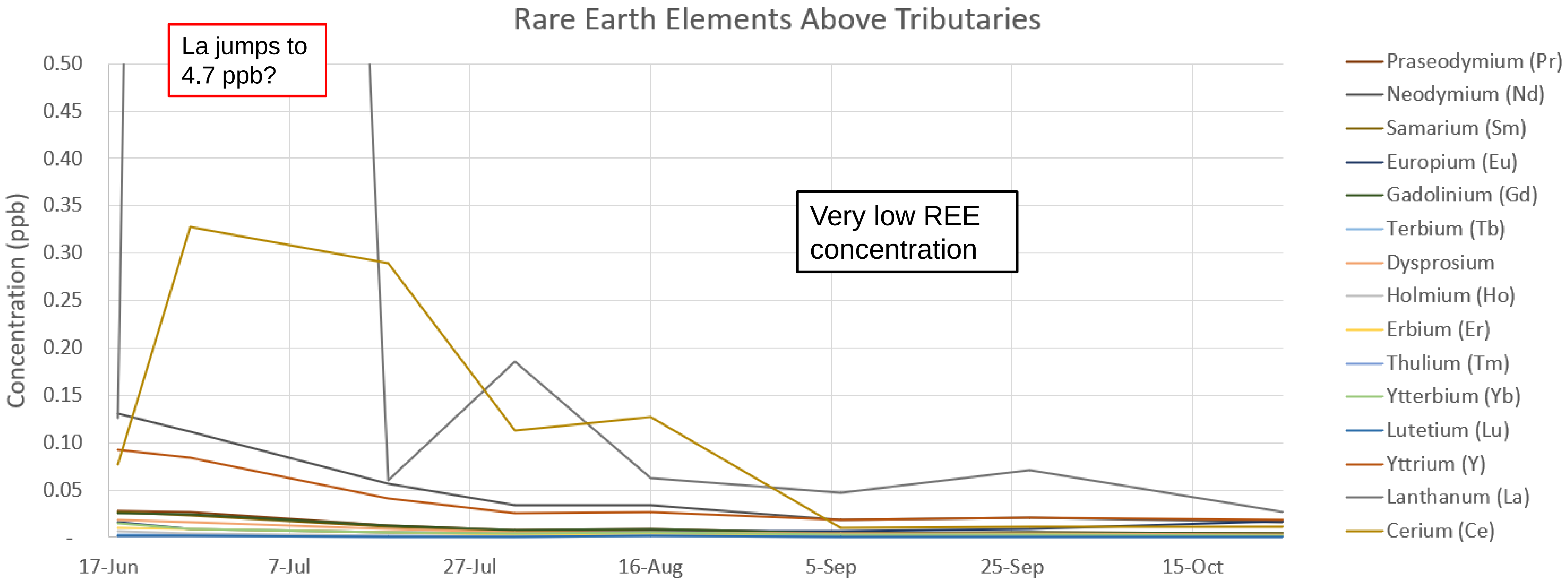
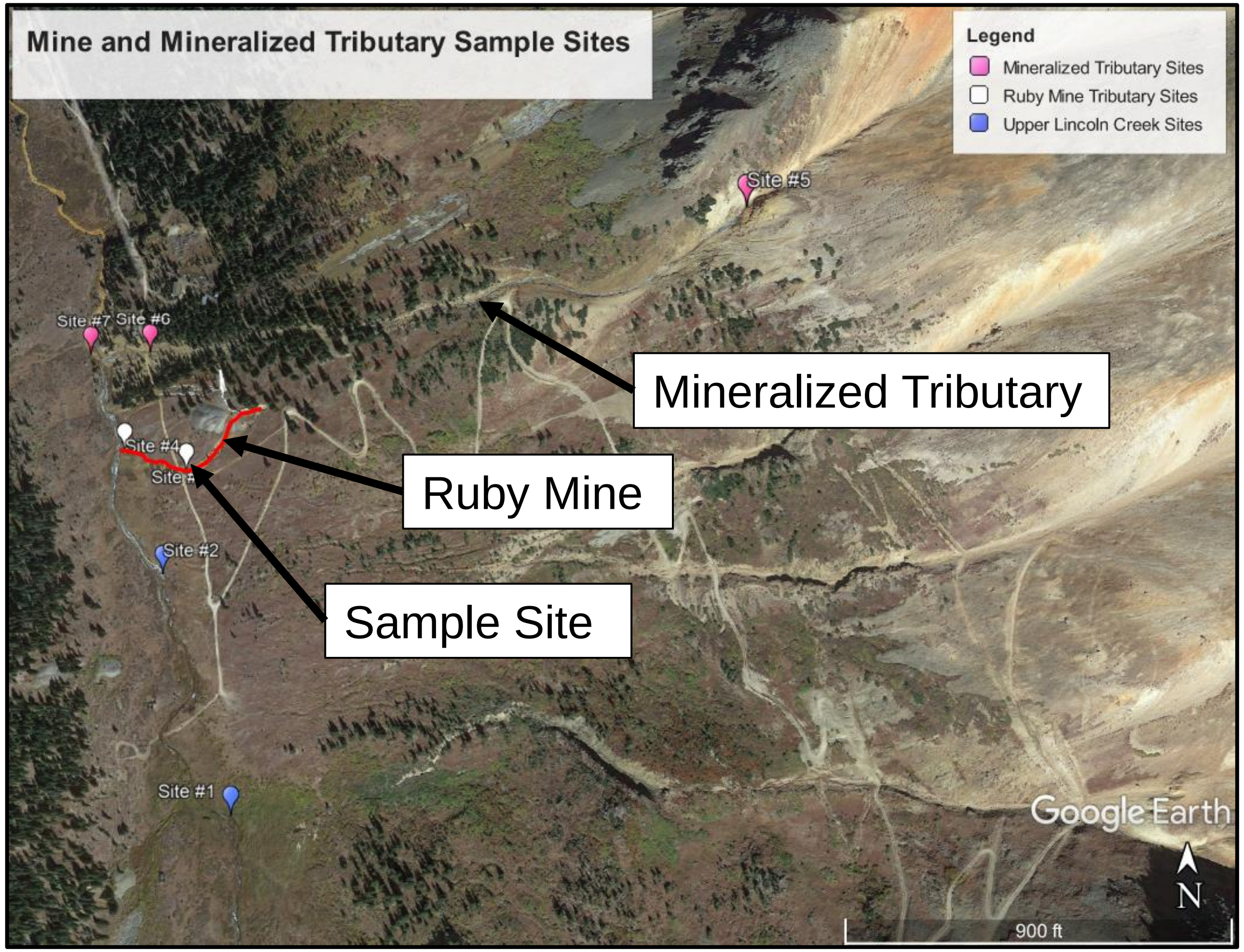


# Preliminary Findings – Ruby Mine Outfall



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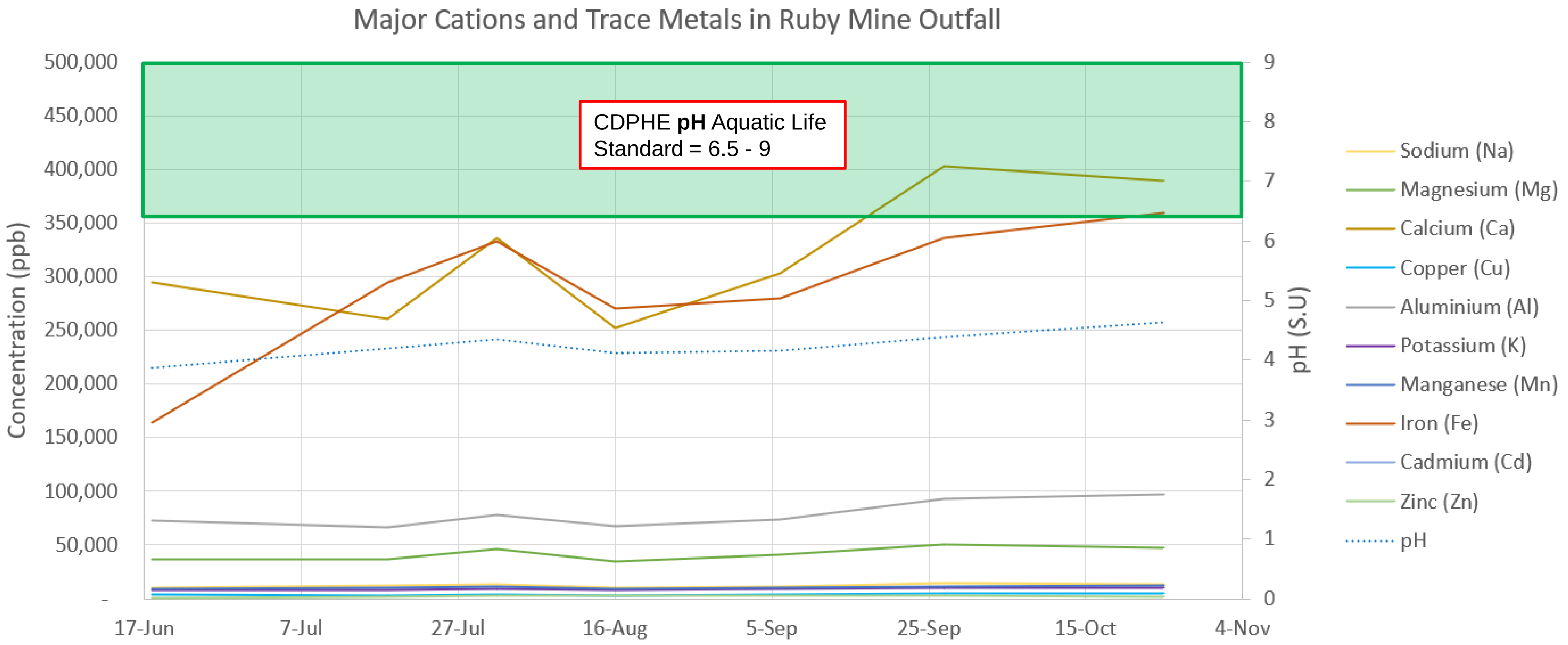

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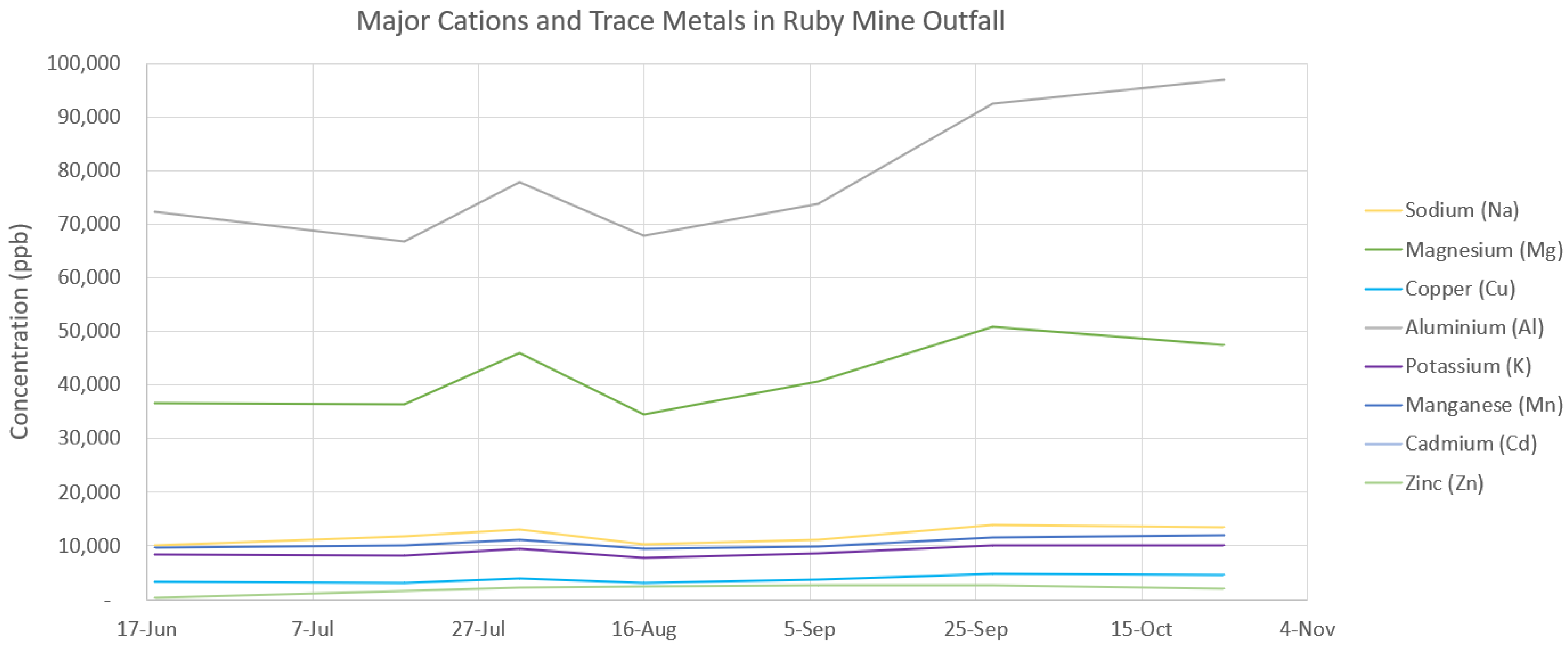

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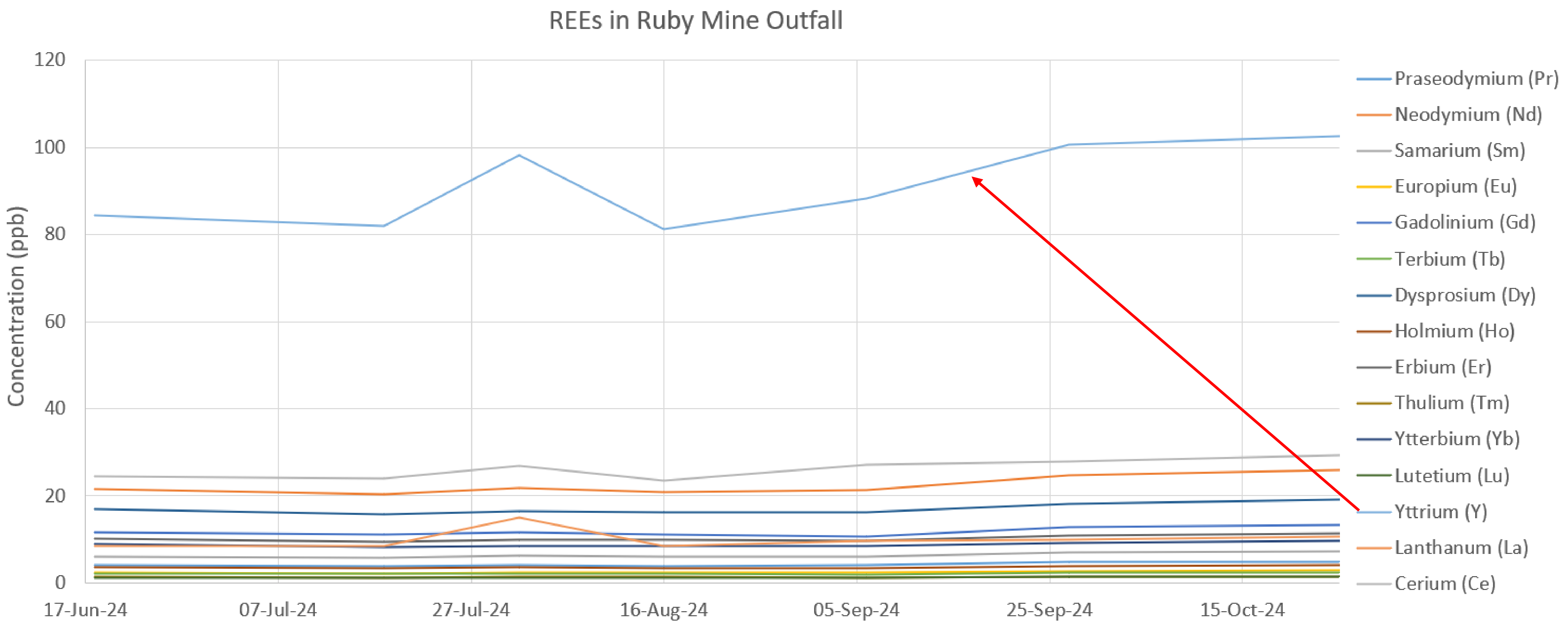
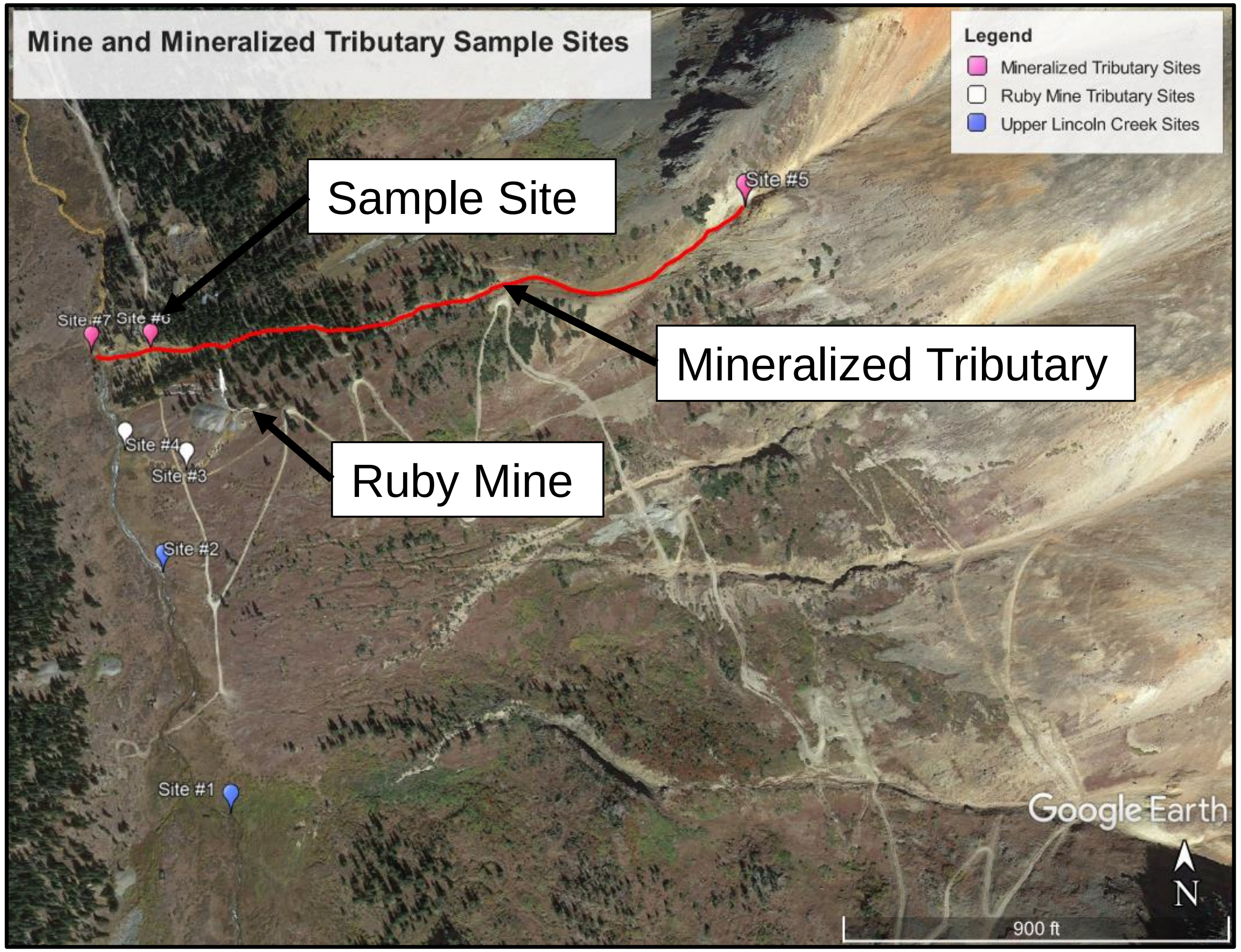


# Preliminary Findings – Mineralized Tributary



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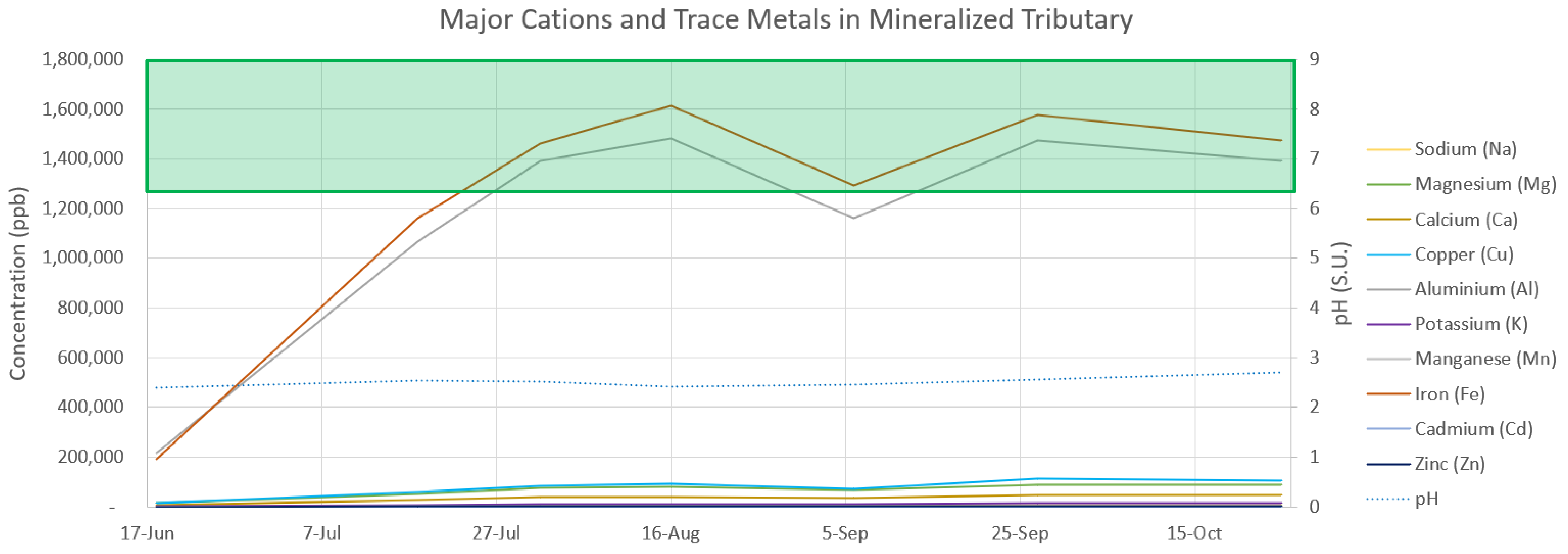

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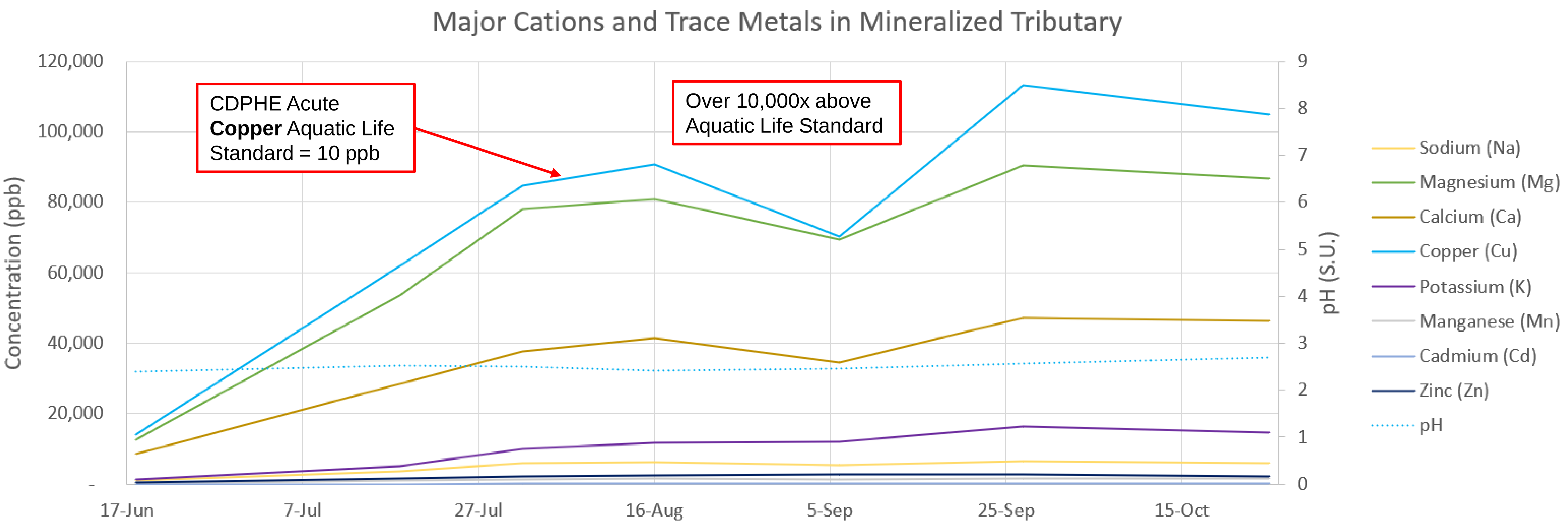

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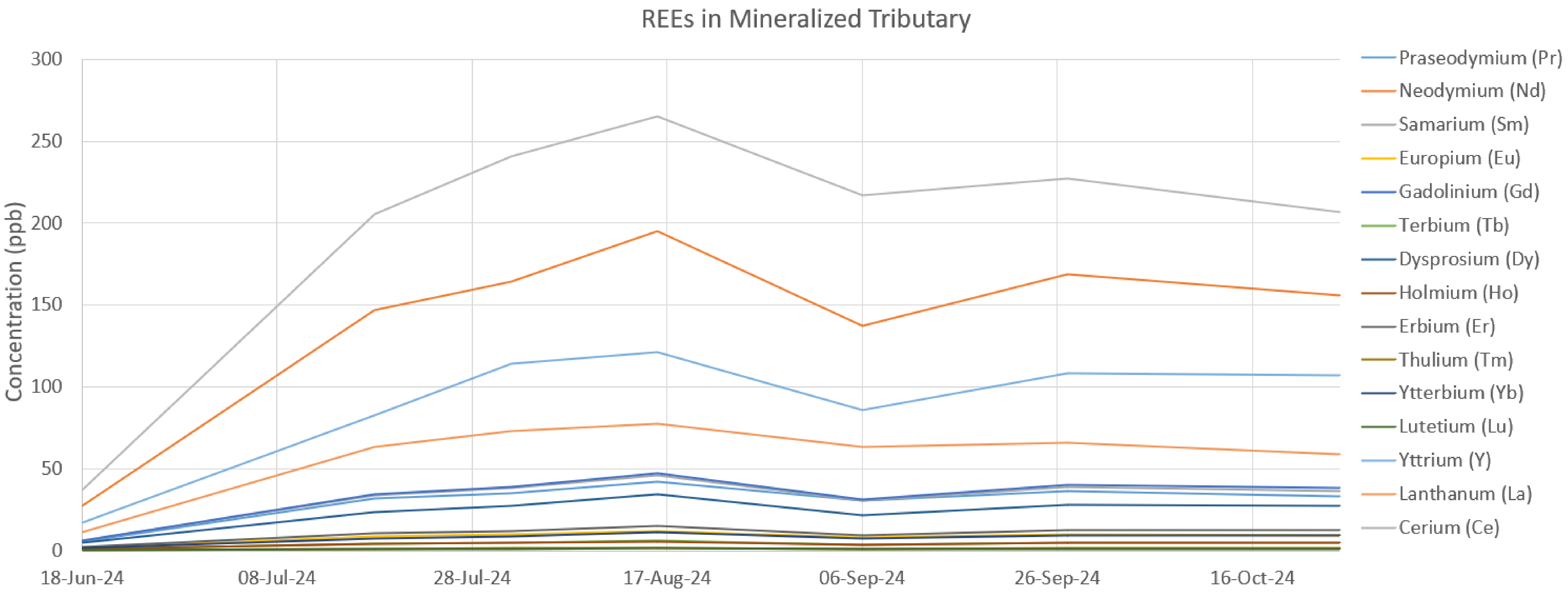
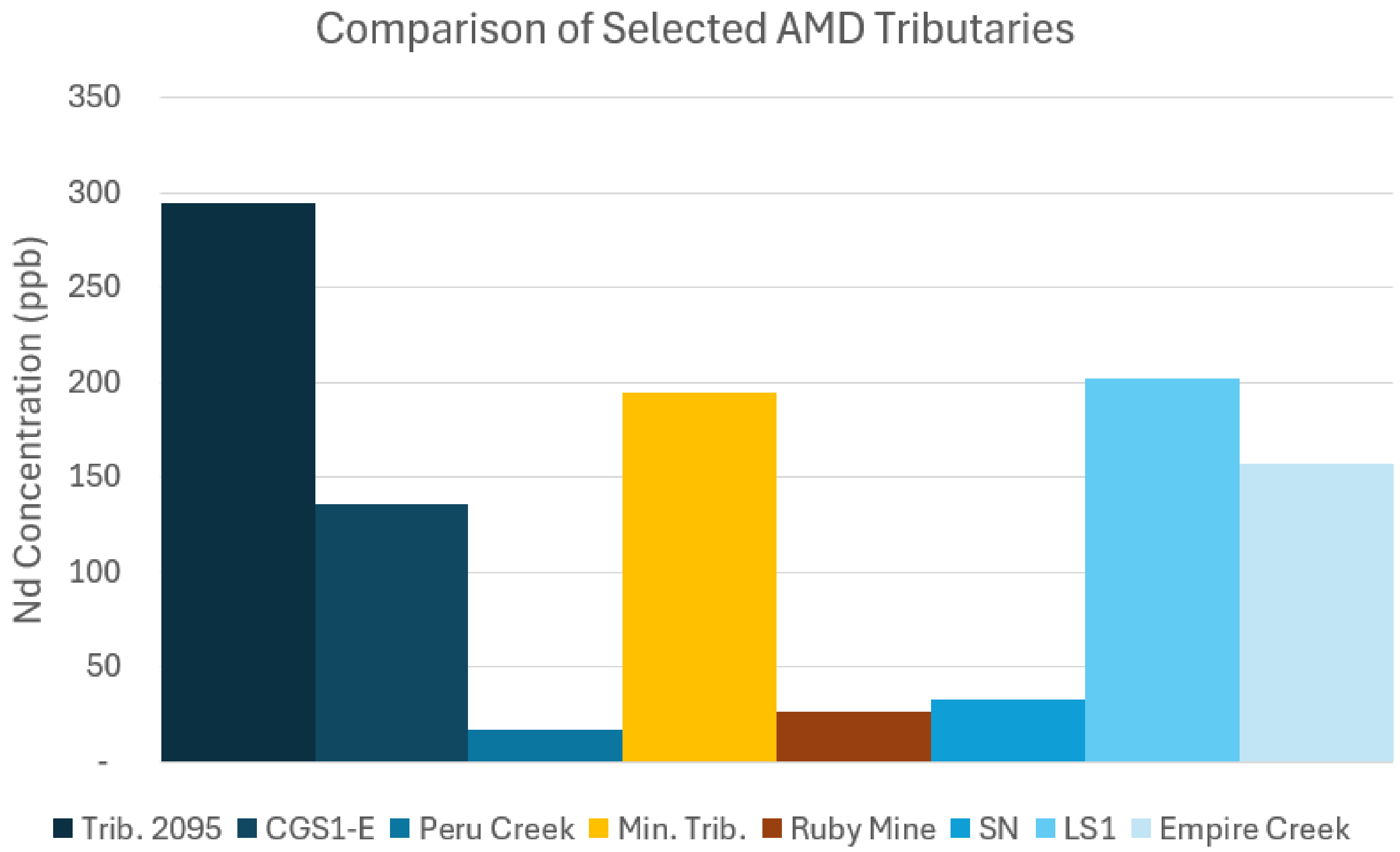


# Let's put this in perspective. How much Neodymium is in the Mineralized Tributary?



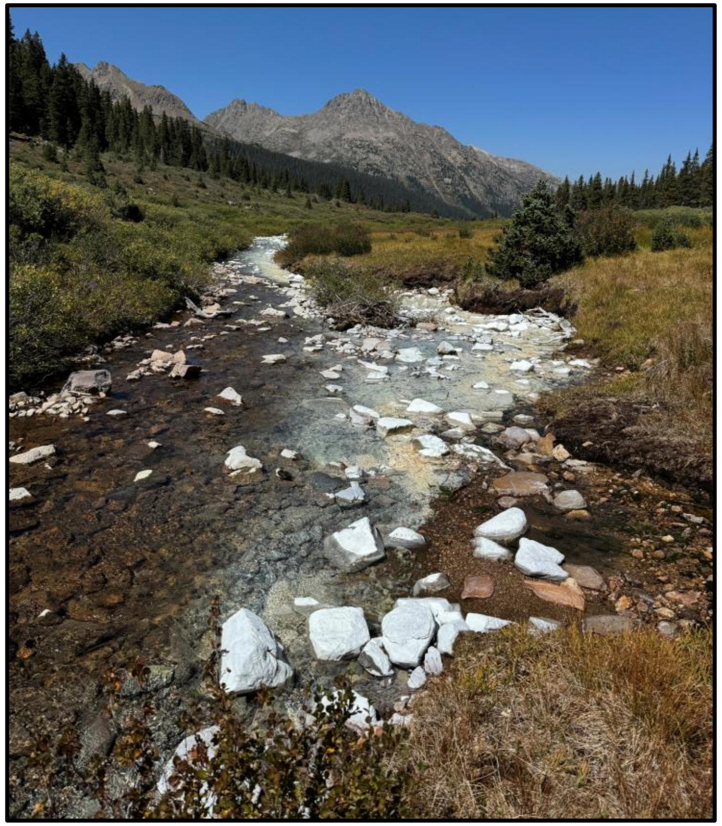
# Let's put this in perspective. How much Neodymium is in the Mineralized Tributary?

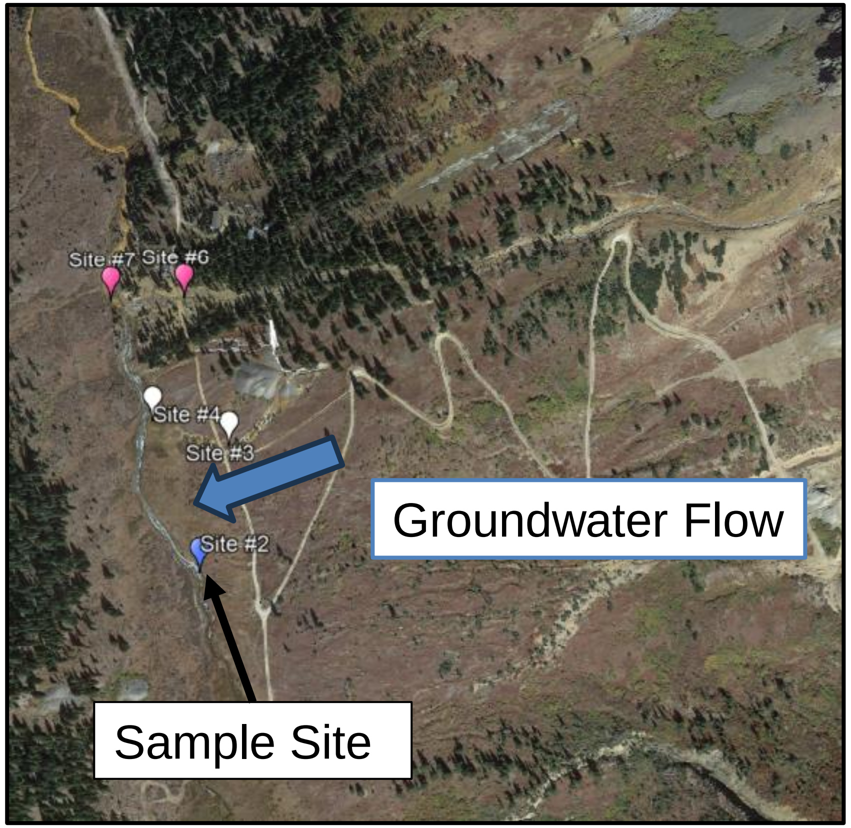
- 195 ppb Nd in the Mineralized Tributary at high concentration
- Flow is ~ 2.5 L/s
- Average amount of Nd in a phone is 160 mg

- 1  phone's worth of Nd every 5.5 minutes
- **Enough Nd to supply 96,000 phones per year**
  - This is for a single tributary!

# A third source of metals?

- Water quality team noticed white floc appearing just above the tributaries
- Could indicate a third source of metals to Lincoln Creek entering through groundwater





# Summary of Preliminary Findings

- Trace metal findings align with those from the EPA
    - Entering Grizzly Reservoir, copper, aluminum, and zinc concentrations are high enough to harm aquatic life according to CDPHE aquatic life standards

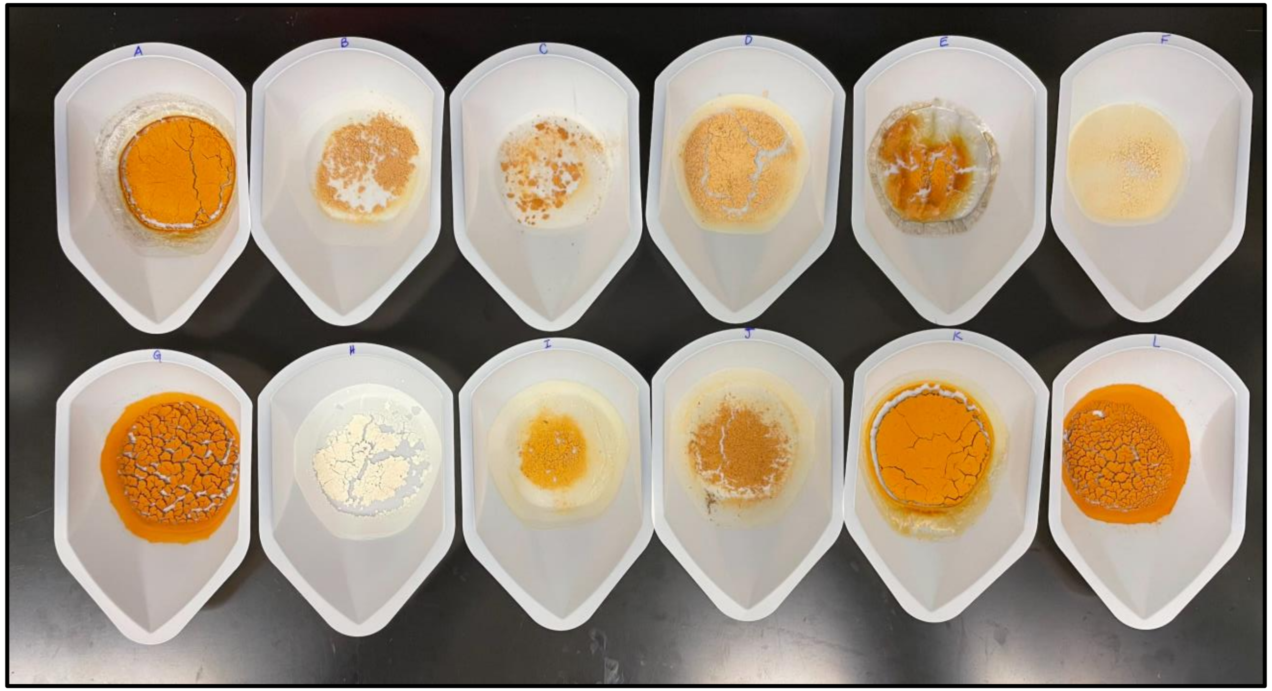
- REEs added to Lincoln Creek via the Mineralized Tributary and Ruby Mine Tributary

- The concentration of REEs in the Mineralized Tributary is comparable to other low pH AMD/ARD tributaries

- A groundwater source could also be adding metals to Lincoln Creek

# Next Steps – Flocculent Scrapings

- Major Cation, Trace Metal, and REE mass in floc.
- Are REEs precipitating alongside other metals?



# Next Steps – Sediment Cores

- Carbon-14 dating
- Has the metal contamination of Lincoln Creek always been this severe?
- Major Cation, Trace Metal, and REE mass in sediment
- Are REEs adsorbing to sediment?

# Next Steps – Benthic Macroinvertebrates

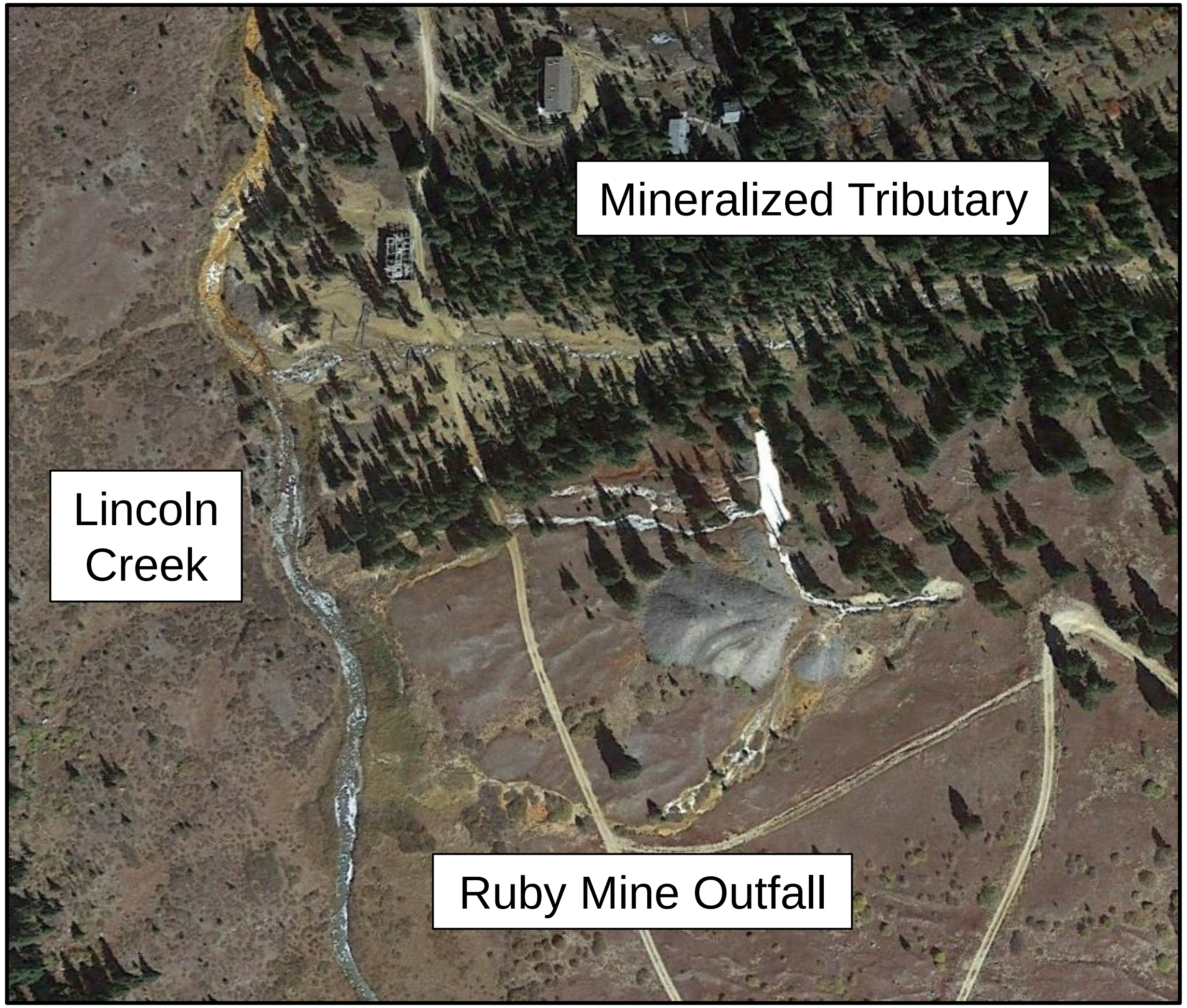
- Analyze functional feeding groups and families to help quantify stream health
- Digest and analyze the BMIs to determine concentration of trace metals and REEs being assimilated



# Impacts of CU's study - Local

- Increase understanding of metal contamination of Lincoln Creek

- Detection is necessary to determine the feasibility of REE extraction

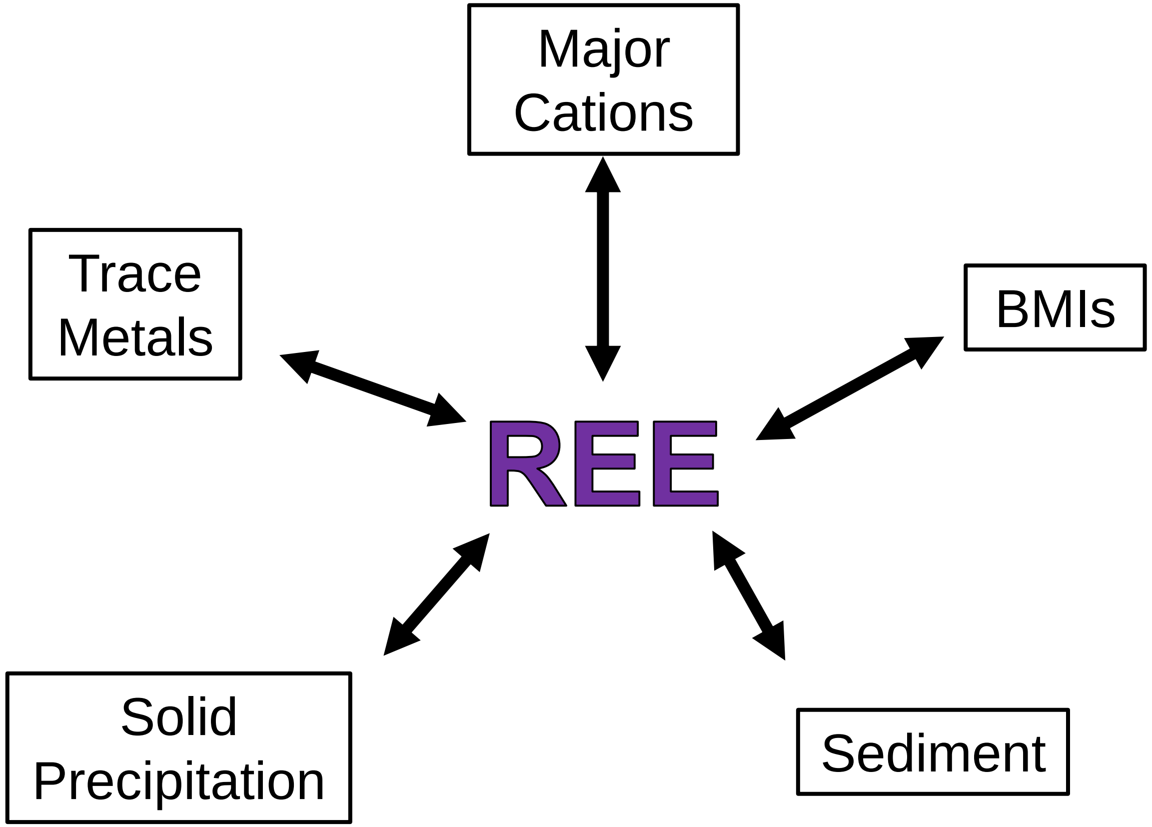


# Impacts of this study – Scientific Community

- The fate of REEs in aquatic systems is not well understood.
  - We are hoping to aid in changing that

- Increase knowledge of REE toxicity to aquatic biota – namely benthic macroinvertebrates

- Examine interactions between Rare Earth Elements and other cations in aquatic systems



# Thank You!

**Questions?**