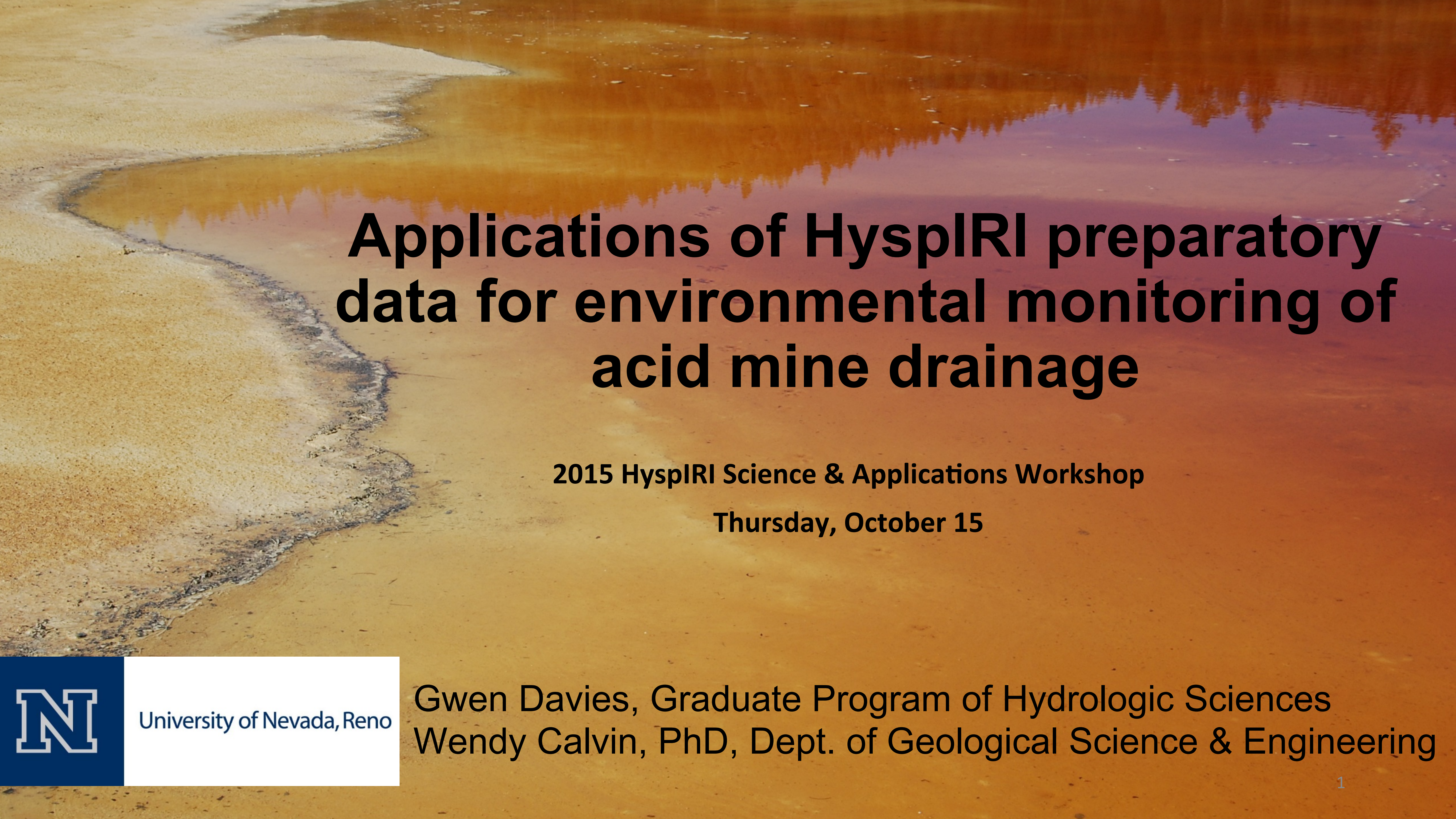


Applications of HyspIRI preparatory data for environmental monitoring of acid mine drainage

2015 HyspIRI Science & Applications Workshop

Thursday, October 15

University of Nevada, Reno

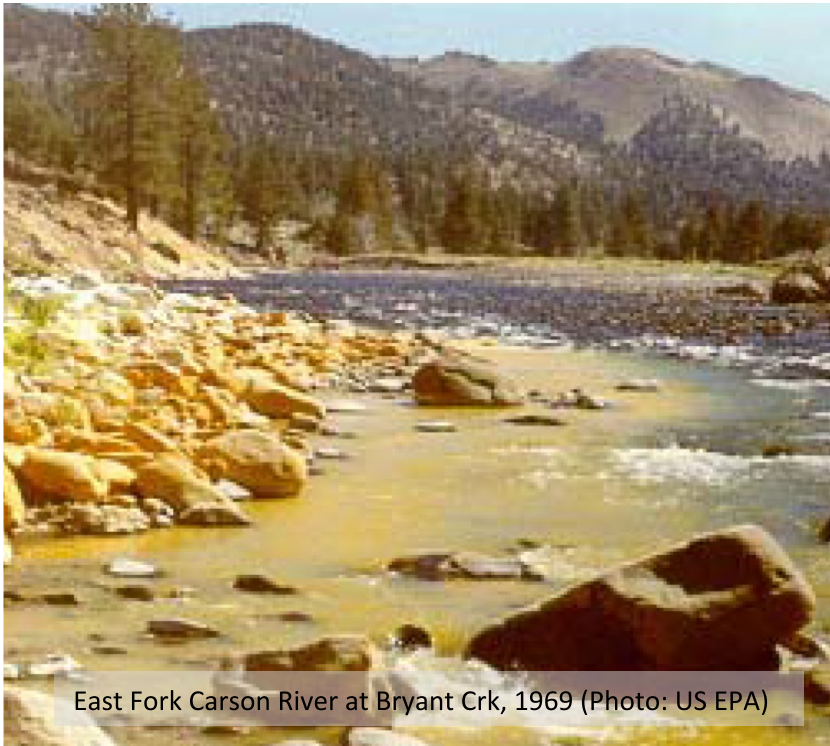
Gwen Davies, Graduate Program of Hydrologic Sciences
Wendy Calvin, PhD, Dept. of Geological Science & Engineering

Motivations:

- Some 20,000 km of river are contaminated by hardrock mining in U.S. (EPA, 1997).
- About 40 pit lakes in the state of Nevada, and increasing (Shevenell, 2000).
- Hyperspectral RS a tool for rapid assessment of acid mine drainage contamination and monitoring environmental quality/regulatory compliance.

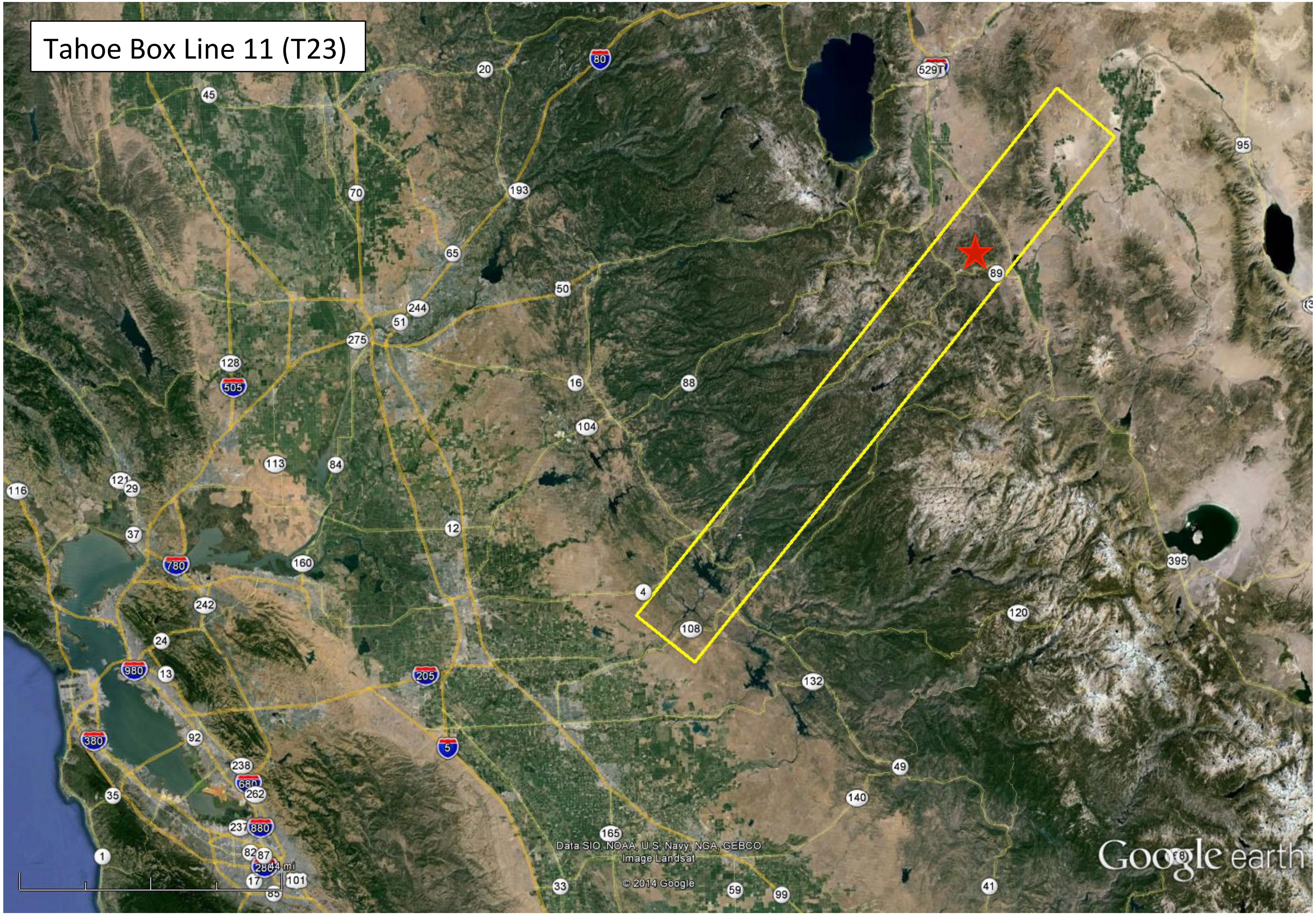
Lone Tree Pit Lake, Nevada, 2009 (Photo: Feltsoulmedia)

Leviathan Crk, 1999 (Photo: US EPA)

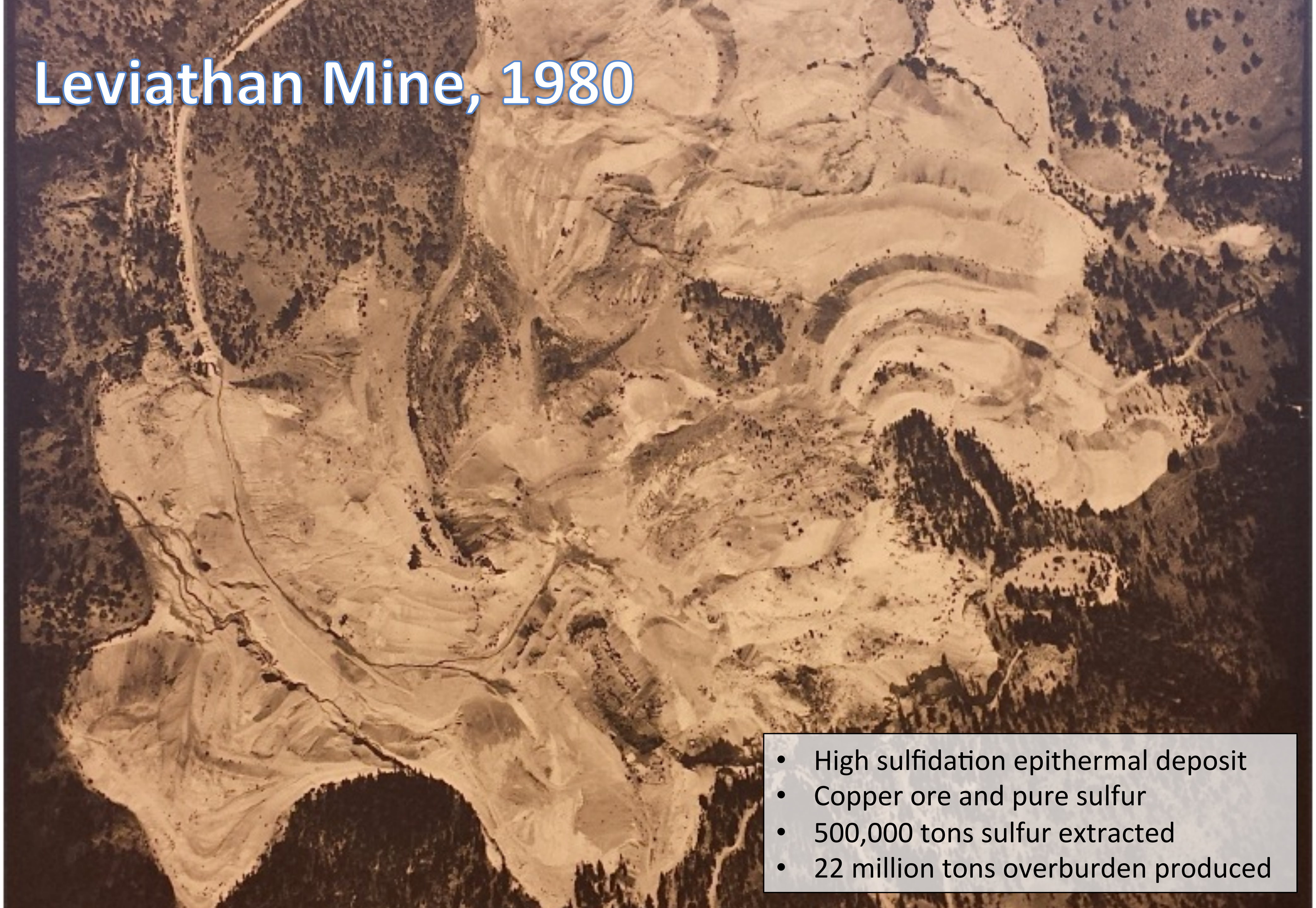


East Fork Carson River at Bryant Crk, 1969 (Photo: US EPA)

Tahoe Box Line 11 (T23)

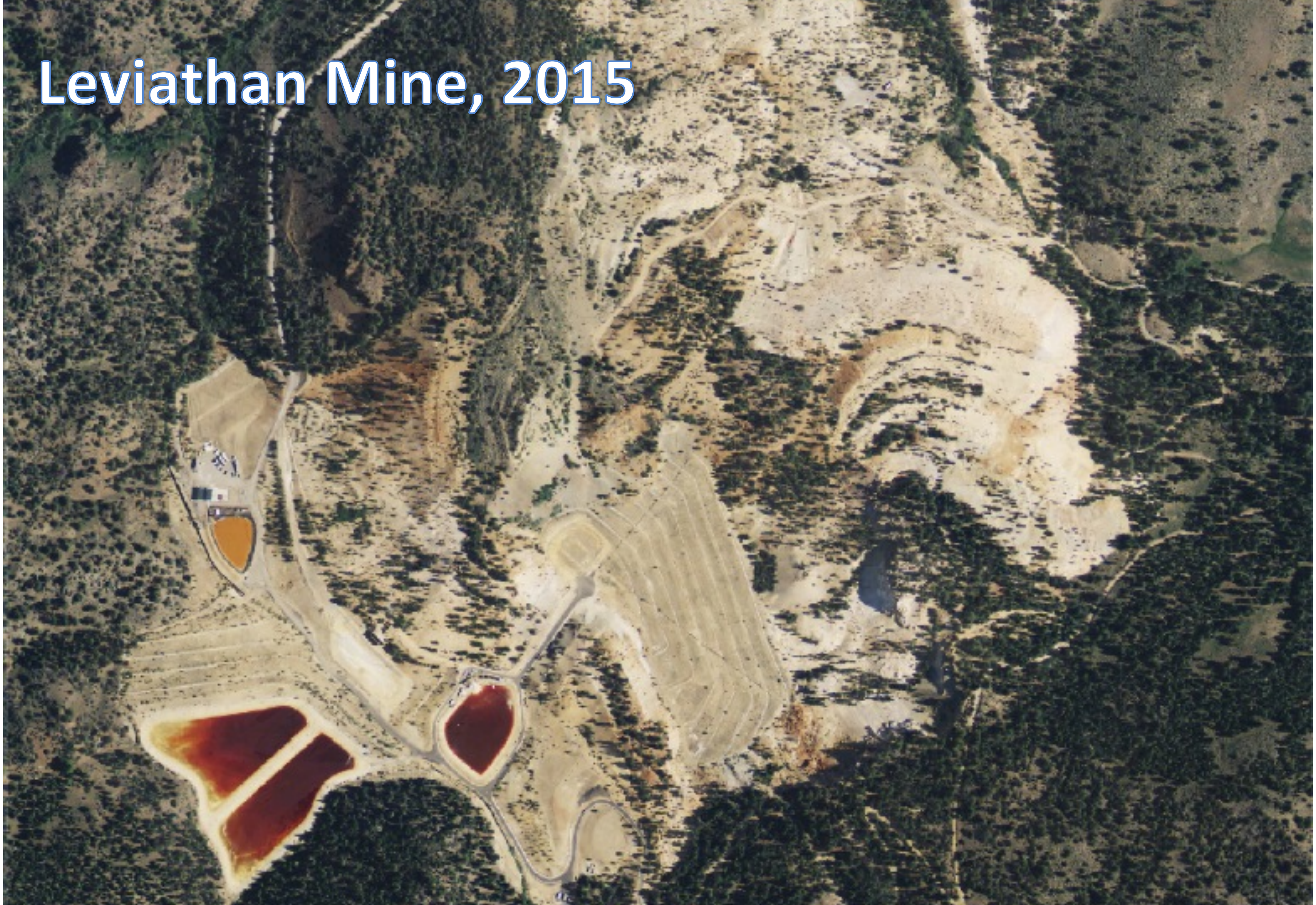


Leviathan Mine, 1980

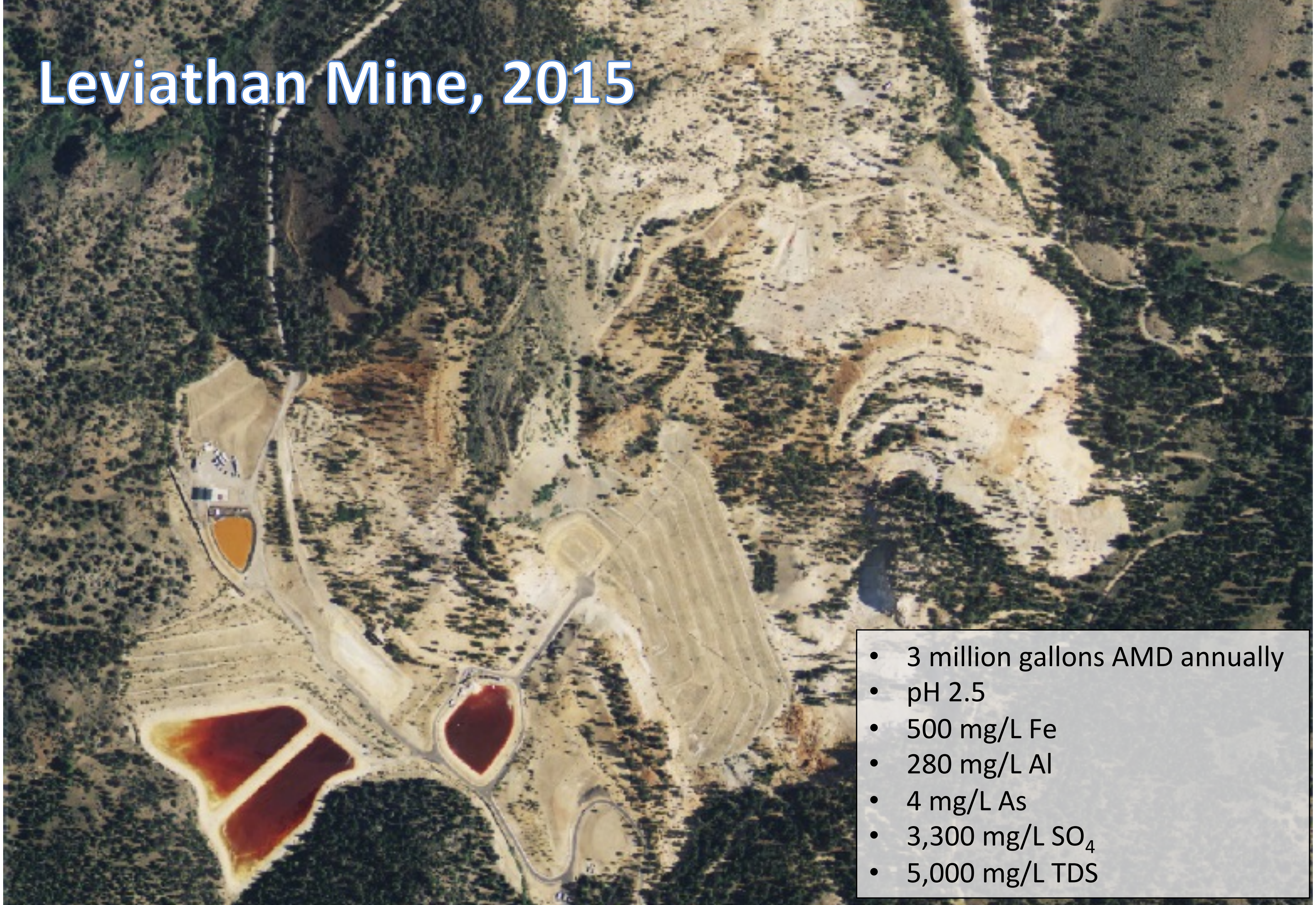


- High sulfidation epithermal deposit
- Copper ore and pure sulfur
- 500,000 tons sulfur extracted
- 22 million tons overburden produced

Leviathan Mine, 2015

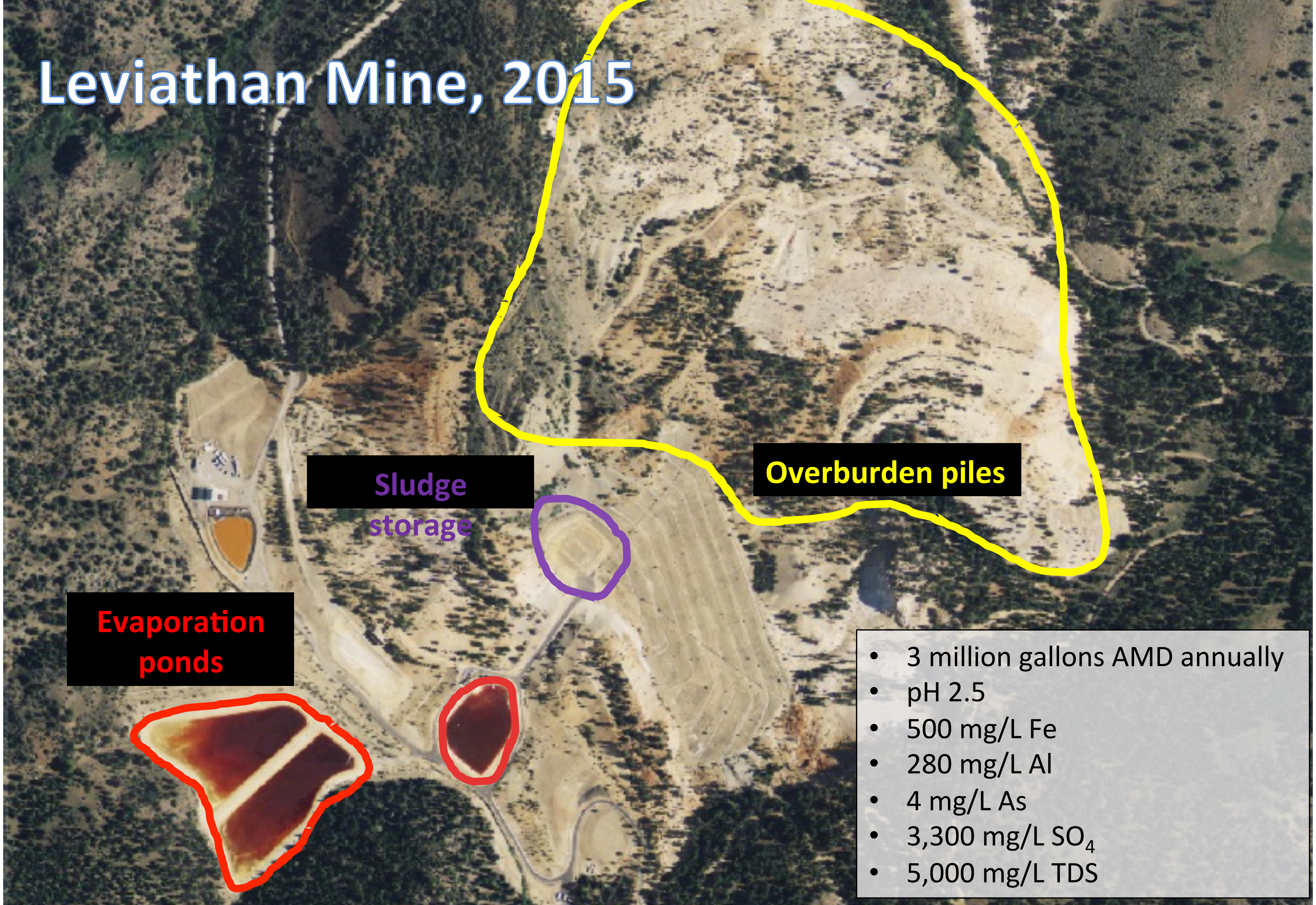


Leviathan Mine, 2015



- 3 million gallons AMD annually
- pH 2.5
- 500 mg/L Fe
- 280 mg/L Al
- 4 mg/L As
- 3,300 mg/L SO_4
- 5,000 mg/L TDS

Leviathan Mine, 2015



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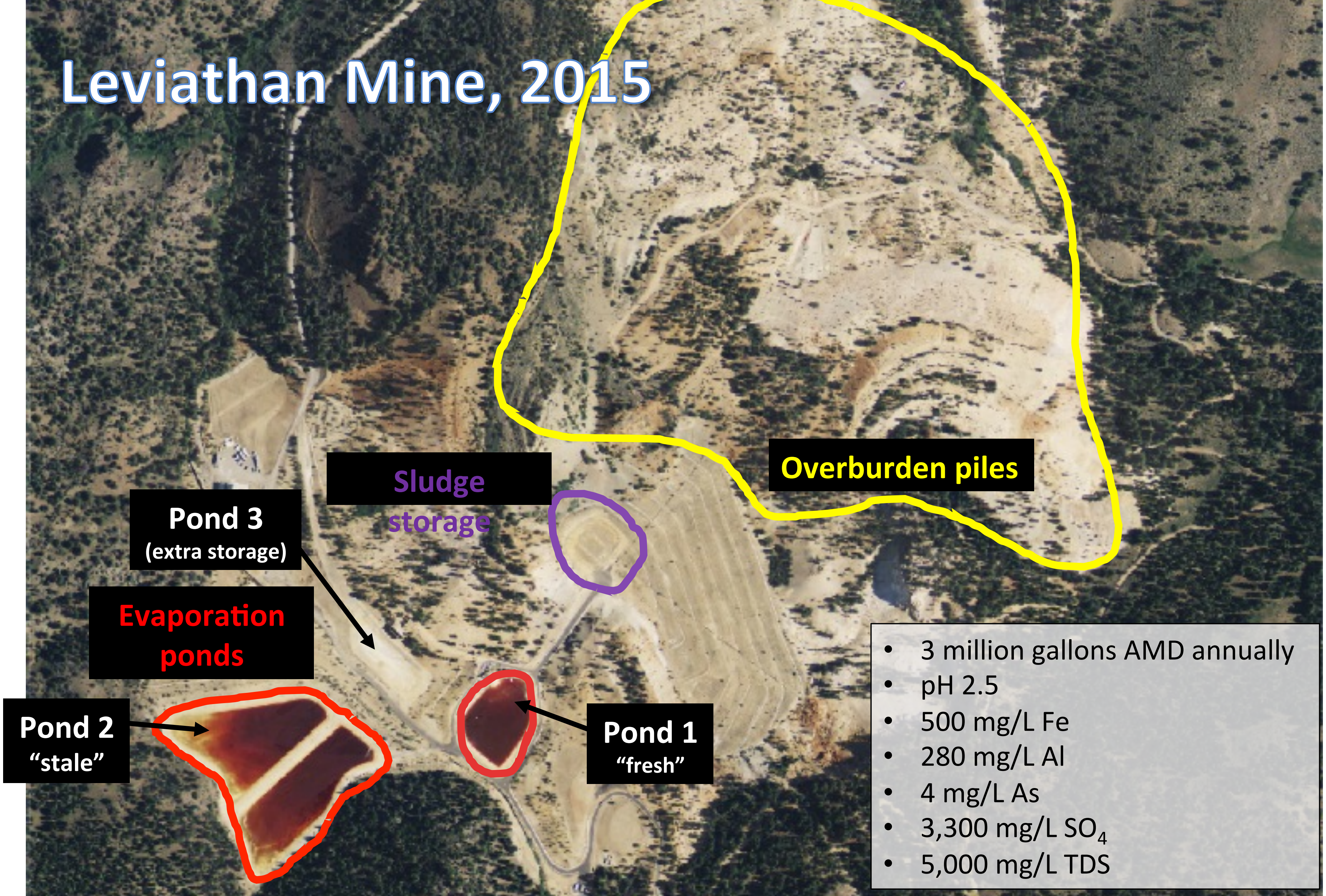
Leviathan Mine, 2015



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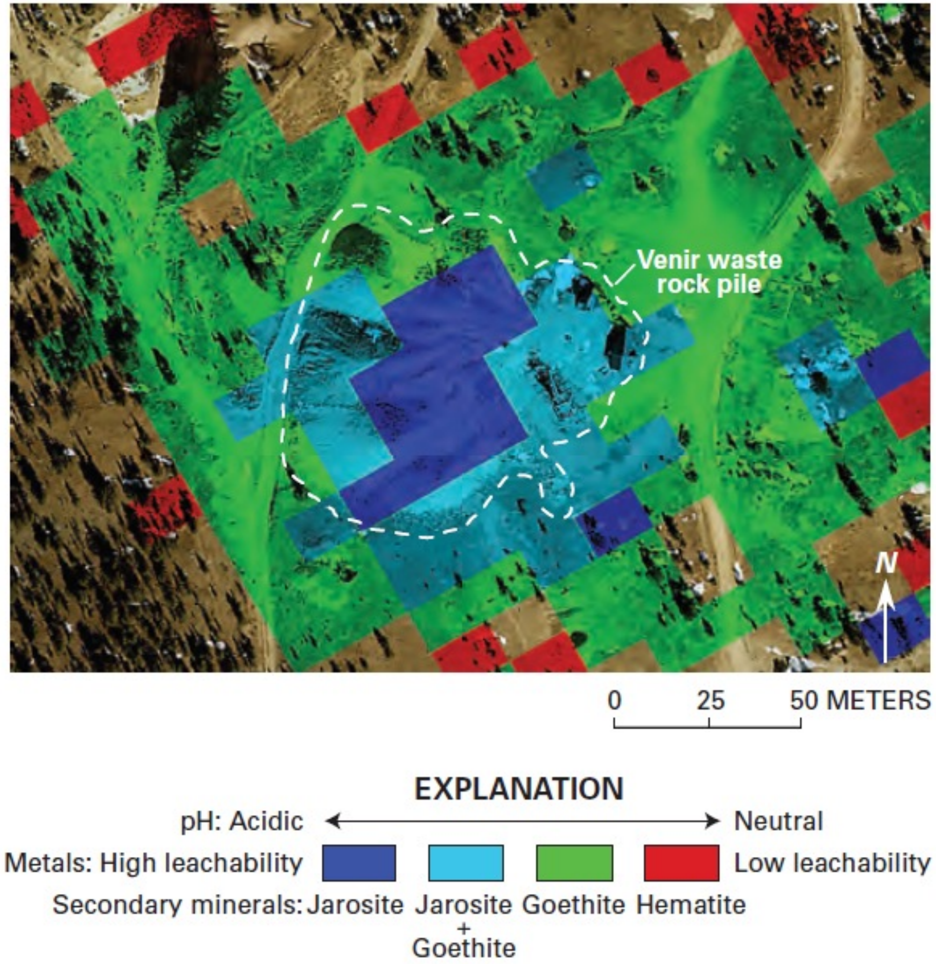
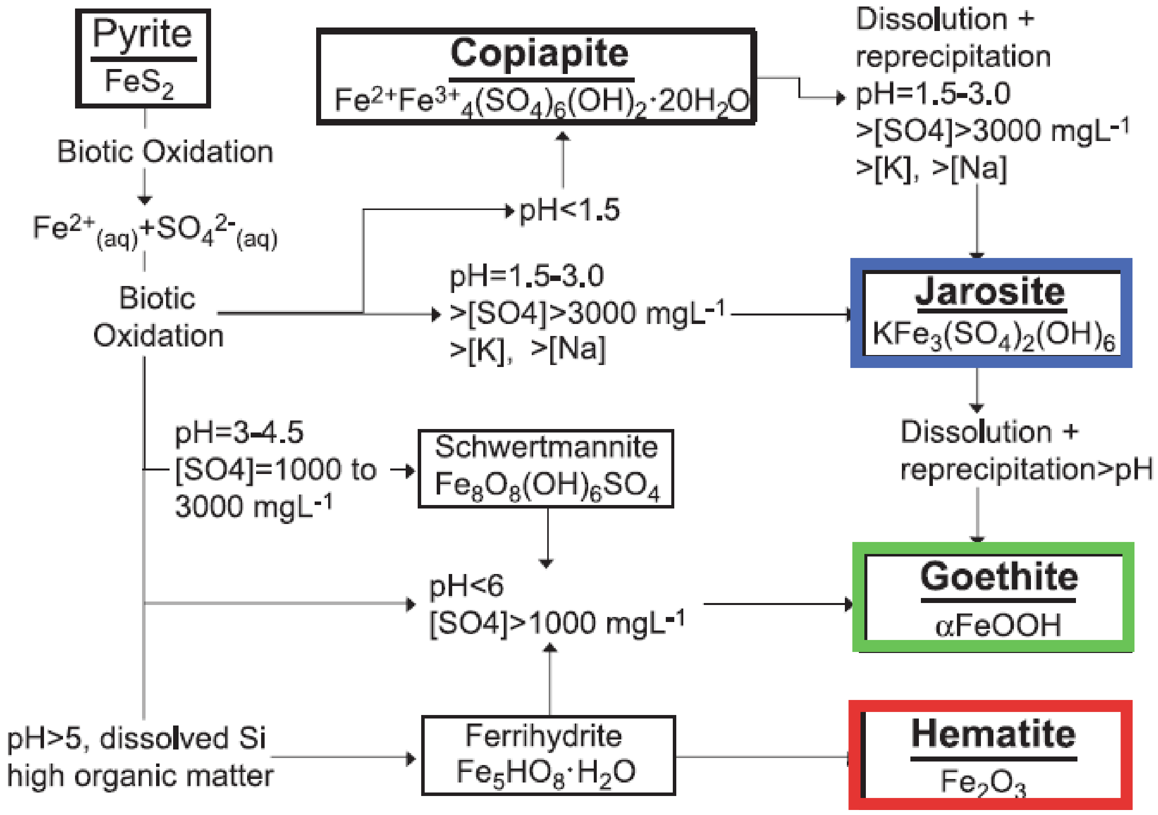
Previous Work:

California Gulch Superfund Site near Leadville, CO
(Swayze et al. 2000)



Penn Mine, CA (Montero et al. 2005)



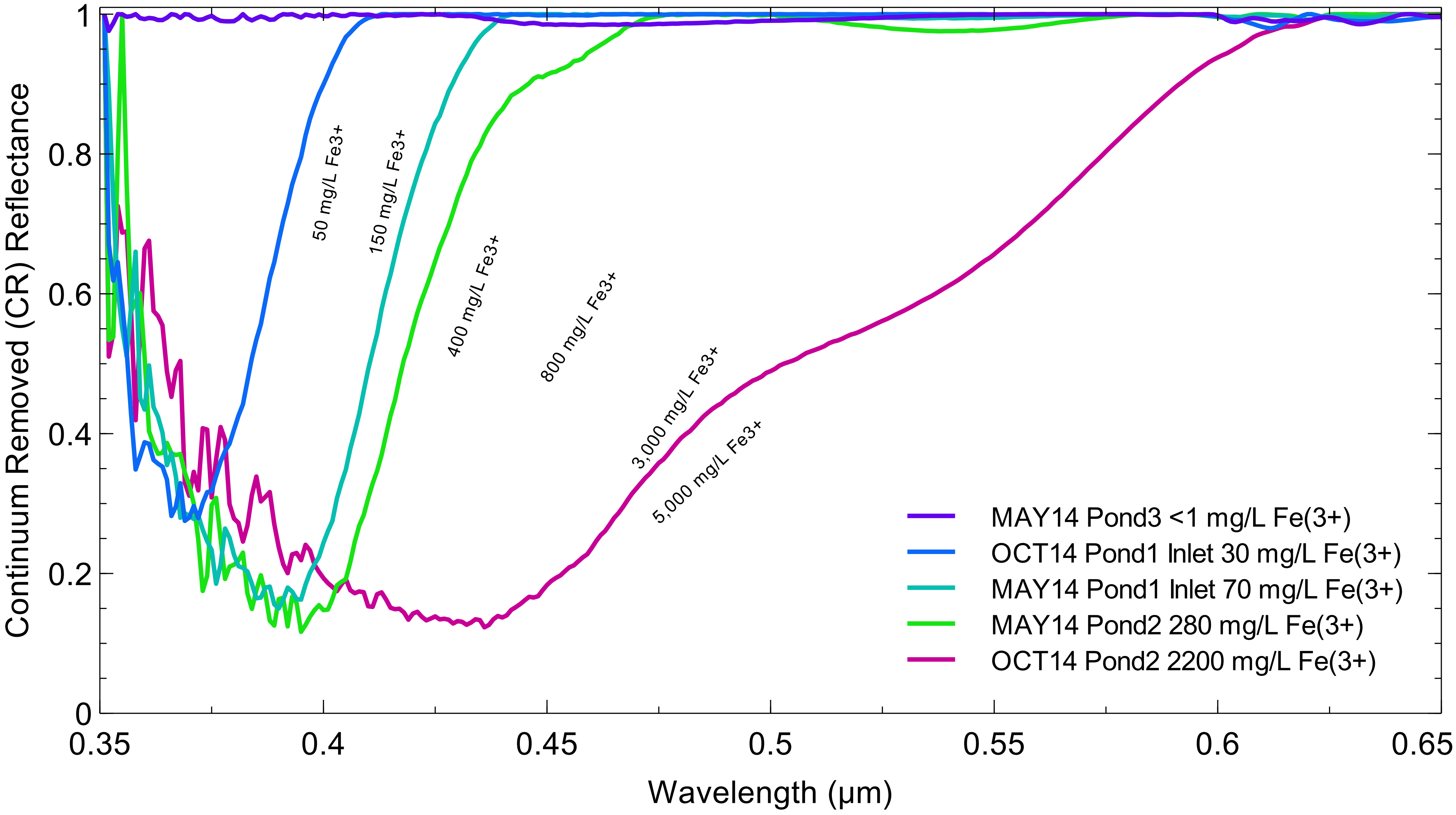
Objectives:

1. Identify unique spectral response of ponded AMD waters (similar to what a filled-in mining pit lake would look like)
2. Identify spectral endmembers from scenes with varying spatial resolution
    - 2 m (commercial flight)
    - 15 m
    - 30 m
    - 60 m

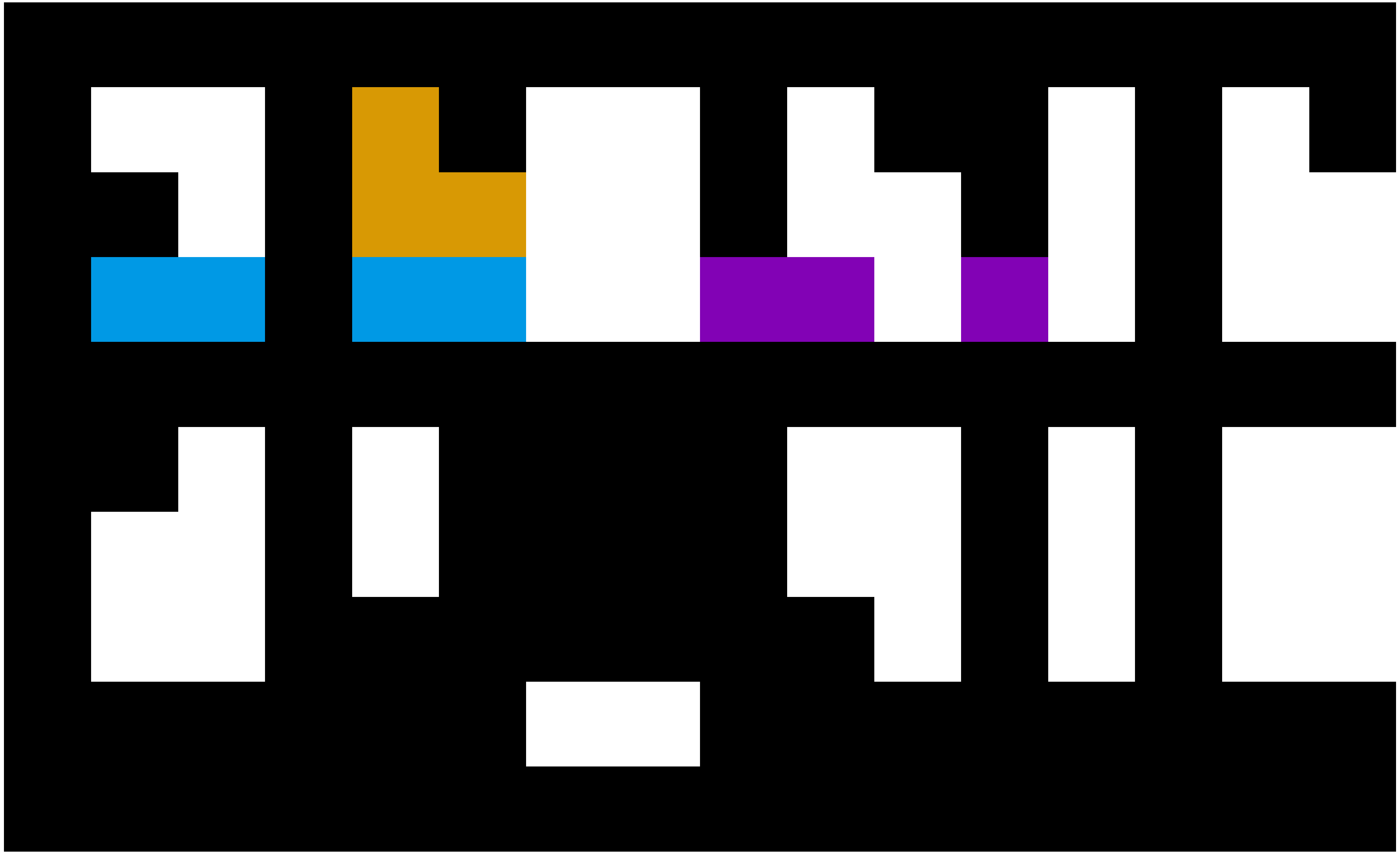
HyspIRI flights

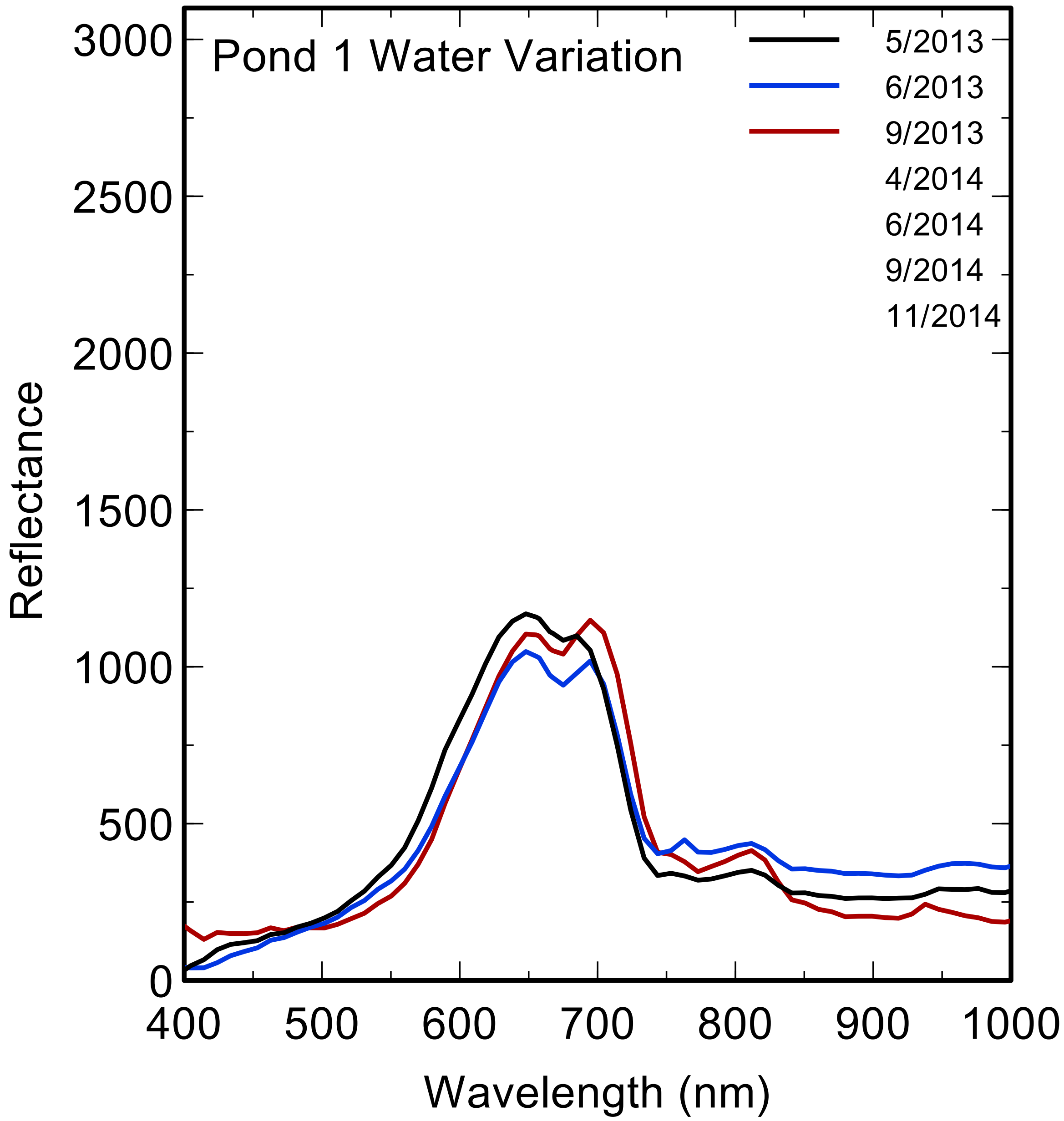
Could HyspIRI be useful in identifying high priority contamination zones at mining sites and monitor mining pit lakes?

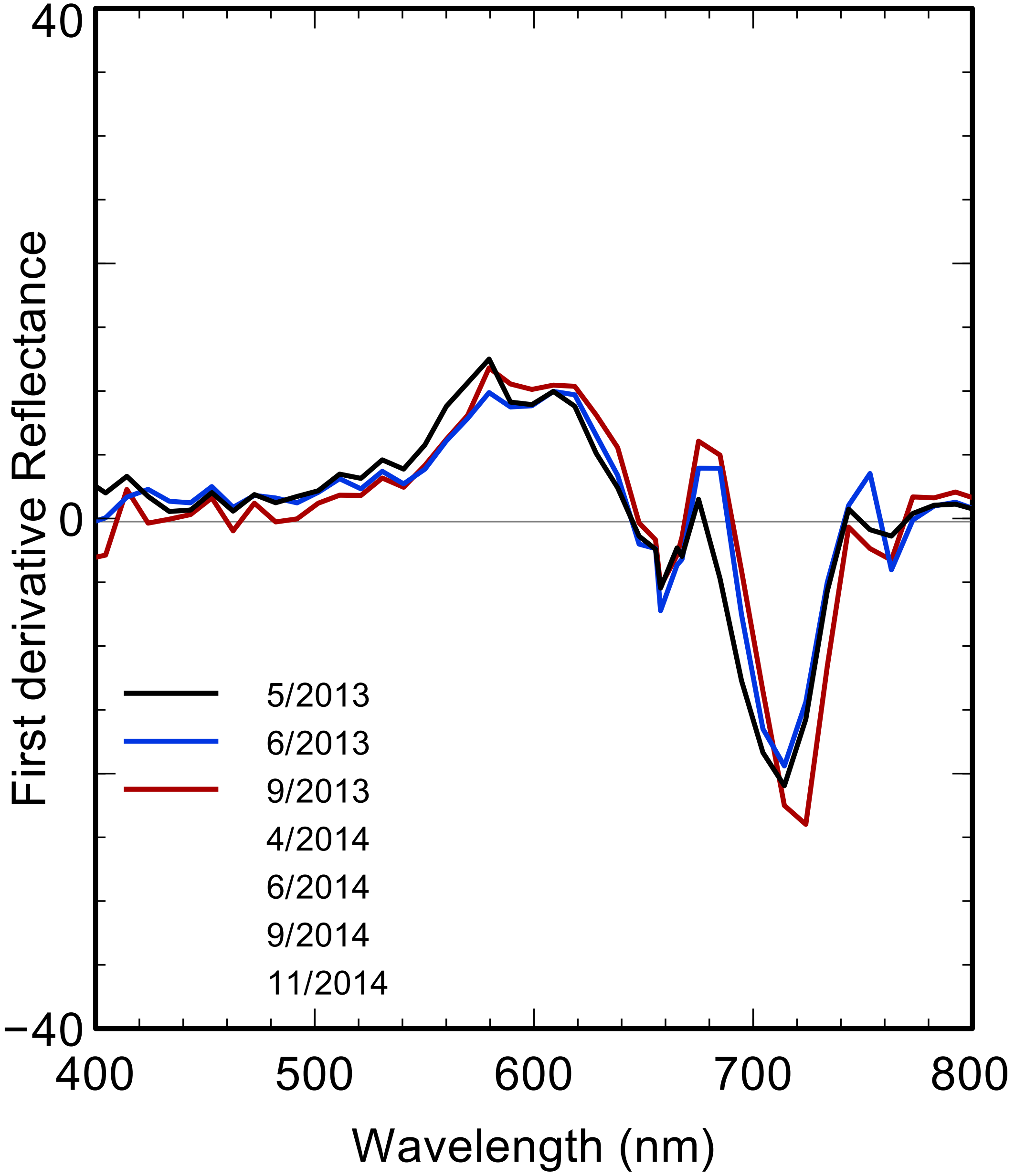
Relationship Between Ferric Iron Concentration and Spectral Reflectance of Aqueous Solutions



Davies G, Calvin W (2015) Quantifying iron concentration in local and synthetic acid mine drainage waters: A new technique using handheld field spectrometers. *(manuscript submitted for publication 9/2015)*




Pond 1 Water Variation
5/2013
6/2013
9/2013
4/2014
6/2014
9/2014
11/2014
Reflectance
0
500
1000
1500
2000
2500
3000
400
500
600
700
800
900
1000
Wavelength (nm)


First derivative Reflectance
40
0
−40
5/2013
6/2013
9/2013
4/2014
6/2014
9/2014
11/2014
400
500
600
700
800
Wavelength (nm)

Methods:

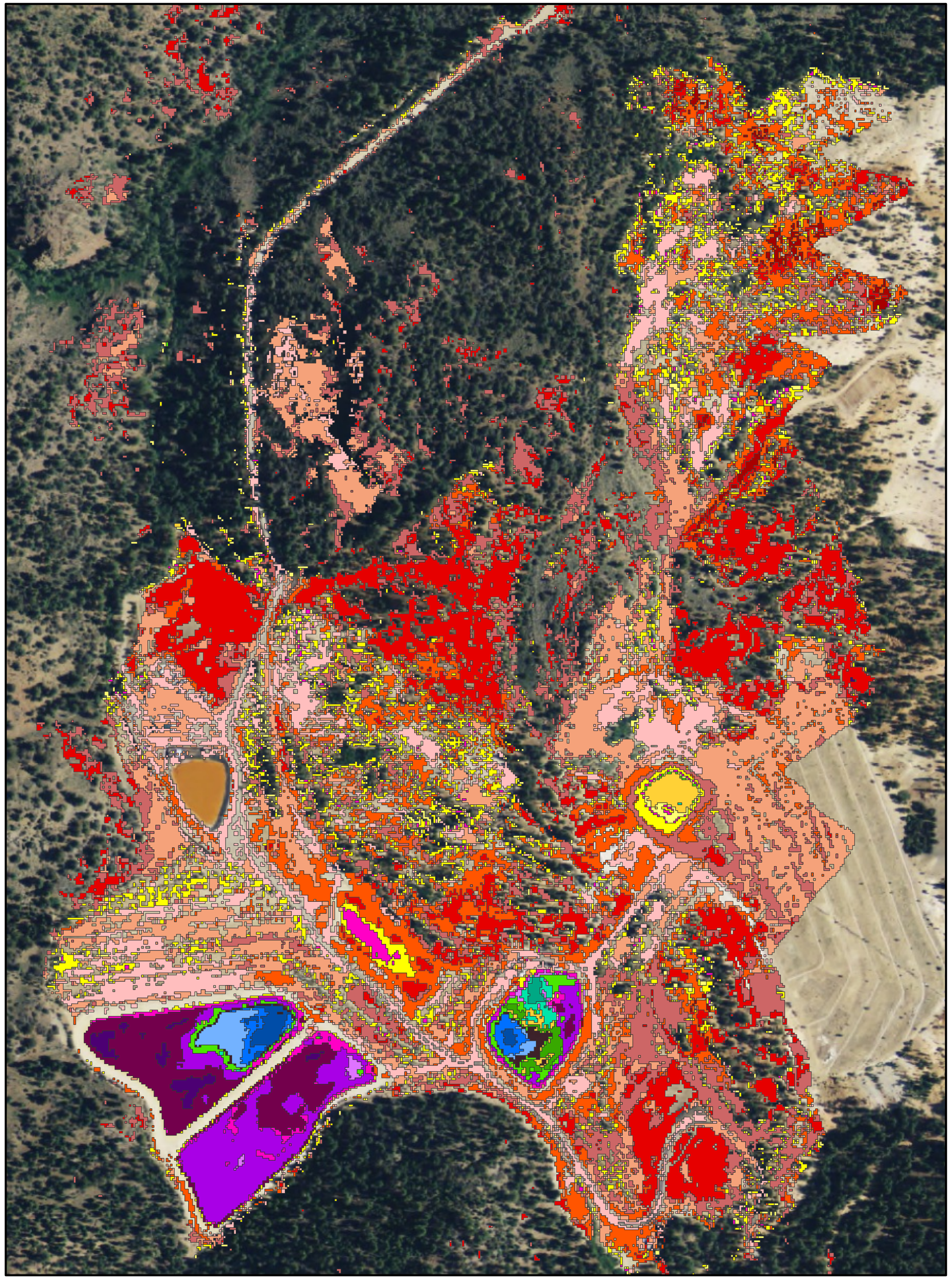
2. Image Classification
    - Subset to mine area, about 11 km^2 area box
    - Amply NDVI mask, threshold 0.5
    - Resampled all HyspIRI images to consistent number of bands
    - ENVI Spectral Hourglass Wizard (MNF, PPI, n-D, SAM)

Results: Classifications

	Endmembers	2m (ProSpecTIR 8/07)	15m (AVIRIS 9/13)	15m (AVIRIS 9/14)	30m (HyspIRI 9/13)	60m (HyspIRI 9/13)
	1.) **Pond water**	Y	Y	--	Y	N
	2.) **Wet Pond Sediment** (algae - chlorophyll influence)	Y	Y	Y	Y	N
	3.) **Pond $FeSO_4$** (strong jarosite features→ acidic/ highly leachability)	Y	Y	Y	Y	Y
	4.) **Overburden FeOHs/ clays** (jarosite + goethite + ferrihydrite + kaolinite mix → neutral/low leachability)	Y	Y	Y	Y	Y
	*Clarifier $CaSO_4$ (gypsum→ non-acid forming)	Y	Y*	Y*	N	N

ProSpecTIR

311 channels (398-2455nm)
2m pixel
8/17/2007



Classifications:

Pond Water
🟦
🟦
🟦

Wet Pond Sediment
🟩
🟩

Mg Sulfate
🟩
🟩

Clarifier Gypsum
🟨
🟨
🟨

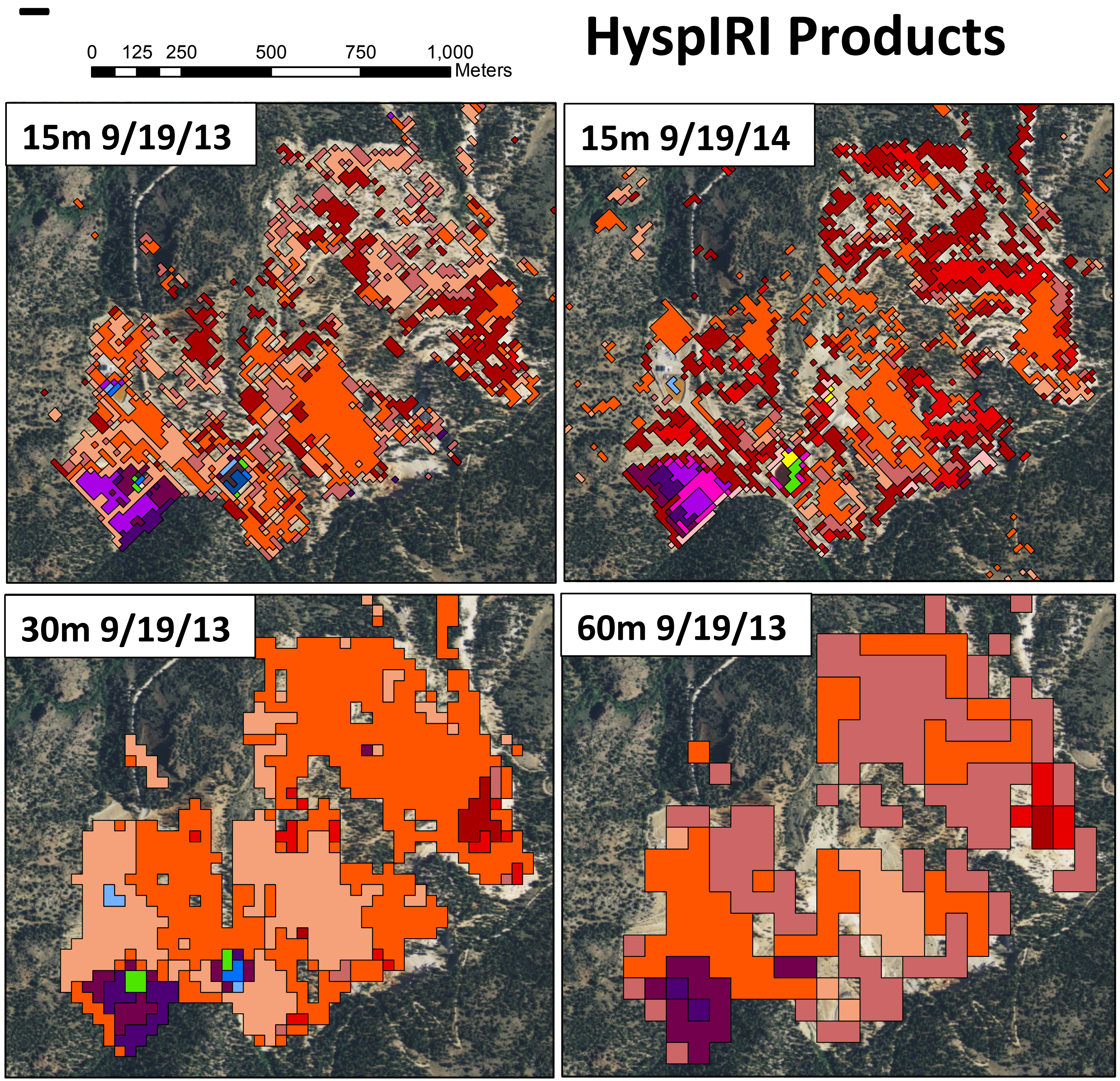
Pond Iron Sulfates
🟪
🟪
🟪
🟪
🟪

AMD minerals

Overburden FeOH/Clays
🟥
🟥
🟧
🟥
🟧
🟥

0 70 140 280 420 560
Meters

HyspIRI Products



Classifications:

Pond Iron Sulfates

🟪
🟪
🟪
🟪
🟪

AMD minerals

Overburden FeOH/Clays

🟥
🟥
🟧
🟥
🟧
🟥

Pond Water

🟦
🟦

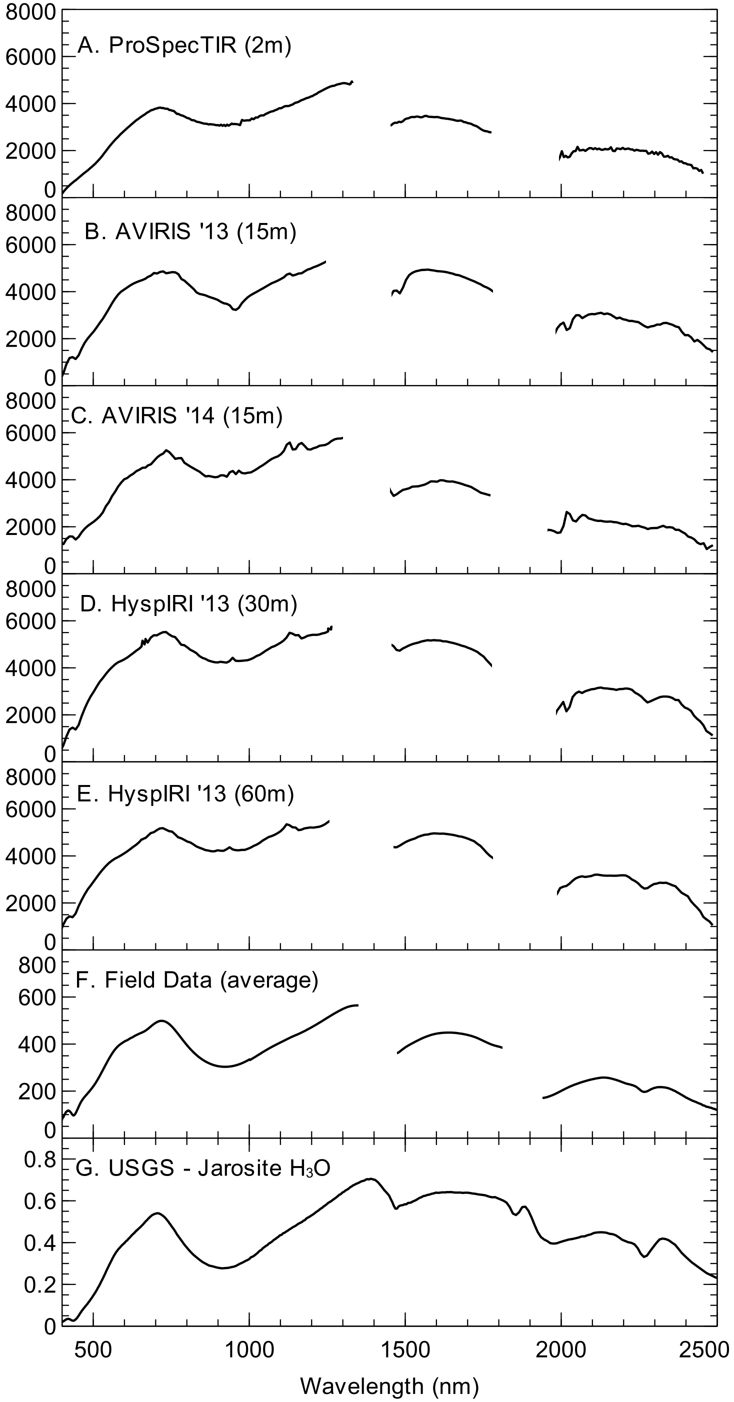
Wet Pond Sediment

🟩

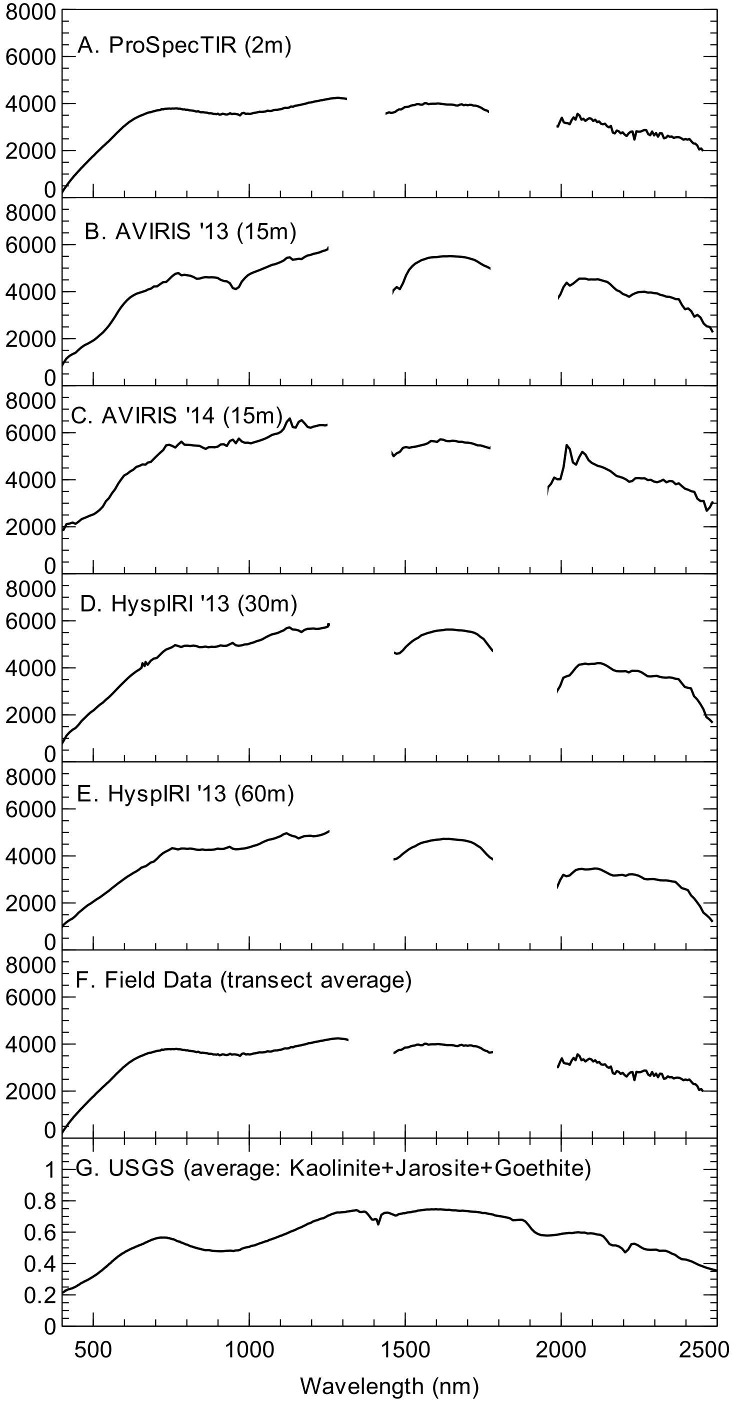
Clarifier Gypsum

🟨

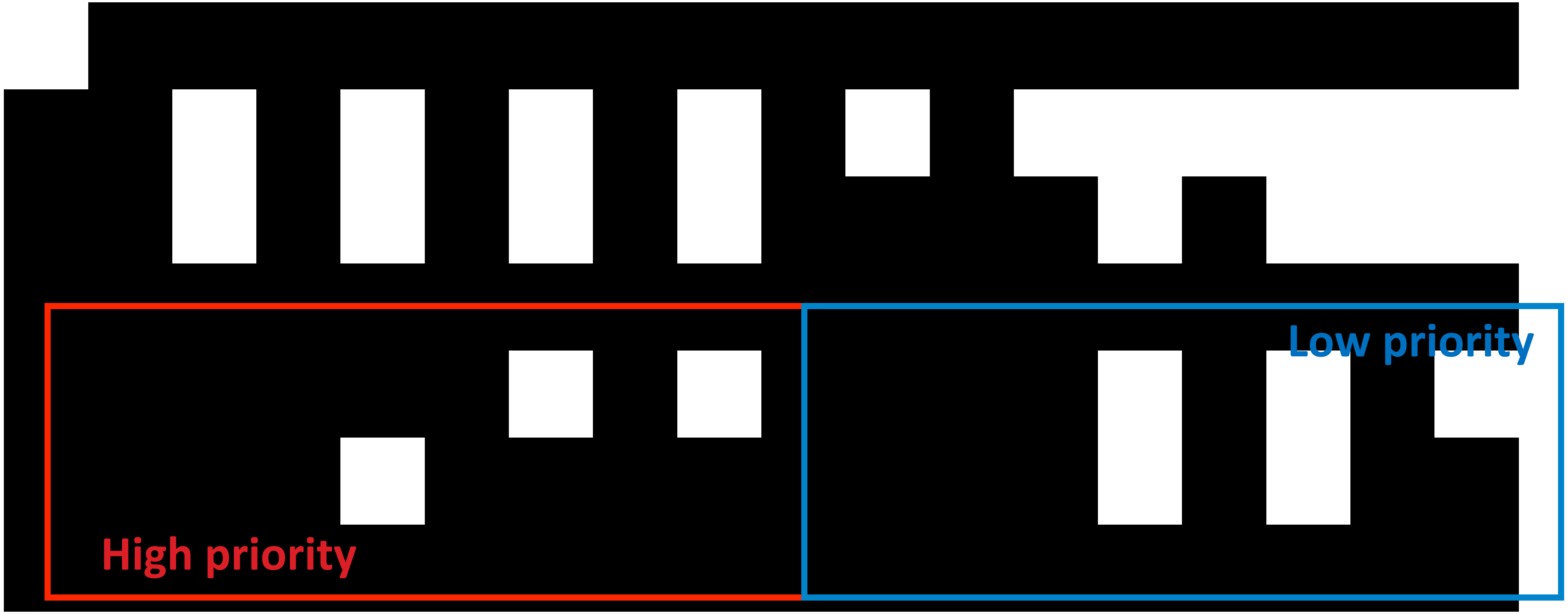
Pond Liners - $FeSO_4$ Endmember



Overburden Piles -FeOH/clay Endmember



Summary: HyspIRI 30m Endmembers



Conclusions:

- HyspIRI (30m) images could be used to identify mine pit lakes from natural lakes and potentially monitor changes in mine pit lake water quality
- HyspIRI (30m) images are useful for identifying high priority contamination zones at mining sites
    - 2m and 15m pixels can resolve more endmembers with superior spatial extent, however 30m and 60m get the job done as well.

Questions

Monitor Pass Mining Area

9/2014

9/2015

References:

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Montero, I.C., Brimhalla, G.H, Alpers, C.N, Swayze, G.A. (2005) Characterization of Waste Rock Associated With Acid Mine Drainage at the Penn Mine, CA, by Ground-Based Visible to Short-Wave Infrared Reflectance Spectroscopy Assisted by Digital Mapping. Chemical Geology 215: 453-472.

Shevenell, L.A. (2000) Water quality in pit lakes in disseminated gold deposits compared to two natural, terminal lakes in Nevada. Environmental Geology 37: 7.

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