Remote Sensing Overflight in Support of Long-Term Monitoring and Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP)

Glen Canyon Dam Adaptive Management Program Adaptive Management Work Group Meeting – August 17, 2022

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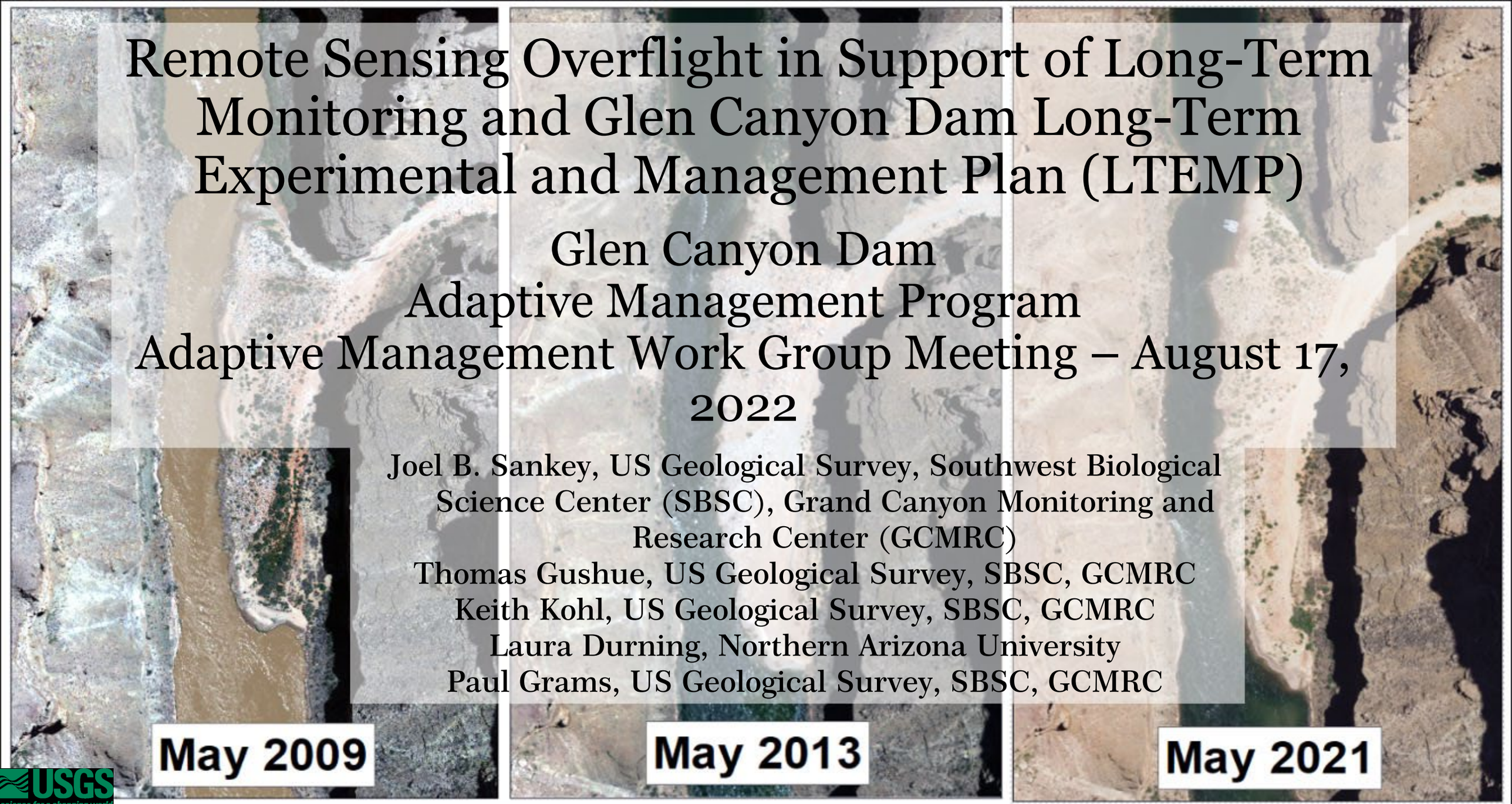

Airborne Remote Sensing in Grand Canyon

The high-resolution image collection from Glen Canyon Dam Adaptive Management Program (GCDAMP) May 2021 overflight is the most recent in a rich archive of aerial imagery that is used to track changes of the Colorado River in the Grand Canyon.

History of aerial remote sensing in Grand Canyon:

- Earliest air photos are black and white prints acquired from an airplane in 1935.
- First set of air photos acquired after Glen Canyon Dam was completed are black and white prints from May 1965
- First color and color-infrared air photos were acquired during flights in the 1980s
- First digital multispectral images were acquired in the late-1990s
- First acquisition similar to the May 2021 overflight (high spatial resolution digital multispectral imagery and digital topography) occurred in May 2002, and then again in 2004, 2005, 2009, 2013, 2021

https://www.usgs.gov/centers/southwest-biological-science-center/science/airborne-remote-sensing-grand-canyon

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Goals, Objectives (Project L FY2021-2023 GCMRC Triennial Work Plan (TWP))

Imagery and derivative data products from overflight remote sensing are used either directly or indirectly by every science project proposed in this TWP to address every resource goal of the LTEMP

Science Questions:

- How has landcover changed in the Colorado River Ecosystem (CRe) in 2021 relative to preceding decades?
- How are observed landcover changes related to dam operations, other land use and management activities, as well as climate and other environmental factors in the ecosystem?

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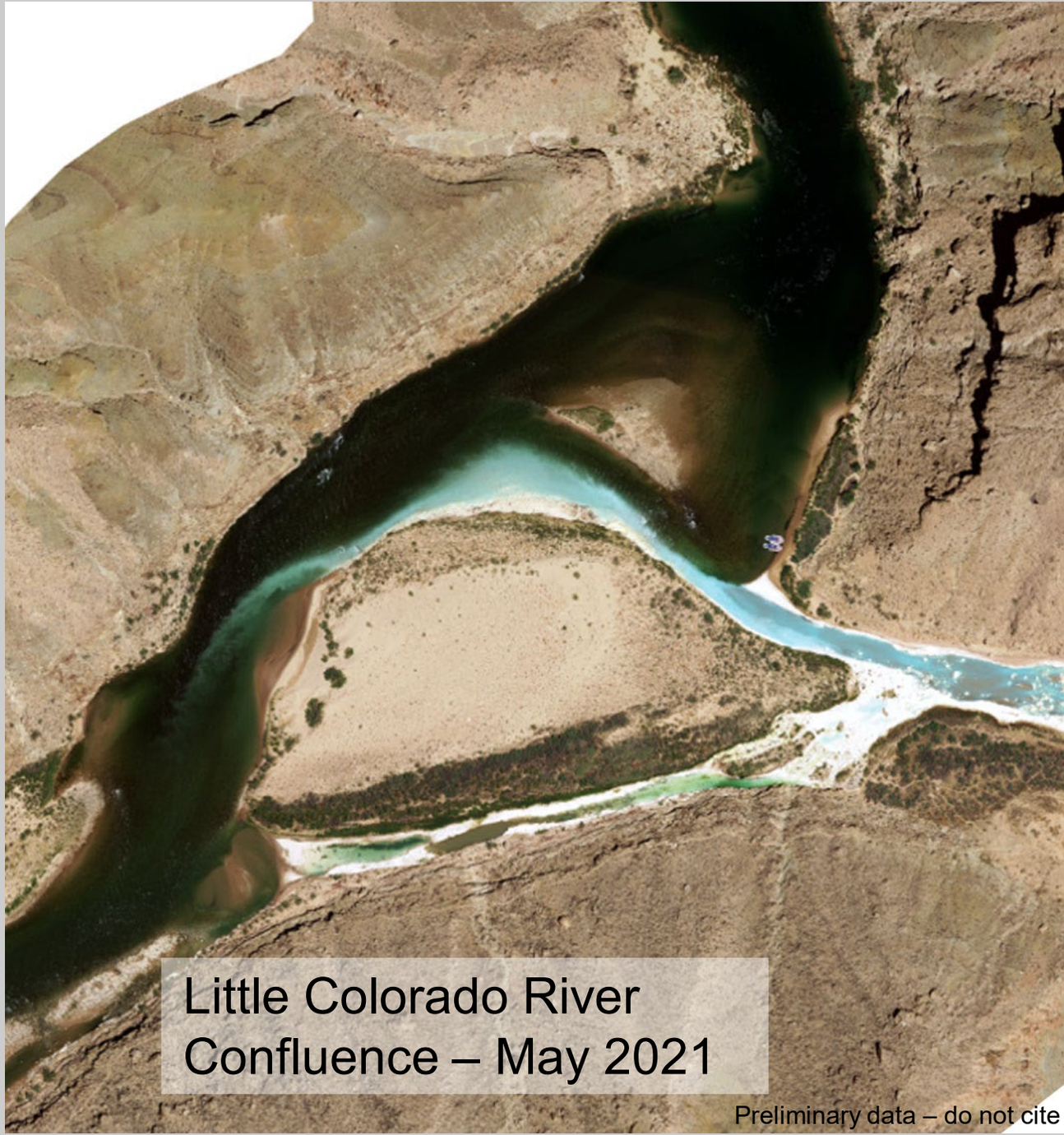
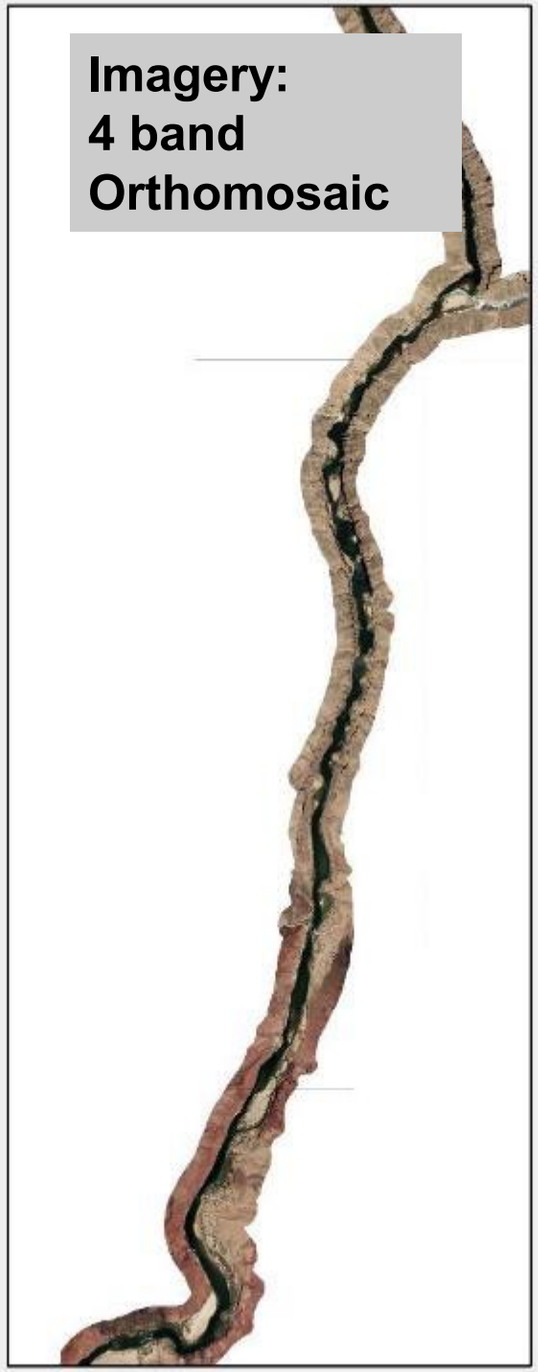
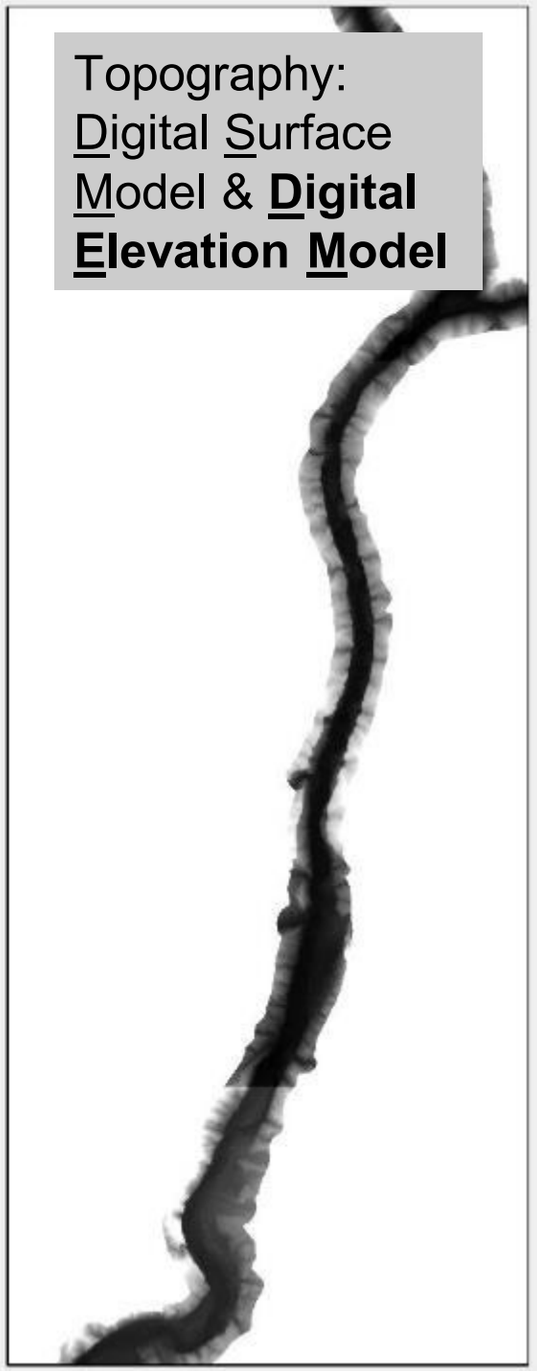


Imagery:
All raw flightlines



Imagery:
4 band
Orthomosaic



Topography:
Digital Surface Model & **Digital Elevation Model**

May 2021 Overflight Deliverables

Preliminary data – do not cite

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May 2021 Overflight Status

Fiscal Year	Quarter(s)	Activities
2021	1st	· Write Task Order and negotiate contract with GPSC (USGS Geospatial Products and Services Contracts) and contractor for overflight mission consisting of imagery and digital topographic data acquisition
	2nd	· Contract awarded to Fugro Earth Data Inc. · Coordinate logistics for the overflight mission with GCDAMP agencies and stakeholders Plan GCMRC logistics, including the rim- and river-level operations to be conducted by GCMRC in coordination with the contractor
	3rd	· Overflight mission · Rim-level GPS base station operations · River-level accuracy assessment and ground-truthing operations
	4th	· Monitor image processing performed by Fugro (contractor)
2022	1st	· Data delivered to GCMRC · QA/QC performed by GCMRC in coordination with vendor
	2nd	· Final modifications to mosaic performed
	3rd & 4th	· Begin publication process for finalized mosaic
2023	All	· Image mosaic published · Landcover classification maps produced by GCMRC remote sensing staff

- GCMRC completed QA/QC of imagery and topography, and requested contractor revise and redeliver both datasets
- Contractor redelivered, and GCMRC accepted, both final datasets in May 2022
- GCMRC publishing the topographic dataset in 2022
- GCMRC editing the orthomosaic dataset and will publish in 2023
- Unpublished version of both datasets are already being used for science projects and river logistics at GCMRC and National Park Service

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2021 Overflight Orthomosaic – River Mapbooks

GCMRC Project B.2 Channel Mapping Trip, Spring 2022

May 2021 Overflight Imagery Positional (Horizontal) Accuracy

- 156 black and white ground truth panels were placed between Glen Canyon Dam and Pearce Ferry to assess positional accuracy on the Earth surface.

- Many of the same ground truth locations were also occupied in previous overflights allowing GCMRC to accurately assess positional accuracy between overflights.

2021 accuracy to Survey Control (meters)			
	Total	Northing (y)	Easting (x)
RMSE	0.521	0.436	0.284
95% Confidence	1.274	0.855	0.557

Results subject to change following GCMRC's publication of the orthomosaic dataset (Preliminary data – do not cite)

May 2021 Overflight Topography Positional (Vertical) Accuracy

- >900 survey control points between Glen Canyon Dam and Pearce Ferry being used to evaluate the accuracy of elevation in digital topographic datasets from 2021 and previous overflights
- Data release in preparation for publication "*Digital elevation model (DEM) and digital surface model (DSM) data for the Colorado River corridor in Grand Canyon National Park and Glen Canyon National Recreation Area (2002, 2009, 2013 and 2021)*"

	Elevation accuracy relative to survey control (n = 926)	
Overflight Digital Surface Model (DSM) Dataset	**RMSE (meters)**	**95% Confidence (meters)**
2021 DSM	0.70	1.38
2013 DSM	0.70	1.38
2009 DSM	0.69	1.35
2002 DSM	0.77	1.51

Results subject to change following GCMRC's publication of the topography dataset (Preliminary data – do not cite)

Measurement of water-surface profile during 2021 overflight

- The water-surface profile at a constant discharge (8,000 cfs) is used to delineate the river shoreline and is used to calibrate models for predicting the water surface at other discharges
- The best profile currently available is based on lidar data collected in 2000
  - Accuracy of water-surface elevations estimated to be ± 0.5 m, based on limited ground-truth data
  - 0.5 m vertical error can equal 25 m or more horizontal error in shoreline location
- Purpose of 2021 effort:
  - Measure continuous profile from at least two sources
    - Overflight digital surface model (lowest ground surface elevation adjacent to water)
    - Moving boat with high-accuracy Global Navigation Satellite Systems (GNSS) receivers
  - Verify accuracy with surveyed check-points throughout river corridor

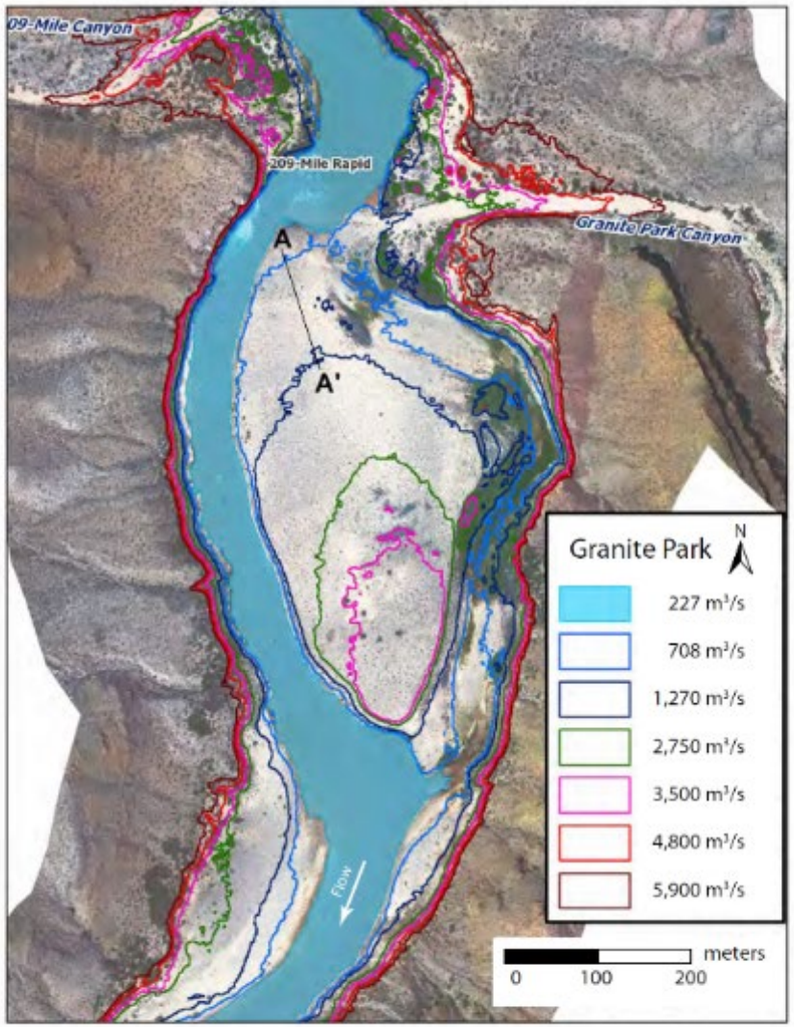

Figure 21. Virtual shorelines at Granite Park (river mile 209) as predicted by the hydraulic model. The line A-A' extends between the 708 and 1,274 m³/s shorelines and rises 1.9 meters across a distance of 100 meters.

From Magirl et al. (2008)

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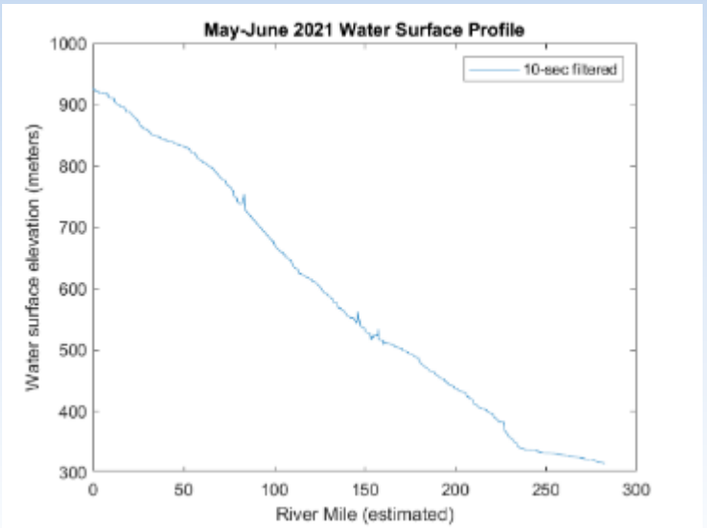
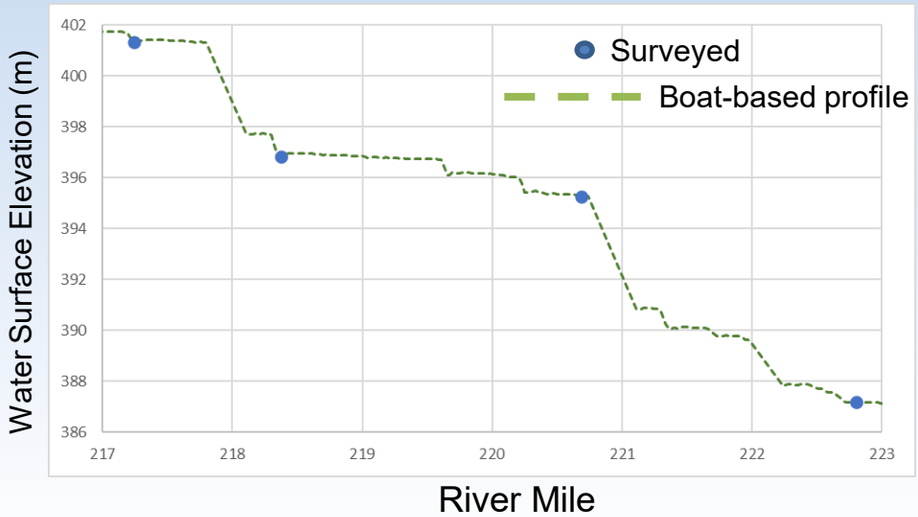
Measurement of water-surface profile during 2021 overflight

- Continuous profile collected by boat from Lees Ferry to Pearce Ferry
- 187 surveyed water surface elevations at (1 every ~1.2 miles)
  - Preliminary comparison between surveyed water-surface elevations and boat-based measurements indicate improved accuracy





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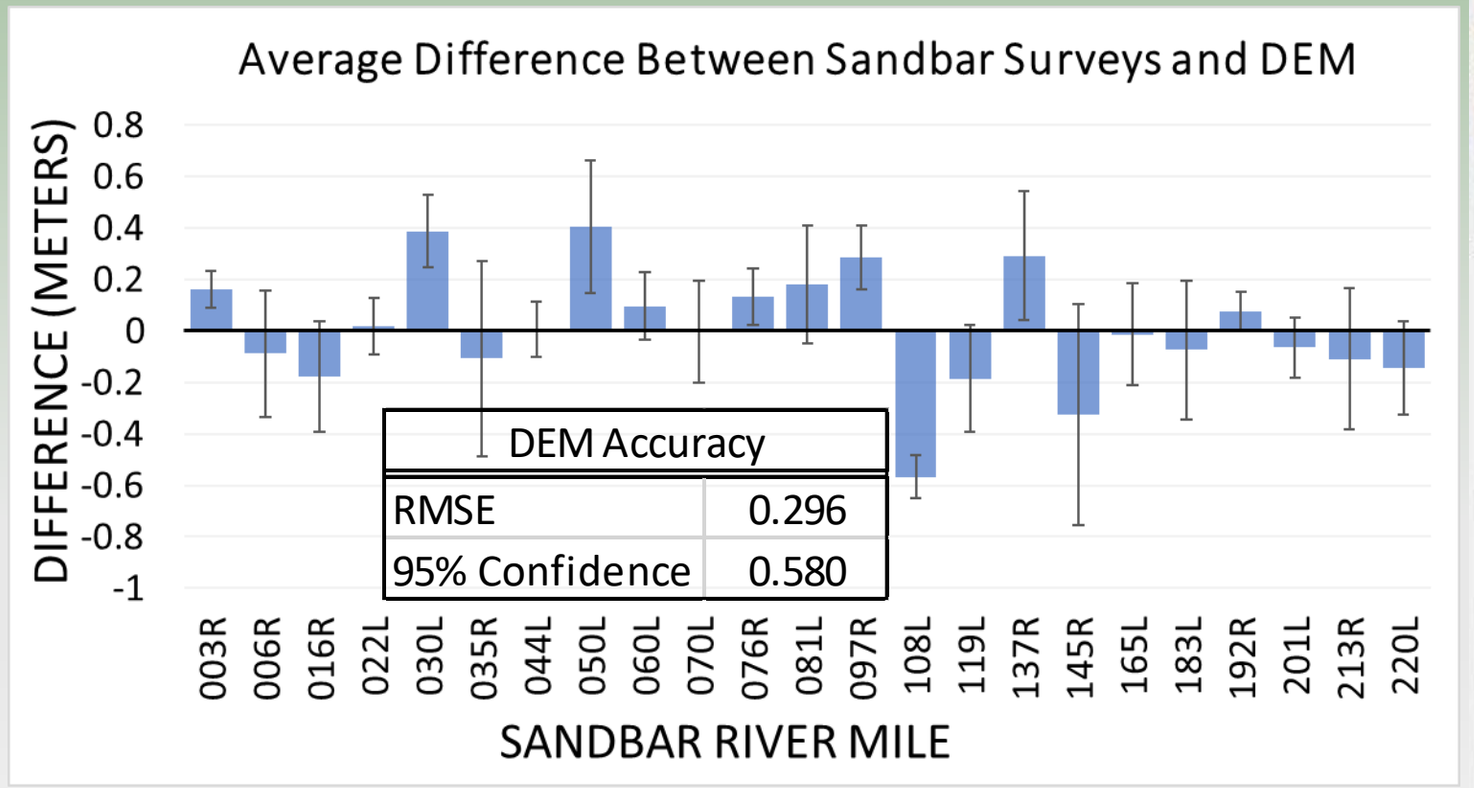
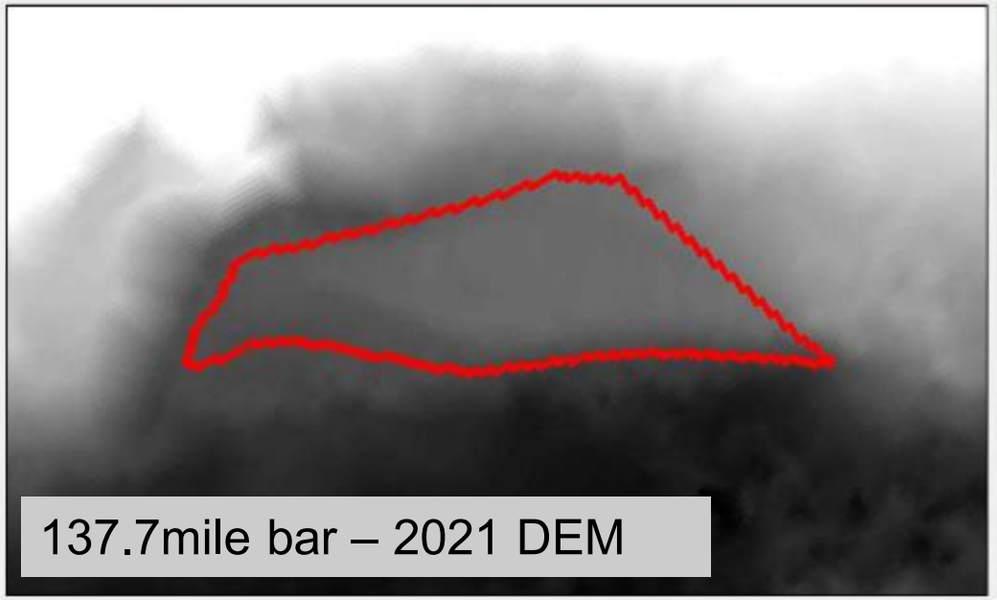
Results subject to change following GCMRC's publication of the topography datasets (Preliminary data – do not cite)

Measurement of sandbar topography during 2021 overflight

- 23 sandbars were topographically surveyed during the overflight steady low flows.
- We use the interpolated survey surfaces for these bars to evaluate the accuracy of the DEM & DSM datasets.





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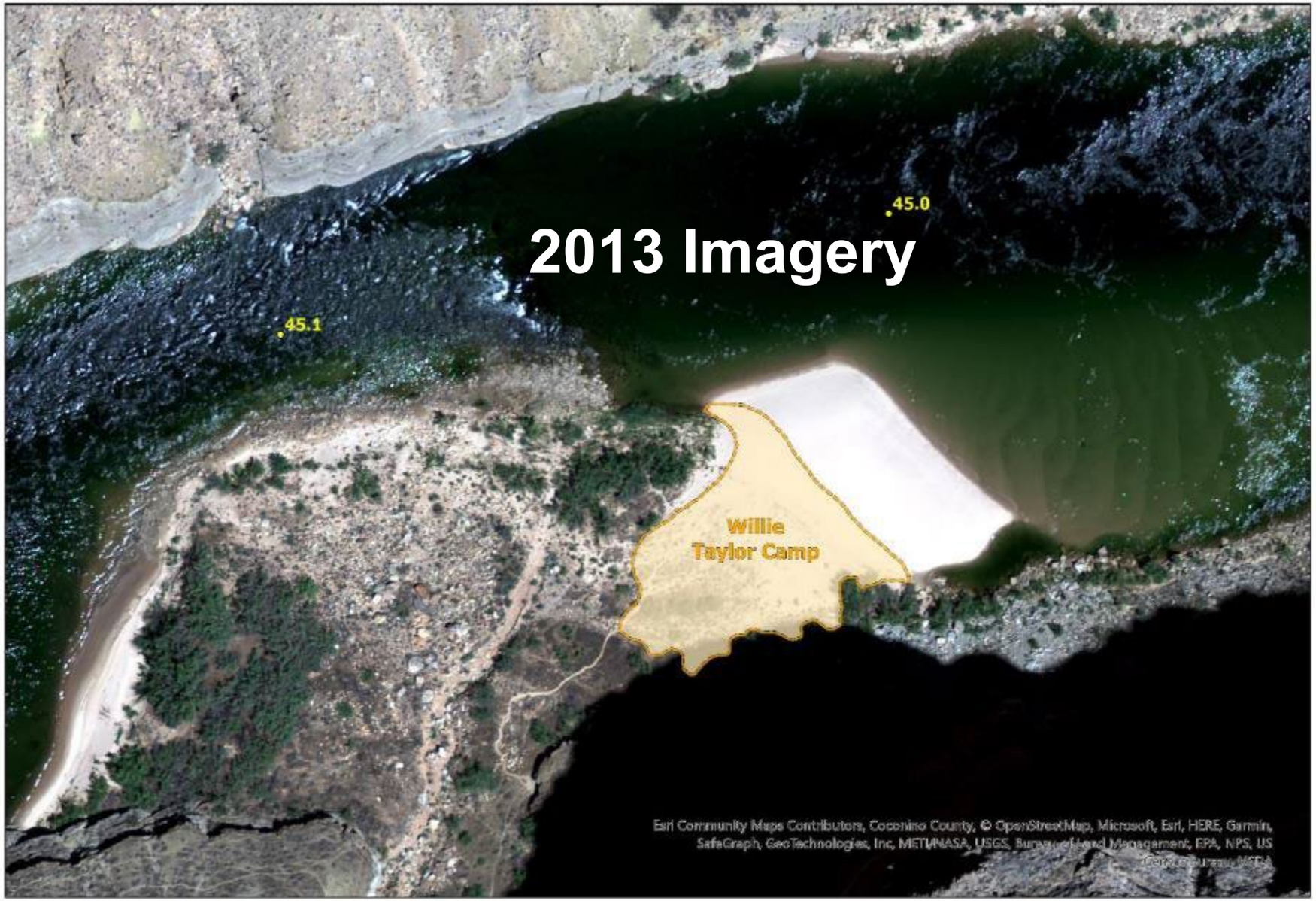
Assessing long-term changes with the 2021 orthomosaic (example)



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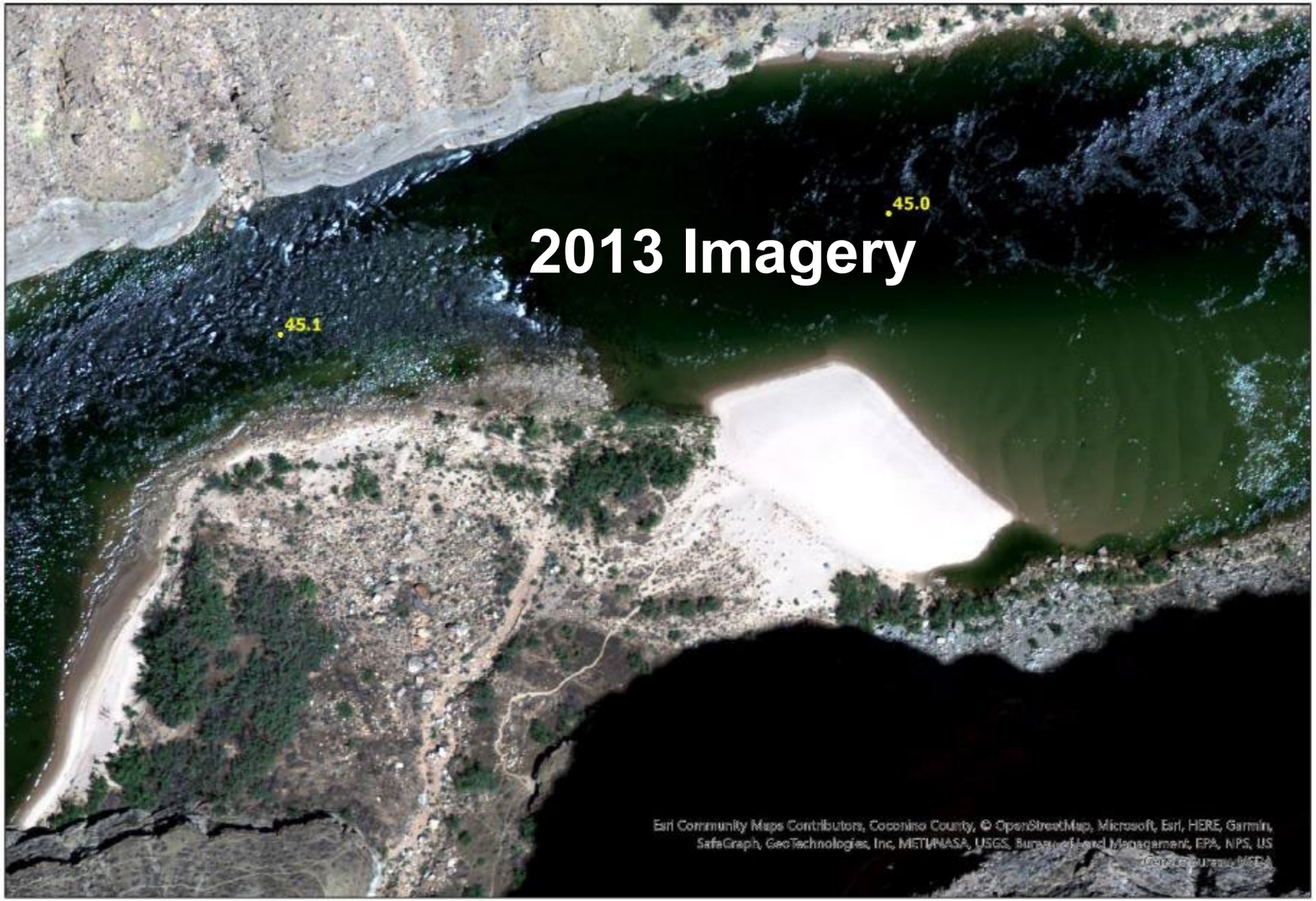

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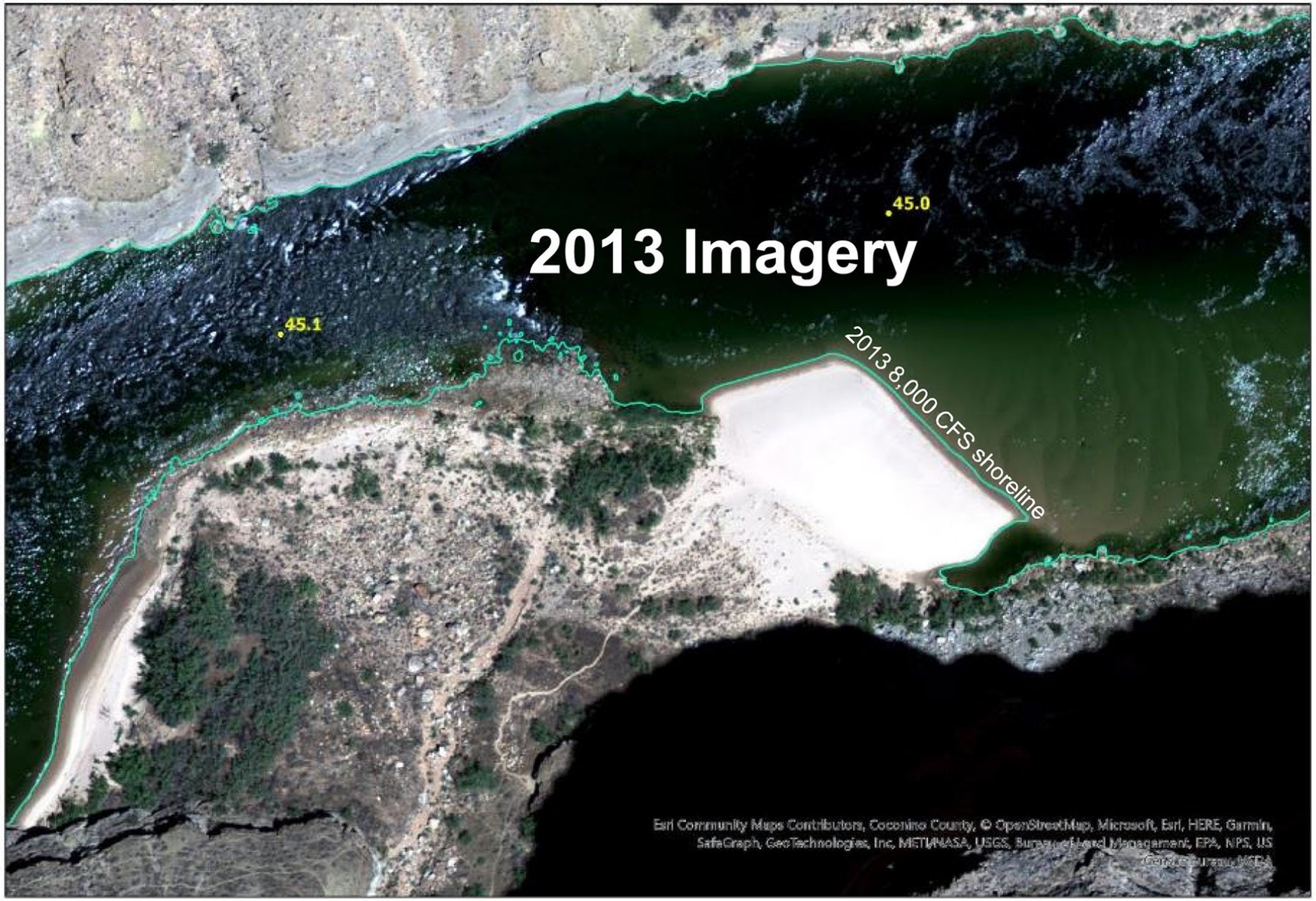

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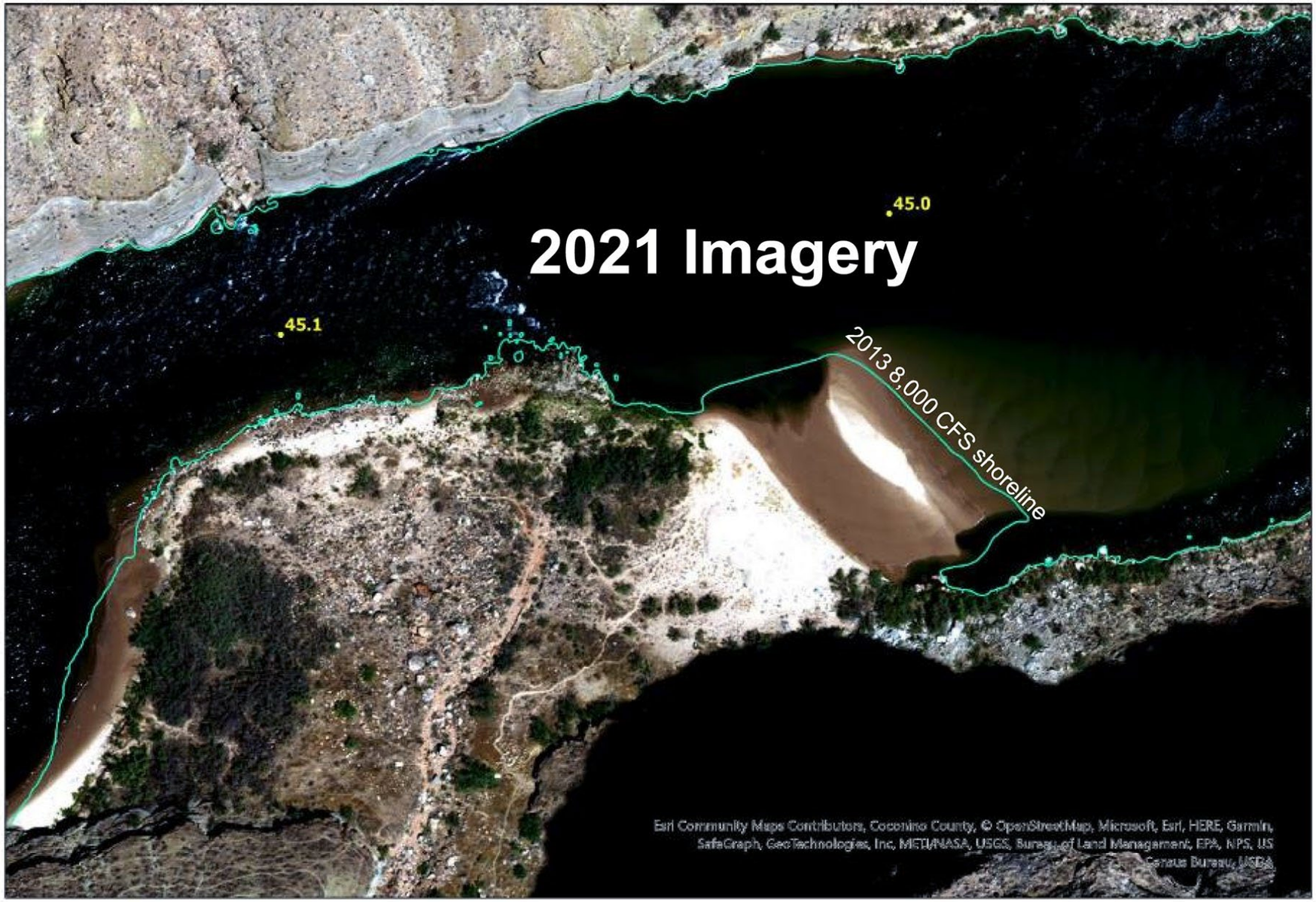

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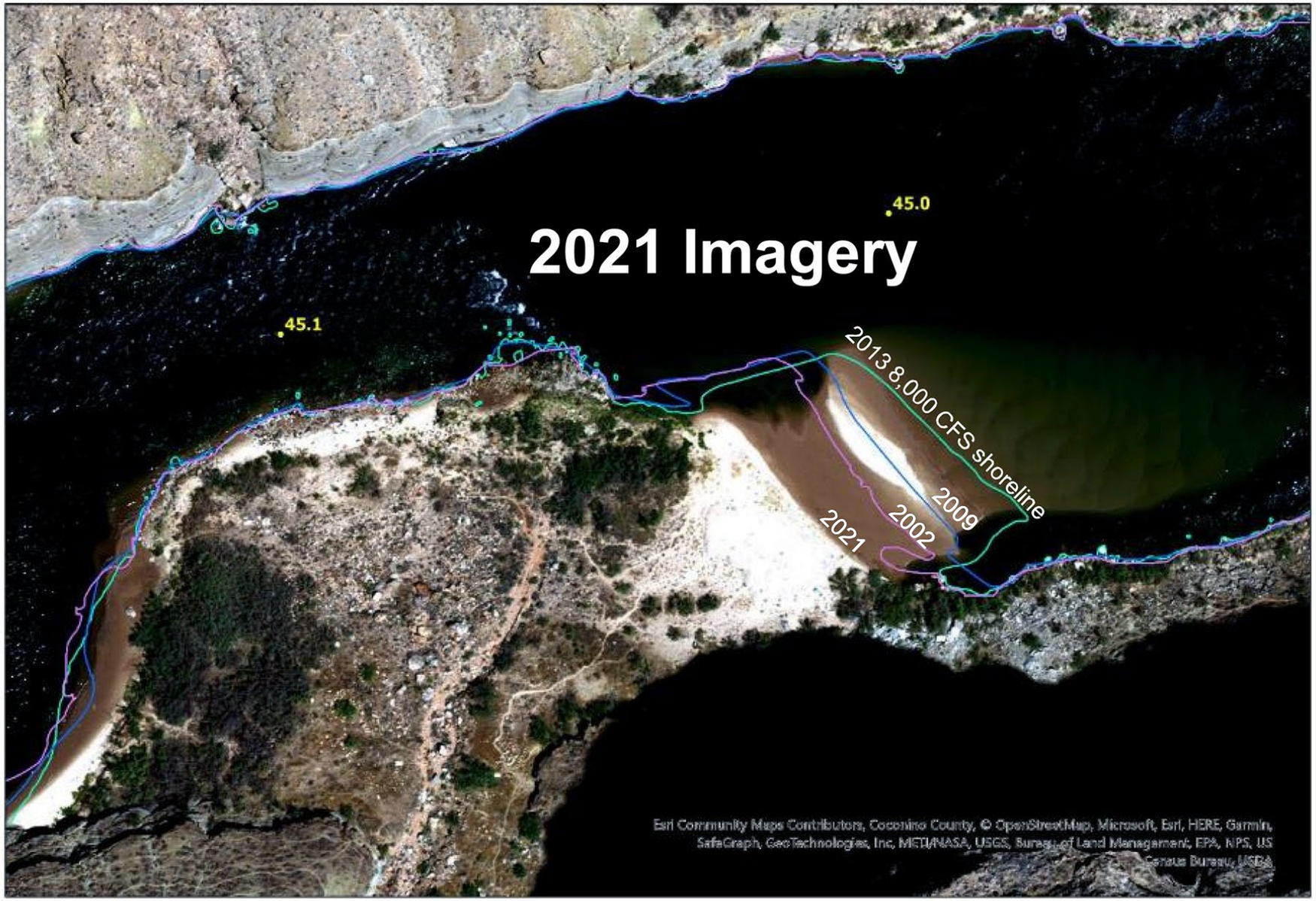

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Thank you for listening!

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U.S. Department of the Interior, March 3, 1849

Bureau of Reclamation

National Park Service

NAU Northern Arizona University