U.S. Department of the Interior
Bureau of Land Management

Unmanned Aircraft Systems (UAS) in the BLM

BLM Aviation Program

- BLM Aviation based at the National Interagency Fire Center (NIFC) in Boise, ID
- Overall program guidance from DOI's Office of Aviation Services (OAS)
- BLM National Aviation Plan (NAP)
  - https://www.doi.gov/sites/doi.gov/files/uploads/opm-11.pdf
- BLM Unmanned Aircraft Systems (UAS) activities coordinated with DOI OAS
  - OPM 13-11 DOI Use of Unmanned Aircraft System (UAS)
  - DOI/FAA Memorandum of Agreement (MOA) for sUAS
- Aviation safety
- Aviation dispatch
- Mission support for wildfire, wild horse gathers, habitat monitoring, cadastral survey, law enforcement, aerial mapping, range survey, etc.

Drones are Coming … Err … Here …

- Coordination – OAS (Policy), BLM National Aviation Office (Aviation), BLM National Operations Center (Data), and partners
- Training – Aviation (5+ courses) and data (1-2 courses)
- Standards – Workflows, metadata, reporting
- Privacy – Records and decisions, public relations
- IT – Data storage, processing, visualization, automation
  - 10 - 500 GB of data with 1000's of images per project

BLM UAS Program Objectives

- Safety comes first!!! Execute safe aerial survey
- Timely and high quality scientific data collection and delivery
- Meet individual project/mission objectives
- Comply with BLM's geospatial data standards and metadata requirements
- Be local – Best value to the government

AeroVironment RQ-11A Raven

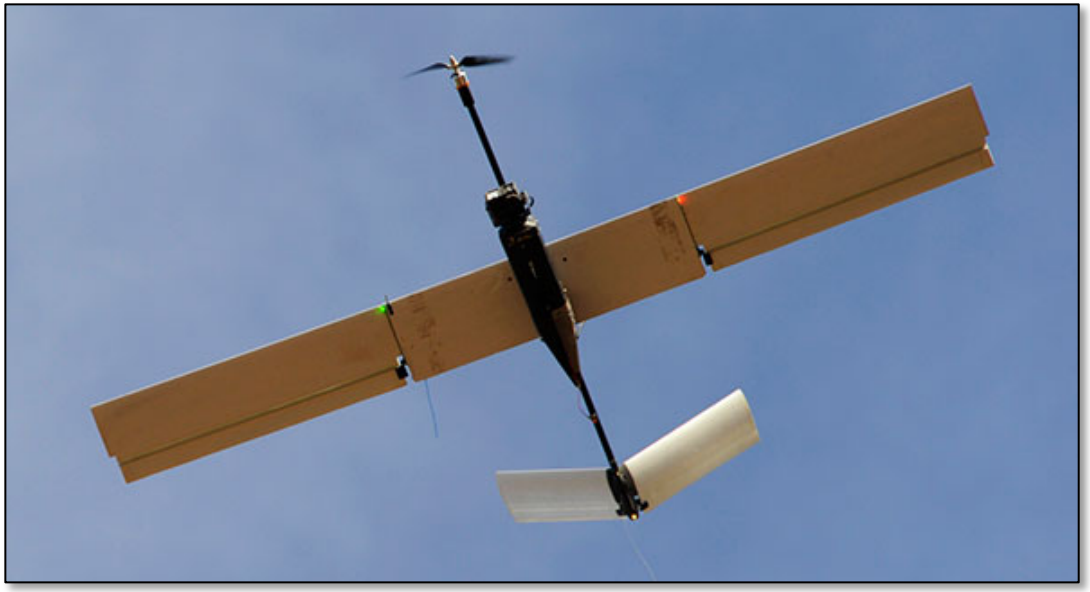
80 Minute Flight Duration

EO and Thermal IR Sensors

Honeywell RQ-16 T-Hawk

40 Minute Flight Duration

EO and Thermal IR Gimbal Sensors



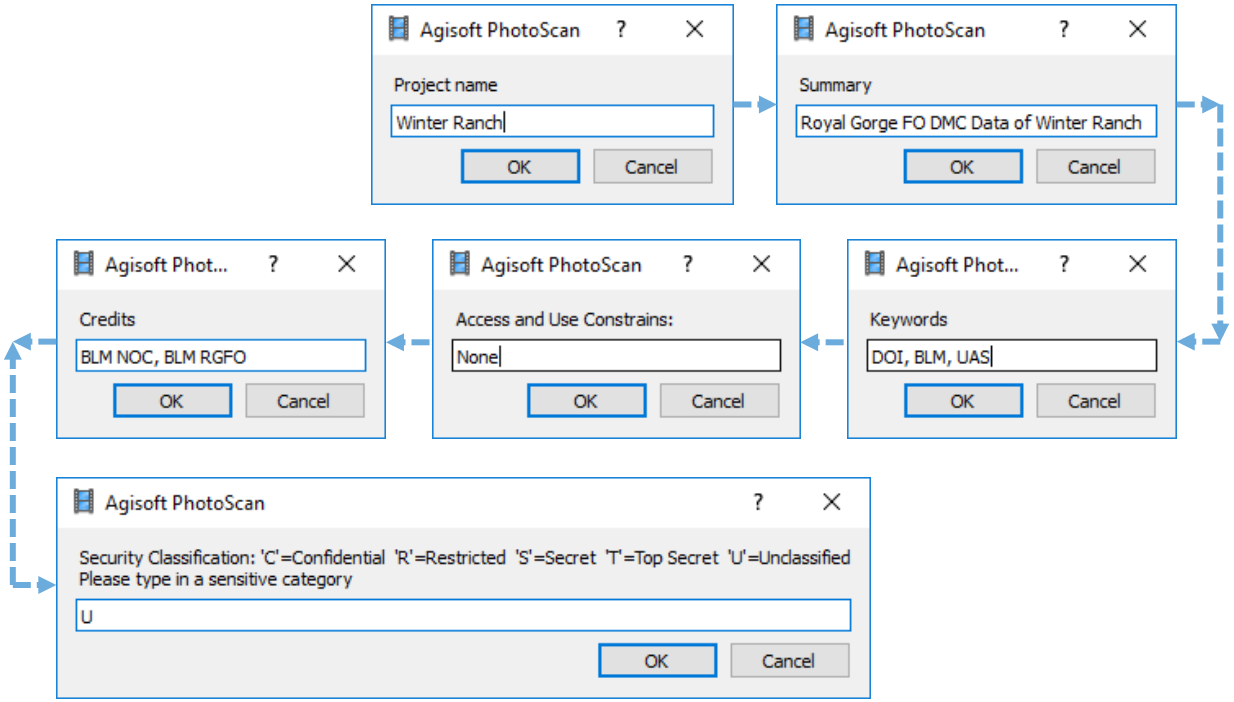
Falcon Unmanned (Fixed Wing)
60+ Minutes Flight Duration
2 lb. Max Payload

3DR Solo
20 Minute Flight Duration
0.92 lb. Max Payload

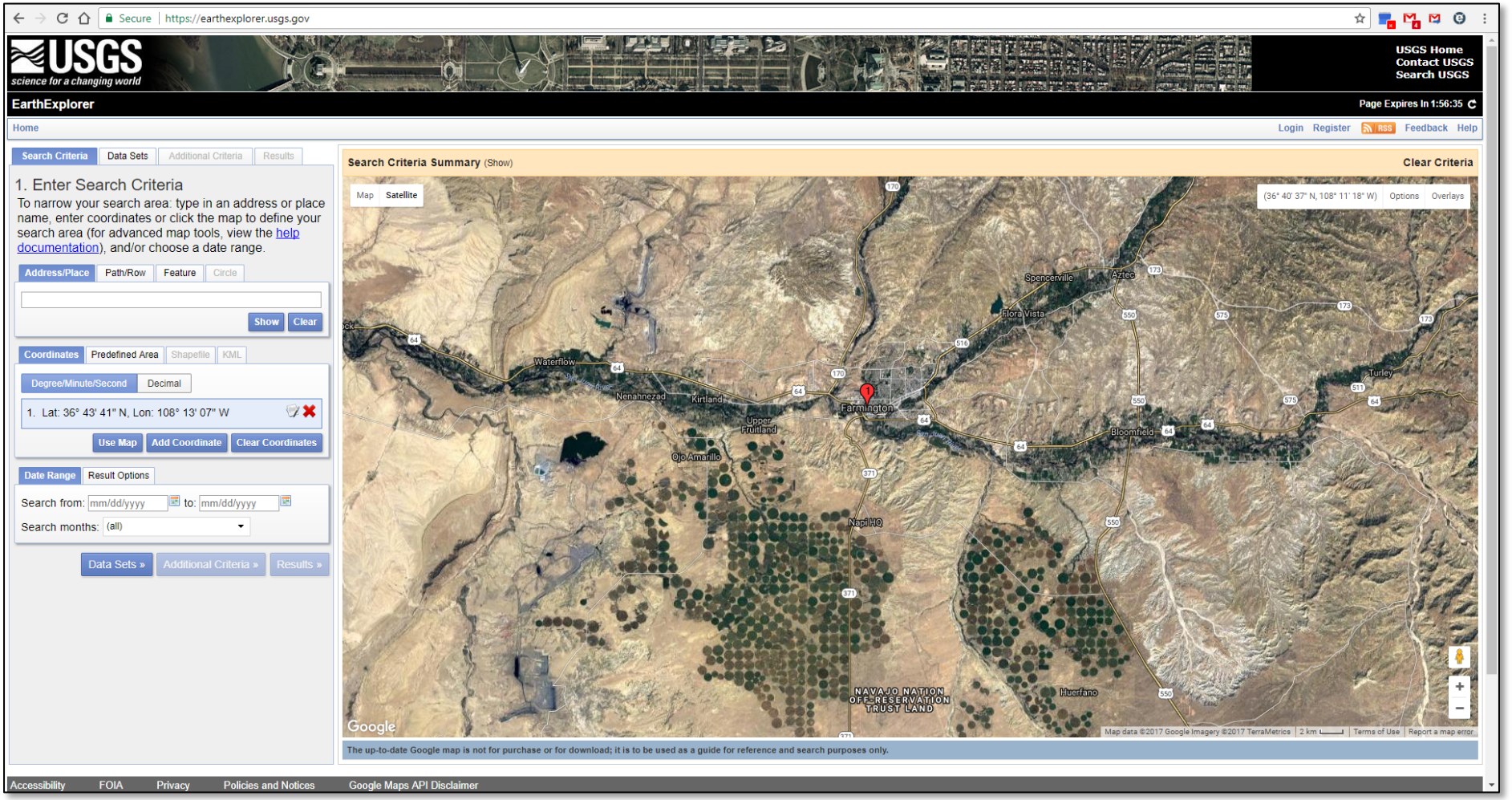
Unmanned Aerial Systems (UAS) Project Request Workflow

Standards, Metadata, Publication and Long-Term Archiving

File Naming Conventions



Metadata Automation



USGS Earth Resources Observation and Science (EROS) Center, Earth Explorer

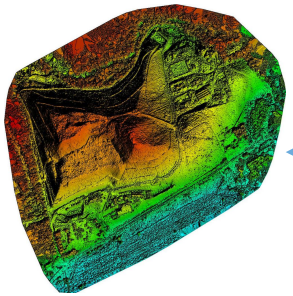
Before You Fly, Ask Why?

- *Why are you collecting data? What is the science/management question?*
- What is the size of the object/area/phenomena you want to identify?
- How large is the area you want to image? Do you need continuous coverage, or would sampling of imagery across the area suffice?
- Does the object you want to identify/map move? How much or how frequently?
- Does the object you want to identify/map have unique characteristics to help it be observed (e.g., seasonal phenology)?
- What levels of precision/accuracy is required to meet your science/ management question?
- Do you need to repeat measurements over time? If so, how frequently?
- Do you need to know where the object is in real world space?
- Do you need to know the height of the object(s)?
- Do we already have relevant data?

General Categories of UAS Projects/Products

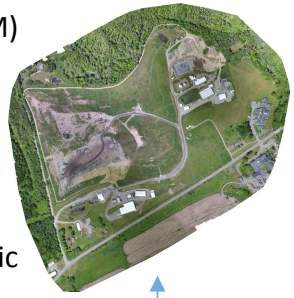
- Situational Awareness Video
- Spatially Enabled Video
- 2D Image Mosaics (Low Precision)
- High Precision 3D Mapping

Full Motion Video (FMV)

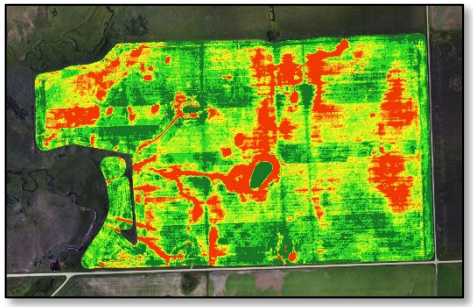


3D Point Clouds

Digital Elevation Model (DEM)



Orthomosaic



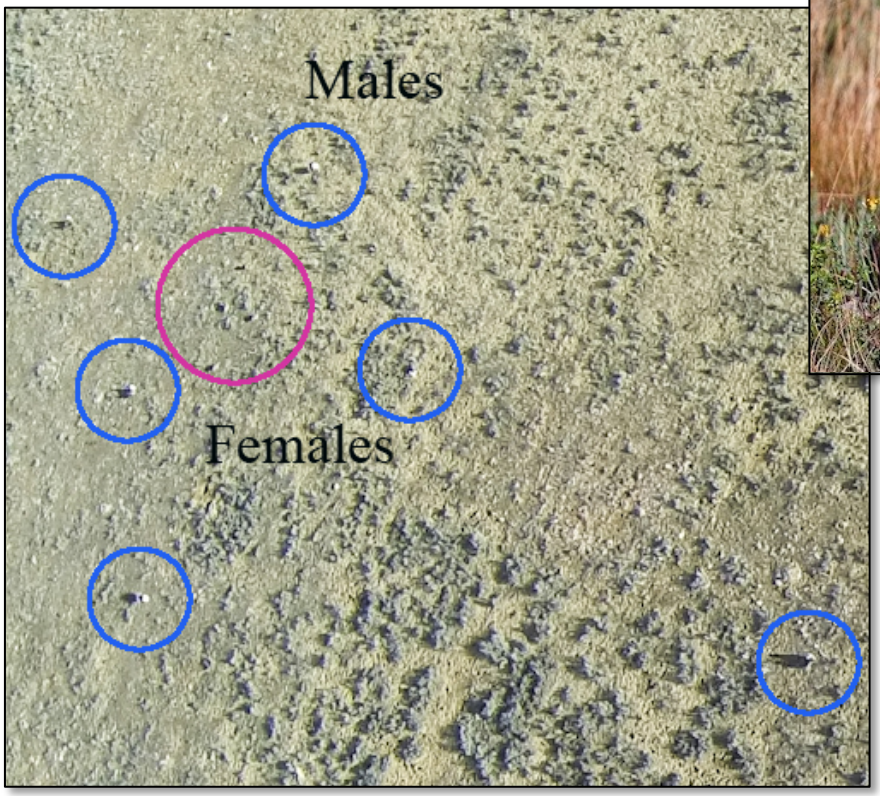
Spectral Vegetation Indices

Other Types:

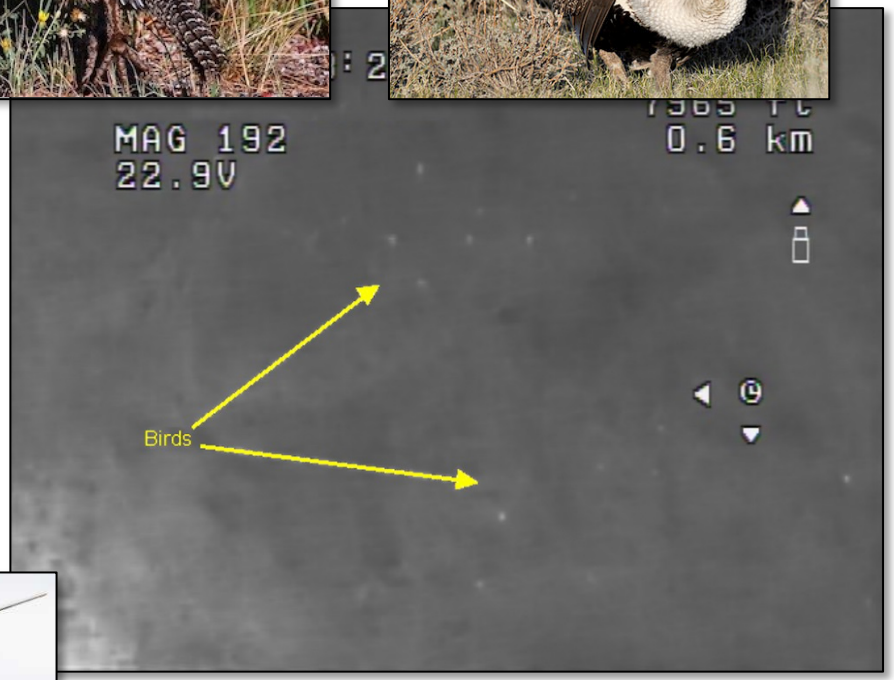
- LiDAR
- Hyperspectral Imagery
- Thermal Infrared (IR) Imagery
- Geophysical and Air Monitoring

Greater Sage Grouse Population Estimate

Middle Park, Colorado



RQ-11A Raven Natural Color Imagery at 150 ft. AGL



RQ-11A Raven Thermal Imagery at 200 ft. AGL

HX Dam Breach

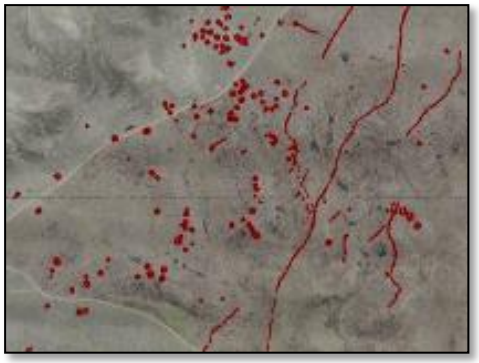
Safford, Arizona

1 ft. Contours Generated from UAS Derived DSM Overlaid on Ortho Imagery

Project measured the impacts of the HX Dam failure. The dam structure was likely compromised by a 5.2 magnitude earthquake that occurred on June 28th, 2014.

Big Bend of the Milk, ACEC

Malta, Montana



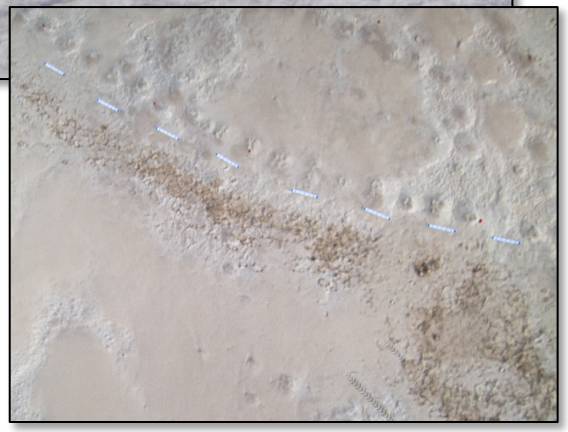
BLM collected very fine spatial resolution UAS imagery after a prescribed fire removed overgrow vegetation at the Henry Smith and Beaucoup sites within the Big Bend of the Milk Cultural Area of Critical Environmental Concern (ACEC).

Both sites are dominated by the presence of an Avonlea-period cultural resource complex, including a buffalo kill site, prehistoric drive lines, anthropomorphic and zoomorphic ground figures, habitation sites, and medicine wheels.

Saved archaeologists several years of ground survey work.

Pleistocene Trackway Mapping

White Sands National Monument, New Mexico



UAS employed to photogrammetrically map fragile fossilized footprints from the late Pleistocene ice age in January, 2014.

USGS science for a changing world

Challis Field Office Fire Documentation

Challis, Idaho

BLM Challis Field Office was destroyed by a fire in the early morning hours of October 4th, 2016. UAS imagery was collected to document the fire.

AML Physical Safety Inventory

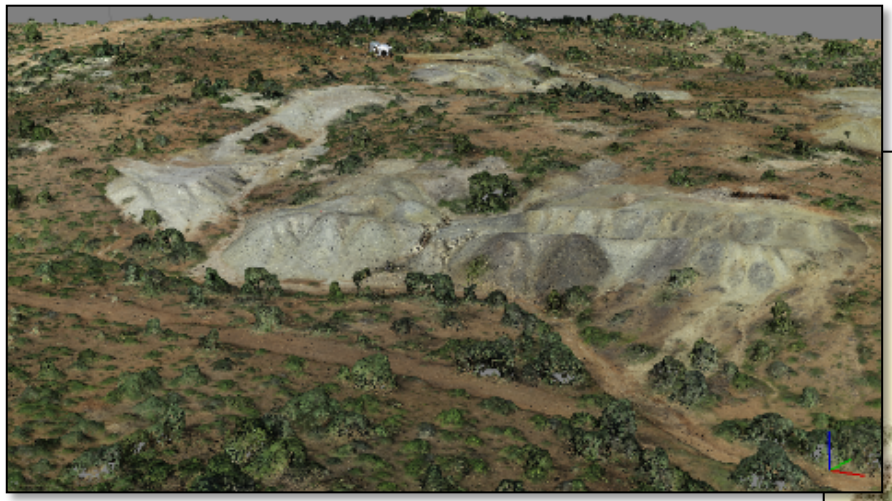
- BLM Elko Field Office in Elko, Nevada requested assistance from the National Operations Center (NOC) to validate 61 Abandoned Mine Lands (AML) sites for potential physical safety hazards.
- The AML features were located on steep/unstable terrain, and would have required the use of significant safety gear and rappelling to perform a traditional ground based inspection.
- Project employed UAS platform to capture very fine scale spatial resolution imagery of each AML site.

AML Safety Inventory – Lessons Learned

- 28 of the 61 total AML features were inspected/validated with UAS operations.
- Shadows were a significant challenge for UAS inspections, and often prevented the determination of whether a site represented a physical safety hazard.
- UAS imagery provided valuable situational site information about the non-validated features that required inspection with conventional ground based methods.
- Located several new AML features that weren't previously included in the known inventory.

Dogtown Mine Site – Volumetric Analysis

BLM Tucson Field Office, Arizona

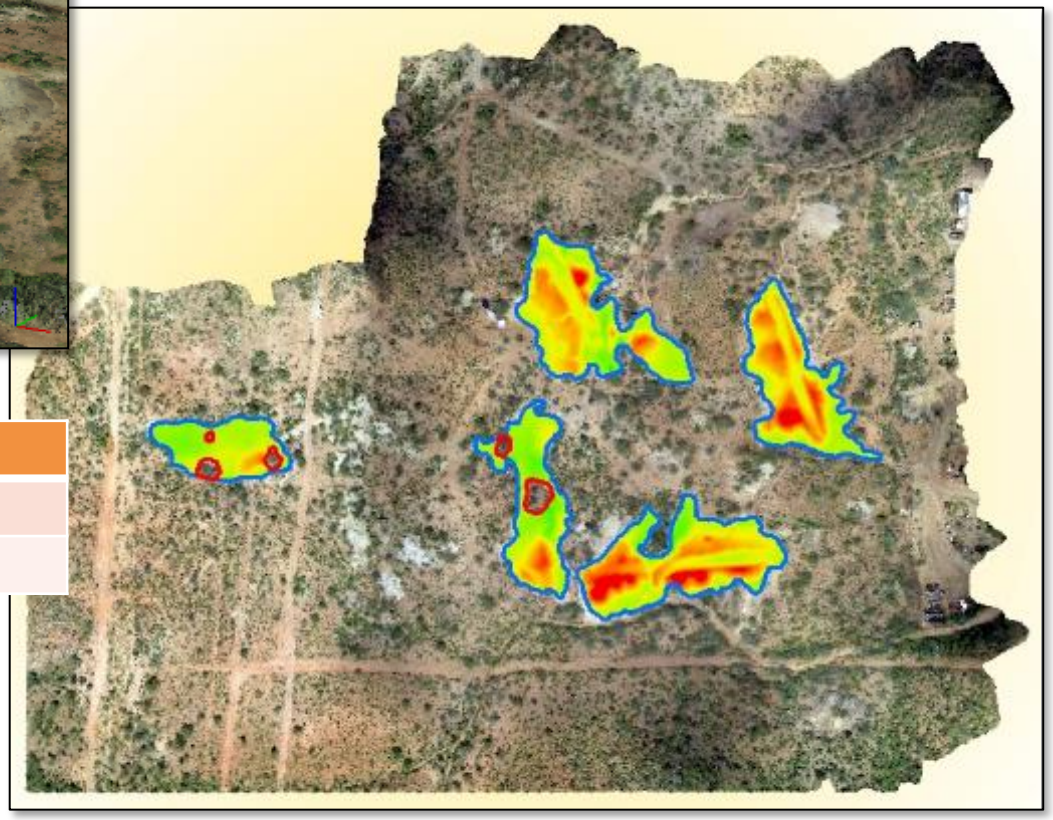


3D Dense Point Cloud

The 30 acre Dogtown mine is contaminated with heavy metals, including lead, arsenic, antimony, and mercury. BLM has CERCLA authority.

Measurement Method	Volume (cubic yds.)
Traditional Survey*	6,456
Photogrammetric Survey	5,678

Honeywell
RQ-16 T-Hawk



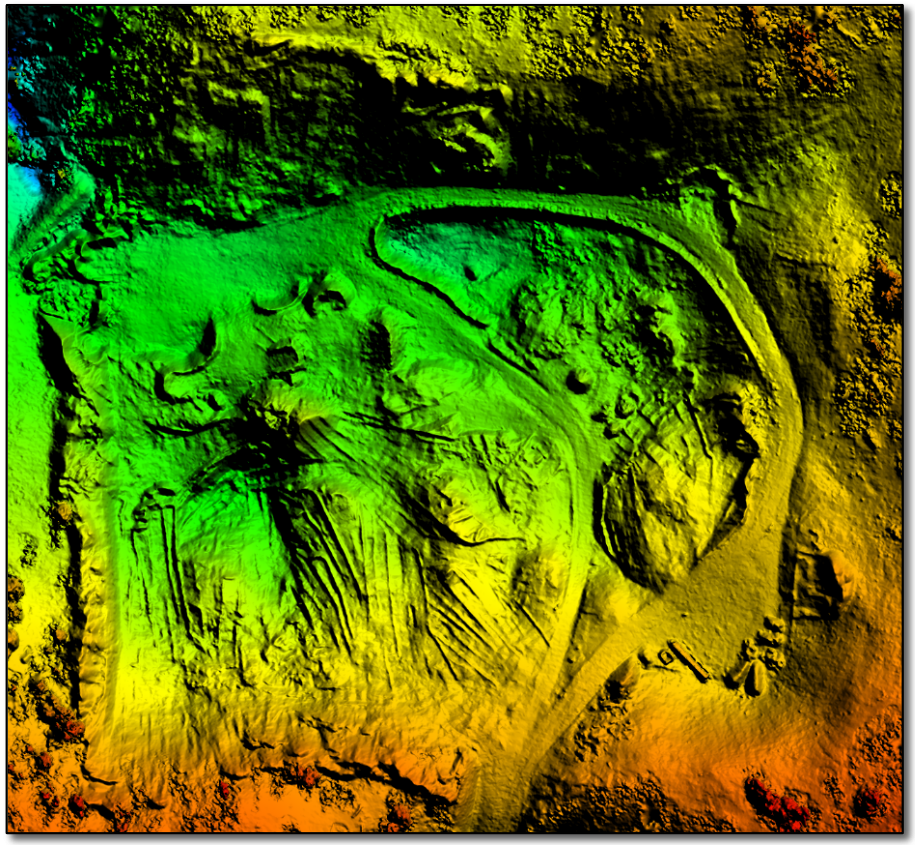
Digital Surface Model (DSM) Draped Over Natural Color Orthomosiac

* BLM Tucson Field Office, Dogtown Mine Site CERCLA Evaluation Report

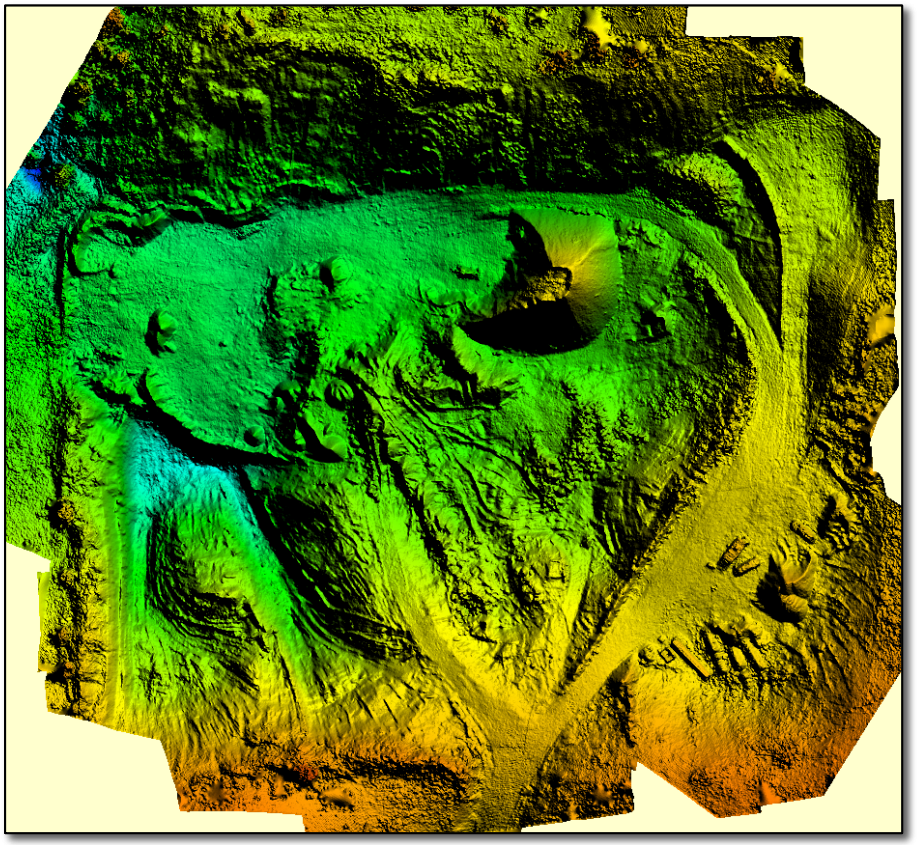
Iron Mountain Quarry – Volumetric Analysis

Cañon City, Colorado

2012 Z/I Imaging DMC Derived DSM (16 cm. x 16 cm.)

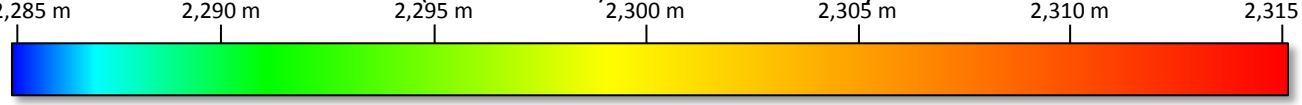


2015 Sony α5100 Derived DSM (4 cm. x 4 cm.)



2012 Z/I Imaging DMC Natural Color Orthomosaic (8 cm. x 8 cm.)

2015 Sony α5100 Natural Color Orthomosaic (2 cm. x 2 cm.)



Z/I Imaging Digital Mapping Camera (DMC)

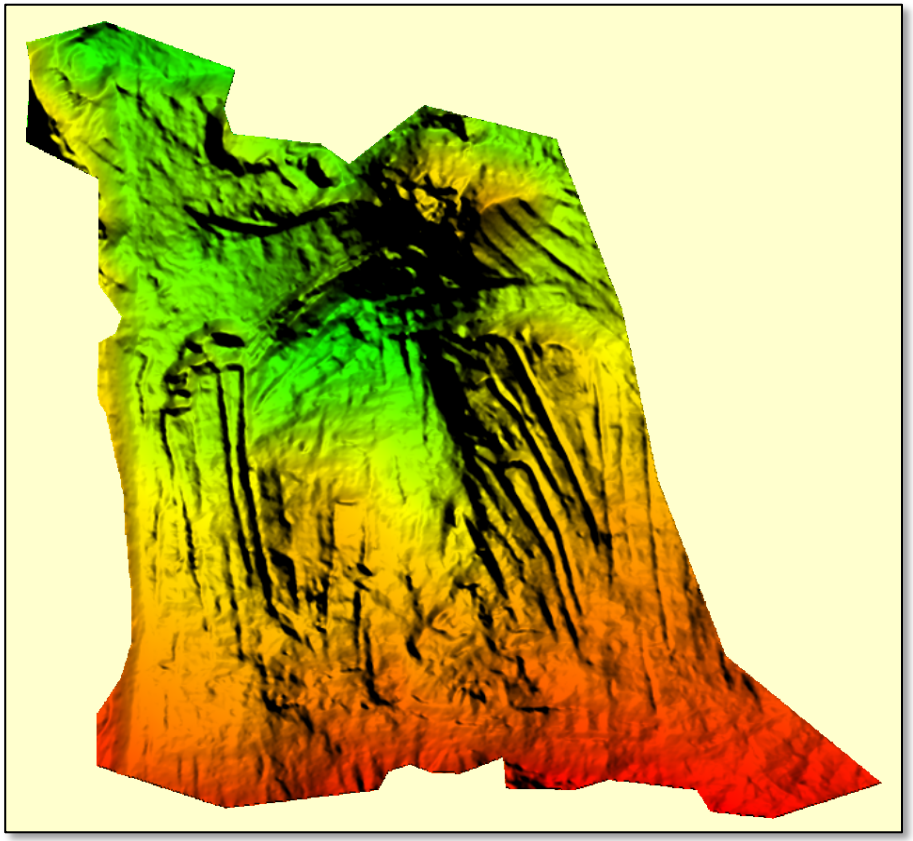
24.3 Megapixel APS-C CMOS Sony α5100

Cessna 441 Conquest II

2015 Sony α5100 Natural Color Imagery (2 cm. x 2 cm.)

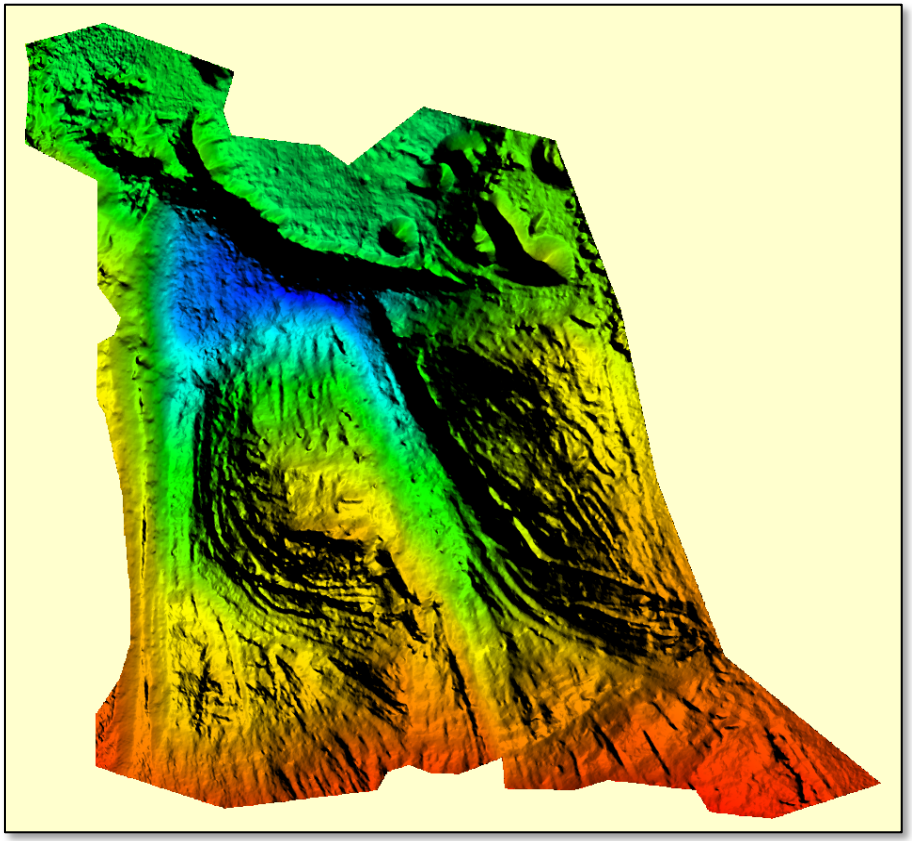
2012 Z/I Imaging DMC Natural Color Orthomosaic (8 cm. x 8 cm.) – Iron Mountain Active Mining Area Shown in Red (6,172.8 sq. m.)

Vertical Error ($RMSE_Z$) = 0.011 m.
95% Confidence Level = $RMSE_Z$ * 1.96 = 0.022 m.

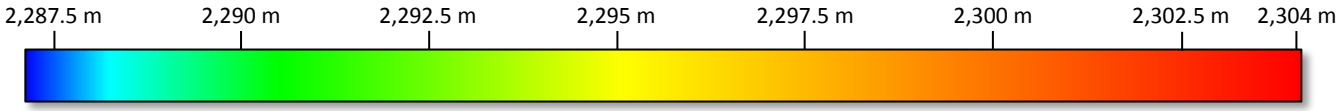


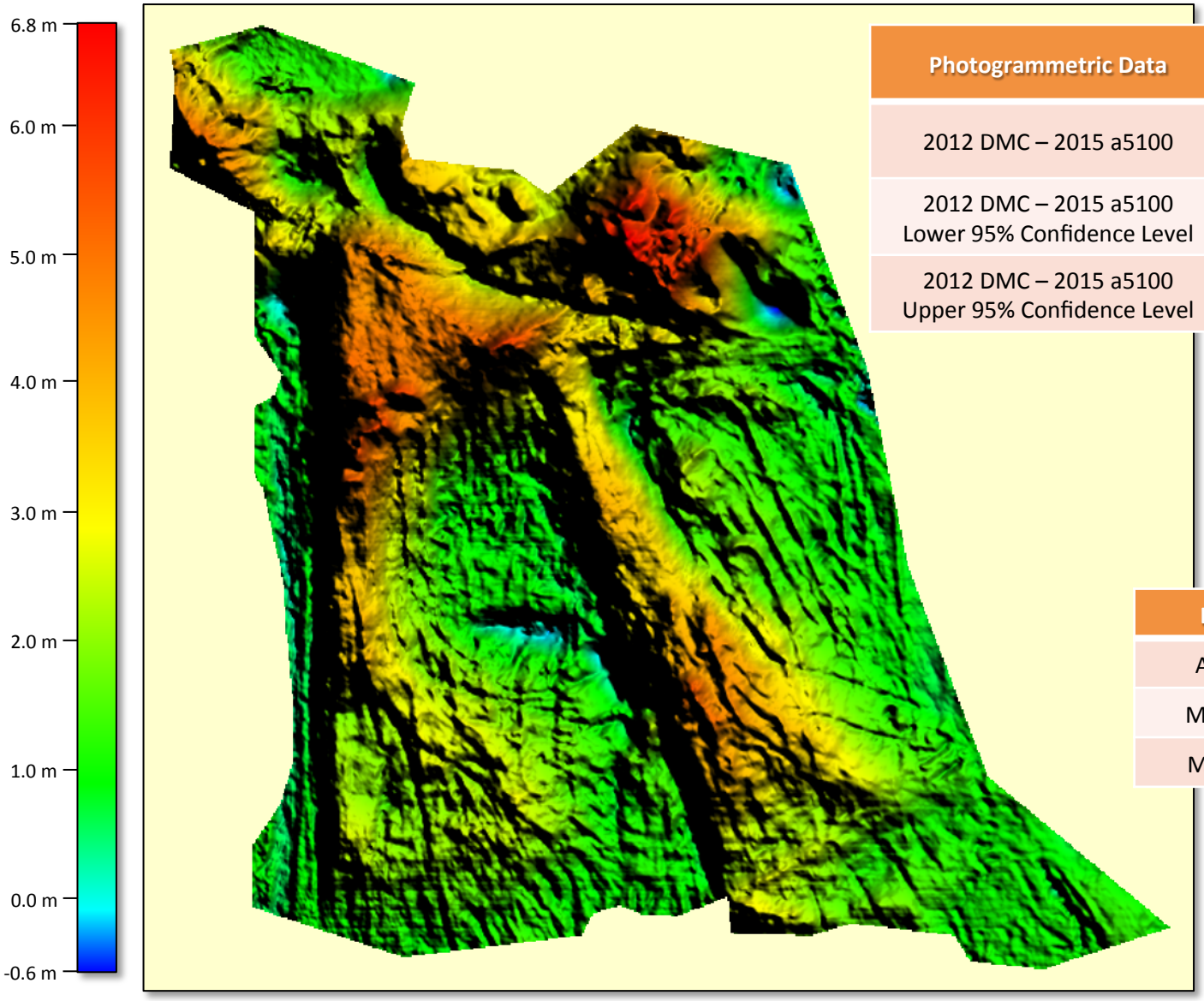
2012 Z/I Imaging DMC Derived DSM (16 cm. x 16 cm.)

Vertical Error ($RMSE_Z$) = 0.039 m.
95% Confidence Level = $RMSE_Z$ * 1.96 = 0.076 m.



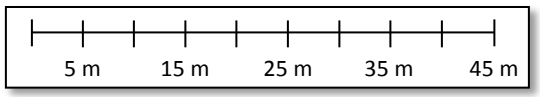
2015 Sony α5100 Derived DSM (4 cm. x 4 cm.)





Photogrammetric Data	Volumetric Change (cubic yds.)
2012 DMC – 2015 a5100	13,484.95
2012 DMC – 2015 a5100 Lower 95% Confidence Level	12,997.58
2012 DMC – 2015 a5100 Upper 95% Confidence Level	13,972.31

Delta Z	Height (m.)
Average	2.19
Maximum	6.77
Minimum	-0.59

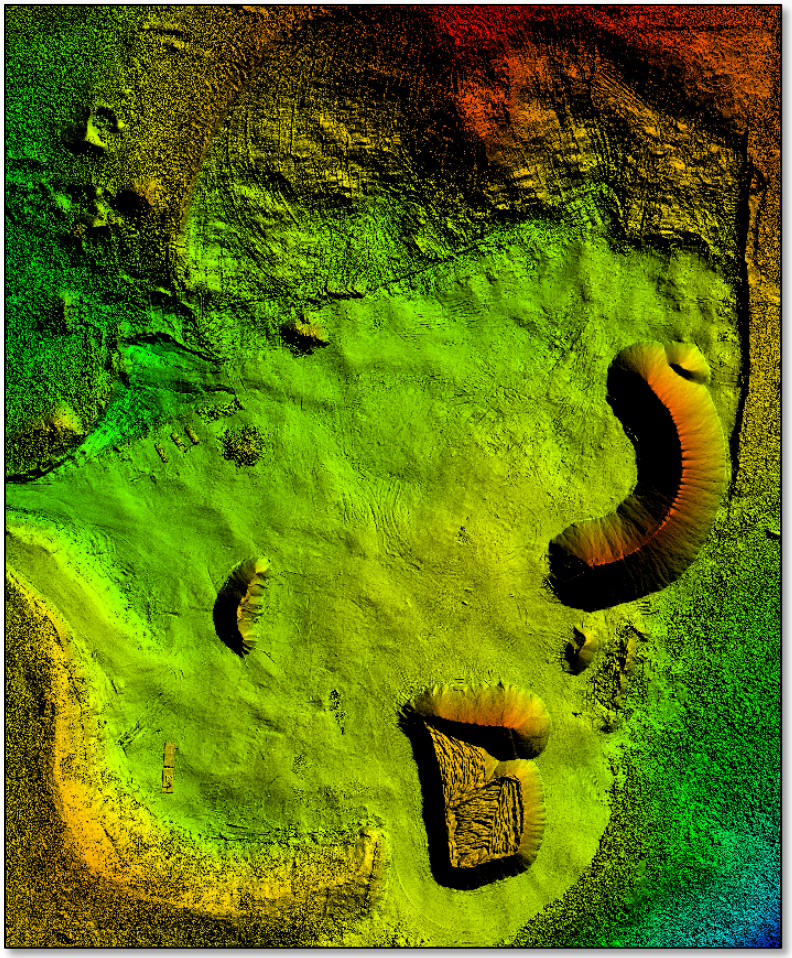


2015 Sony α5100 Derived DSM Subtracted from 2012 Z/I Imaging DMC Derived DSM

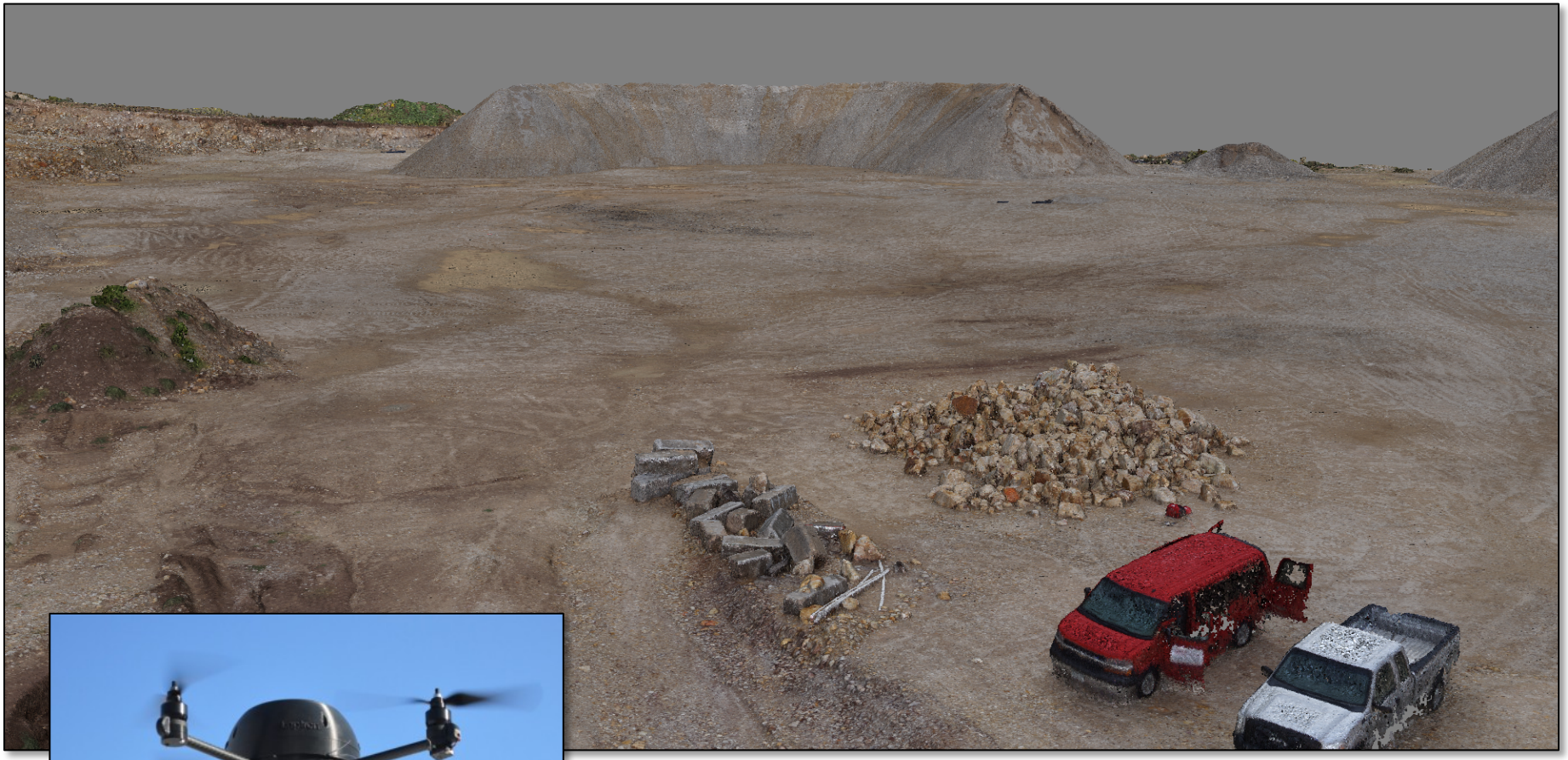
Indian Sunset Quarry – Volumetric Analysis

Westcliffe, Colorado

2016 Sony α6000 Natural Color Orthomosaic (1 cm. x 1 cm.)



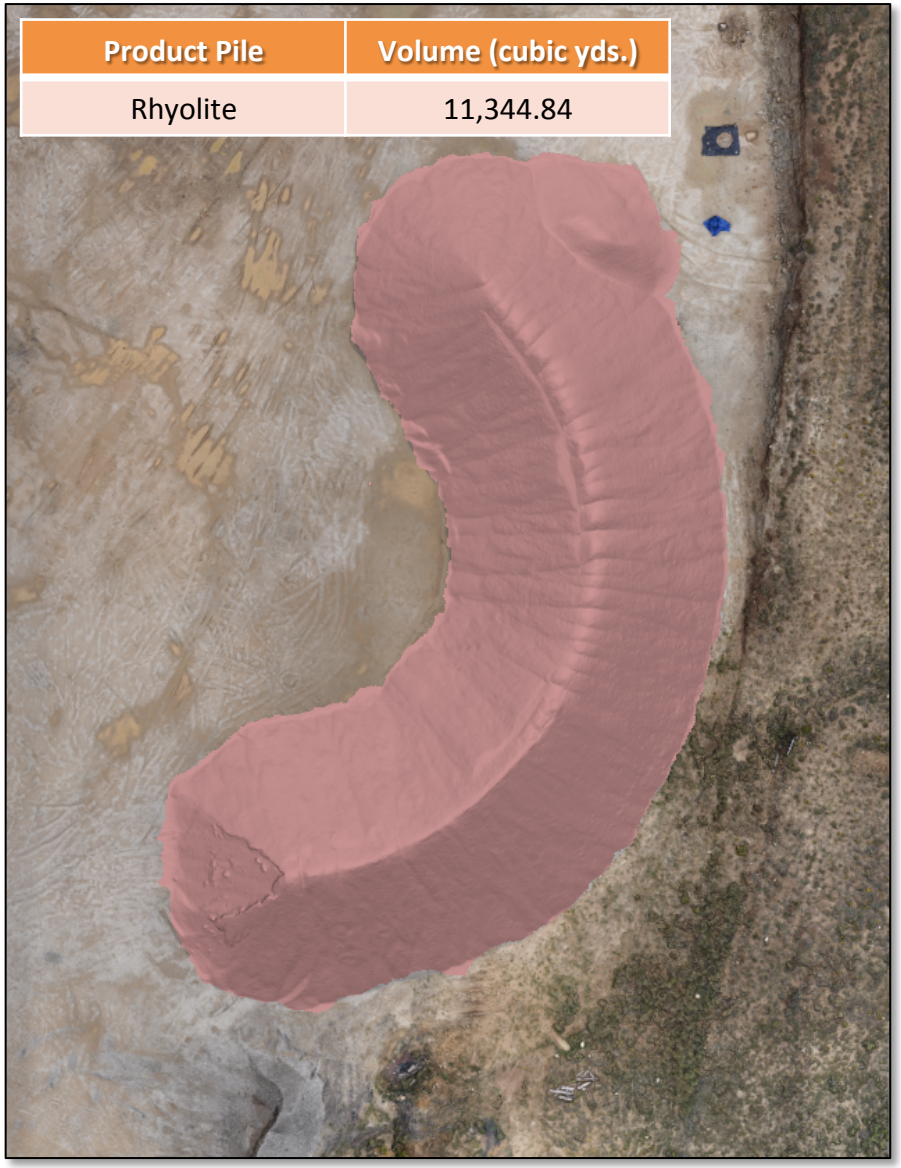
2016 Sony α6000 Derived DSM (2 cm. x 2 cm.)
Vertical Error ($RMSE_Z$) = 0.054 m.



3D Dense Point Cloud Derived from Sony α6000 Natural Color Stereo Imagery

Leptron Unmanned Aircraft Systems, Inc.
Rapidly Deployable Aerial Surveillance System (RDASS)

2016 Sony α6000 Derived 3D Mesh



Product Pile	Volume (cubic yds.)
Rhyolite	11,344.84

3D Mesh Faces Selected for Volume Calculation

Can the Work be Contracted?

7,500+ UAS Drone Pilots, Manufacturers, Retailers, and Service Providers with FAA Section 333 Authorization
FAA Part 107 - New Rules for Commercial Operators – August 2016

U.S. Department of the Interior
Bureau of Land Management

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