A remotely sensed approach to assess riparian vegetation development and flow pathways in relation to remediation approaches at a historic

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Funded through Bureau of Land Management grant #L23AC00655

Bentonite Mining in Northwestern South Dakota

- Since at least the early 1900s in the Montana, Dakota, and Wyoming region
- Surface mining to extract bentonite clays
- Uses: kitty litter, drilling mud, ditch/pond liner, cosmetics, and pharmaceuticals

- Mining practices prior to environmental laws in the 1970s
- Area conditions
  - Assumed sodic/saline
  - Poor soil development and little to no vegetation in mined areas

Our project (Three-year timeline)

Characterize the study area (Years 1 and 2)

- Quantify the current state of the landscape, including surface waters
  - EPA Pre-CERCLA screening for soils and water
  - Field observations
  - Remote Sensing
- Determine baseline conditions
- Identify barriers to ecological development

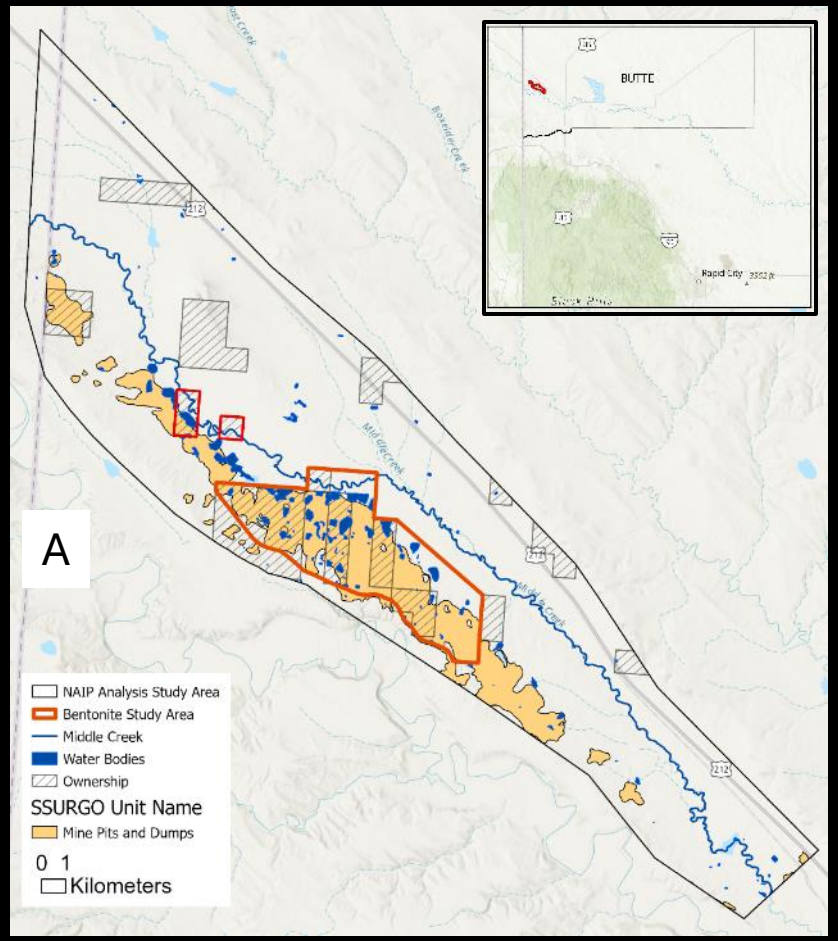
Develop restoration options (Years 2 and 3)

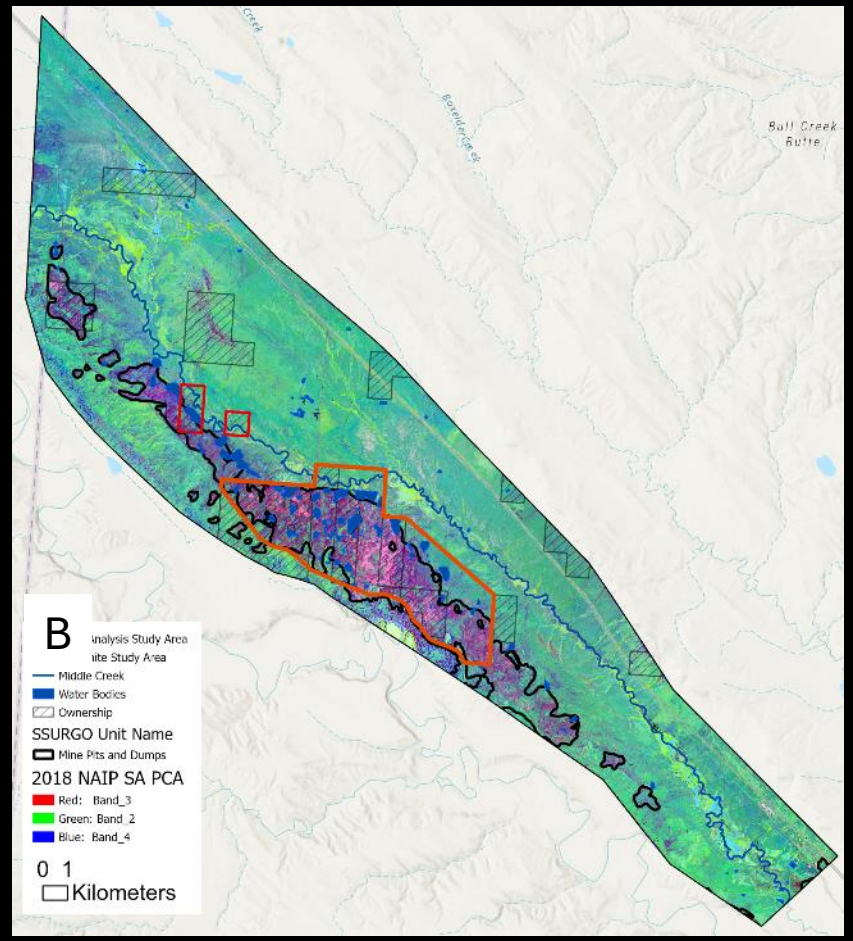
- Identify realistic restoration objectives
  - Address the concerns
  - Investigate the feasibility

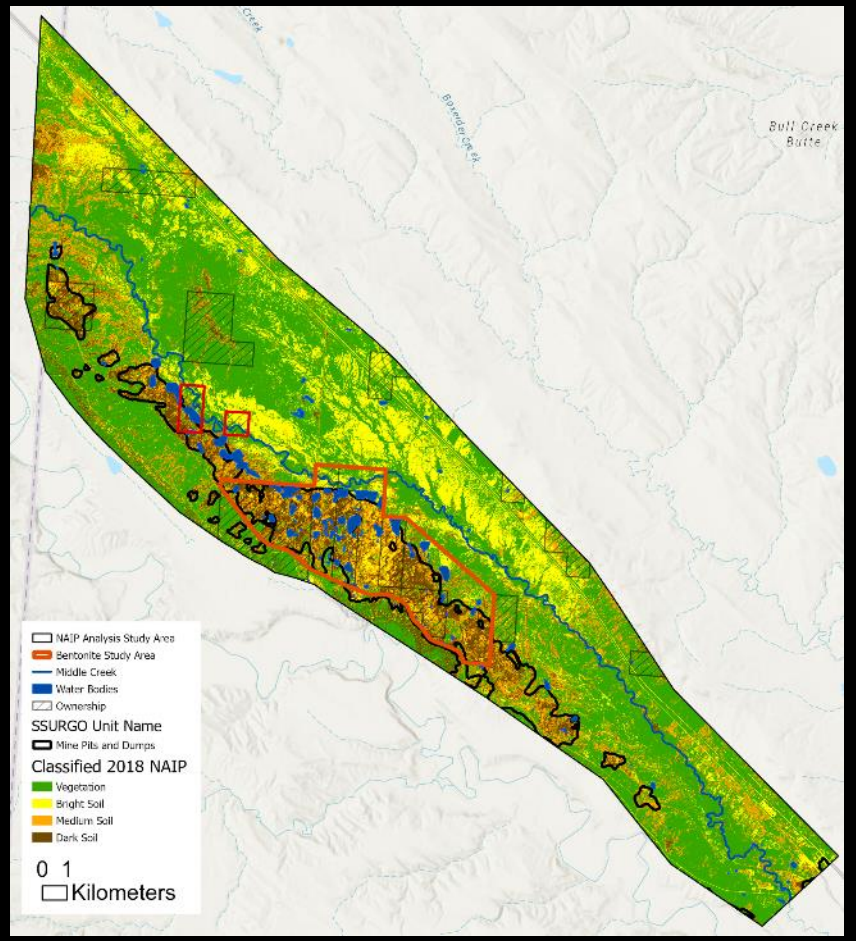
Bentonite Study Area Landscape differentiation using NAIP imagery

Analysis using 2018 NAIP imagery

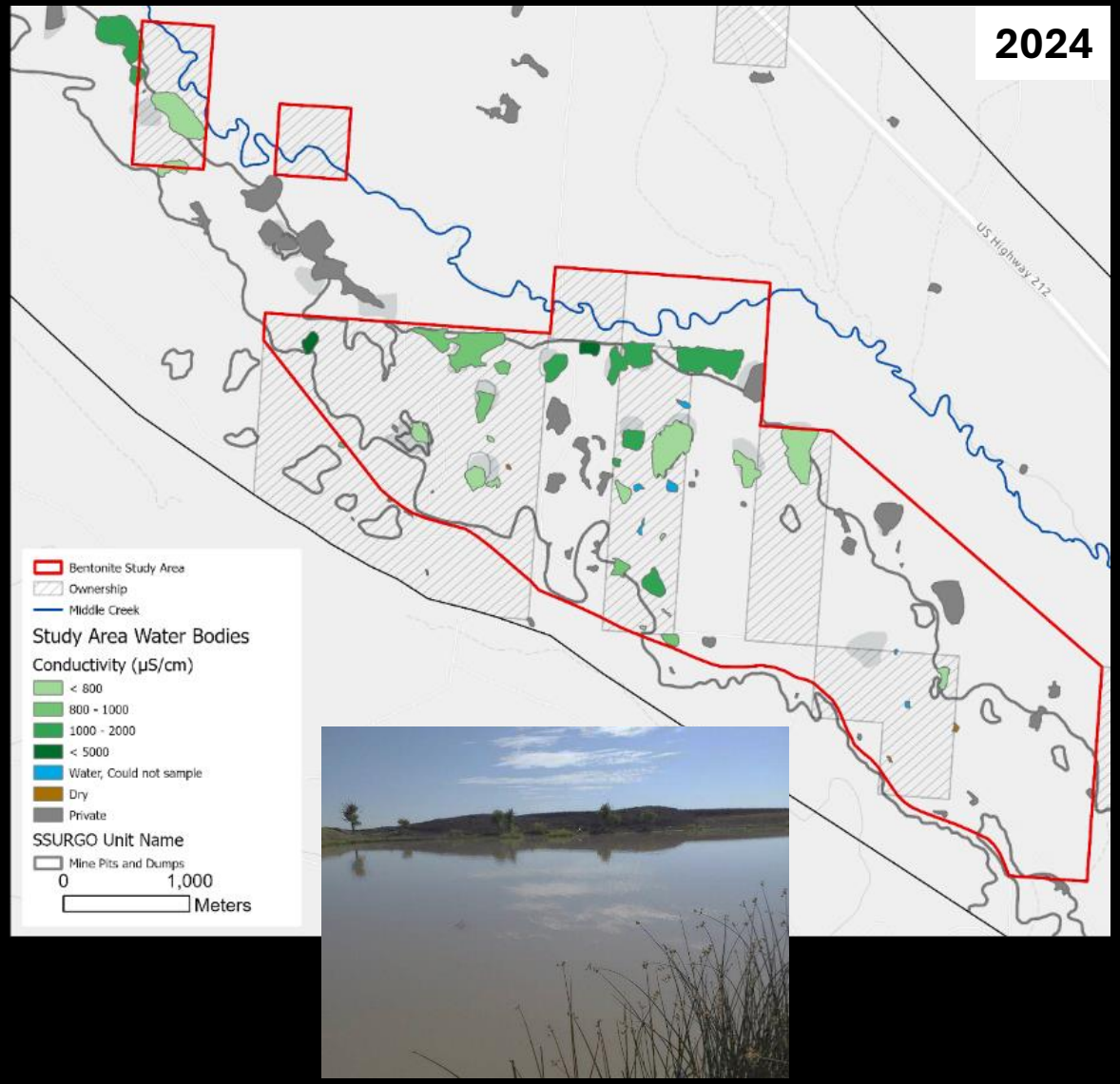
- Ran a Principal Component Analysis (PCA) and classified

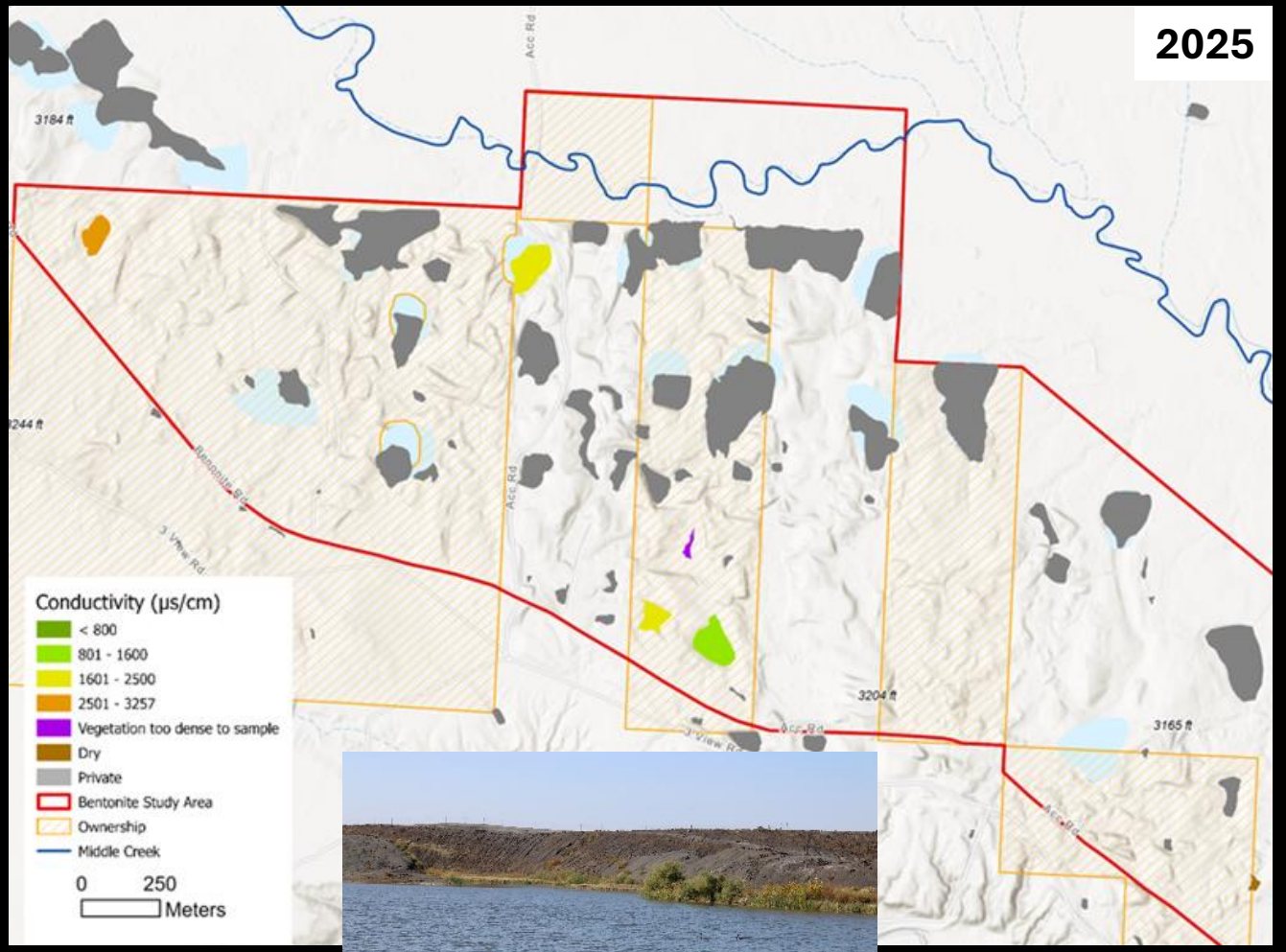




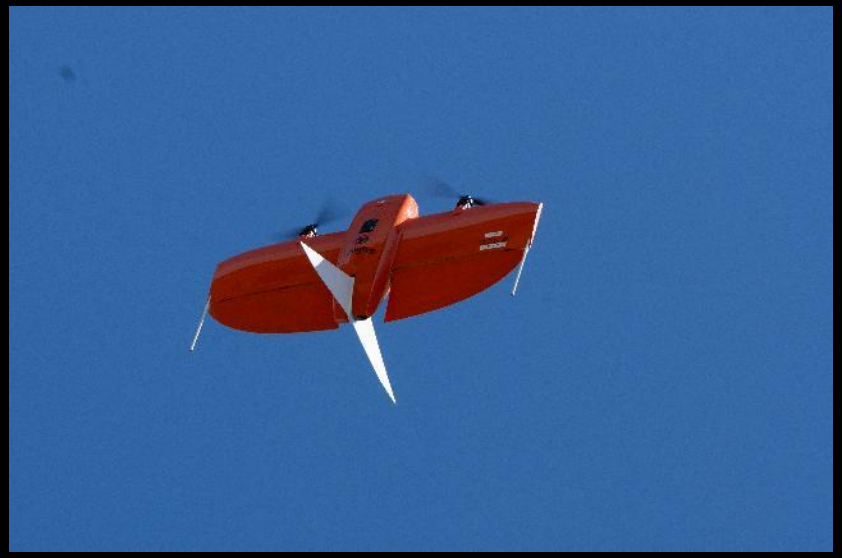


Water sampling

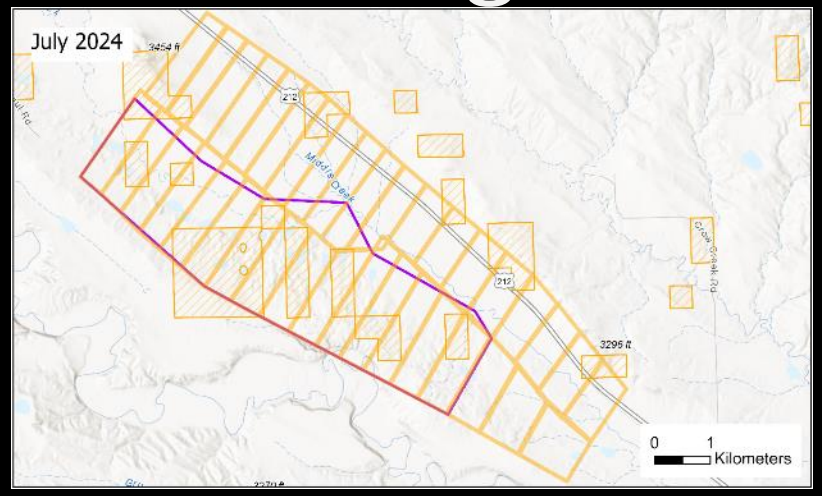


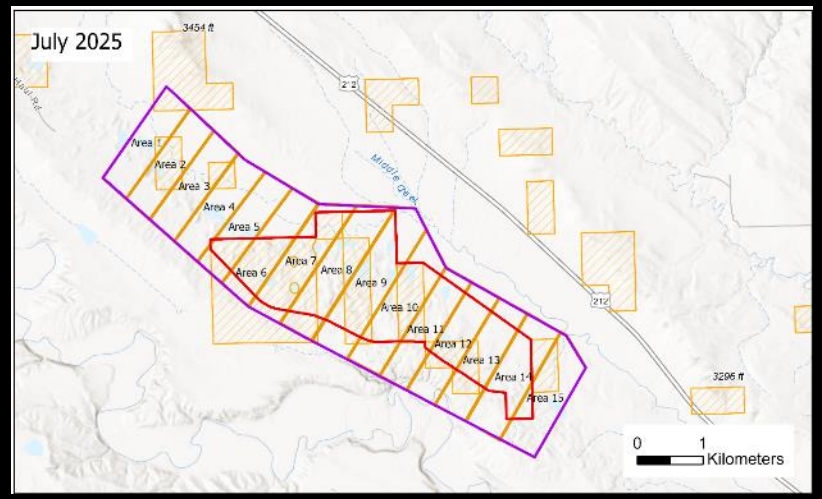


SD Wing Civil Air Patrol



Drone Flights in 2024 and 2025





- Two sets of flights in 2024
- One set of flights in 2025

- 2024: 54 Flights, 21 square miles
- 2025: 15 Flights, 6 square miles

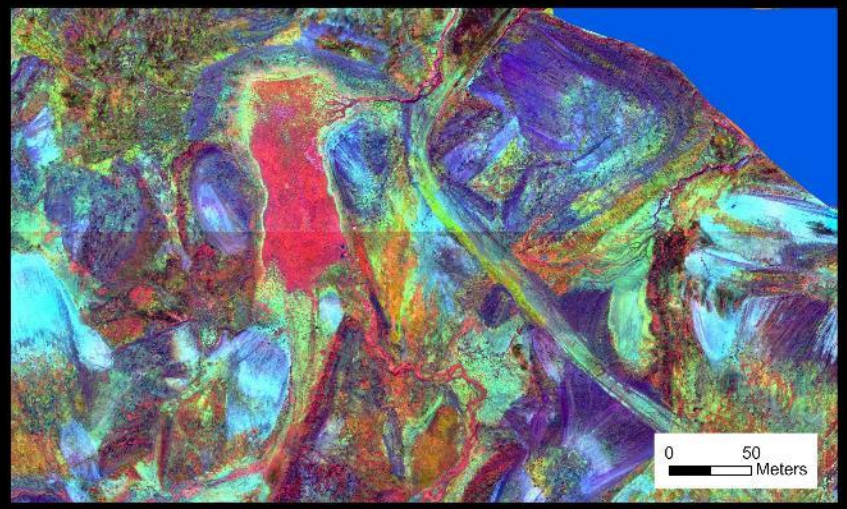
- Visible and near infrared imagery
- 7 cm spatial resolution

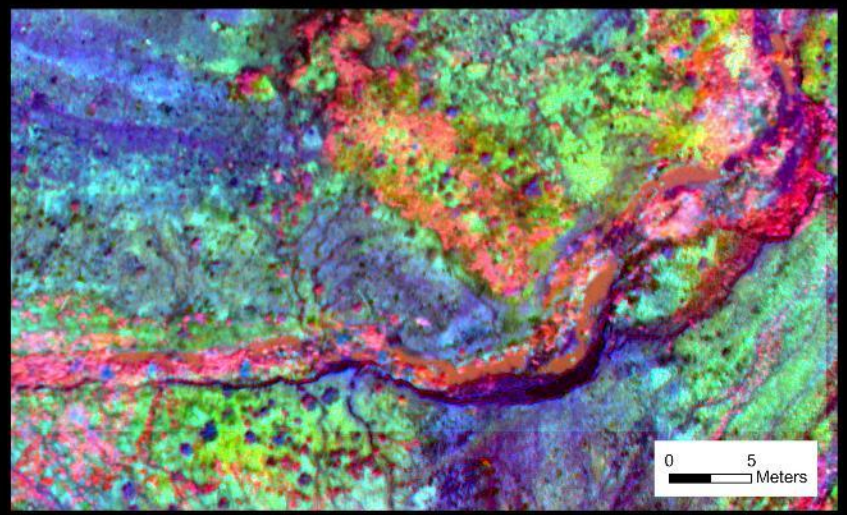
Initial Classification Drone Flights

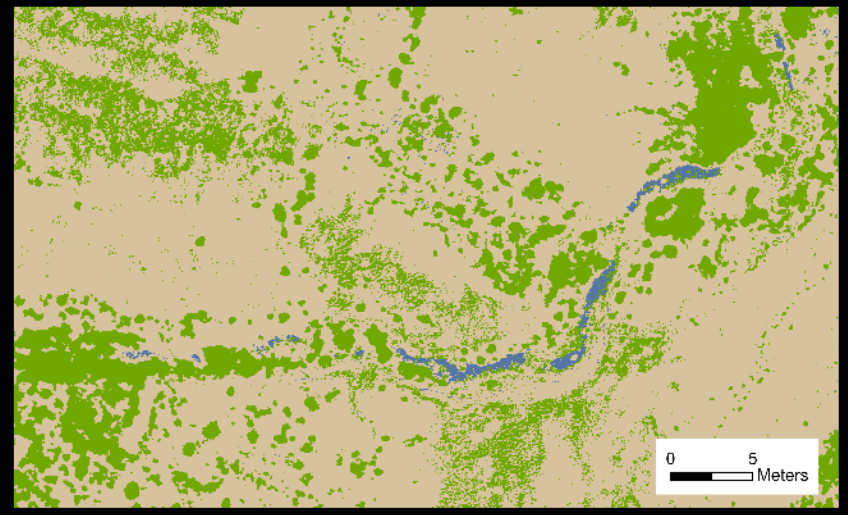
True Color

Principal Component Analysis

Machine Learning Classification



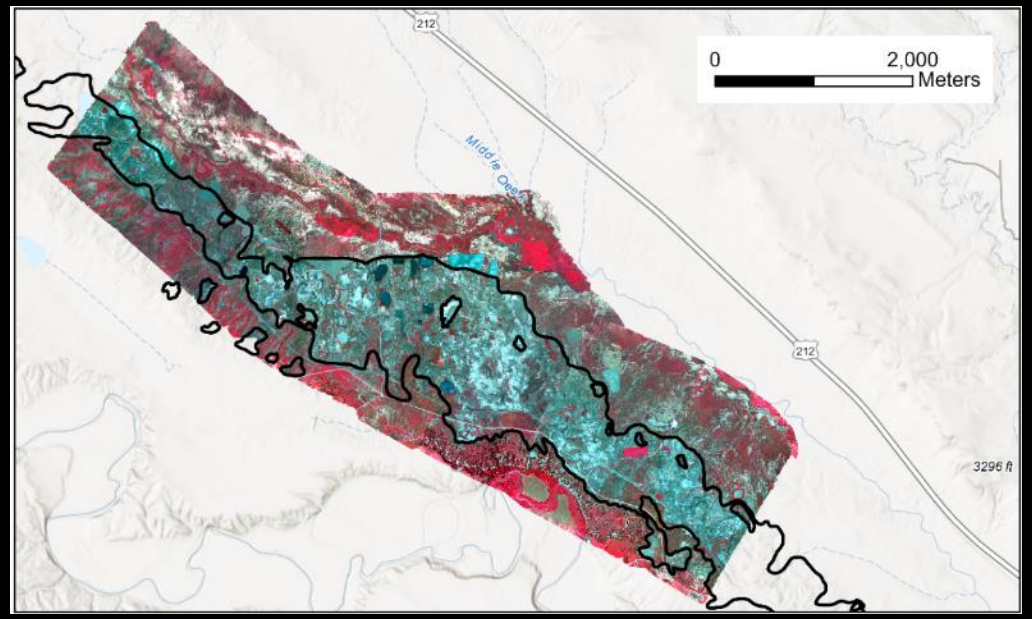


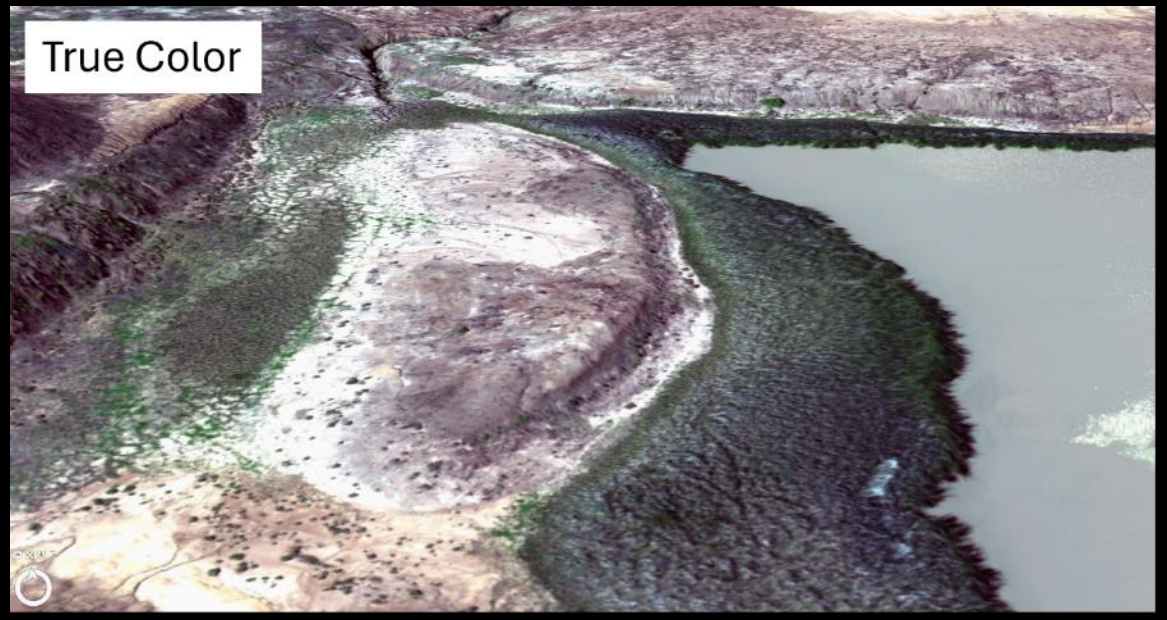


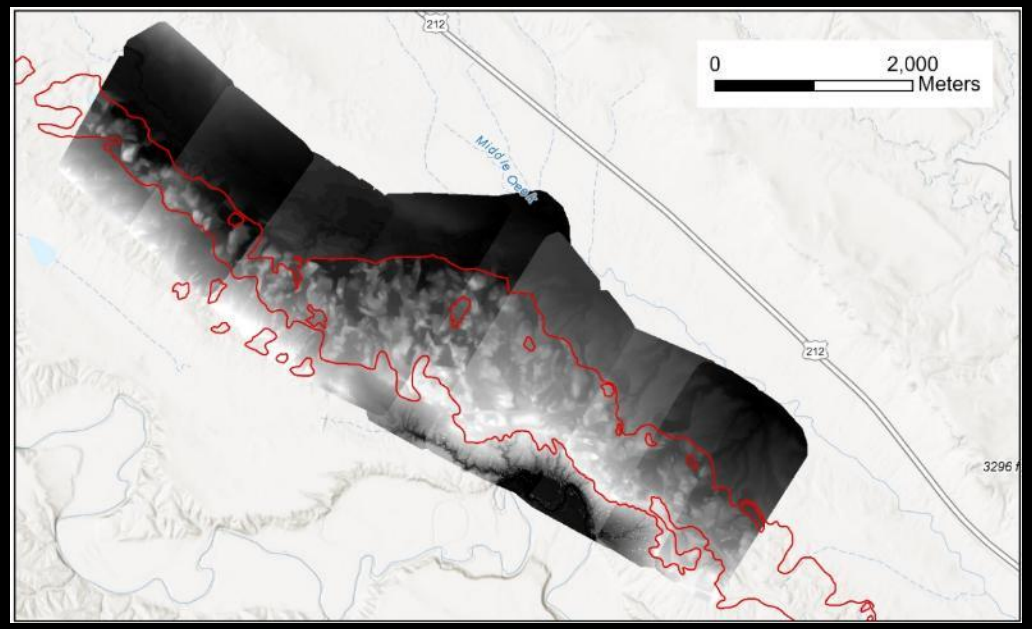
Vegetation

Bare Ground

Water


0
2,000
Meters
212
212
3296 ft


True Color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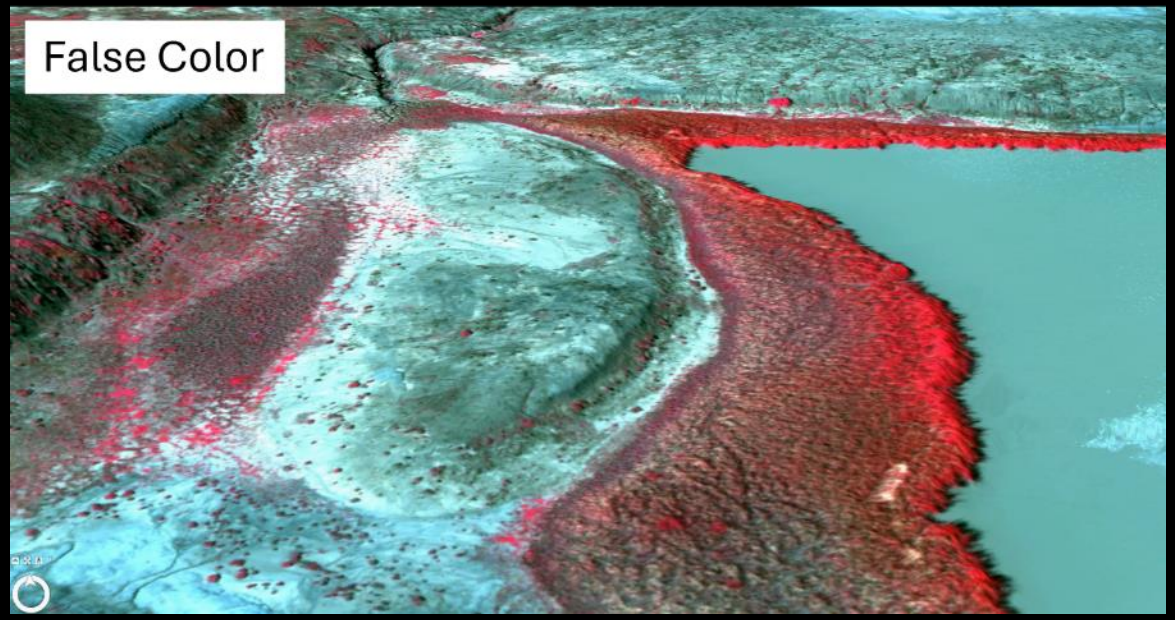
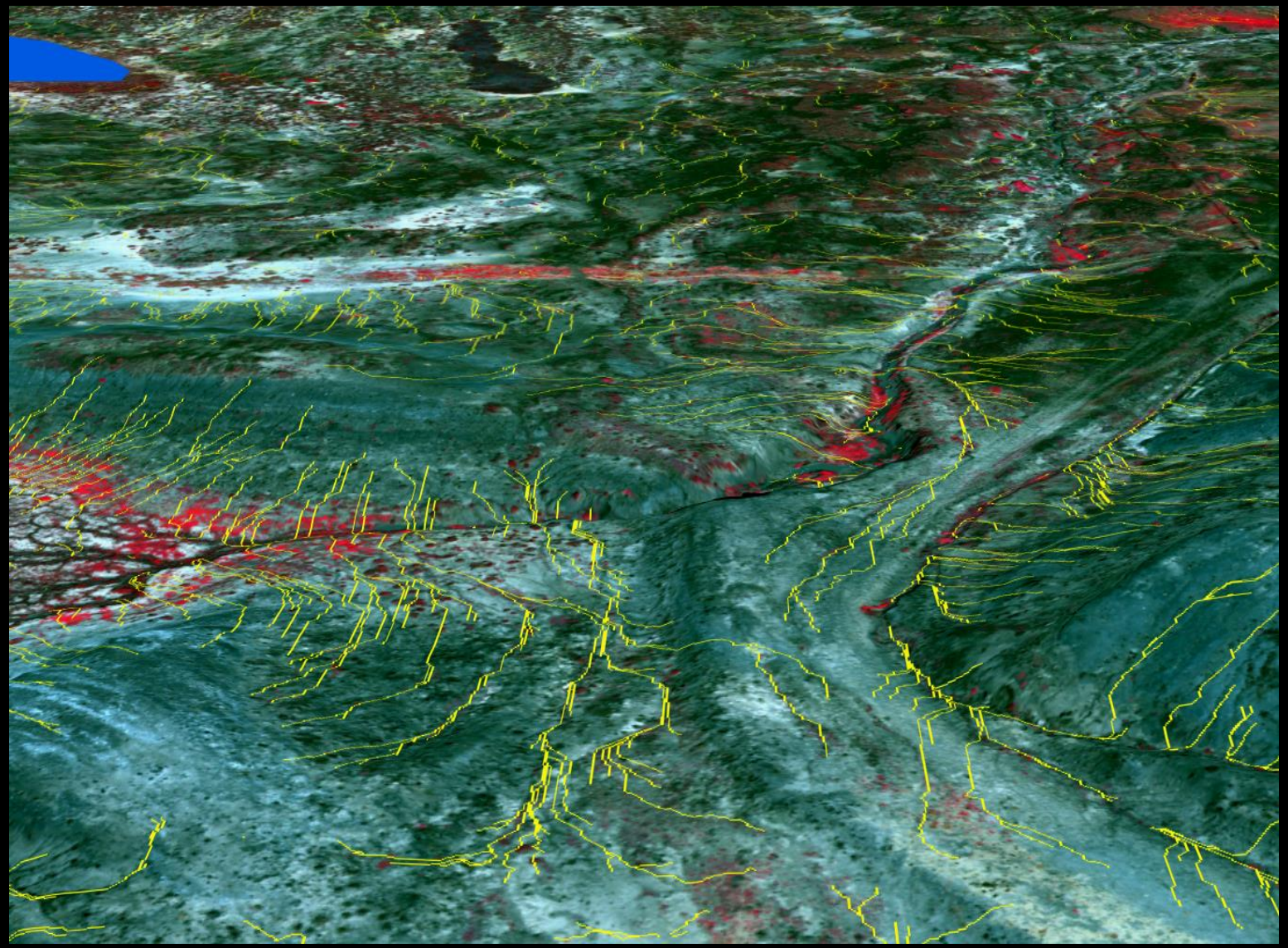
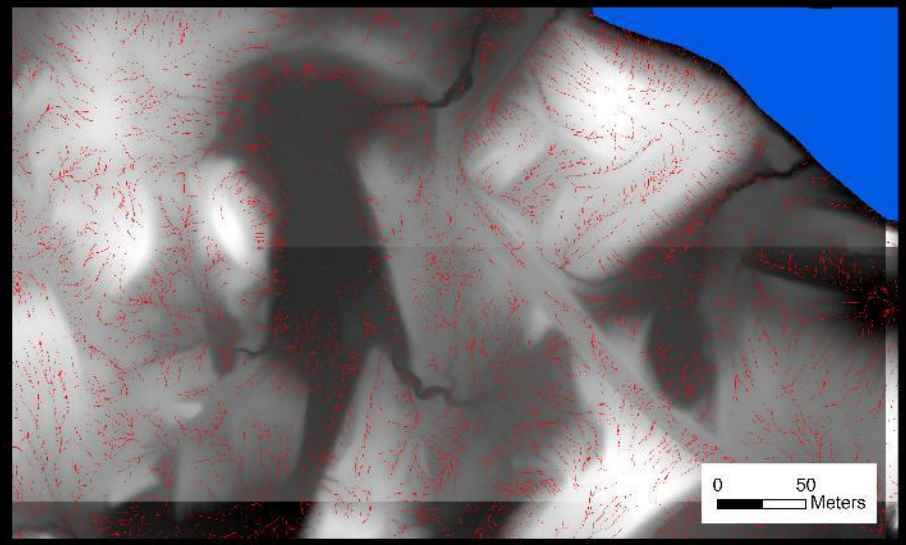
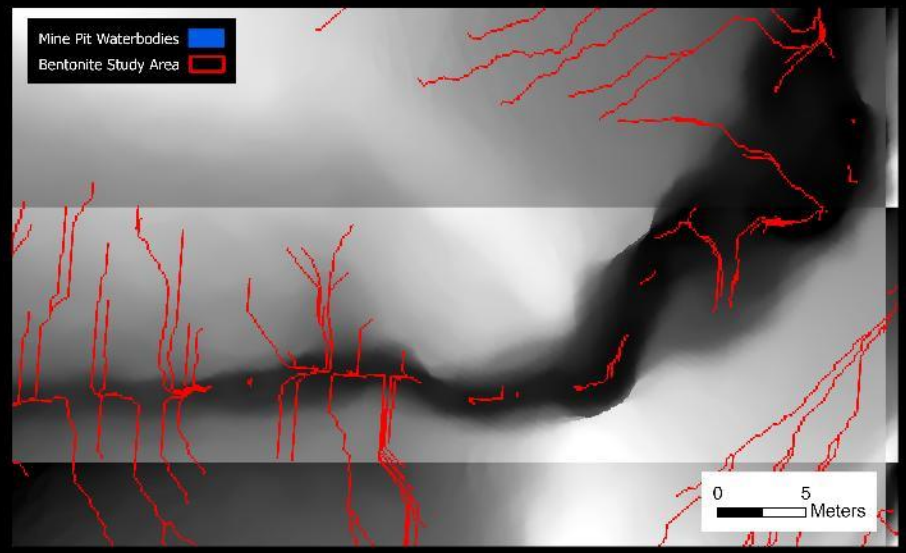
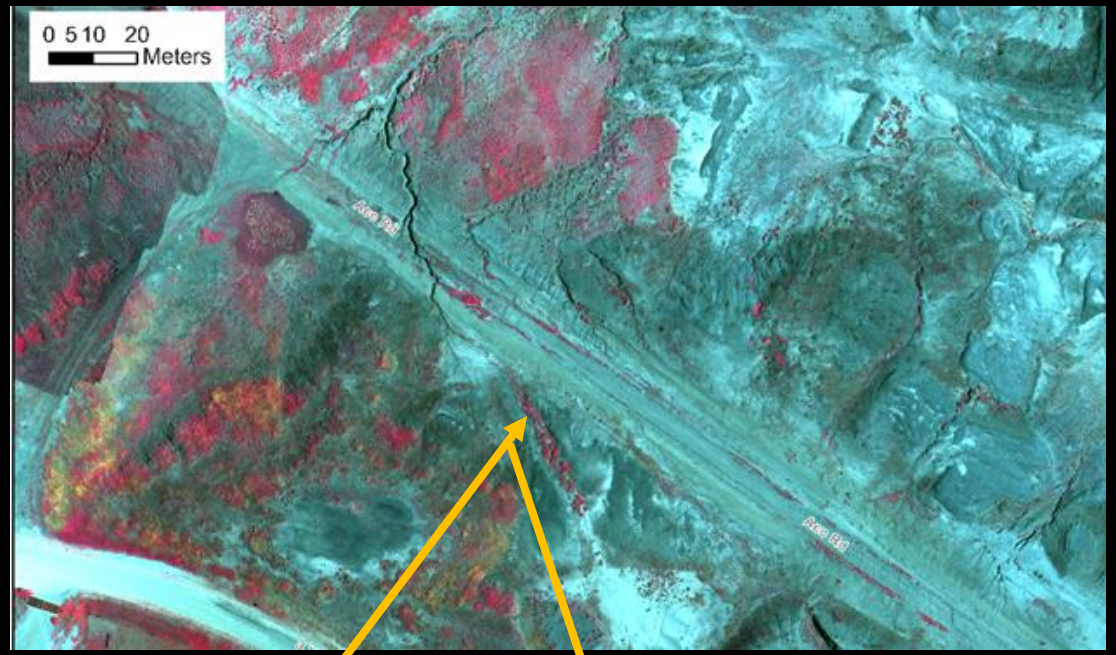

False Color

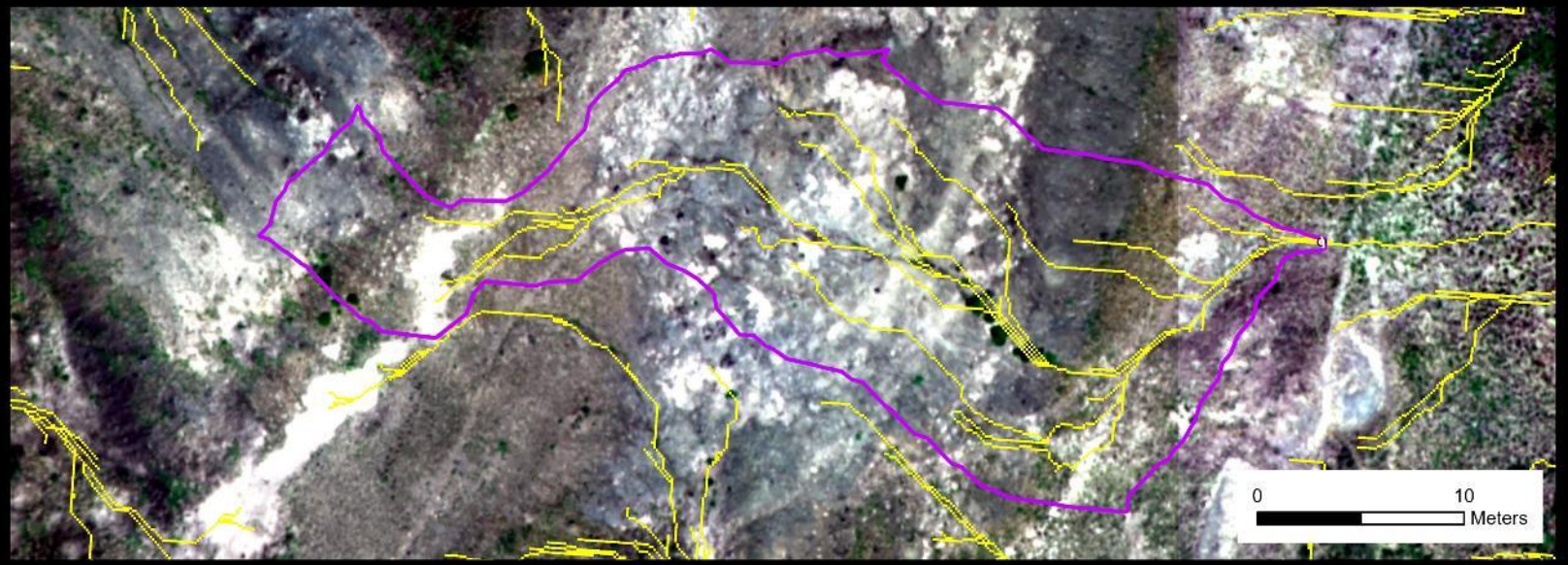
Initial Water Flow Drone Flights








0 5 10 20
Meters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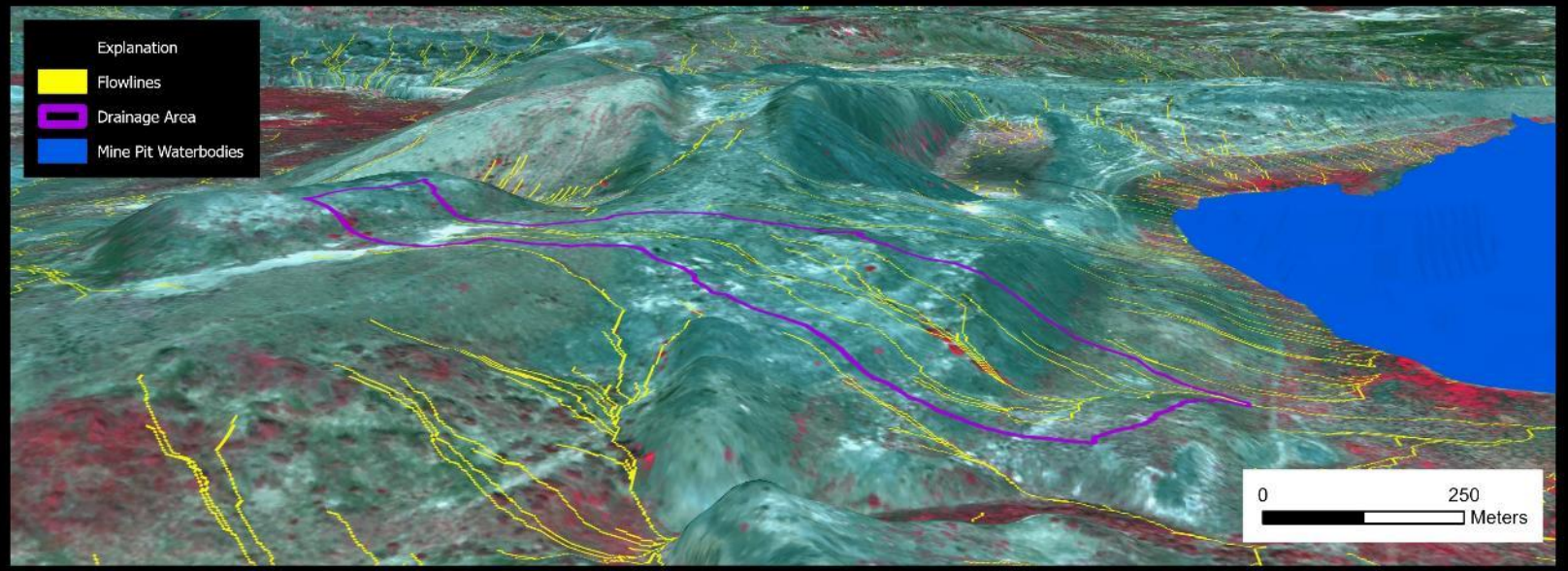
10
Meters


Explanation
Flowlines
Drainage Area
Mine Pit Waterbodies
0
250
Meters

Bunds Hun!

Low cost

- Can literally be done with a pick and time
- Not a fast solution, but one that works in the environment

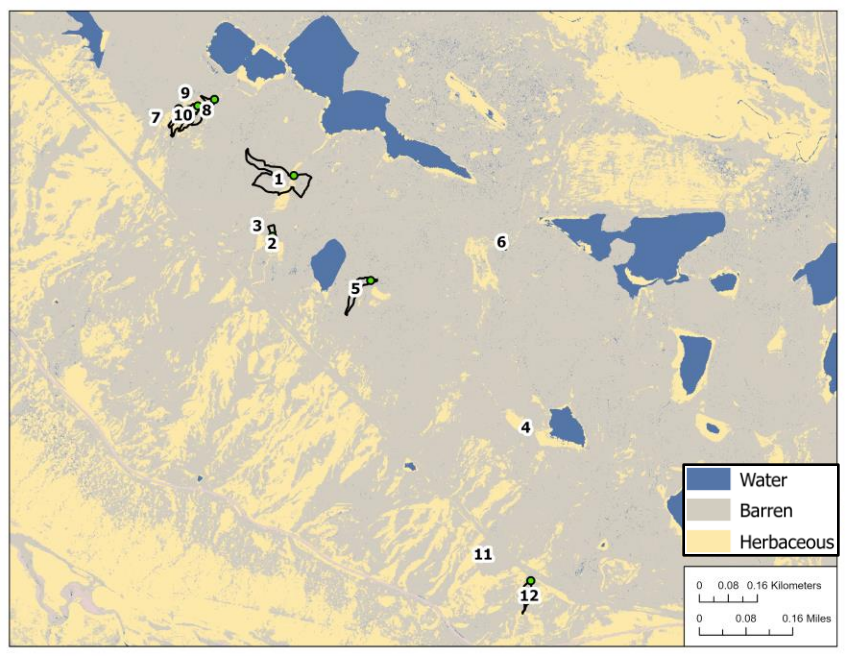
Allow soil development

- Will trap fines along drainage routes
- Can be built with organic matter additions to stimulate microbial communities
- Potential for native seed placement to speed the process

Reduce erosion and gully formation

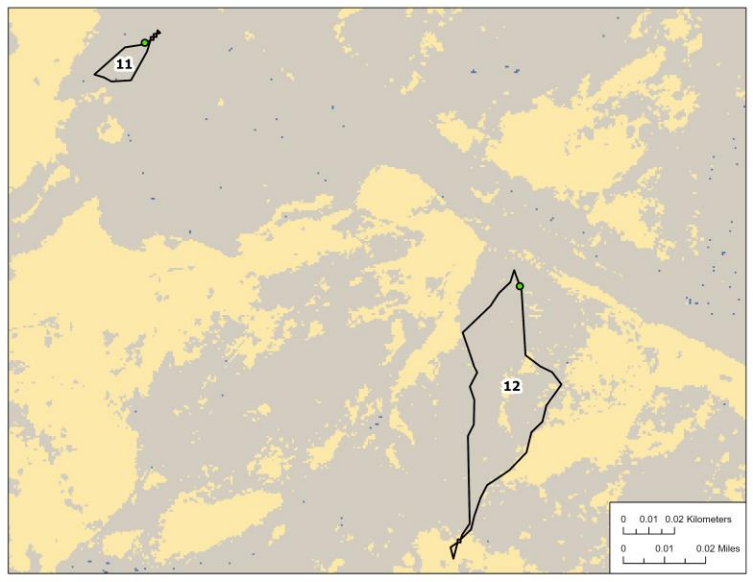
- Stops erosional runoff and downcutting
- The vegetative growth will help stabilize newly built soils

Allow a natural ecological progression in the landscape instead of traditional remediation approaches



Watershed 11

Watershed 12



Conclusions and Future Work

Complete Investigations between water bodies with and without riparian vegetation

- Topography and sediment dynamics
- Allow development of process-based remediation pathways

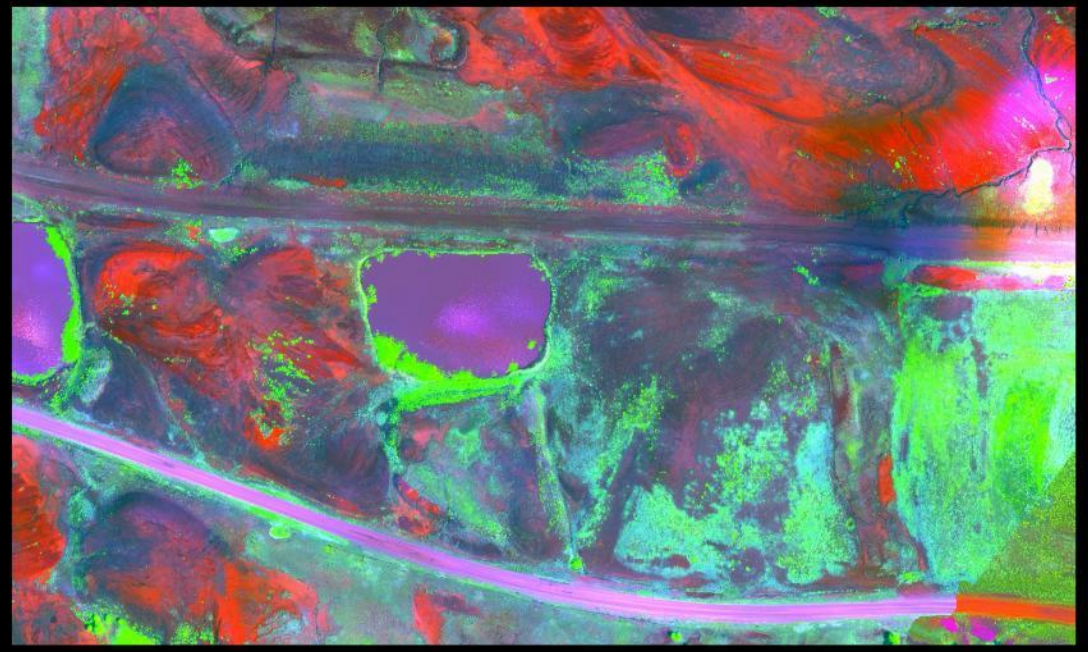
Look at the testing of the sulfate hypothesis

- Turbidity and correlation to conductivity

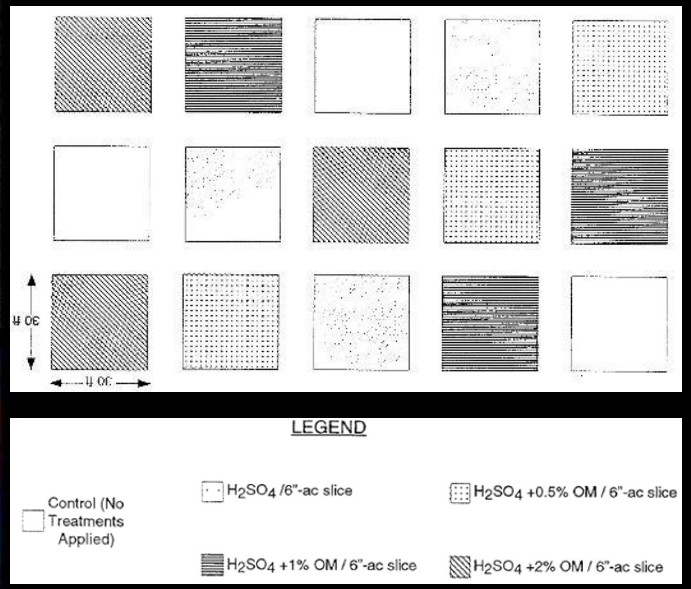
Complete Investigation of soils along erosional paths

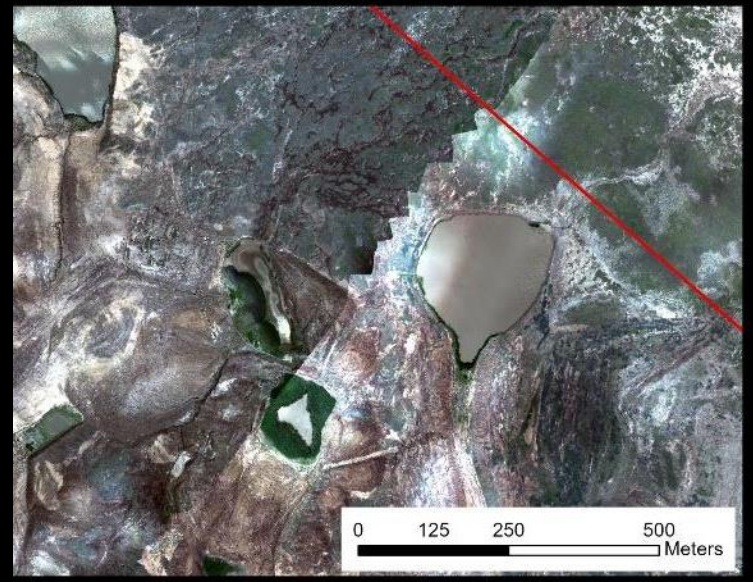
- Test as an approach to process-based remediation
- Field test and Soil analysis

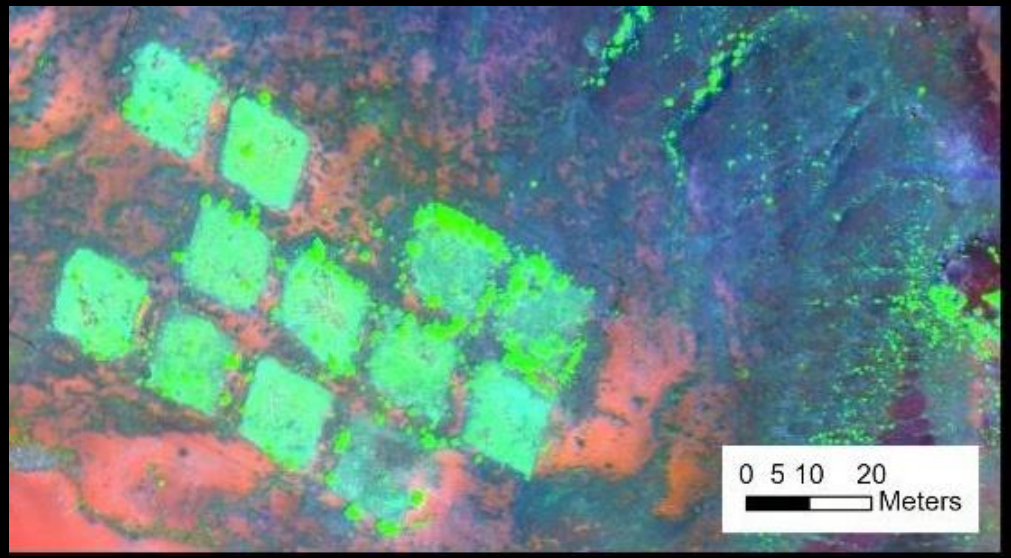
Develop process-based restoration ideas

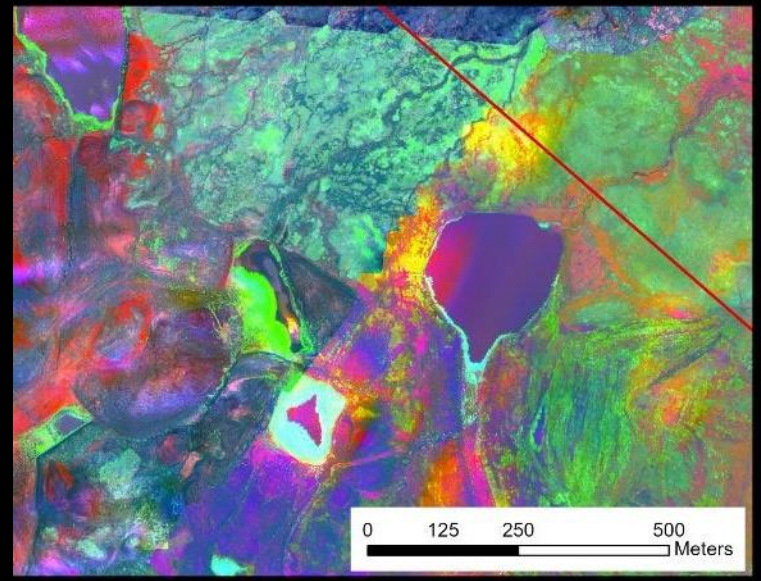


Interesting Finds From Drone Flights









Questions

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Sustainable Solutions