Monitoring water quality & soils at Leviathan Mine, CA

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- Exploration for Renewable Energy (Geothermal)
- Signatures of Critical Mineral Resources
- Landscape change associated with large scale energy and mineral development
- Natural Hazards
  - Acid Mine Drainage Environments
  - Volcanic Activity

Overview of Project

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Leviathan Mine
Mono-Inyo Craters
Salton Sea
Great Salt Lake Desert
Nevada
Sierra Nevada Mountains
San Jose
Fresno
Bakersfield
Los Angeles
Riverside
San Diego
Santa Cruz Island
Santa Rosa Island
Anacapa Island
Sonoran Desert
Baja California
© 2013 INEGI
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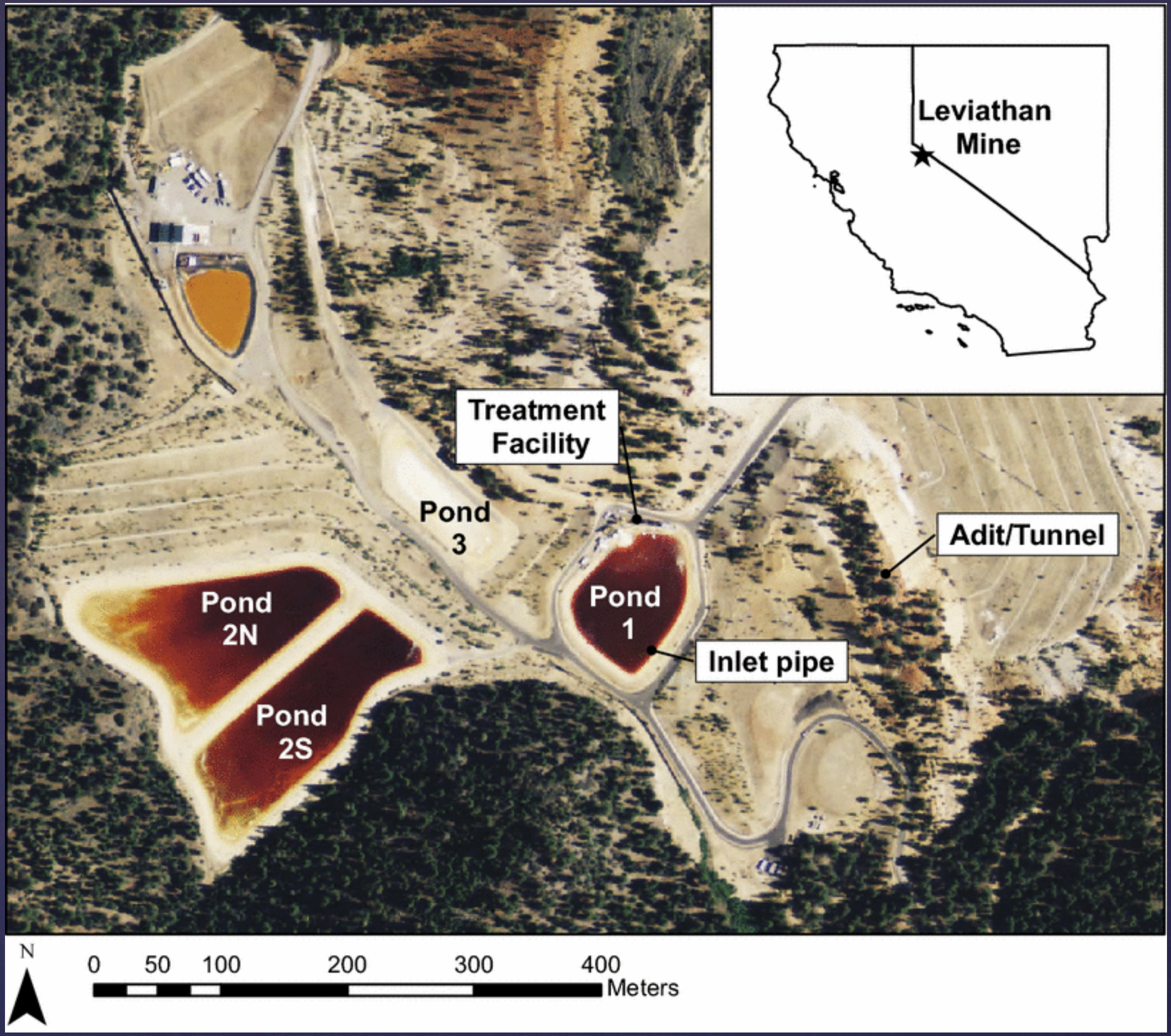
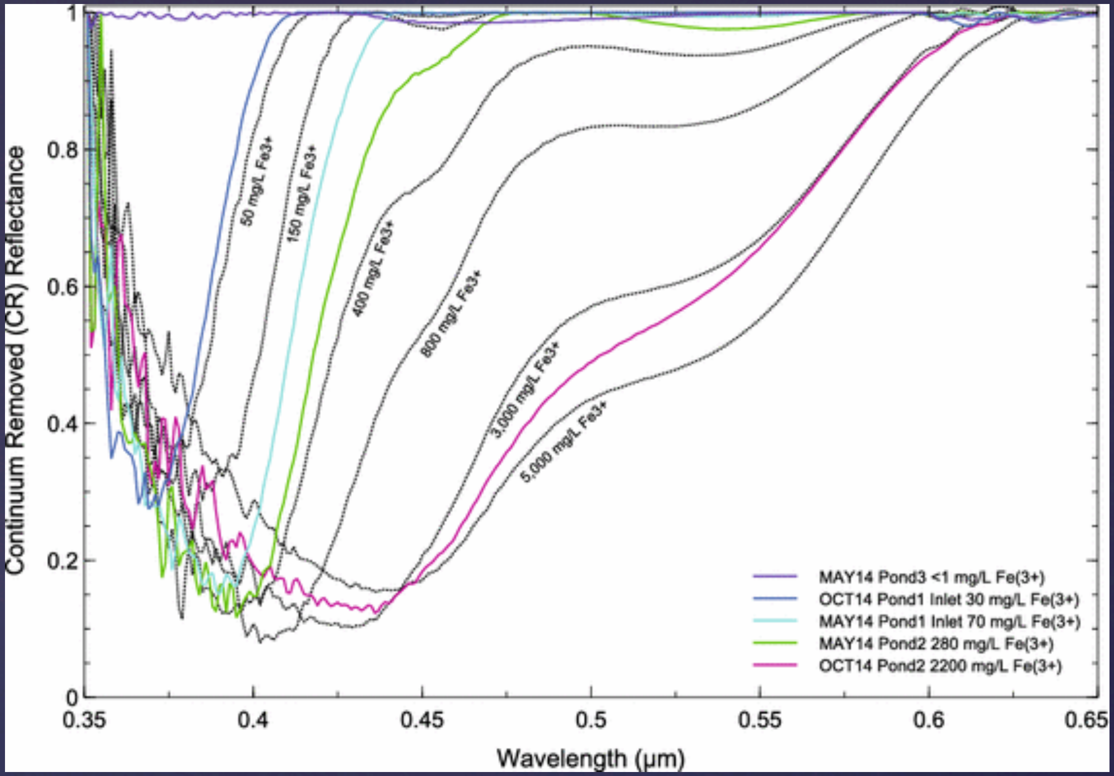
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
35°32'33.26" N 118°54'07.34" W elev 1052 ft eye alt 646.66 mi

Publications to Date

- Davies, G. E. and W. M. Calvin, Quantifying iron concentration in local and synthetic acid mine drainage: A new technique using handheld field spectrometers, *Mine Water and the Environment*, 1-11 DOI 10.1007/s10230-016-0399-z, 2016.
- Calvin W. M. and Pace, E. L., Utilizing HyspIRI Prototype Data for Geological Exploration Applications: A Southern California Case Study, *Geosciences*, *6*(1), 11; doi:10.3390/geosciences6010011, 2016.
- Nearing submission
  - Davies, G. E. and W. M. Calvin, Using multi-season airborne hyperspectral imagery to examine mine affected water bodies.
  - Davies, G. E. and W. M. Calvin, Mapping acidic mine waste with seasonal airborne hyperspectral imagery at varying spatial scales: An evaluation for application of future spaceborne hyperspectral imagery to hazardous mine waste monitoring.



Leviathan Mine



There is a good correlation between iron concentration and absorption feature strength in synthetic laboratory solutions. Concentration is somewhat over predicted for natural waters.

Mine Water & Environment

Properties of mine waters in airborne data

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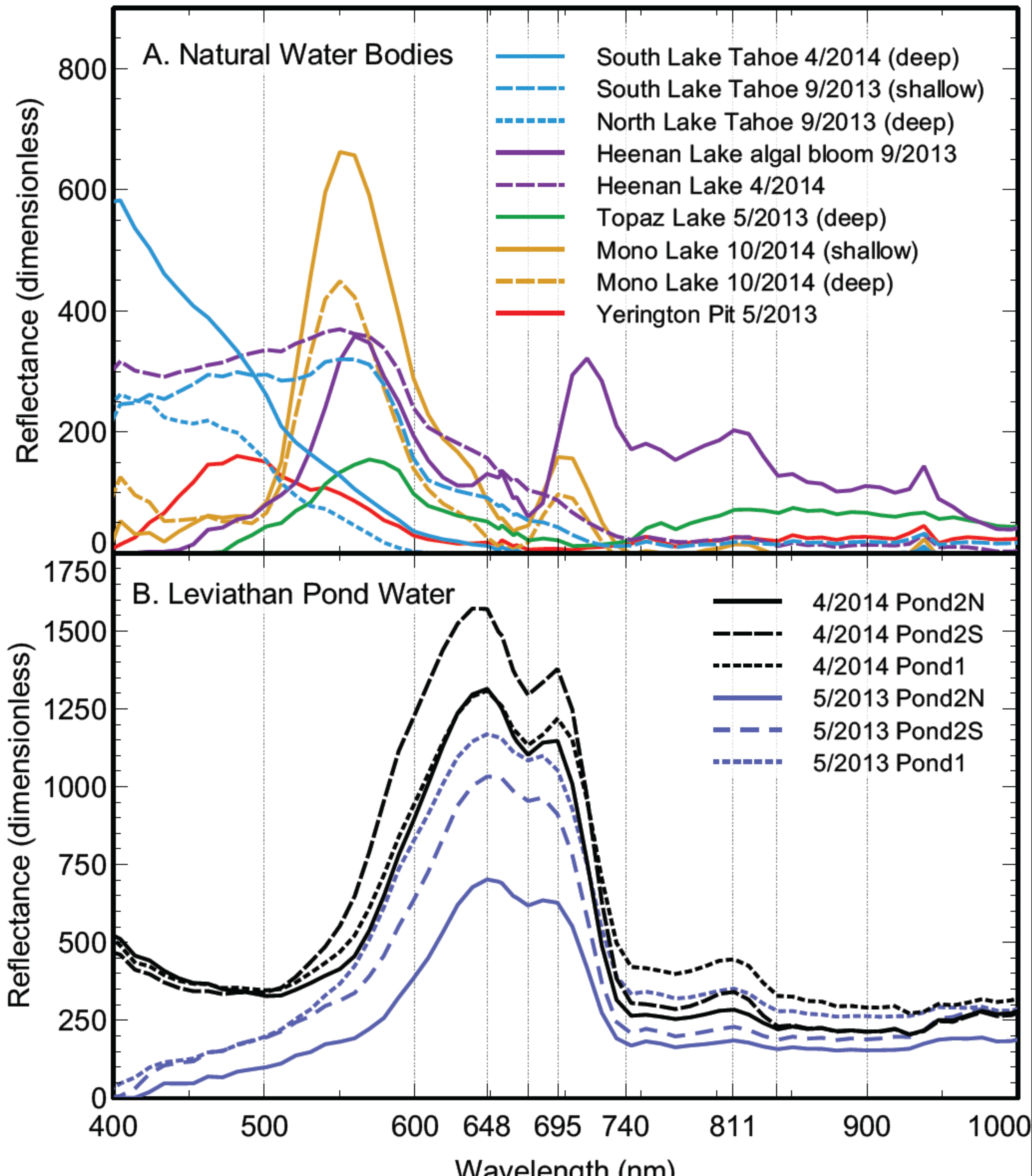
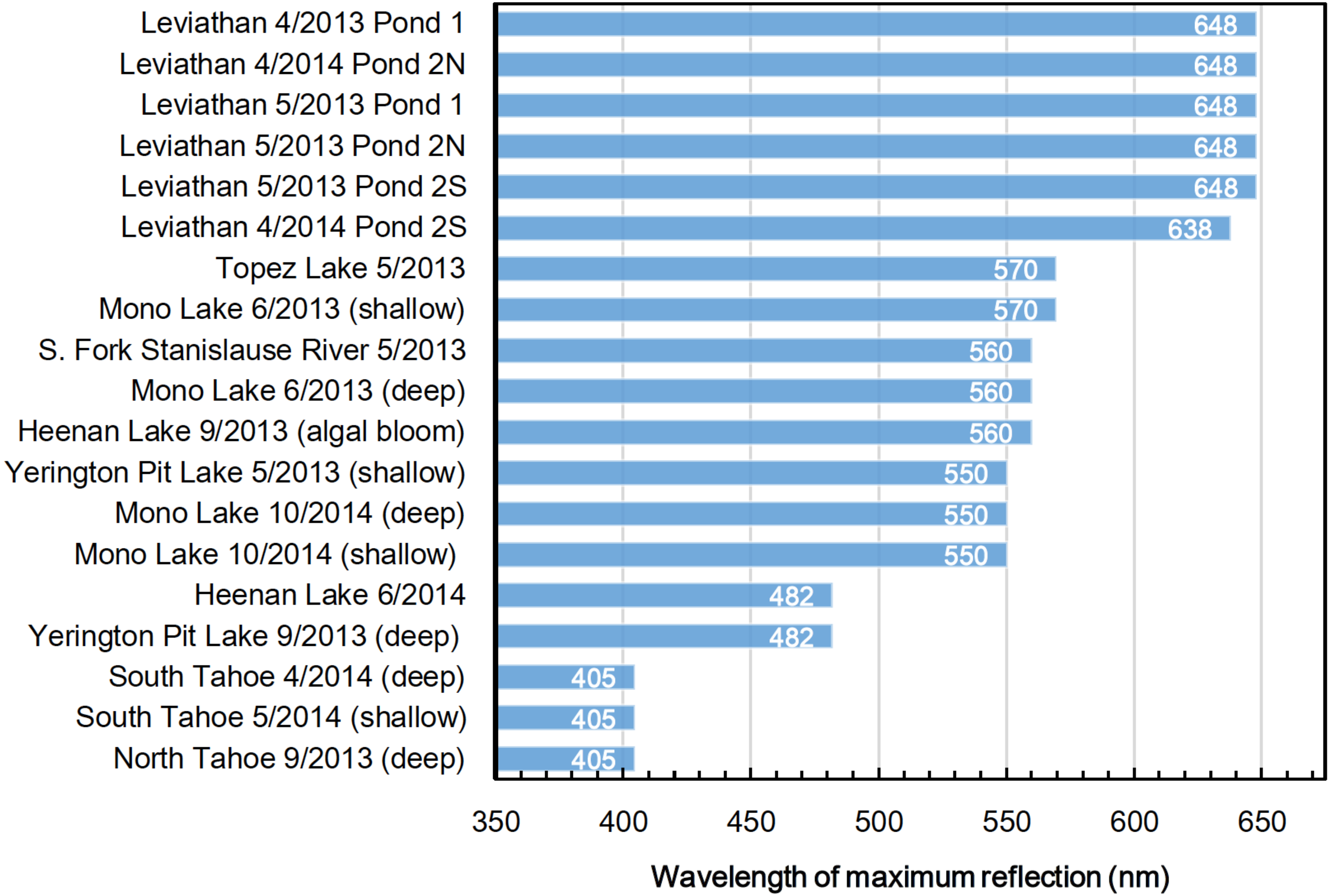
Attempted to apply laboratory curves to AVIRIS data.

Concentrations don't vary significantly across the ponds (pH is between 2 & 3)

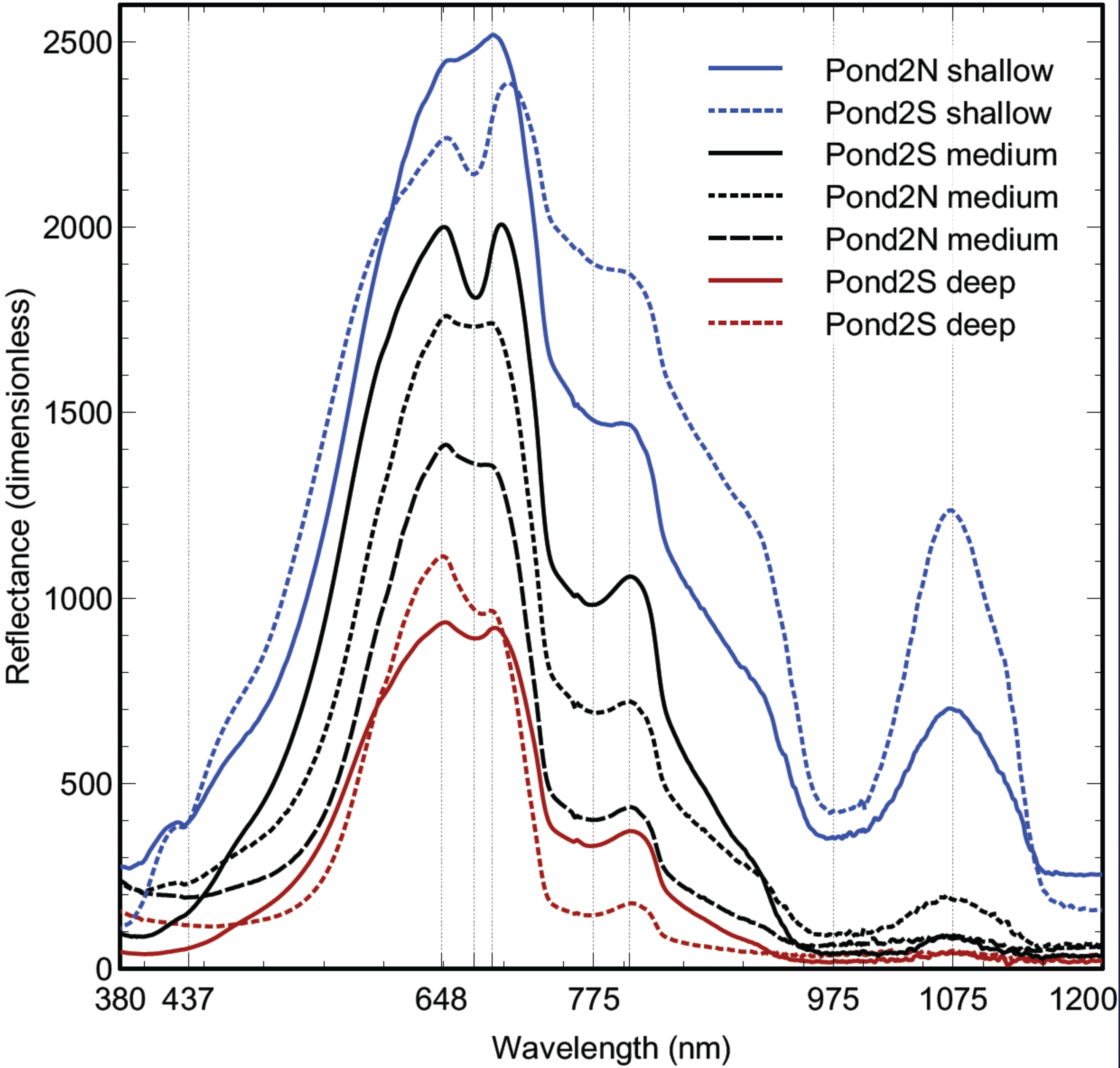
Ponds are shallow and drying with time, complicating the signal with turbidity and bottom reflectance.

Focused on spectral shifts from other natural waters in the scenes.





Leviathan 4/2013 Pond 1
Leviathan 4/2014 Pond 2N
Leviathan 5/2013 Pond 1
Leviathan 5/2013 Pond 2N
Leviathan 5/2013 Pond 2S
Leviathan 4/2014 Pond 2S
Topez Lake 5/2013
Mono Lake 6/2013 (shallow)
S. Fork Stanislause River 5/2013
Mono Lake 6/2013 (deep)
Heenan Lake 9/2013 (algal bloom)
Yerington Pit Lake 5/2013 (shallow)
Mono Lake 10/2014 (deep)
Mono Lake 10/2014 (shallow)
Heenan Lake 6/2014
Yerington Pit Lake 9/2013 (deep)
South Tahoe 4/2014 (deep)
South Tahoe 5/2014 (shallow)
North Tahoe 9/2013 (deep)
648
648
648
648
648
638
570
570
560
560
560
550
550
550
482
482
405
405
405
350
400
450
500
550
600
650
Wavelength of maximum reflection (nm)



Pond2N shallow
Pond2S shallow
Pond2S medium
Pond2N medium
Pond2N medium
Pond2S deep
Pond2S deep
Reflectance (dimensionless)
2500
2000
1500
1000
500
0
380
437
648
775
975
1075
1200
Wavelength (nm)

- Iron impacted waters have a strongly different peak reflectance than natural waters.
- The Leviathan site presented complications from shallow ponds and seasonal drying.
- Deeper pit lakes can be monitored for changing acidification (iron concentration) with time, but will need a different location/data set.

Summary of acid water

Surface Mineralogy at varying spatial scales

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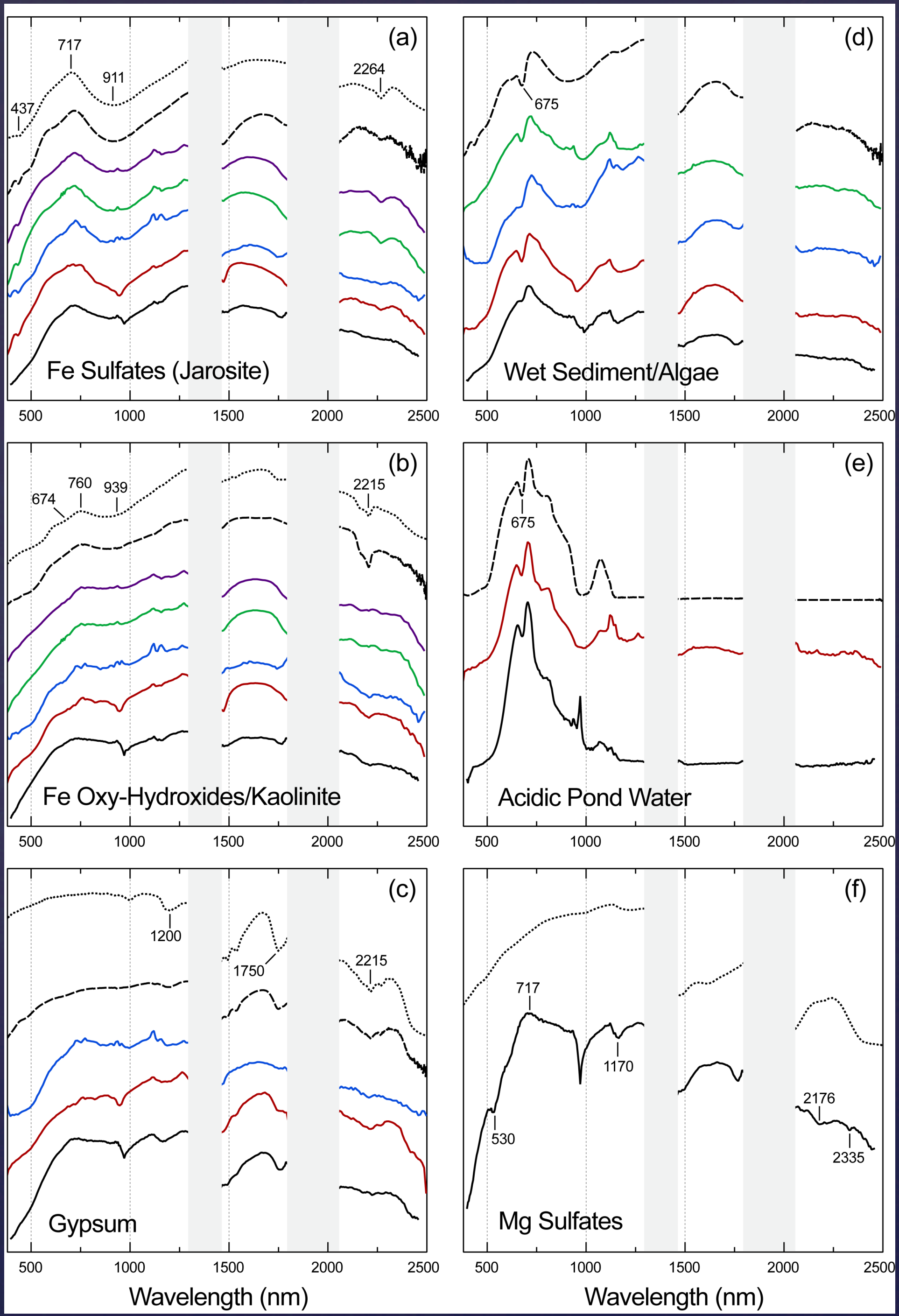
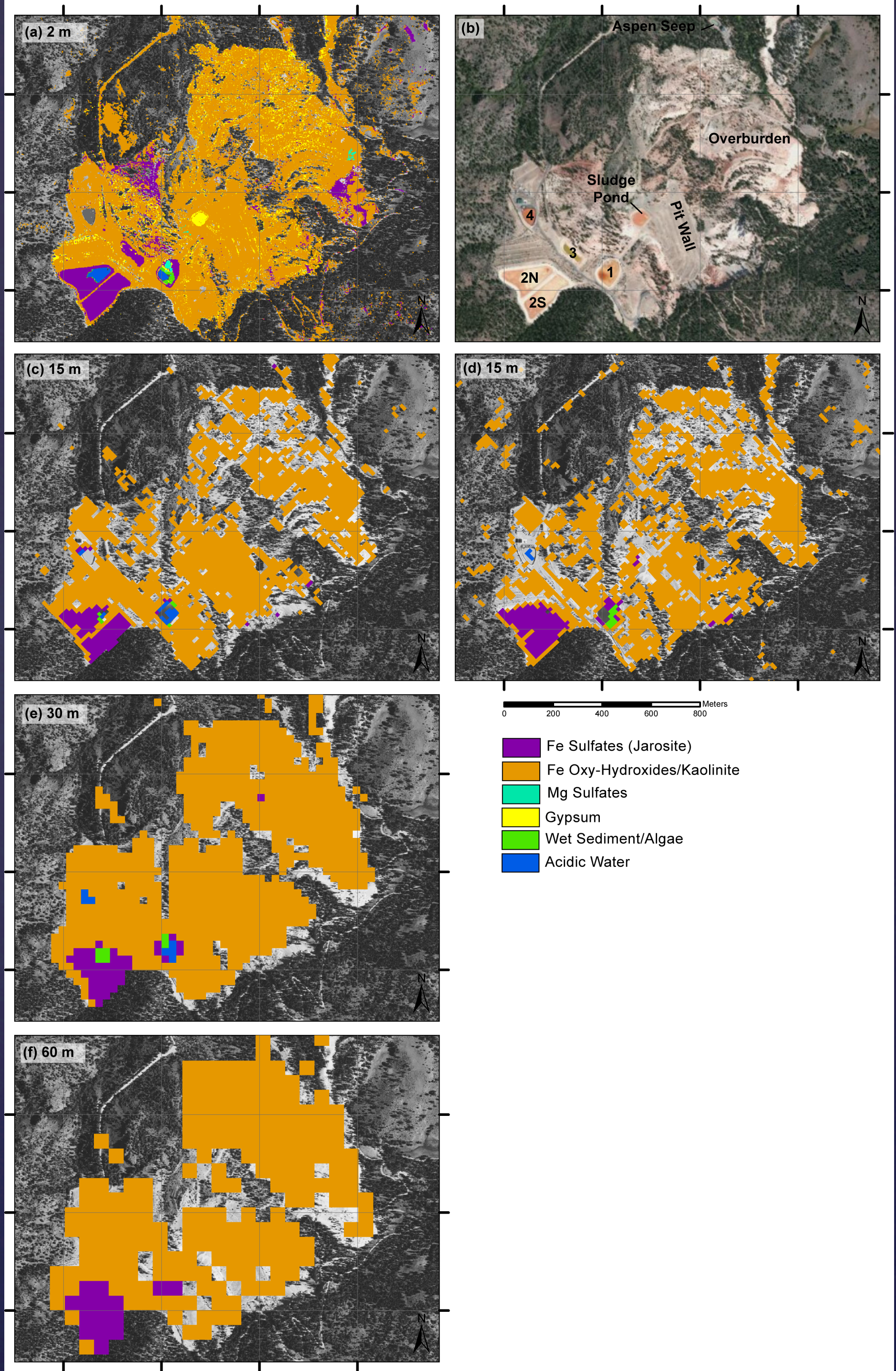
Used 2m data collect from 2007 (black); 15m data in 2013 and 2014 (red and blue); HyspIRI 30m (green) and 60m (purple) data products.

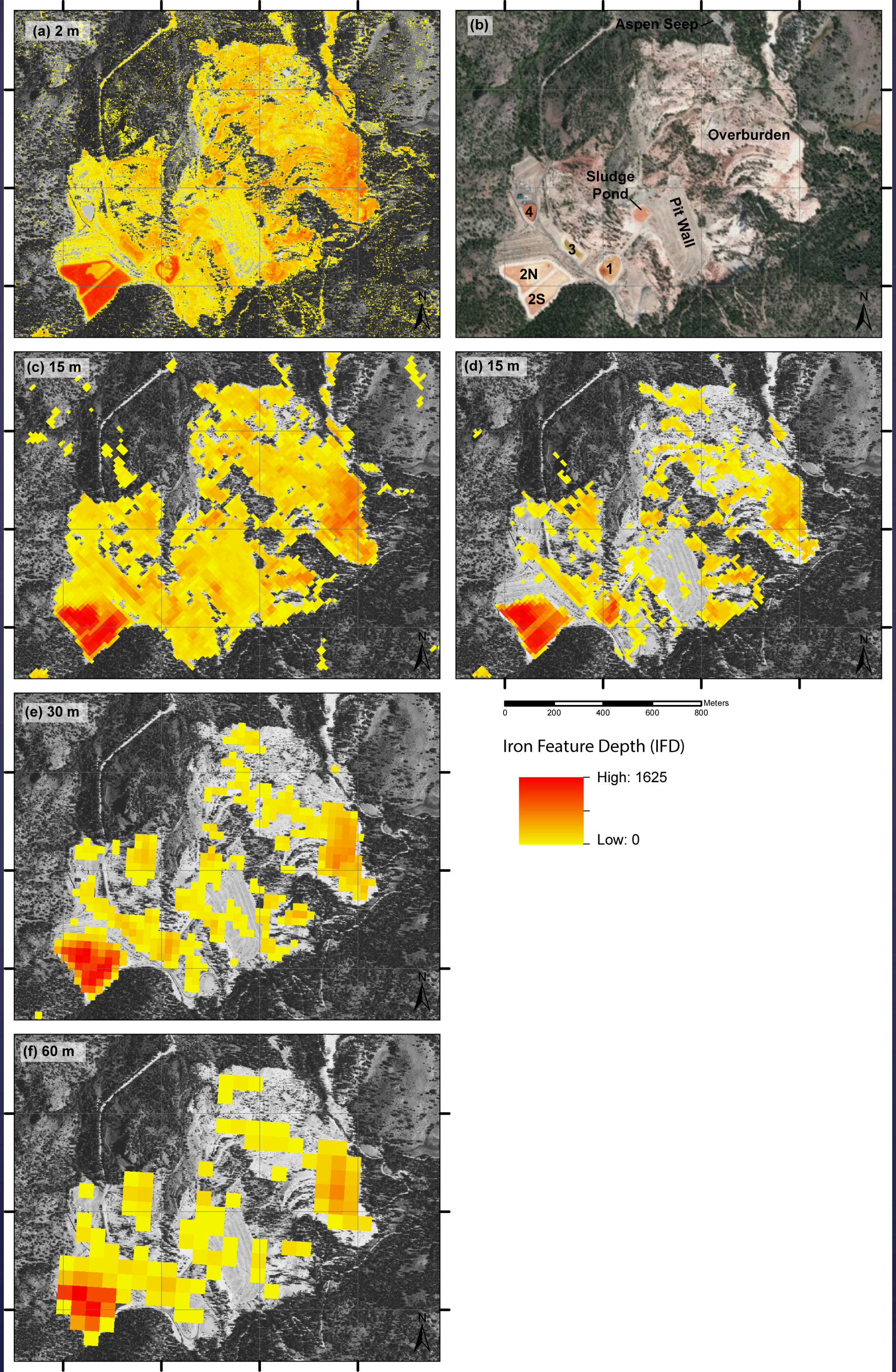
Identified six common spectral types.

Field data (dashed) and library (dotted) to support the interpretations.



Maps of these spectral groups are consistent between years and platforms, but show loss of detail at the coarsest spatial resolution.





A simple and rapid analysis tool is to examine the depth of the absorption centered near 900 nm using a continuum removed band depth.

This iron feature depth is consistently high for regions where the potential for acidic soils is high, both in the ponds, but also in the overburden.

These locations are also clearly identified in the 60m simulated data.

- Iron sulfate and iron oxides were identified in all data sets and all spatial resolutions.
- Wet soils/algae were not identified at 60m resolution.
- Some sulfates identified only in 2007 data set may reflect changing surface conditions over time.

Summary of soils

Conclusions

- HyspIRI will be useful for the global identification and monitoring of acid soils and mine impacted waters.
- Simple band parameters can rapidly identify sites of critical interest.
  - Water peak wavelength
  - Iron feature depth
- Detailed spectral analysis will further refine priority sites for remediation.
- 60m/pixel loses significant detail, especially when mapping subtle mineralogical differences.