



Unmanned Aerial Systems for Superfund Mining Sites

Ed Hathaway, John Hillenbrand,
Joy Jenkins and Kirby Biggs
Thursday, May 2nd, 2:00PM ET



Overview

1. Welcome – *Michele Mahoney*

2. Use of Drones at Copper Bluff Mine – *John Hillenbrand*

3. Gilt Edge Mine Case Study and Resources – *Kirby Biggs*

4. Aerial Imagery – *Ed Hathaway*

5. "How to" Resources – *Joy Jenkins*

6. Q&A



What is your familiarity/experience with Unmanned Aerial Systems (UAS)?

Share your answer in the poll

Use of Drones at Copper Bluff Mine - Agenda

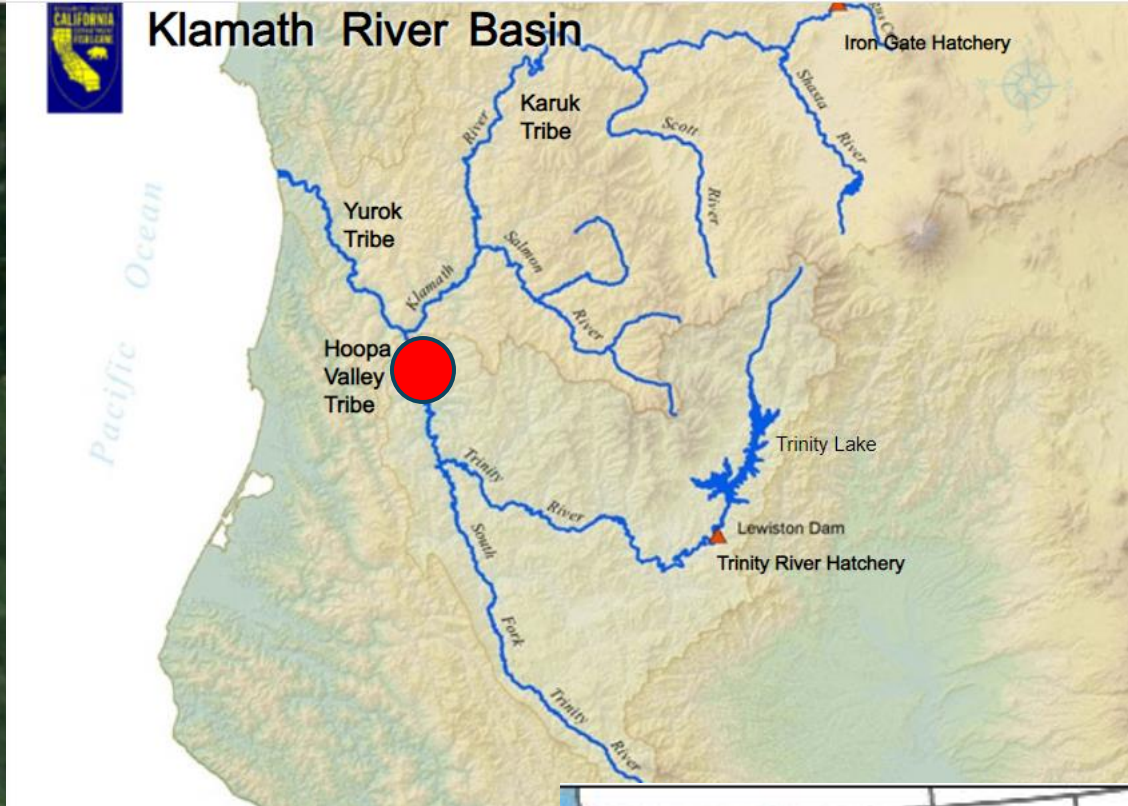
- Background
- LIDAR mapping of topography – Airplane- DEM
- Underground LIDAR mapping and video using UAS
- Thermal imaging using UAS
- River tracer dye tracking using UAS

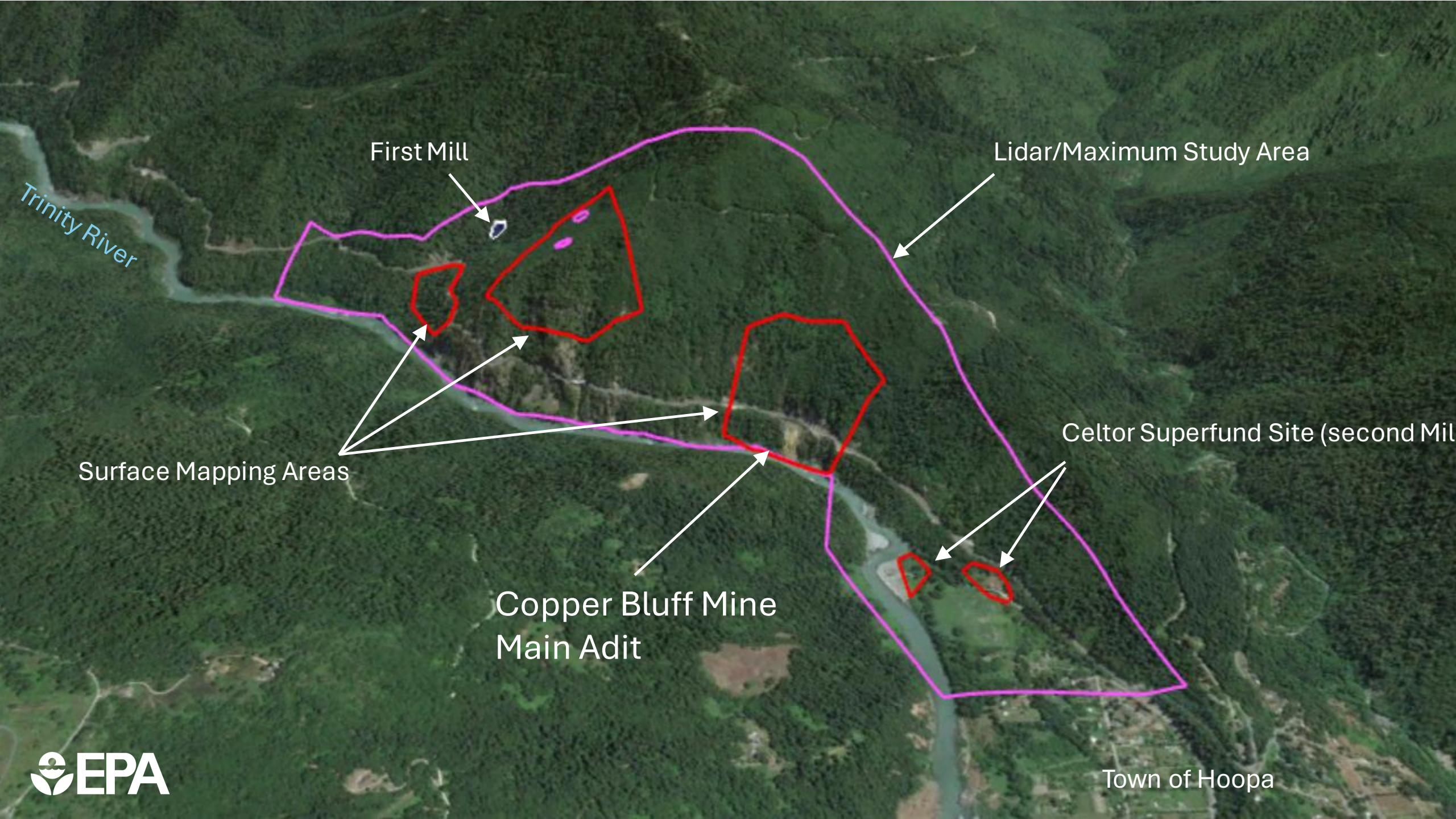
Copper Bluff Mine

- Mine Type: Copper/Zinc mine
- Operated : 1957-1962
- No PRP
- AMD discharge into Trinity River (3 to 450 gpm)
- Listed on NPL in 2019 and in RI phase
- Site entirely on Hoopa Valley Tribe land
- 53 inches of rain, little snow



Main Adit, Copper Bluff Mine





First Mill

Lidar/Maximum Study Area

Trinity River

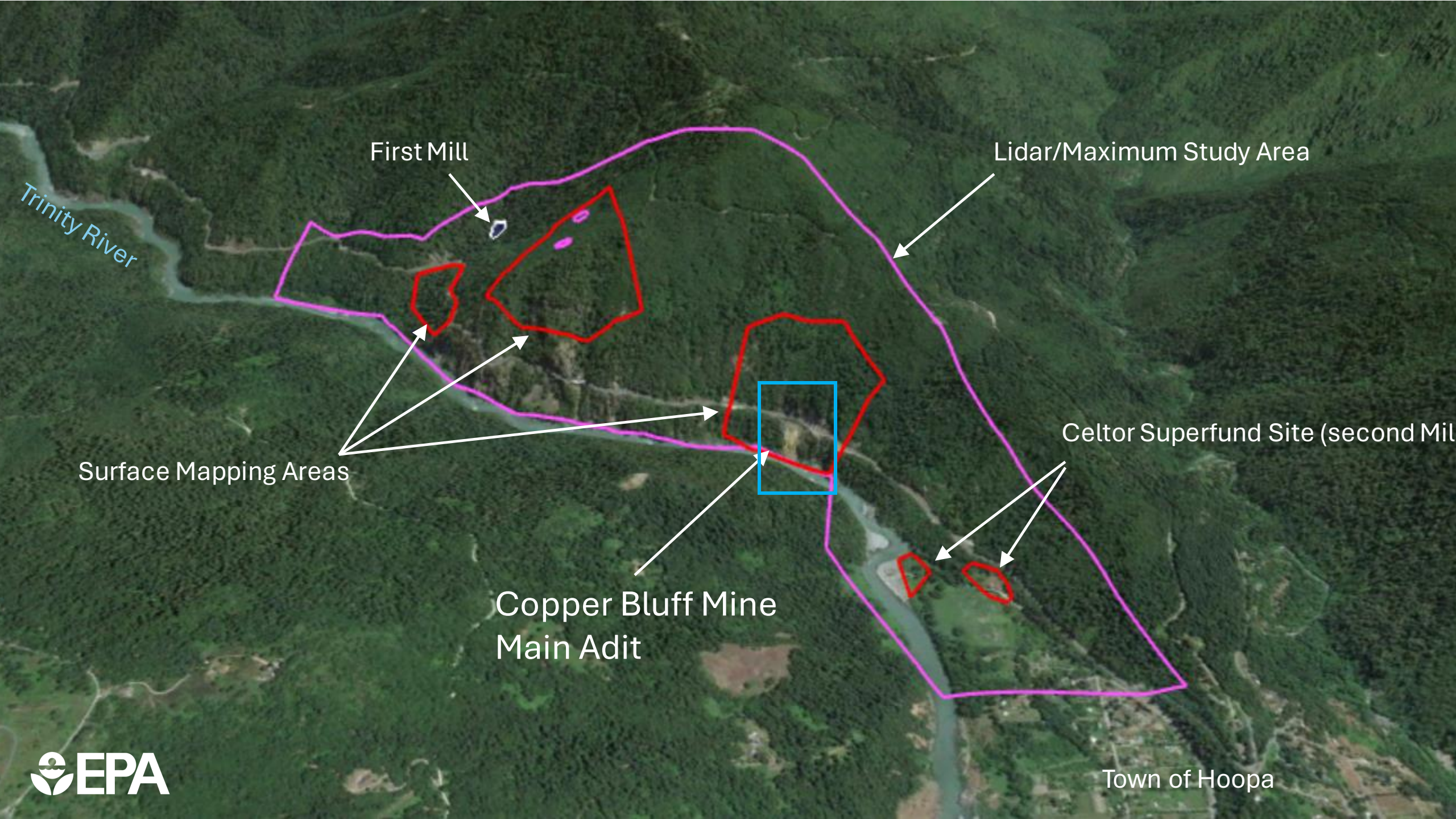
Surface Mapping Areas

Celtor Superfund Site (second Mil)

Copper Bluff Mine
Main Adit

Town of Hoopa





First Mill

Lidar/Maximum Study Area

Trinity River

Surface Mapping Areas

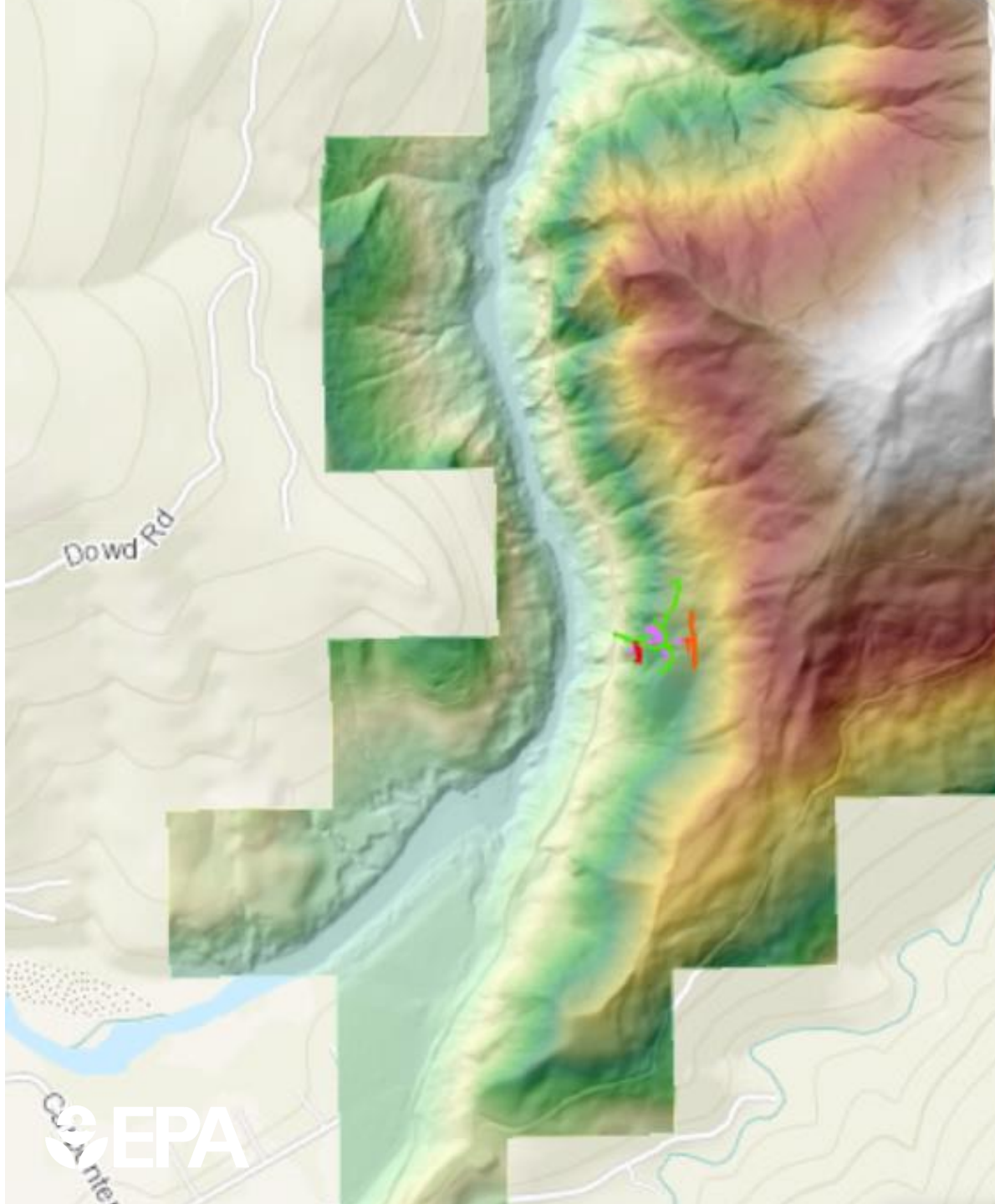
Celtor Superfund Site (second Mill)

Copper Bluff Mine
Main Adit

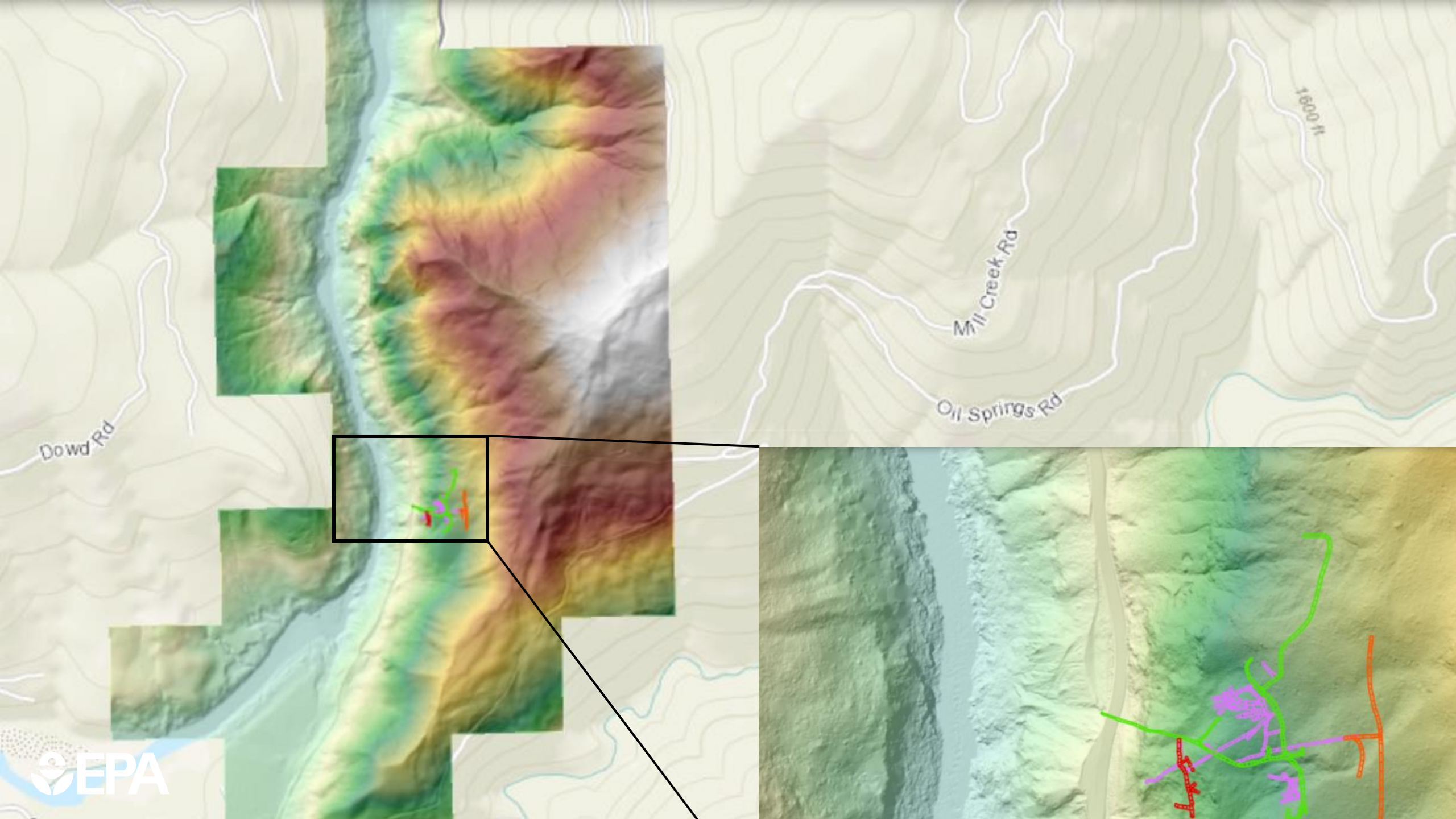
Town of Hoopa

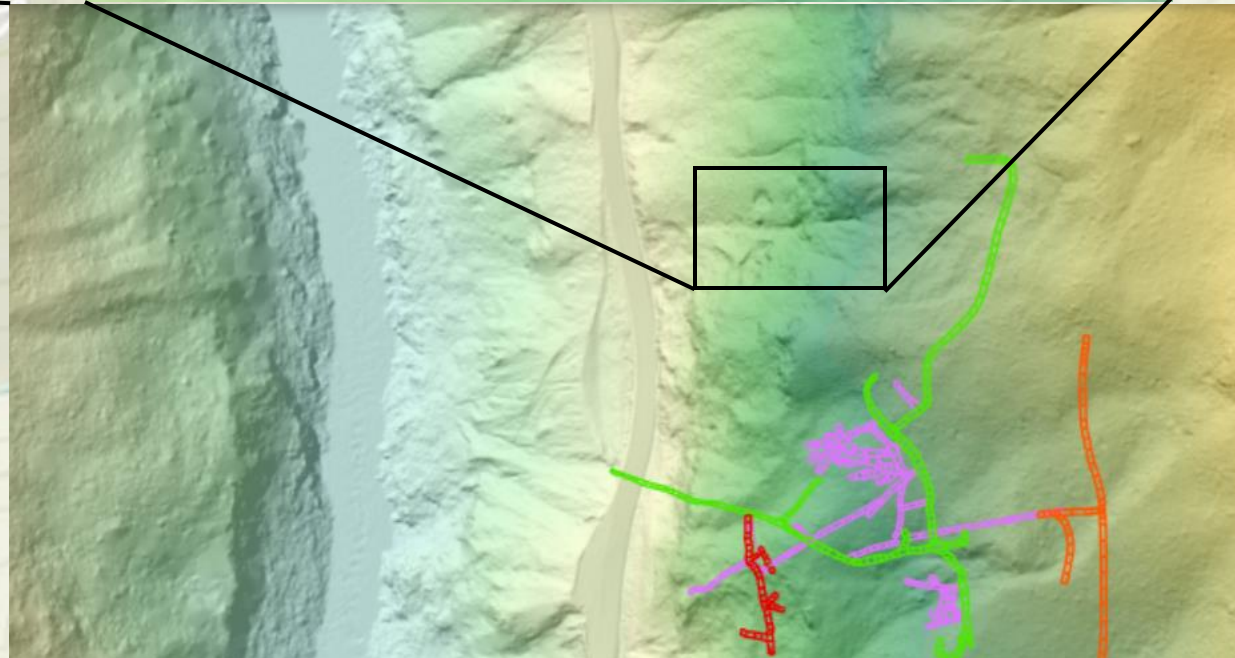
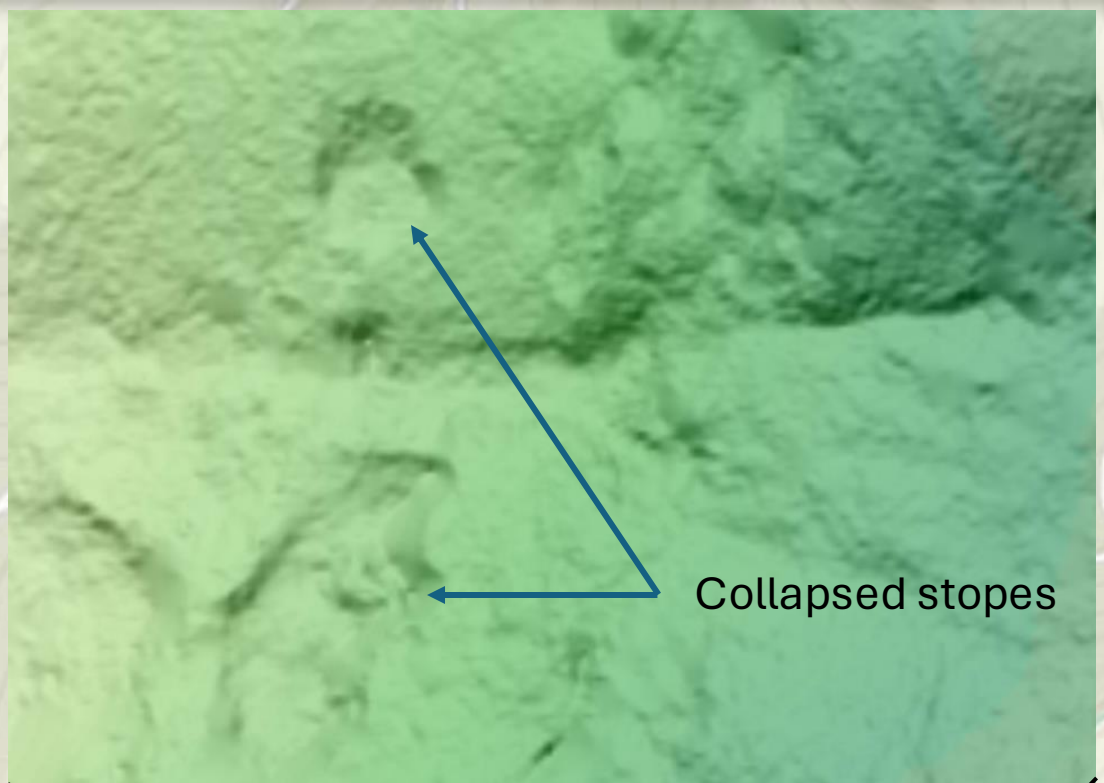
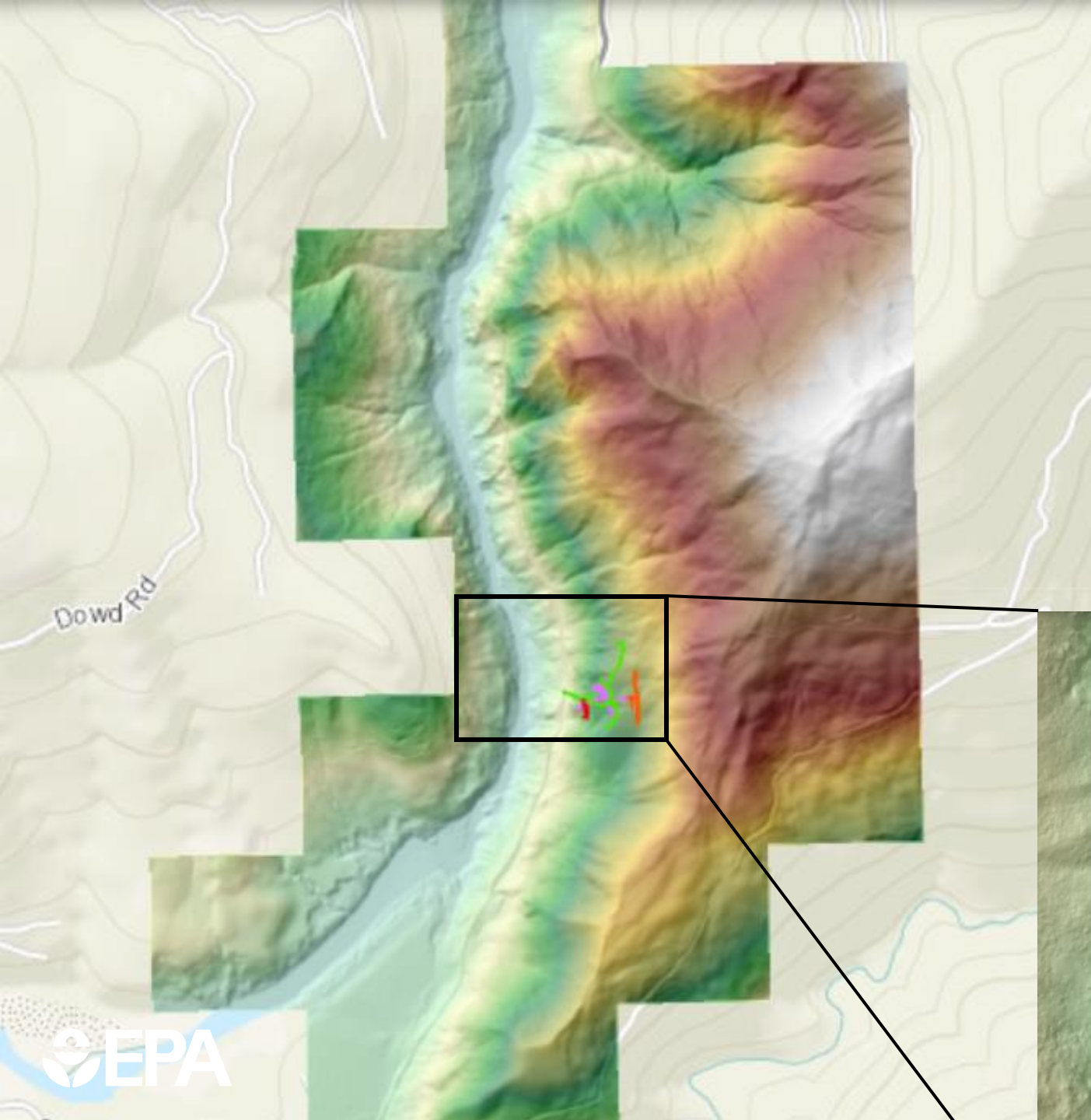


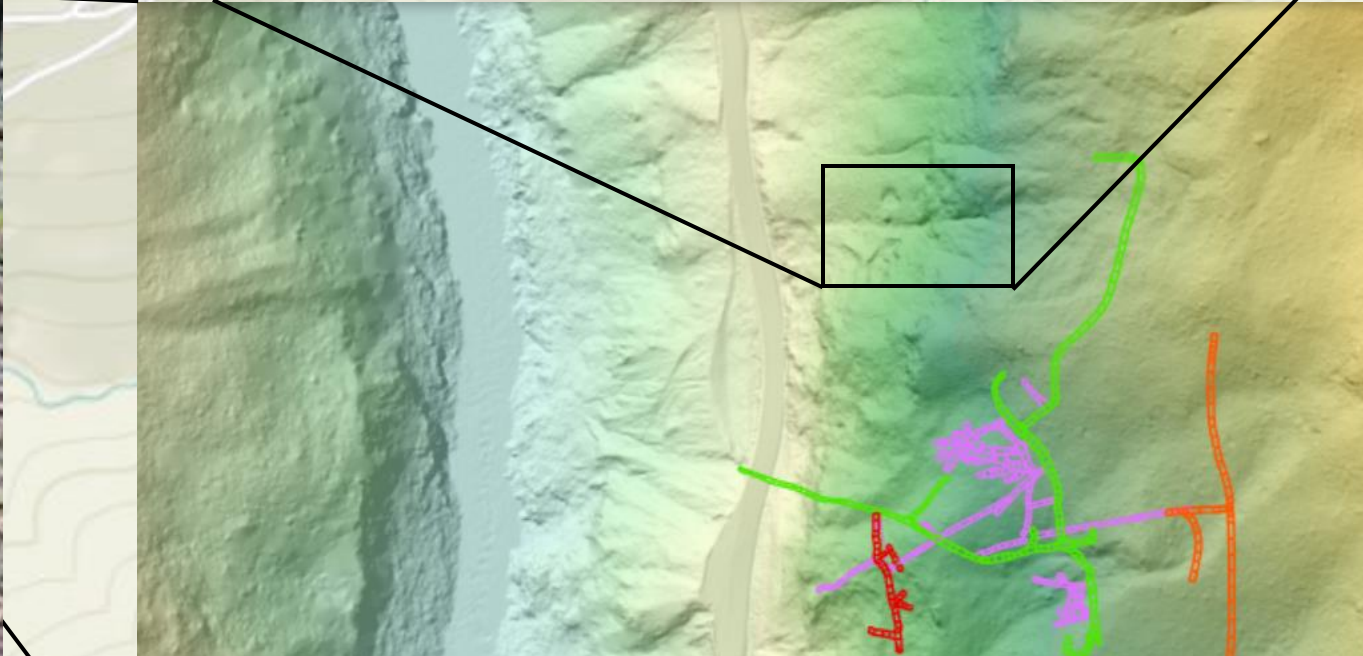


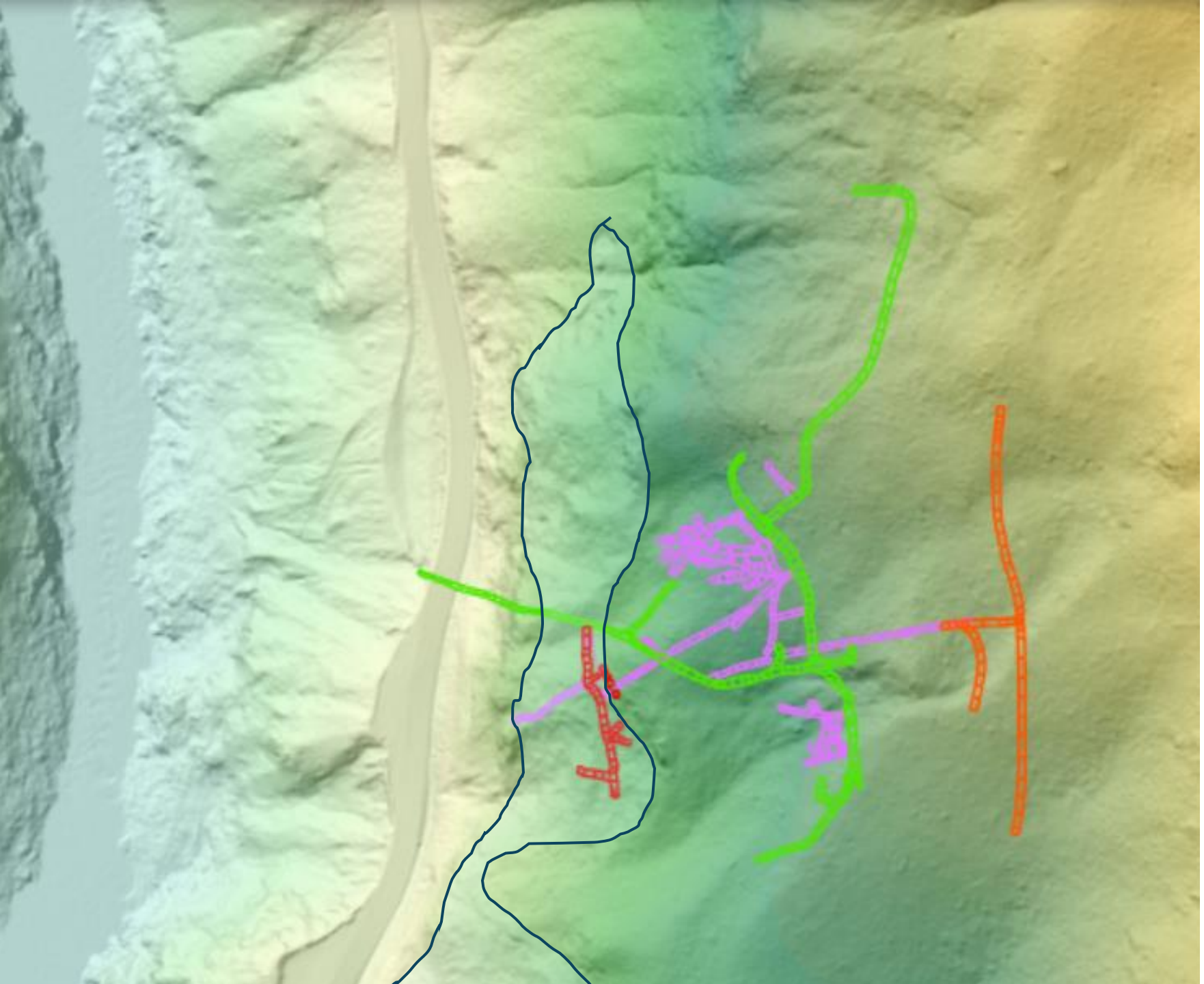


- LIDAR mapping of Topography
 - Digital Elevation Model (DEM)
 - Flown by manned airplane
 - Resolution of a few centimeters
 - Could see “through vegetation”
 - Included
 - Field ground truth survey
 - High resolution air photos
 - 1 foot contour topo map
 - Loaded onto tablets for field use
 - \$46,000 (2021)









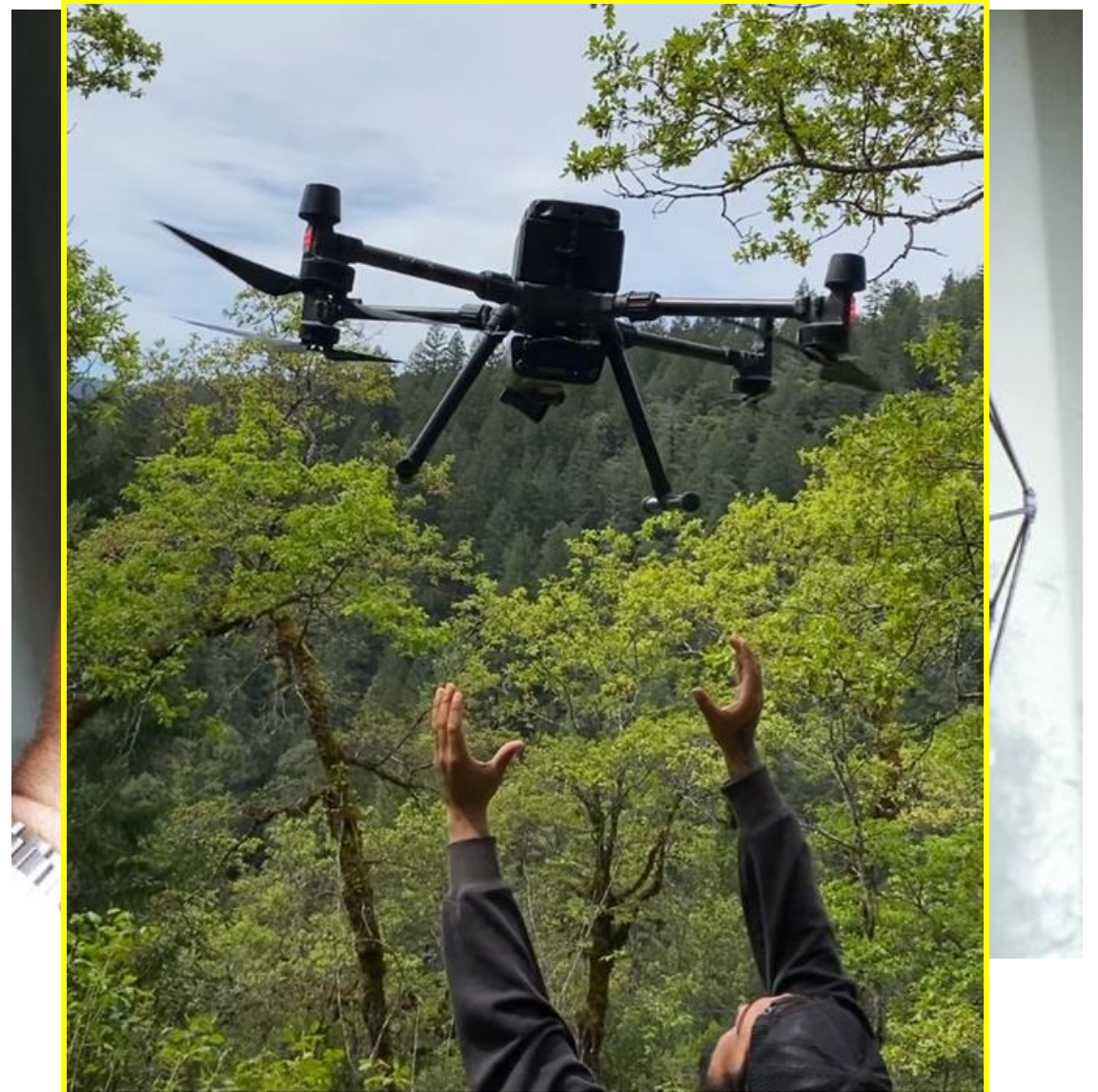
Copper Bluff – Remote Technologies

- Specialty UAV – Flyability Elios
 - 4K-20mp Camera (video and photo)
- Traditional UAV – DJI M300
 - Emesent Hovermap Laser CMS
 - LIDAR



Copper Bluff – Remote Technologies

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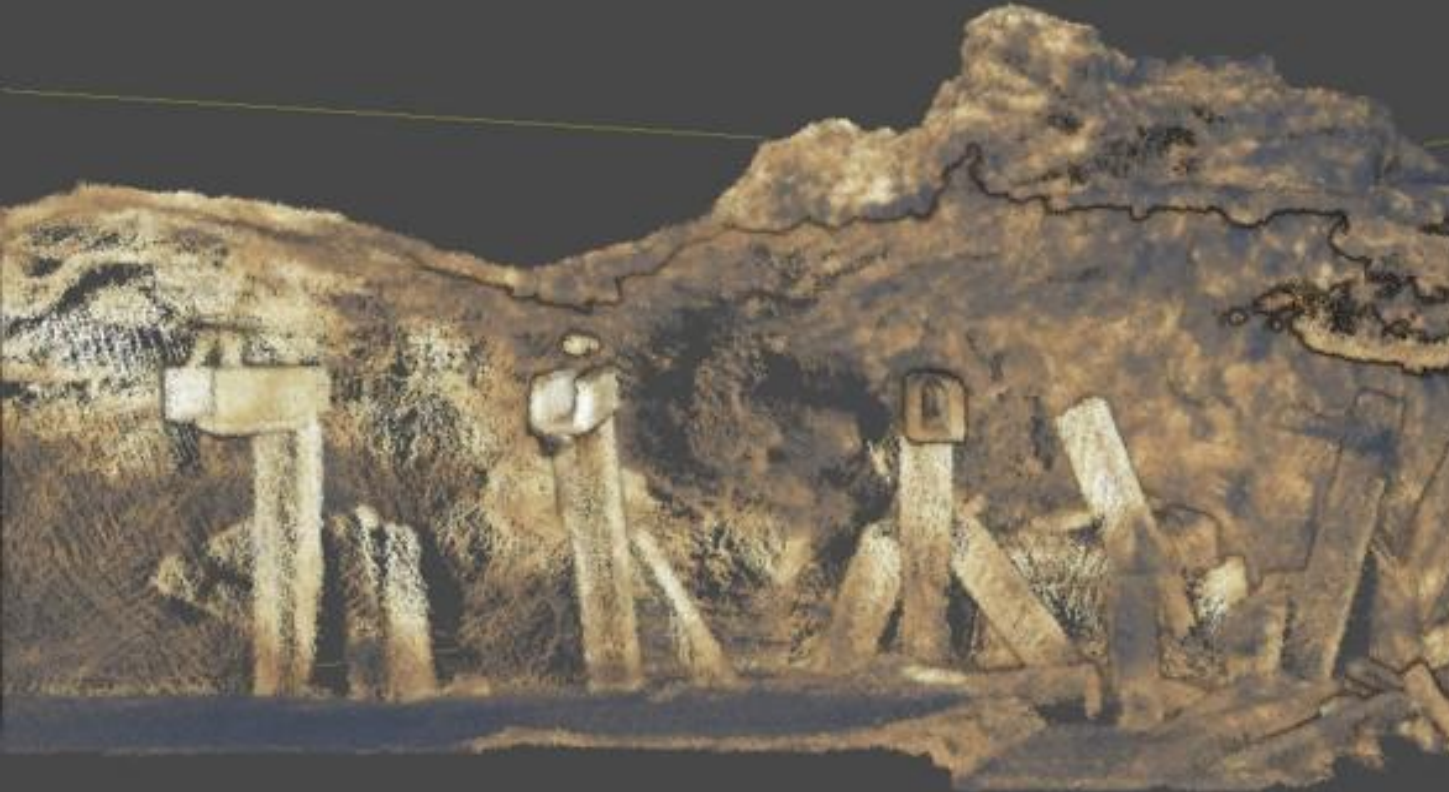


Underground UAV

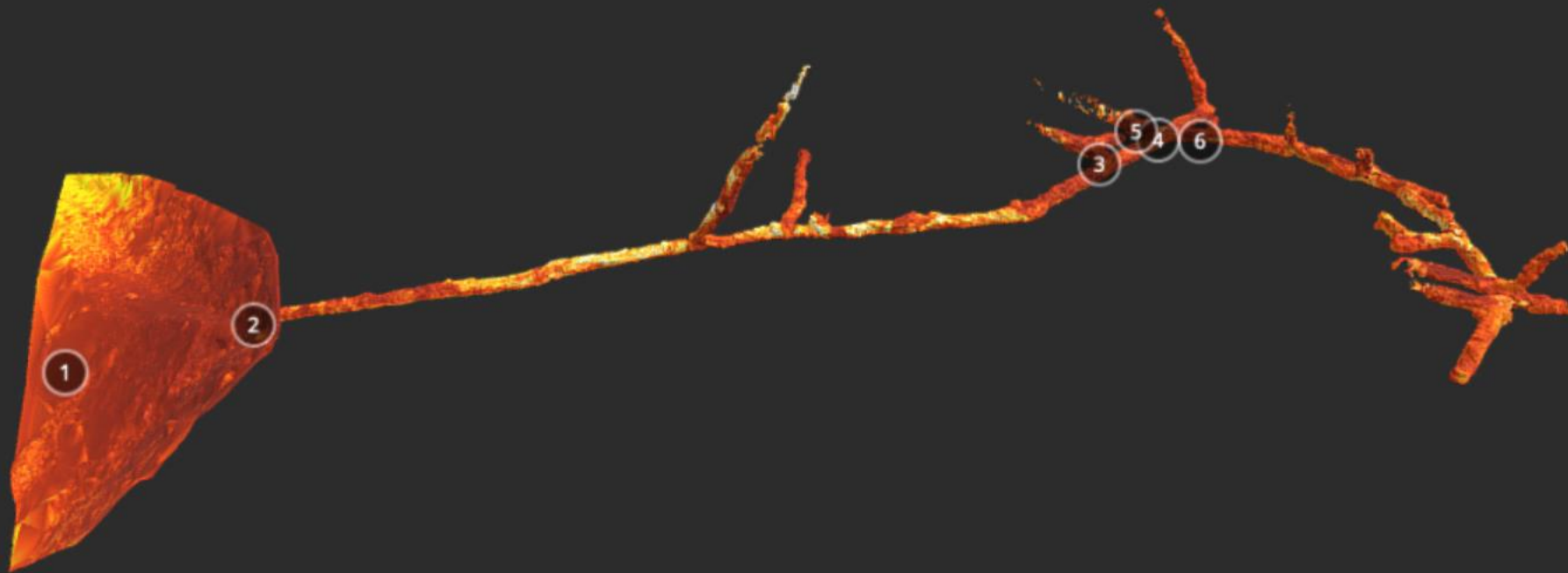
- Used to explore and map underground workings
- Add safety and accessibility
- Deliverables
 - Video
 - Point Cloud
 - Photos
- \$10,000



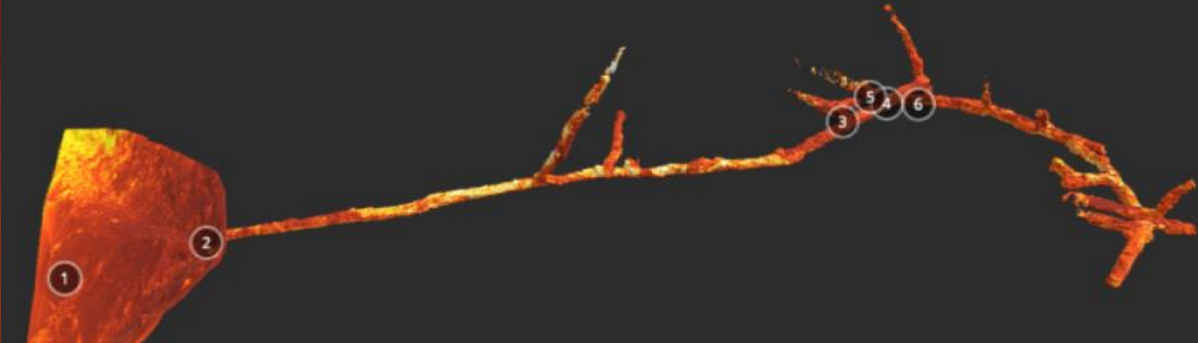
Point Cloud and Video

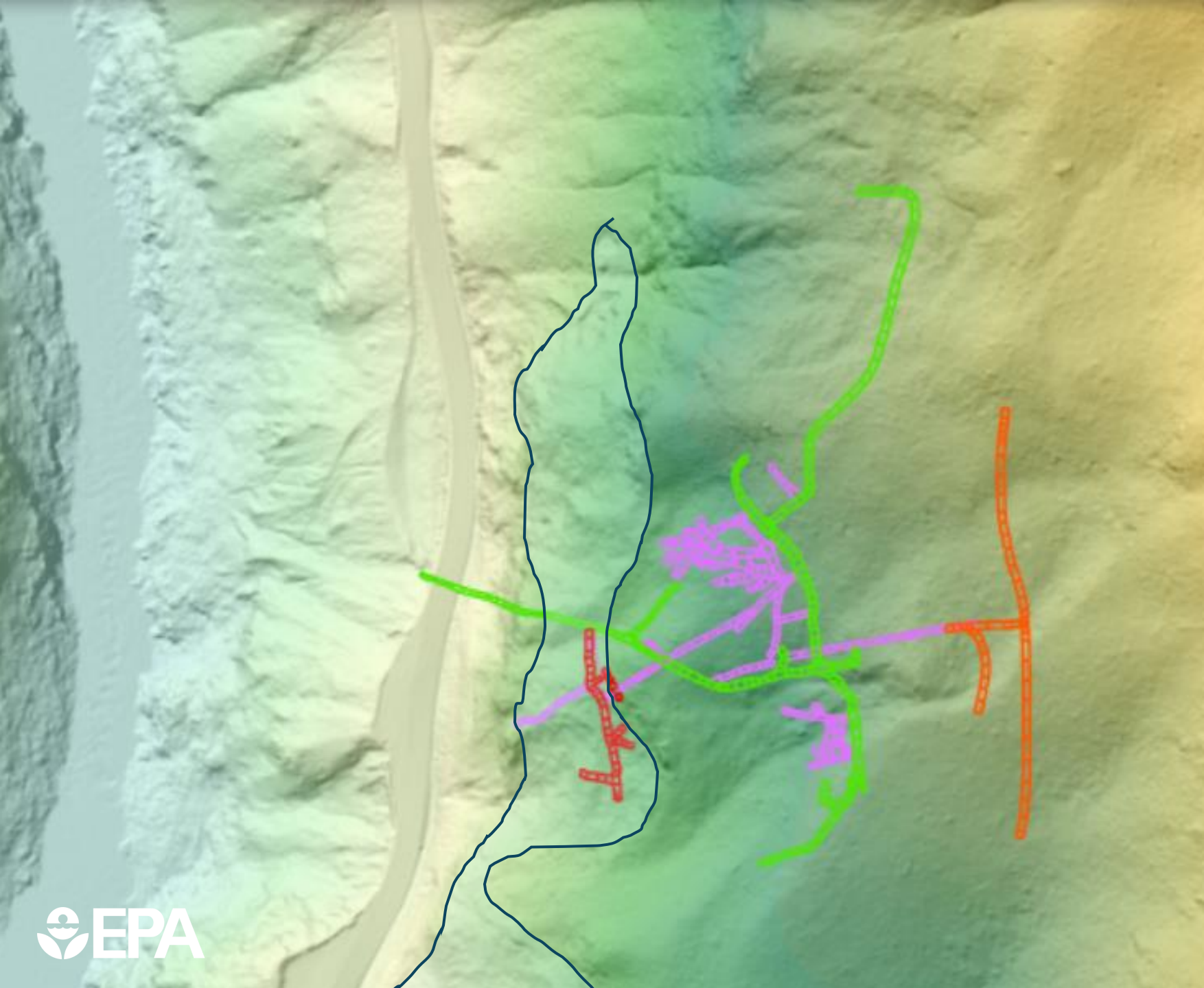






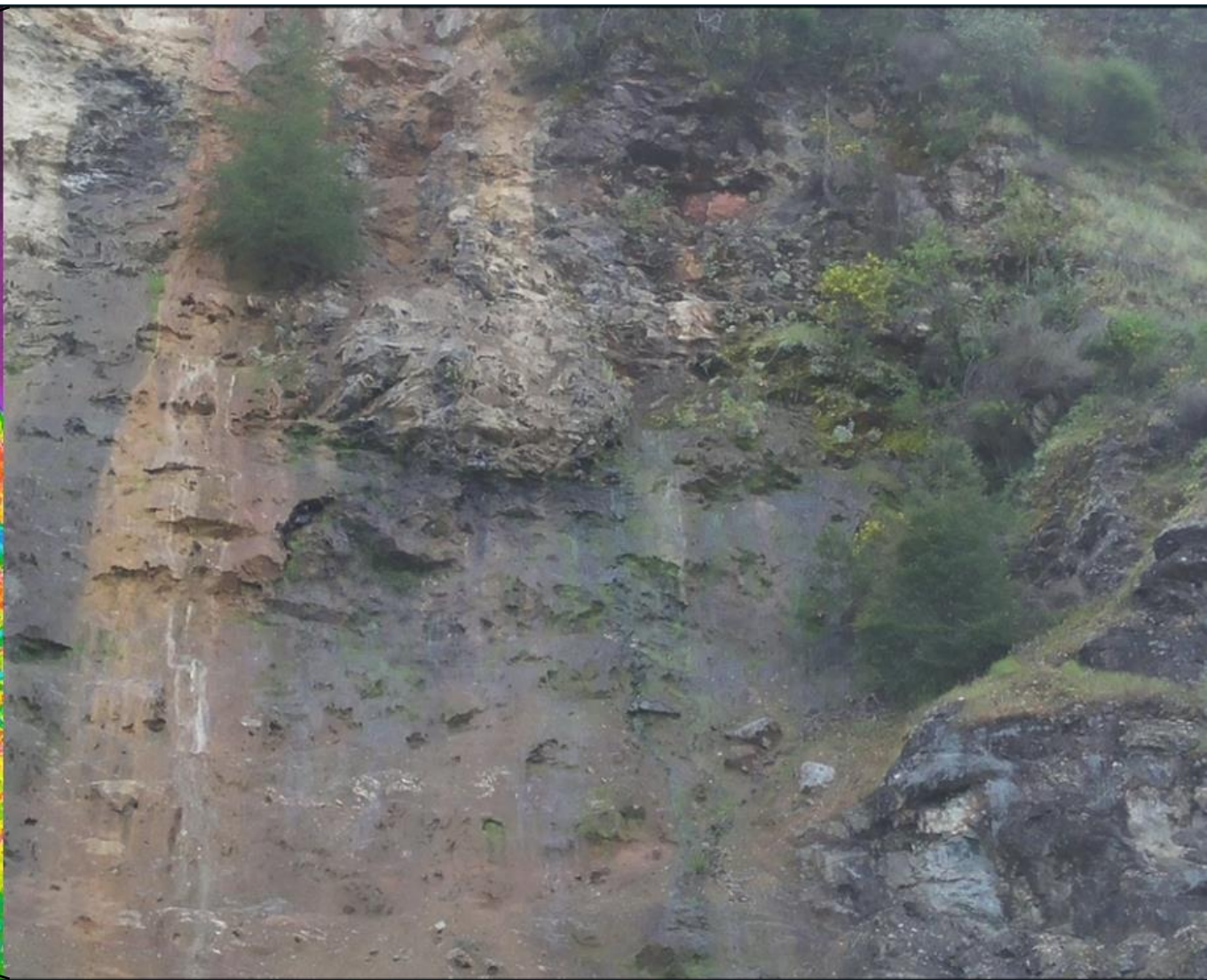
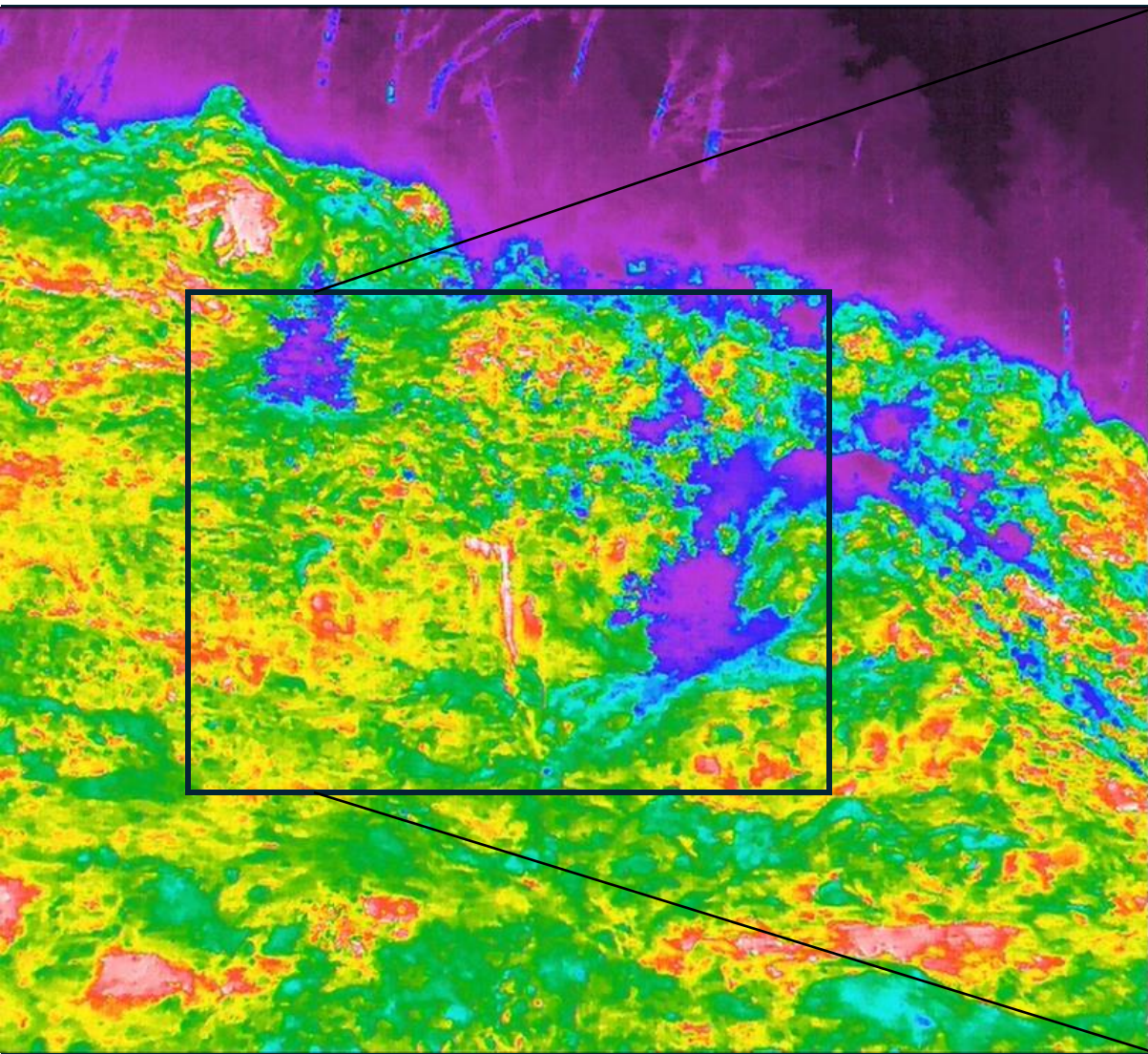
SAVE VIEW

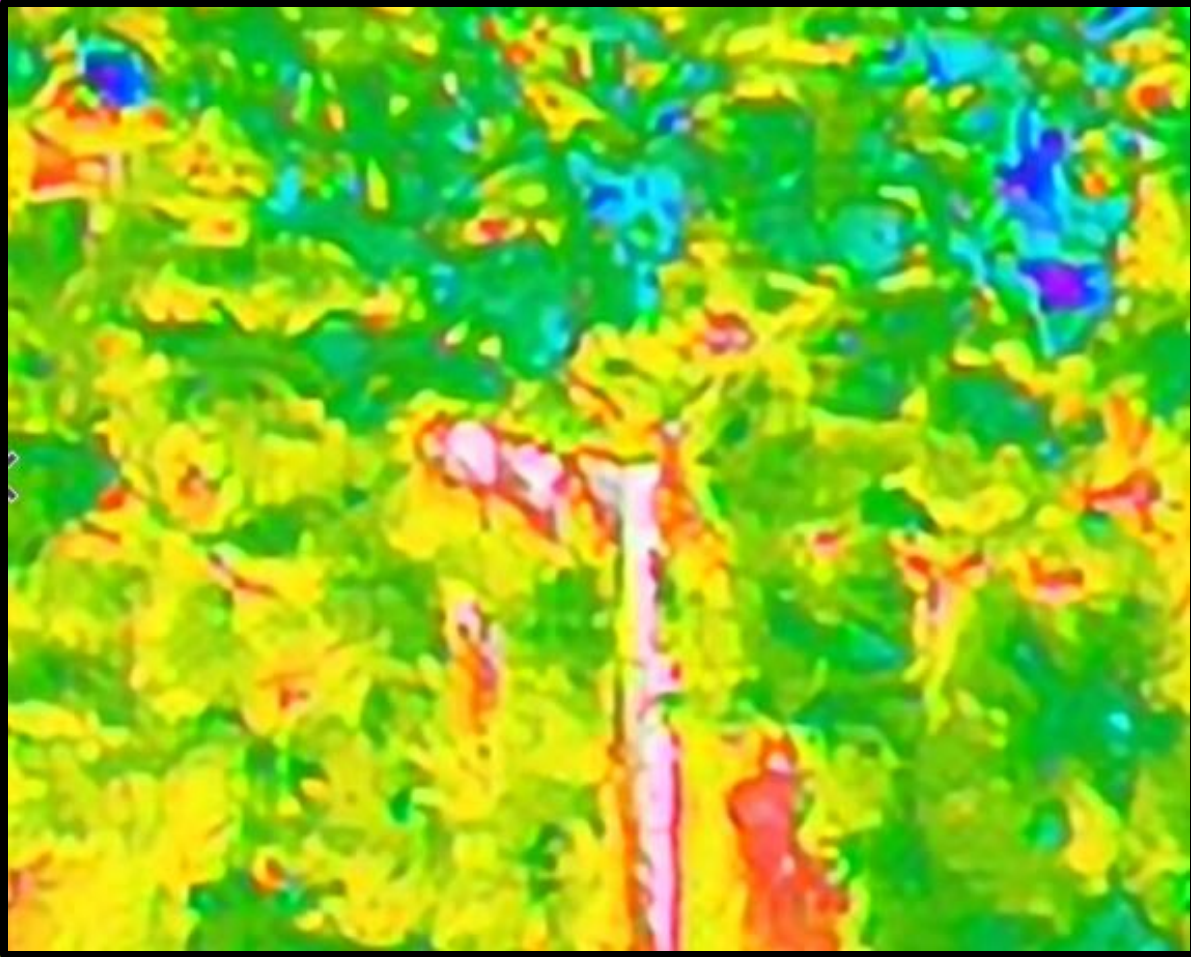












Above ground UAV

- Used to obtain video and photos of Trinity River
- Add new perspective on understanding site
- Used both video and photos
- \$1,000 for direct contractor or 10k for outside consultant





Areas of Surface Collapse



Main Adit



UAS Case Study – Gilt Edge Mine



Photogrammetry Via Use of Drone to Support Remediation

Project Background and Setting

- Abandoned open pit, cyanide heap leach gold mine developed in highly sulfuric rock.
- Operations began in 1800s; ceased in 1999. Added to NPL in 2000.
- Site actions > installing new pipeline / pumping systems, dewatering ponds and pits, constructing sludge disposal cell, transferring sludge to cell, plugging mine openings, blasting to generate material to fill pits, and restoring site.
- Primary mine disturbance area - approximately 360 acres.



Project Surveying Requirements

- Establish initial excavation limits.
- Develop as-built drawings of acid rock drainage collection systems, sludge cell construction, mine opening plugging, borrow pit boundaries, roadways, and pipelines.
- Document end-of-work conditions.
- Document progress of remedial action and provide verifiable quantity estimates for various remedial action activities as take-offs for contractor payment.



UAS Equipment Used at the Site



DJI Phantom 3 Professional Drone



Sony 16 mega-pixel (mp) complementary metal oxide semiconductor (CMOS) camera



3D photogrammetry processing software



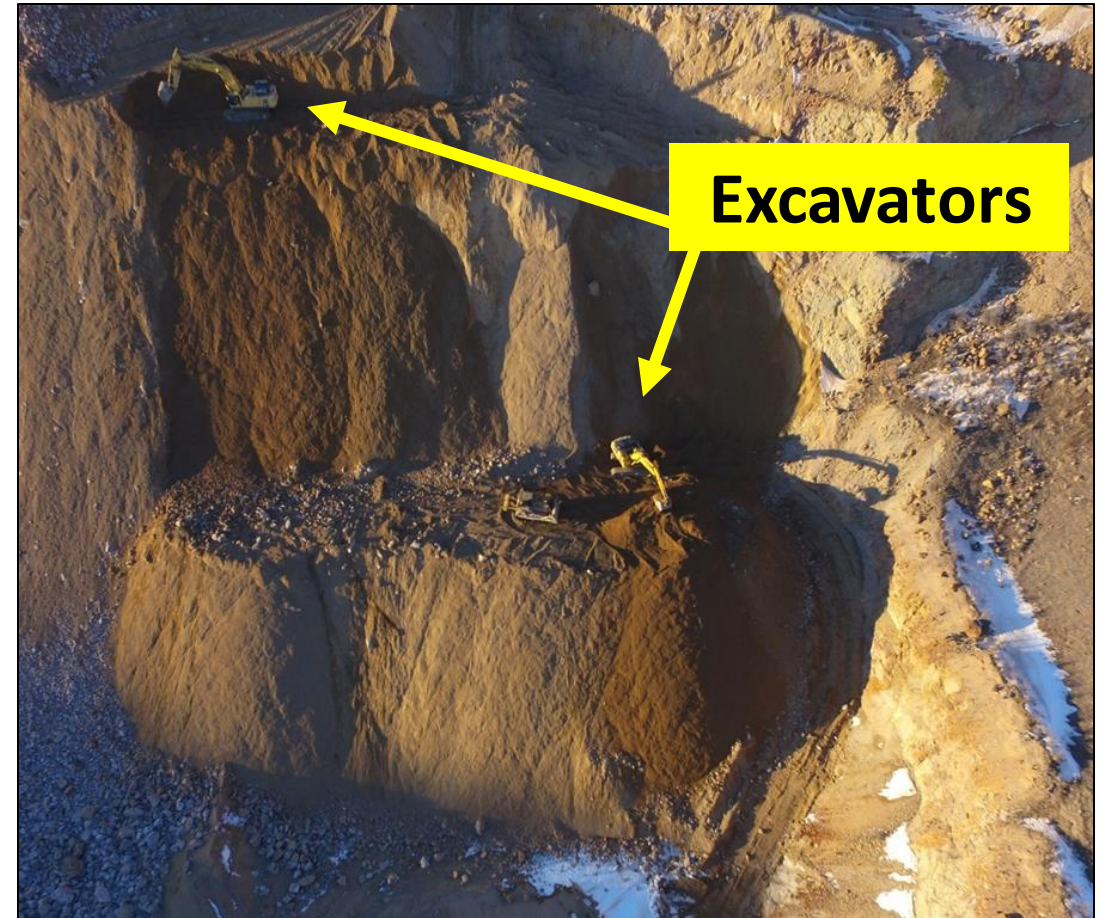
AutoCAD software



Note: Use of UAS involves regulatory, safety, and quality control considerations.

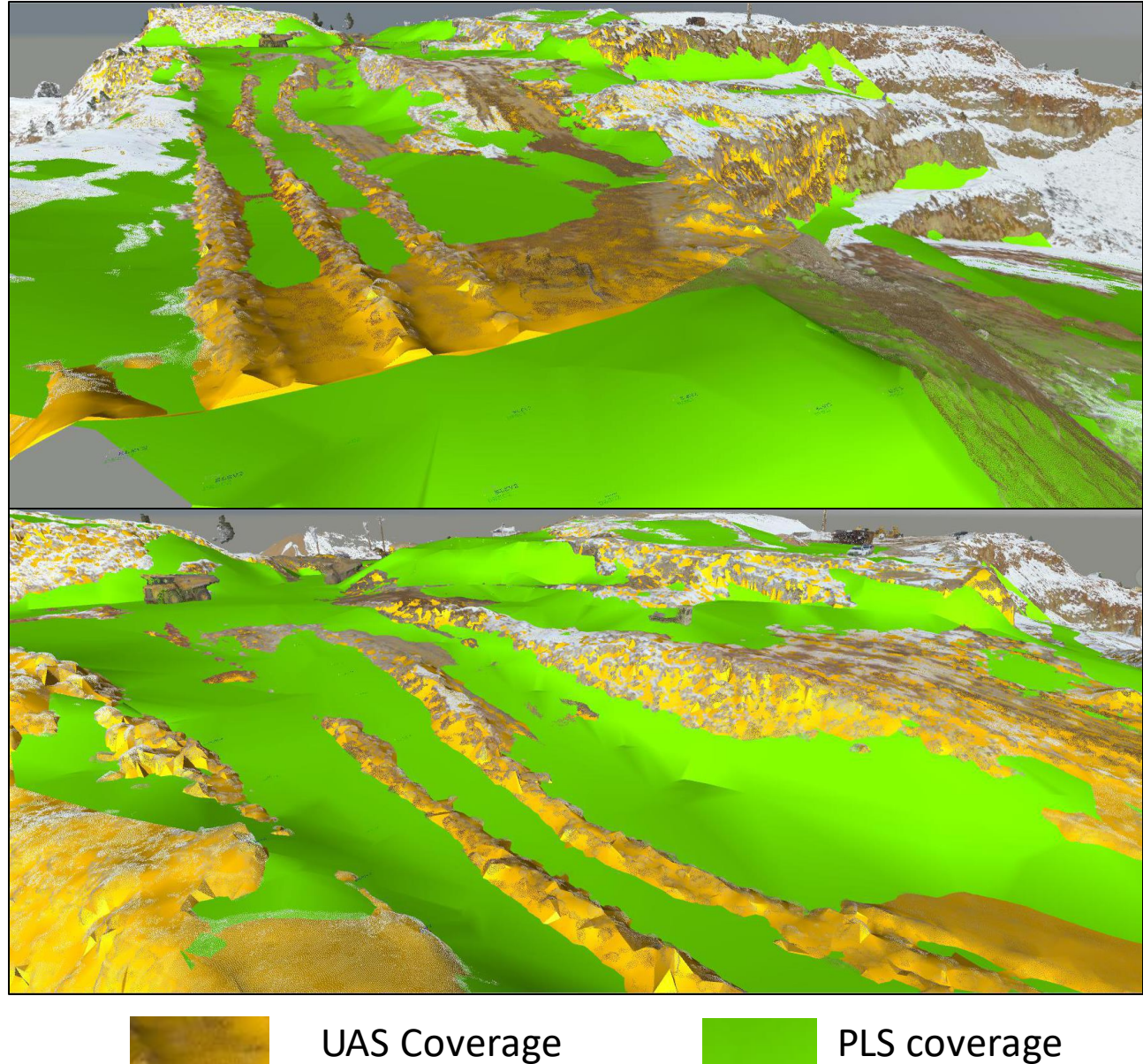
Drone Surveying vs PLS Used at the Site

- Professional land surveyor (PLS) and aerial drone comparatively used to document construction progress.
- Performance metric was quantities of rock and/or soil removed or placed.
- Advantages of using aerial drone:
 - Field work uninterrupted during the PLS survey.
 - Eliminated need for PLS staff to navigate dangerous terrain and access potentially hazardous areas.
 - Work was conducted more efficiently than traditional survey methods, which helped maintain project schedule.



Comparison of UAS and PLS Surveys at Sunday Pit

- 8.1 acres surveyed to determine material quantities moved for contractor payment
- UAS provided more spatial coverage
- PLS' survey: 3.5 days = 226,807 CY
 - Required shutdown of all construction during survey
- UAS survey afterward: 20 min = 230,872 CY
 - +5 hours Data Processing
 - Construction uninterrupted
- Contractor estimated 3,169 additional CY moved between survey events
 - UAS survey indicated 4,065 CY moved
 - Contractor actually moved additional 896 CY
 - Result = equitably increased contractor payment
- UAS surveying was sustained as QC
 - Enabled contractor to obviate 20 construction days of accumulated schedule delay
 - Reduced original end schedule by net 10 days



Attributes of Survey Data Collected Using UAS

- Uses: Real-time progress monitoring and materials quantification.
- Time efficient: Example: 37-acre Heap Leach Pile with ~2.5 million CY of material surveyed in 30 minutes vs 3.5 days for PLS using GPS methods.
- Accuracy: Comparable to PLS GPS zero benchmark.
- Detail: 2.5M data points (pixels) in UAS “point cloud” compared to ~10,000 GPS points.
- Coverage: Multiple aerial surveys can be conducted on adjacent parcels and joined together in photogrammetry software with georeferenced data.
- Integrated Multimedia: Survey data and corresponding still photos at specific locations can be quickly obtained and spatially georeferenced in GIS media.

Use of 3D Photogrammetry for Engineering & Design

- Walking 3D photographic survey of oil refinery
- Images collected with digital SLR camera
- 32 different process areas photographed in 4 hours
- Generated 3D data point cloud
 - ~285 million data points per location
 - ~9.1 billion data points total (pixels)
 - Actual scale; georeferenced
- 3D data processing and deliverables: 96 hours
 - Average of 3 hours per area
- Results used as-built / as-is conditions for design of refinery modifications
- Total cost of services ~\$8,000; not including travel



UAS Resources - Technical Resource Hub (Beta)

The screenshot displays the 'UAS Mockup' website interface. At the top left is the 'UM' logo and the page title 'UAS Mockup'. A navigation menu includes 'Home', 'Pages', 'Accessibility Mode', 'Internet Resources', 'Site contents', 'Training Resources', and 'Edit'. A 'Share' button is located at the top right. Below the navigation, there are utility links for '+ New', 'Page details', and 'Analytics'. A publication date of 'Published 12/14/2022' and 'Edit' options are visible on the right. The main content area features four large image-based tiles: 'UAS Technical Resources Library' (with a globe image), 'Internet-Based UAS Resources' (with a 3D arrow on a grid), 'UAS Data Collection Road Map' (with a winding road and a speed limit sign), and 'UAS Policy and Guidance' (with a close-up of a clock face). To the right of the 'UAS Policy and Guidance' tile is another tile for 'UAS Training Resources' showing a stack of books. Below these tiles is a teal banner titled 'Other EPA UAS Resources' containing seven white buttons with icons and text: 'EPA UAS Program', 'EPA UAS Policy', 'UAS Community o...', 'OLEM UAS Page', 'EPA UAS Usage Report', 'UAS Reporting Tool', and 'ERT UAS Resources'.

<https://usepa.sharepoint.com/sites/UASMockup>

UAS Community of Practice (COP)



◆ EPA Unmanned Aircraft System (UAS) COP

- » Shares UAS news, requirements, experiences and technical information with EPA staff.
- » Aims to standardize UAS practices across EPA, contribute to UAS resource development, build technical and practical knowledge base.

◆ Currently working on developing and/or implementing:

- » Updating and maintaining UAS documentation
- » Quarterly Community of Practice Meetings

Ø <https://usepa.sharepoint.com/sites/EPAUASCommunityofPractice>

UAS Technical Resource Hub (Beta)


EPA UAS Policy and Guidance

The screenshot shows a SharePoint page for 'UAS Mockup'. The top navigation bar includes 'Home', 'Pages', 'Accessibility Mode', 'Internet Resources', 'Site contents', 'Training Resources', and 'Edit'. A secondary bar contains '+ New', 'Send to', 'Promote', 'Page details', and 'Analytics'. The page features a large header image of a beach with the text 'UAS Policy and Guidance'. Below the header are two green boxes with the U.S. Environmental Protection Agency logo and text: 'U.S. ENVIRONMENTAL PROTECTION AGENCY' and 'Unmanned Aircraft Systems (UAS) Policy | US EPA'. A 'Like' button is visible at the bottom.


UM UAS Mockup Home Pages Accessibility Mode Internet Resources Site contents Training Resources Edit Share

+ New Send to Promote Page details Analytics Published 3/1/2022 Edit

UAS Policy and Guidance

 **U.S. ENVIRONMENTAL PROTECTION AGENCY**

Unmanned Aircraft Systems (UAS) Policy | US EPA

 **U.S. ENVIRONMENTAL PROTECTION AGENCY**

EPA Unmanned Aircraft Systems (UAS) Program | US EPA

Like

UAS Technical Resource Hub (Beta)

Internet-Based UAS Resources *Technical, Case Studies and Research*

The internet resources provided below include a link to mine site-related information on EPA's CLU-IN website and non-EPA technical documentation for UAS and sensor systems, case studies and academic research.

CLU-IN: Characterization, Cleanup, and Revitalization of Mining Sites



CLU-IN: Characterization, Cleanup,
and Revitalization of Mining Sites

Non-EPA Internet Resources

[See all](#)

[+ New](#) [Edit in grid view](#) [Share](#) [Copy link](#) [Export to Excel](#)

[All Items](#) [?](#)

Title	Description	Resource Type	Website Address
Review of Some Applications of U...	The research is devoted to the analysis of opportunities and obstacles to the adaptation of IUAVT in the economy.	Academic Resear...	https://www.mdpi.com...
NH DOT UAS Fact Sheet	New Hampshire DOT UAS Case Studies	Case Study	https://www.nh.gov/d...
FAA Certificated Remote Pilots inc...	Part 107 Rules	Technology	https://www.faa.gov/u...
Application of Postprocessing Kin...	UAS Methods for Forest Ecosystems	Academic Resear...	https://academic.oup.c...

UAS Technical Resource Hub (Beta)

Internet-Based UAS Resources *UAS Data Collection Standards and Guidance Documents*

The resources below provide guidance on UAS and mapping industry standards and specifications from state and federal agencies, professional societies, and commercial entities. These resource documents contain the most current standards and specifications relevant to the UAS industry.

Data Collection Standards and Guidance Documents

[See all](#)

+ New ↑ Upload Edit in grid view Sync Export to Excel

General Sharing ⓘ

Document Title <input type="checkbox"/>	Name <input type="checkbox"/>	Organization T... <input type="checkbox"/>	Source <input type="checkbox"/>	Document Date <input type="checkbox"/>	Enterprise Key... <input type="checkbox"/>	File Size <input type="checkbox"/>
UAS and ASPRS Mapping Standards	ASPRS UAS and Mapping Standar...	Professional Society	American Society for Photogrammetry and Remote Sensing	5/1/2019	workflow Photogrammetry accuracy standards ground control	932 KB
ASPRS Positional Accuracy Standards for Digital Geospatial Data	ASPRS_Accuracy_Standards_for_D...	Professional Society	American Society for Photogrammetry and Remote Sensing	11/1/2014	terminology validation point ground control accuracy standards check point terms lidar	0.98 MB
ASPRS Accuracy Standards for Digital Geospatial Data	ASPRS_Accuracy_Standards_for_D...	Professional Society	American Society for Photogrammetry and Remote Sensing	12/1/2013	planimetric mapping accuracy standards accuracy statistics lidar ortho photos	605 KB
ASPRS LIDAR GUIDELINES: Horizontal Accuracy Reporting	ASPRS_Horizontal_Accuracy_Repo...	Professional Society	American Society for Photogrammetry and Remote Sensing	3/1/2005	ground gps network flight conditions error effects planimetric accuracy horizontal accuracy existing standards terminology lidar	1.24 MB
LAS Specification 1.4 - R15	ASPRS_LAS_Specification_1_4_r15...	Professional Society	American Society for Photogrammetry and Remote Sensing	7/1/2019	variable length records georeferencing data types coordinate reference syste lidar	313 KB

UAS Technical Resource Hub (Beta)

UAS Roadmap to New Data Collection: Preliminary Application



EPA Unmanned Aerial Systems Data Collection Road Map



Welcome to the Unmanned Aerial System (UAS) Data Collection Road Map.

This application is designed to walk you through the key steps for planning data collection via UAS. Each major step in the planning process is outlined below, and for each step additional interactive planning tools are available.

STEP 1: Define Target Dataset



Define Target Dataset

The first step in planning a UAS data collection is defining your target dataset. In other words, what questions are you hoping to answer with the data collected via UAS?

Click the button below to access the Target Dataset Questionnaire, which will collect information on your target dataset. That information will be used to evaluate whether UAS is an appropriate data collection platform for your project, and guide the selection of potential sensors.

[Target Dataset Questionnaire \(To Be Developed\)](#)

Questions



Kirby Biggs

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Office of Land and Emergency Management
Office Superfund Remediation and Technology Innovation
Technology Innovation and Field Services Division
Technology Integration and Information Branch
Washington D.C.**

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Phone: 202-566-2196



What are future plans for UAS in regard to your site(s)?

Just generally learning more

Thinking of using it at your site(s)

Already using it at your site(s)

Share your answer in the poll

Aerial Imagery using UAS

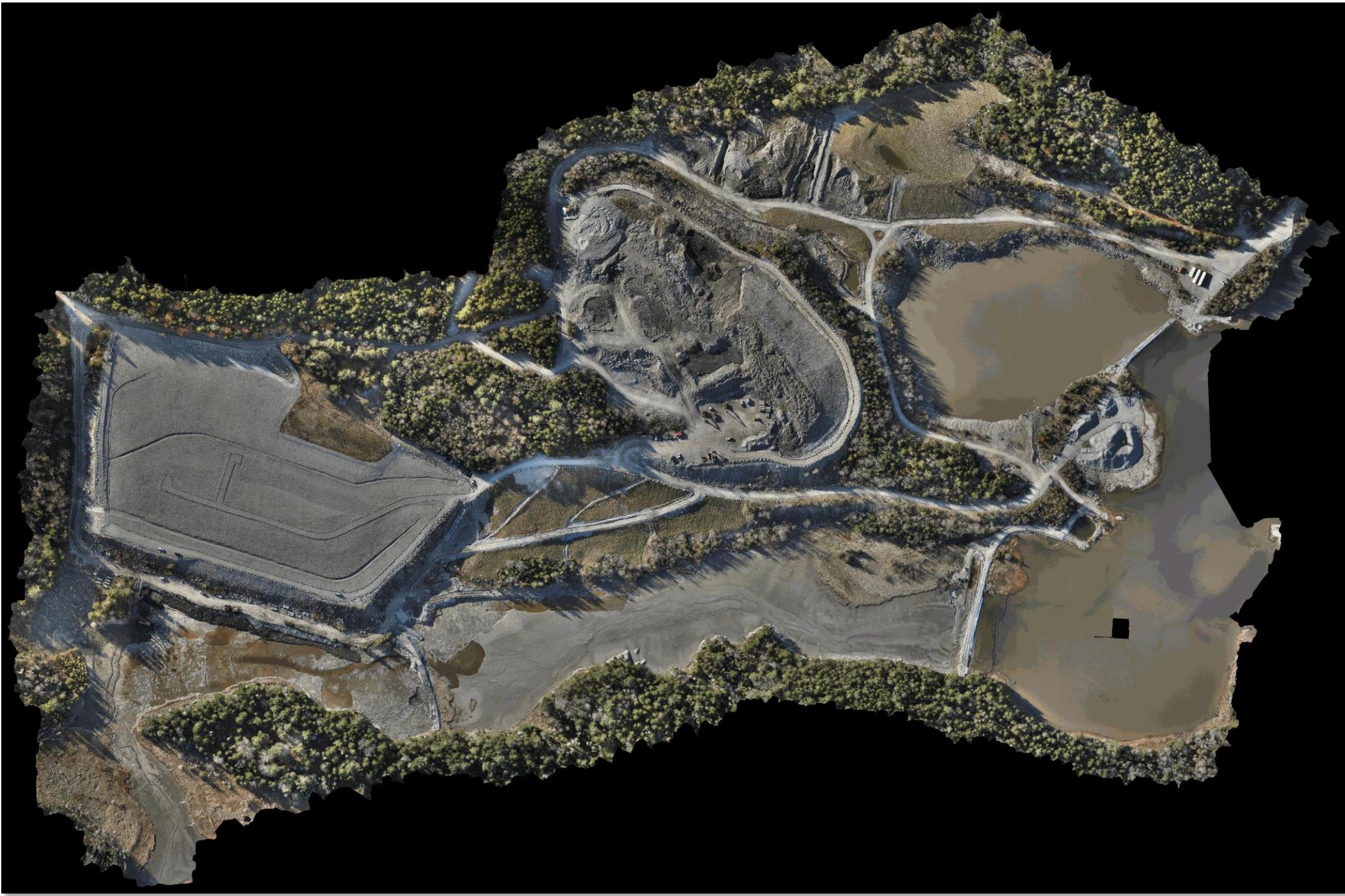
- Provides a unique perspective on site
- Better context for layout of the site
- Can see features not easily observed at ground level
- Time series photos provide a good mechanism for showing progress to the technical team, stakeholders, and within EPA
- Integrates well with figures for planning work
- Site-specific UAS flight provides opportunity to select dates and photo angles vs high quality satellite photos
- UAS flights must be carefully planned to prevent collecting data not within areas where access permission has been granted.
- Often need to crop out information outside intended area
- A few examples provided on the following slides

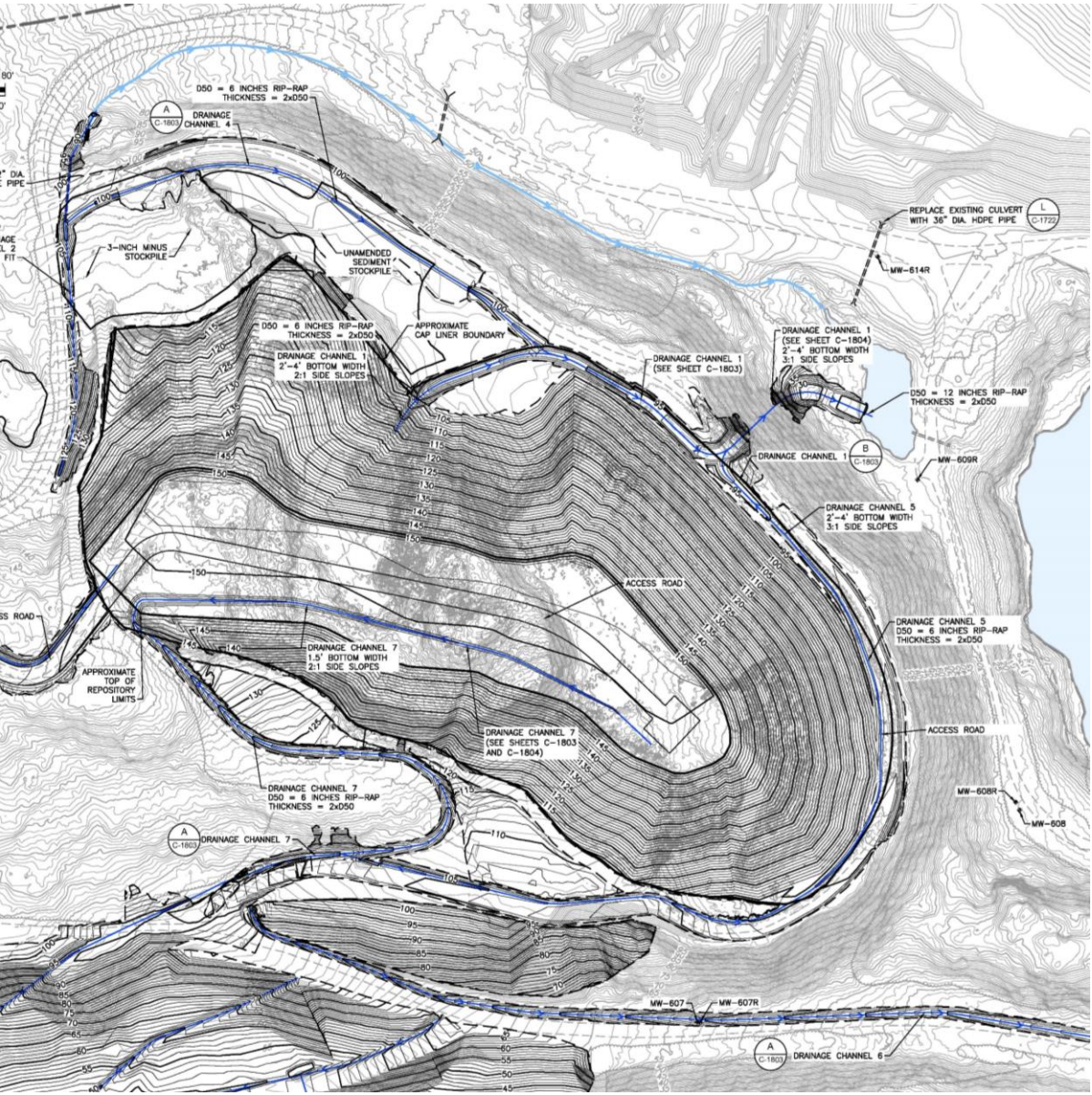


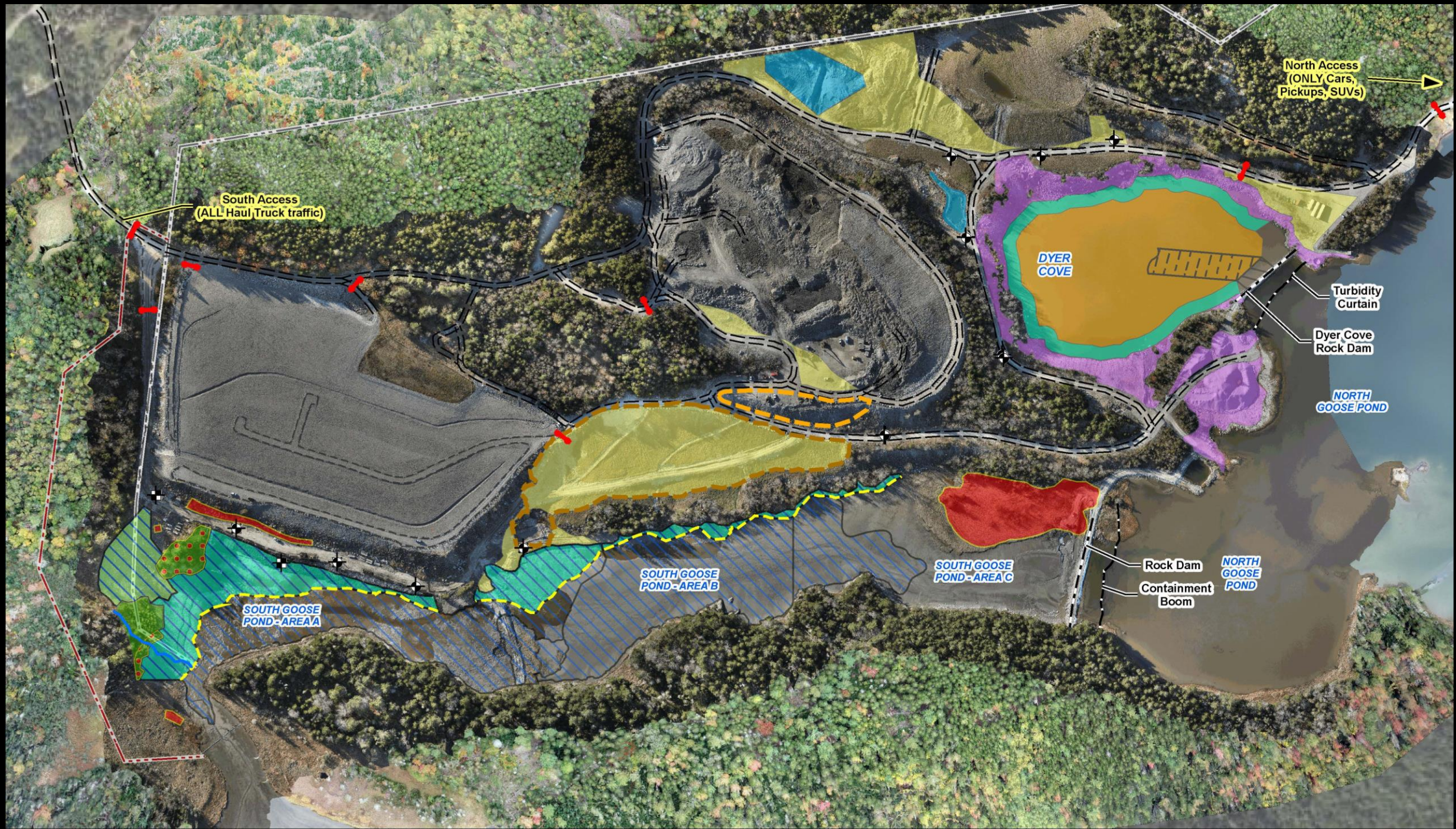












North Access
(ONLY Cars,
Pickups, SUVs)

South Access
(ALL Haul Truck traffic)

DYER
COVE

Turbidity
Curtain

Dyer Cove
Rock Dam

NORTH
GOOSE POND

SOUTH GOOSE
POND - AREA A

SOUTH GOOSE
POND - AREA B

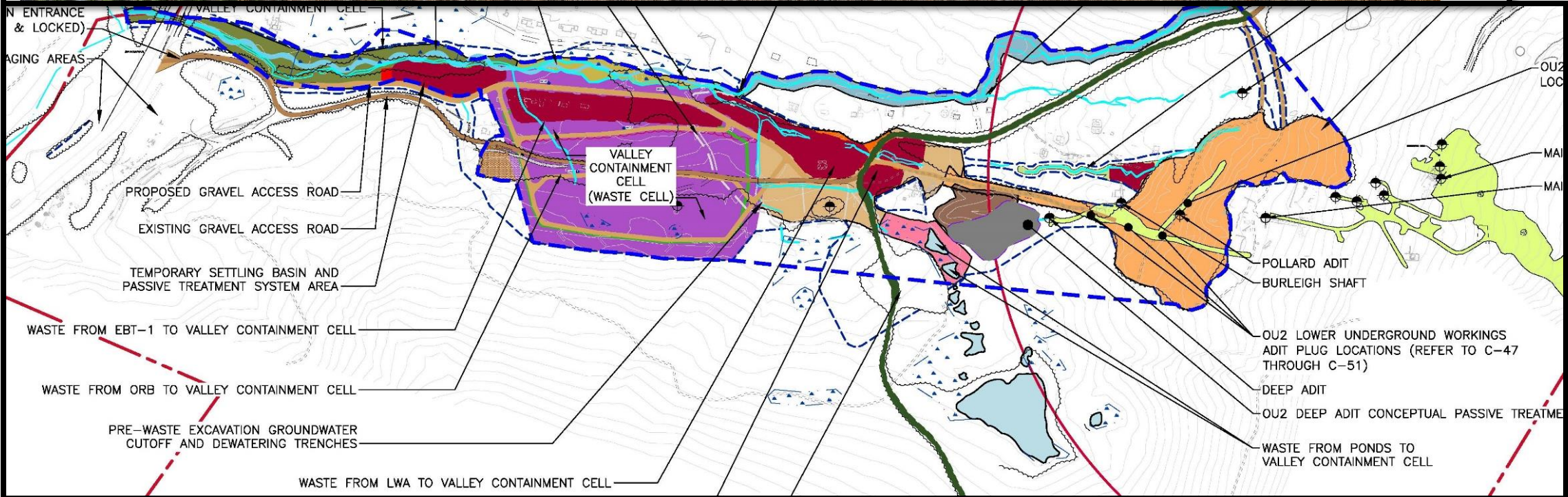
SOUTH GOOSE
POND - AREA C

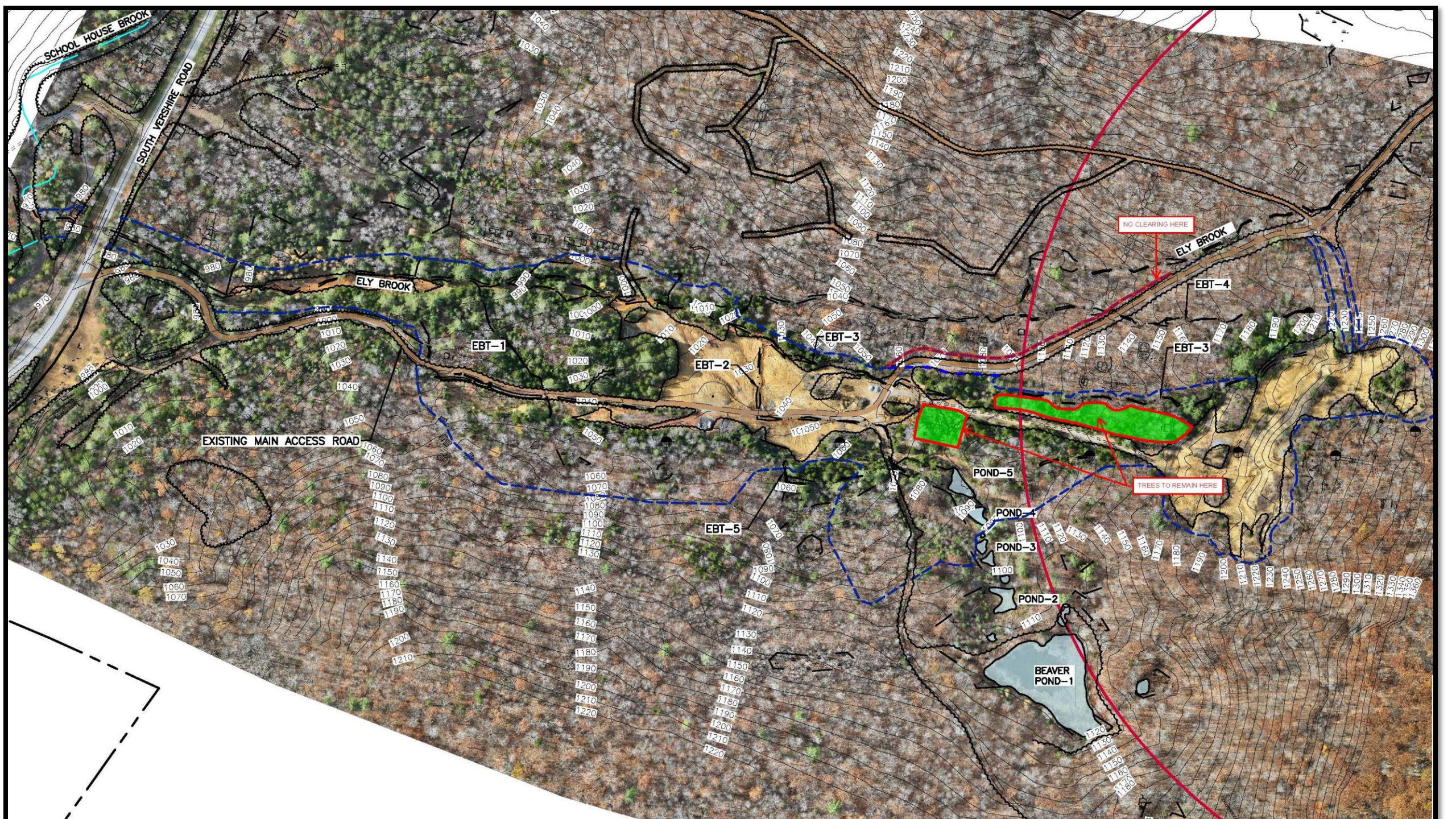
Rock Dam

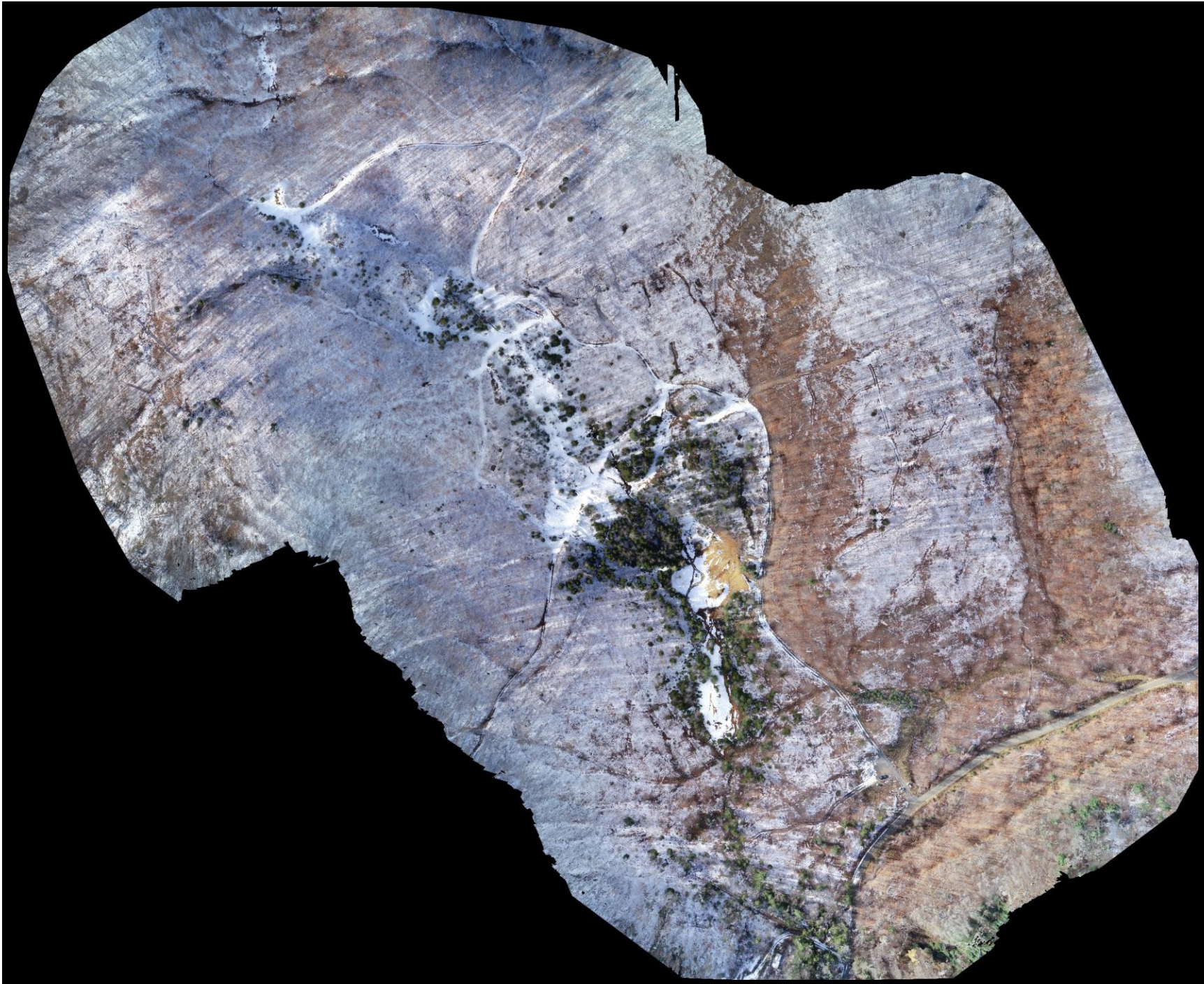
NORTH
GOOSE
POND

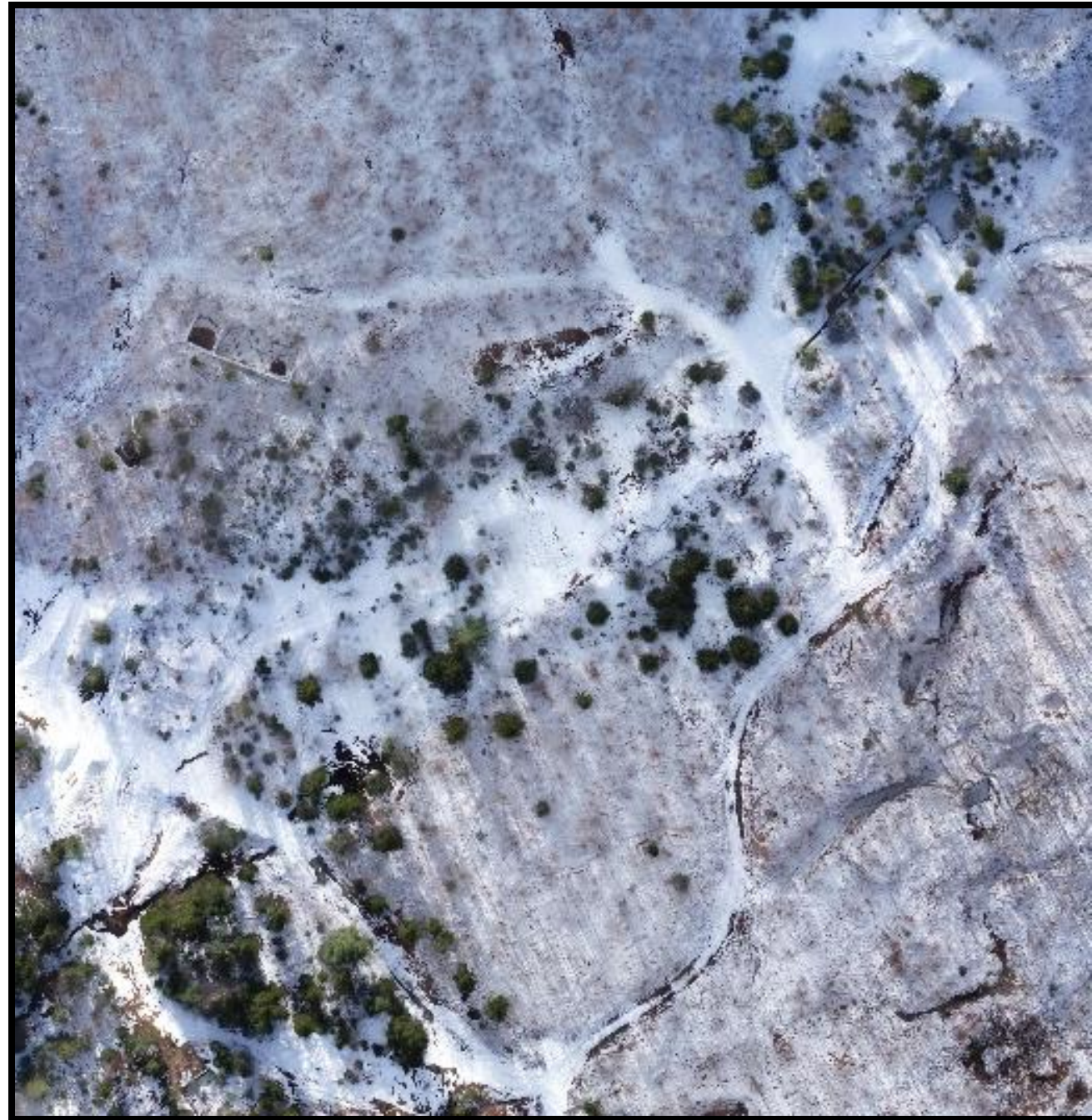
Containment
Boom



















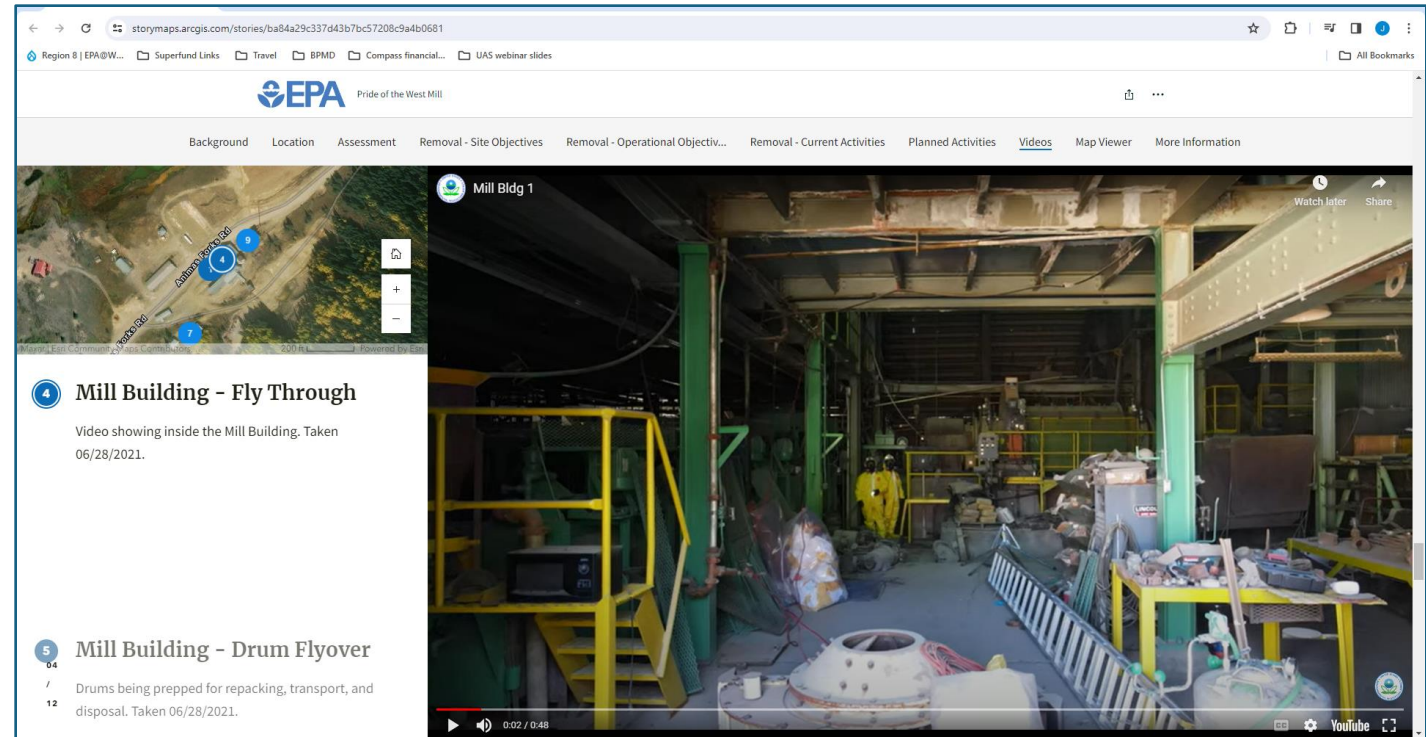
What programs are represented in the audience?

Superfund Remedial?
CERCLA Removal?
Site Assessment?
Technical Support?
Other?

Share your answer in the poll

Emergency Response Story Map & UAS Indoors

- Pride of the West Mill @ Bonita Peak Mining District NPL Site
- Unmaintained Mill building unsecured chemicals
- UAS used to look at upper decks before personnel access & above equipment
- Integrated information into a Story Map
- Video 1: <https://www.youtube.com/watch?v=ofAStIJ0toA>
- Video 2: <https://www.youtube.com/watch?v=CPanH2wJ7fc>



Credit to R8 OSCs Marty McComb*, Paul Peronard, Joe Payne

<https://storymaps.arcgis.com/stories/ba84a29c337d43b7bc57208c9a4b0681>

"How To" Resources & Basic Steps

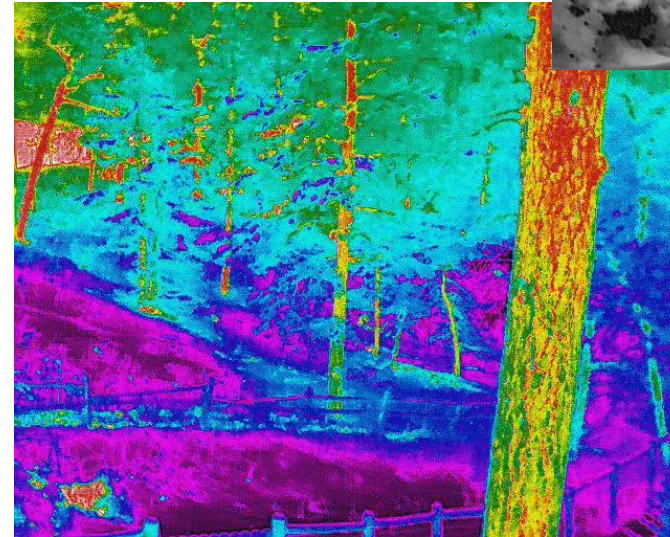
Specific OLEM requirements
(OSRTI & OEM) and CERCLA & OIL



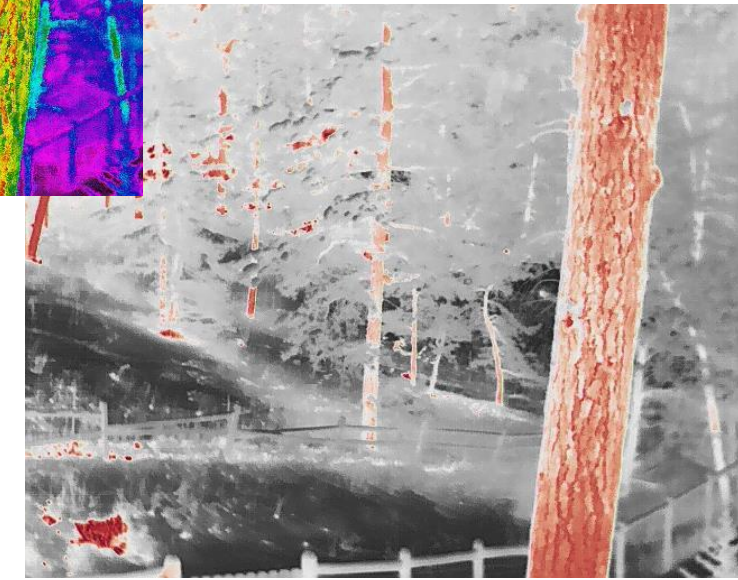
- Resource for steps to follow:
https://usepa.sharepoint.com/sites/OLEM_UAS
- Training is required within the last two years
 - Read: EPA UAS Policy Directive no 2137.1 (2022)
 - Read: OLEM Procedures & Approval Memo (2023)
- EPA cannot own, lease, or operate a UAS!
- EPA can access UAS services through a Contractor(or Sub) or Interagency Agreement
 - Operator is responsible for licensing/registration and FAA requirements
- Type of funding & FY matters! The annual appropriations bill specifies what is allowed
- FY24 included CERCLA “T” funds but not SF Tax nor Special Account
- Past years’ BIL/IIJA funds ok

"How To" Resources & Basic Steps

- OLEM request memo (template)
 - SEMD division director signature
 - Describe scope of work
 - Procurement type
 - UAS Work Category
 - Interior
 - Standard Operations
 - < 400 ft above ground
 - High Elevation
 - Beyond Visual Line-of-Site
 - Emergency Response
 - Controlled or Restricted Airspace
- Commit to follow up in OLEM reporting tool

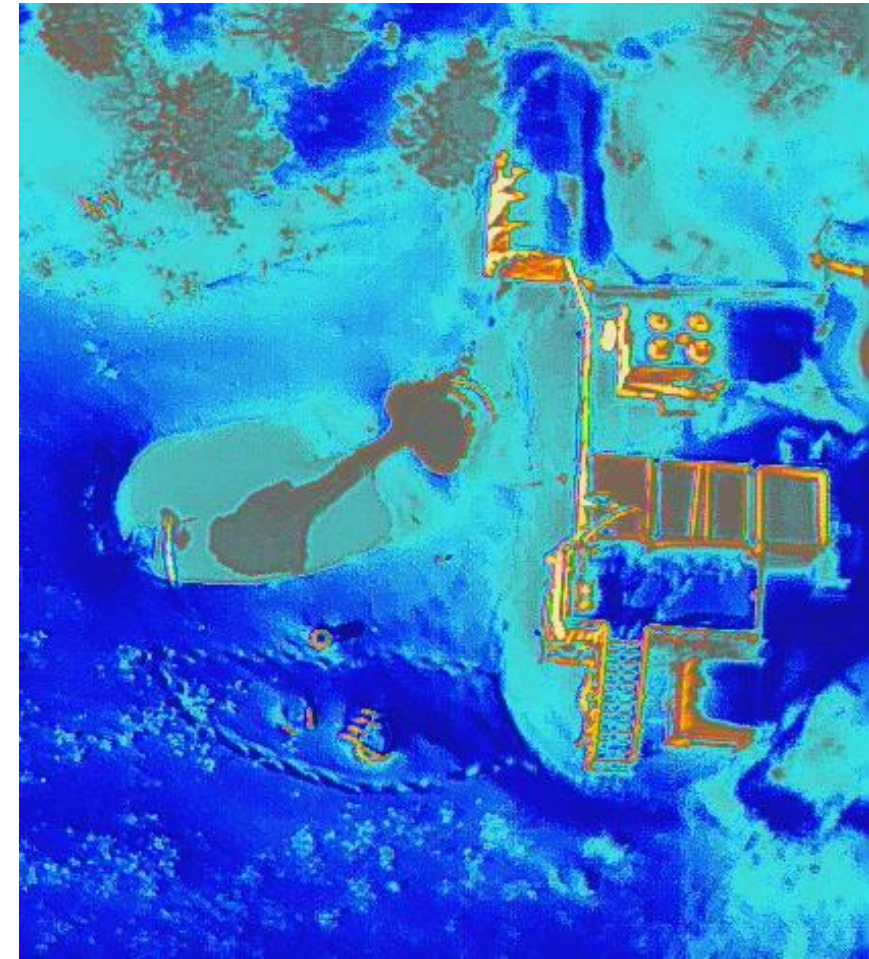


Test Run of Thermal Sensor



"How To" Resources & Basic Steps

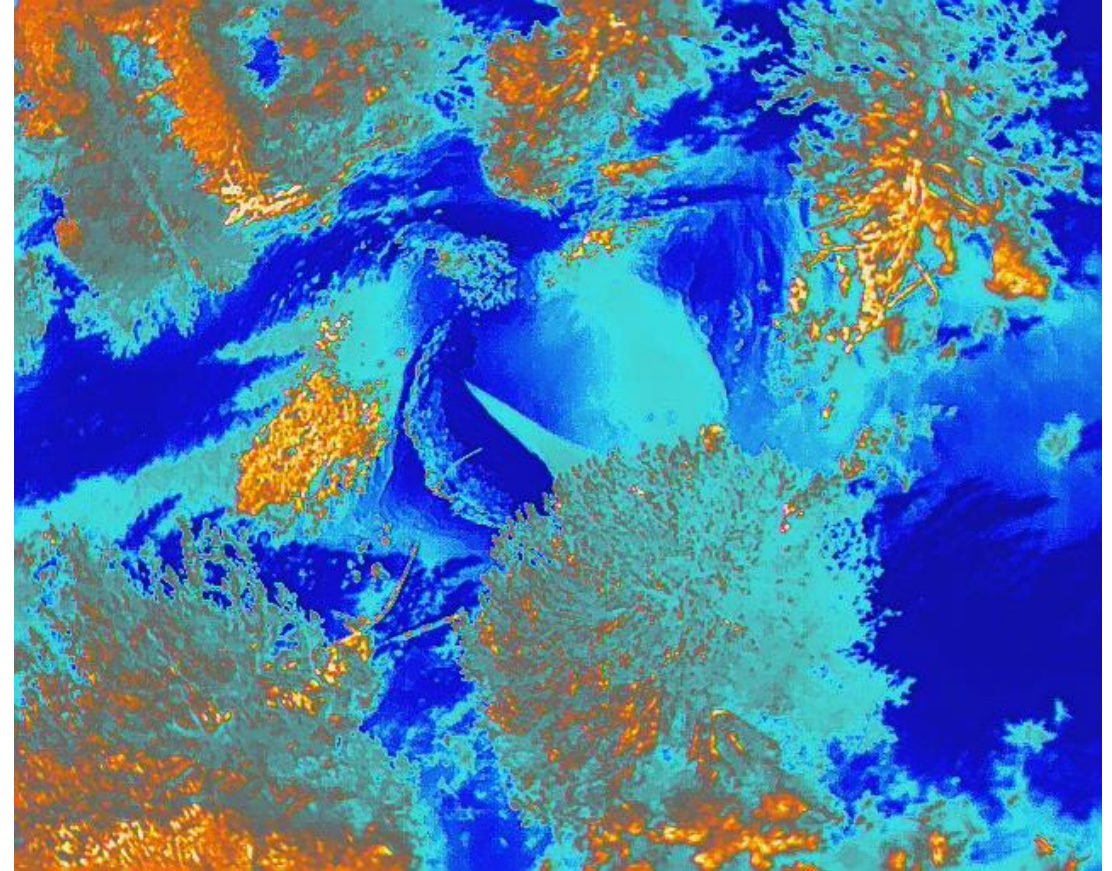
- Obtain consent for access to collect data
- Check local ordinances for restrictions and notifications
 - May have a UAS use request process
- Involve your Community Involvement Coordinator
 - Messaging about the work might be needed to nearby properties and other entities
- Ensure data collection is covered in QAPP/SAP & operation addressed in HASP
- Remove accidental capture of PII (license plates, people's images, etc) & where access was not obtained
- Privacy protection is paramount



Thermal imaging of Captain Jack External Treatment System-Test

Other Things to Navigate

- EPA Contracts: UAS needs to be in scope
- State Cooperative Agreements with CERCLA funding can use UAS if included with terms & conditions in the CA Scope and budget
 - Verify with grants program before proceeding
 - Each State may have additional requirements for UAS use
- Interagency Agreements with USACE
 - USACE requires UAS specific language in contractor's scope
 - USACE abides by DOD requirements
 - Blue UAS cleared list
<https://www.diu.mil/blue-uas-cleared-list>
- Read EPA policy, check with Contracting Officer or Project Officer as you begin planning!



Thermal Sensor Looking for mine shaft heat release
– but all we saw were hot trees and rocks!



Questions?



Contact Information

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