Overflight Remote Sensing in Support of Long-Term Monitoring and LTEMP

Glen Canyon Dam Adaptive Management Program Annual Reporting Meeting 2023
January 24-25, 2023, Phoenix, AZ

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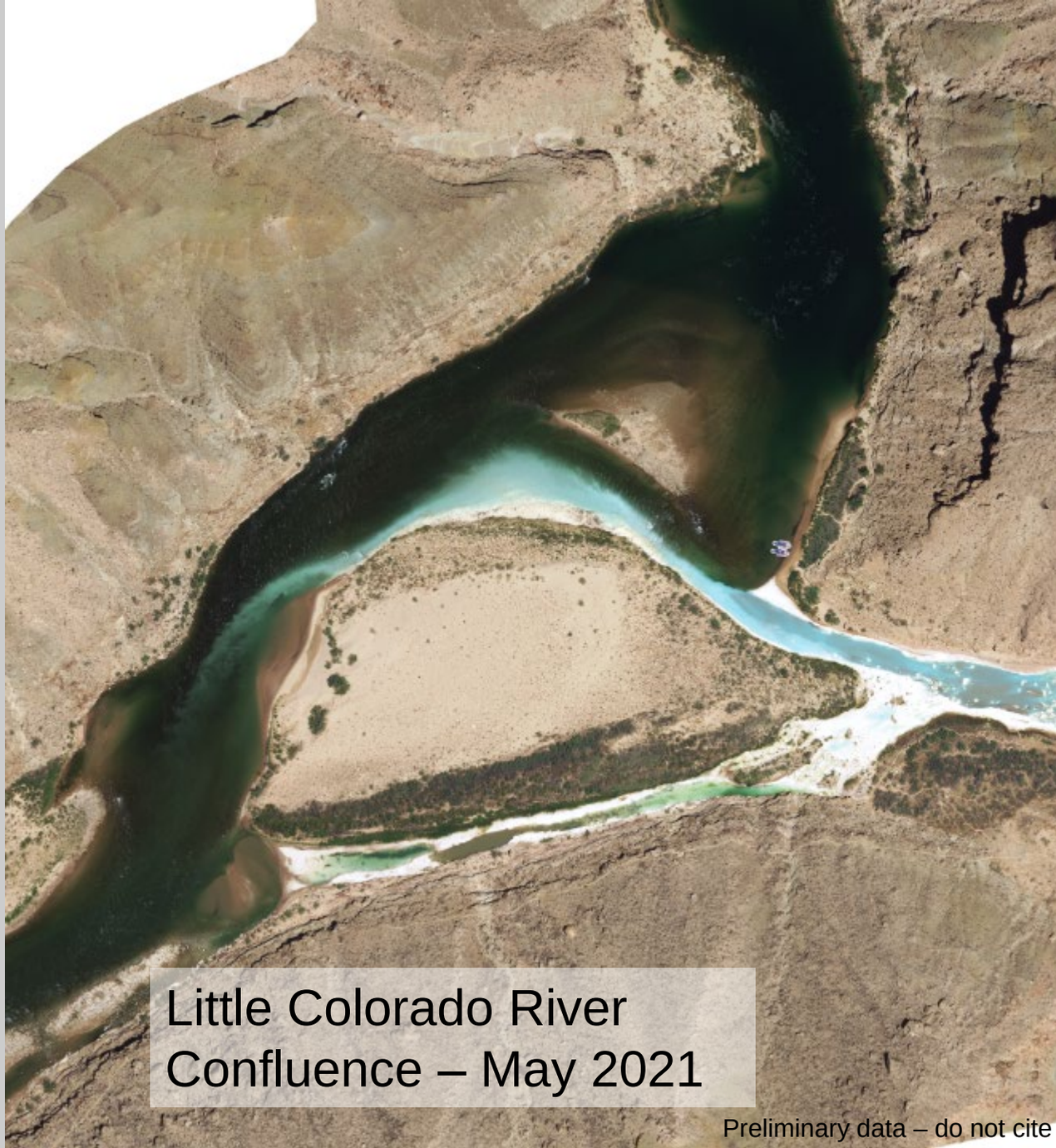
Project Goals and Objectives

GCMRC Triennial Workplan (TWP)
Project L FY2021/2022/2023
Budget $892k/$284k/$316k

Imagery and derivative data products from overflight remote sensing are used either directly or indirectly by every science project proposed in the 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?



Little Colorado River Confluence – May 2021

Preliminary data – do not cite

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Airborne Remote Sensing in Grand Canyon

The high-resolution image collection from GCDAMP's 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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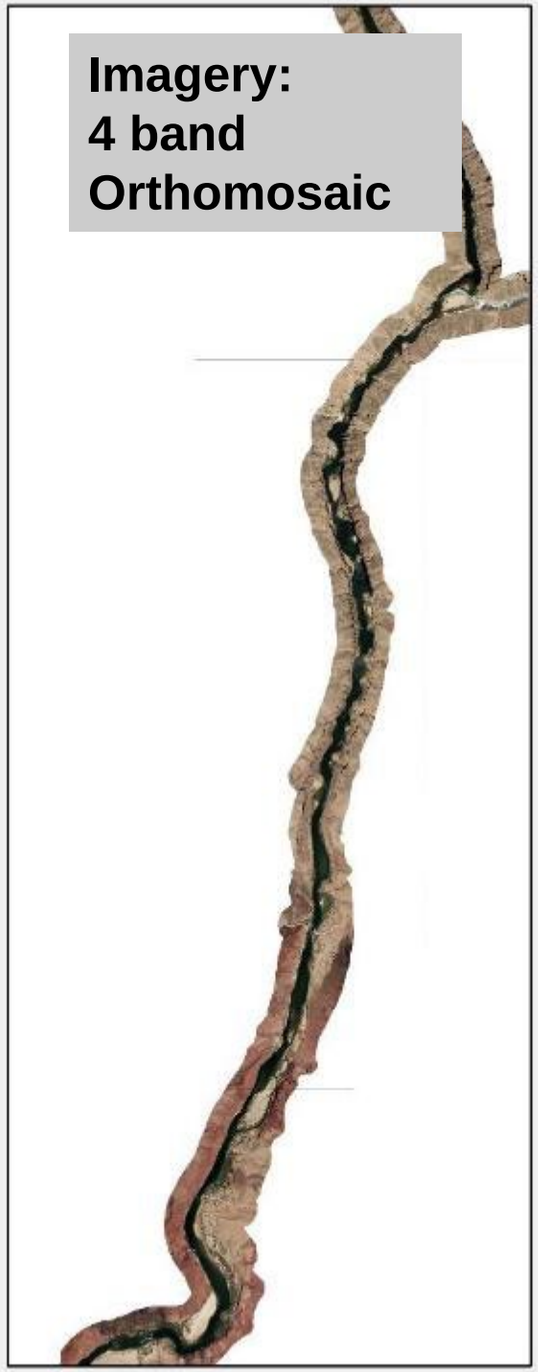

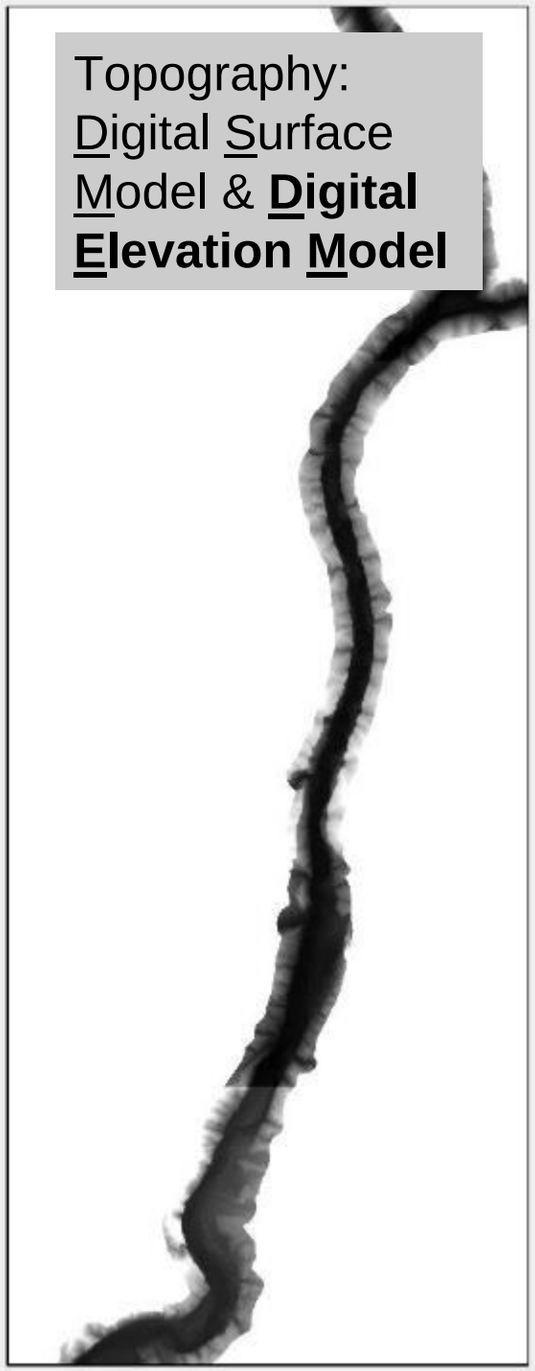

May 2021 Overflight Deliverables

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 finalized the topographic (DSM/DEM) dataset in 2022 for publication
- GCMRC is currently 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 NPS

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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

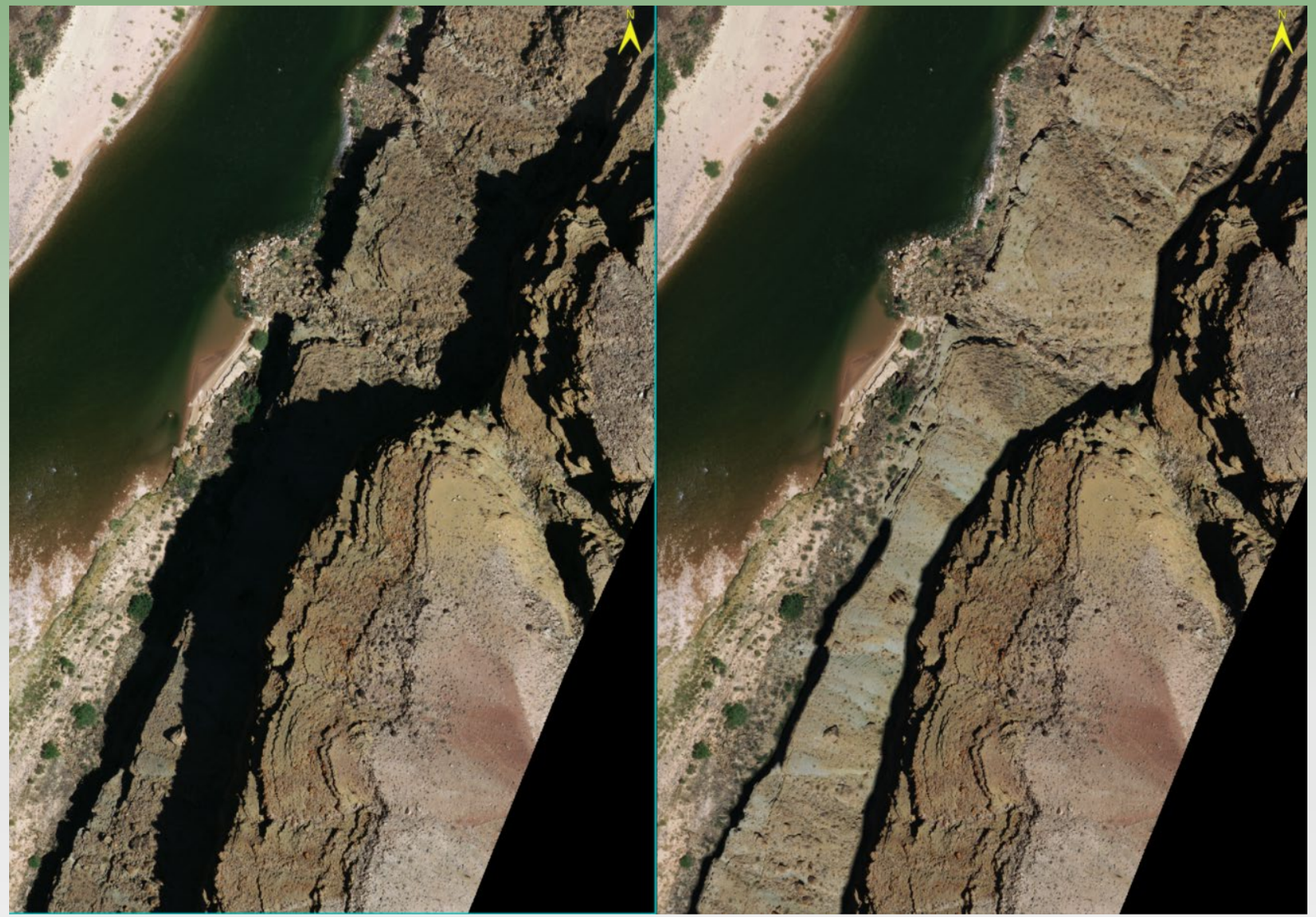
- >900 survey control points between Glen Canyon Dam and Pearce Ferry being used to evaluate the accuracy of elevation in digital topographic datasets from 2021 and previous overflights
- Data release in preparation for publication "*Digital elevation model (DEM) and digital surface model (DSM) data 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)

May 2021 Overflight Imagery Final Modifications

- **Reducing shadows**



May 2021 Overflight Imagery Final Modifications

- ❑ Reducing shadows
- ❑ **Smoothing cutlines**

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May 2021 Overflight Imagery Final Modifications

- ❑ Reducing shadows
- ❑ Smoothing cutlines
- ❑ **Fixing vegetation smear**

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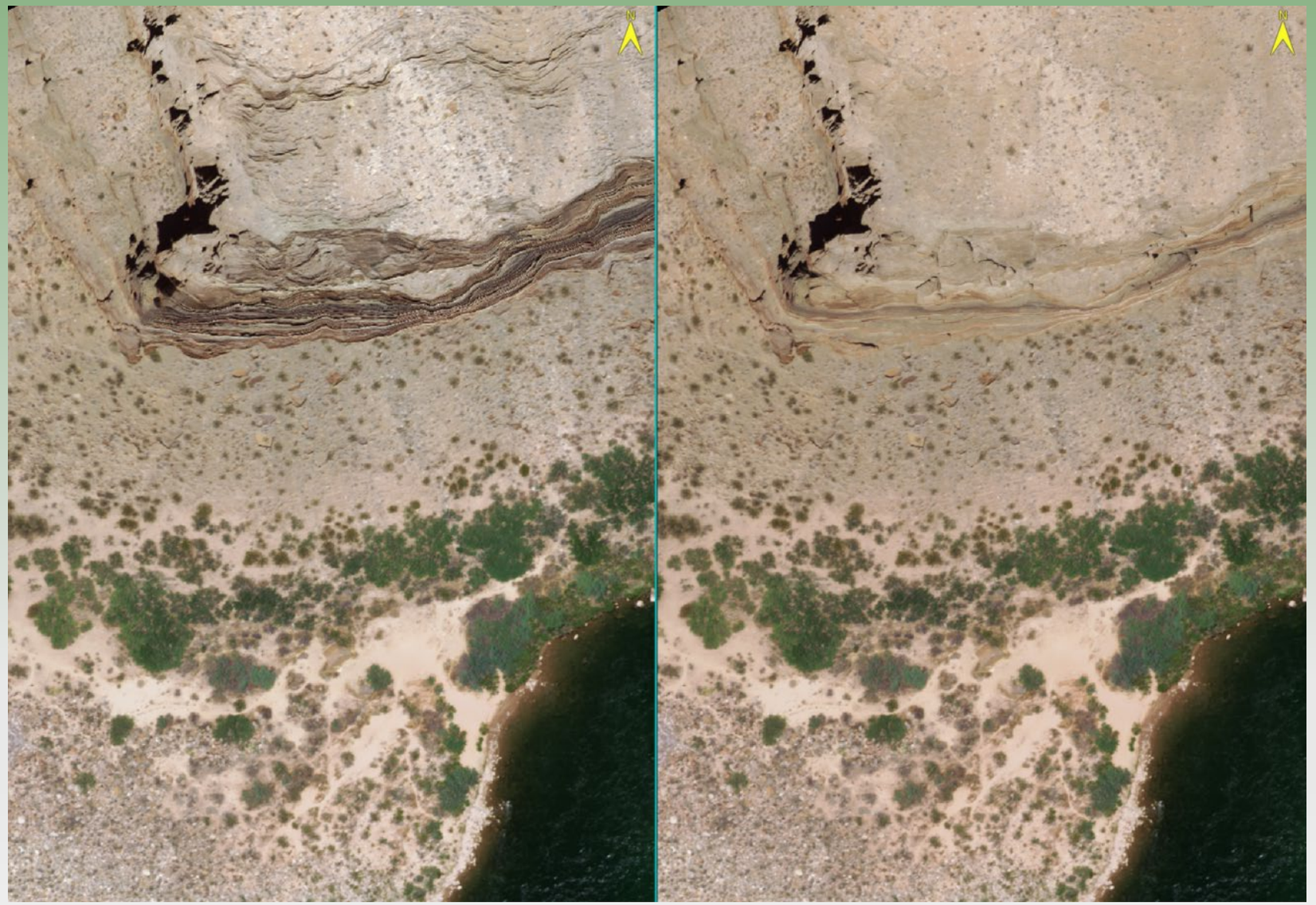
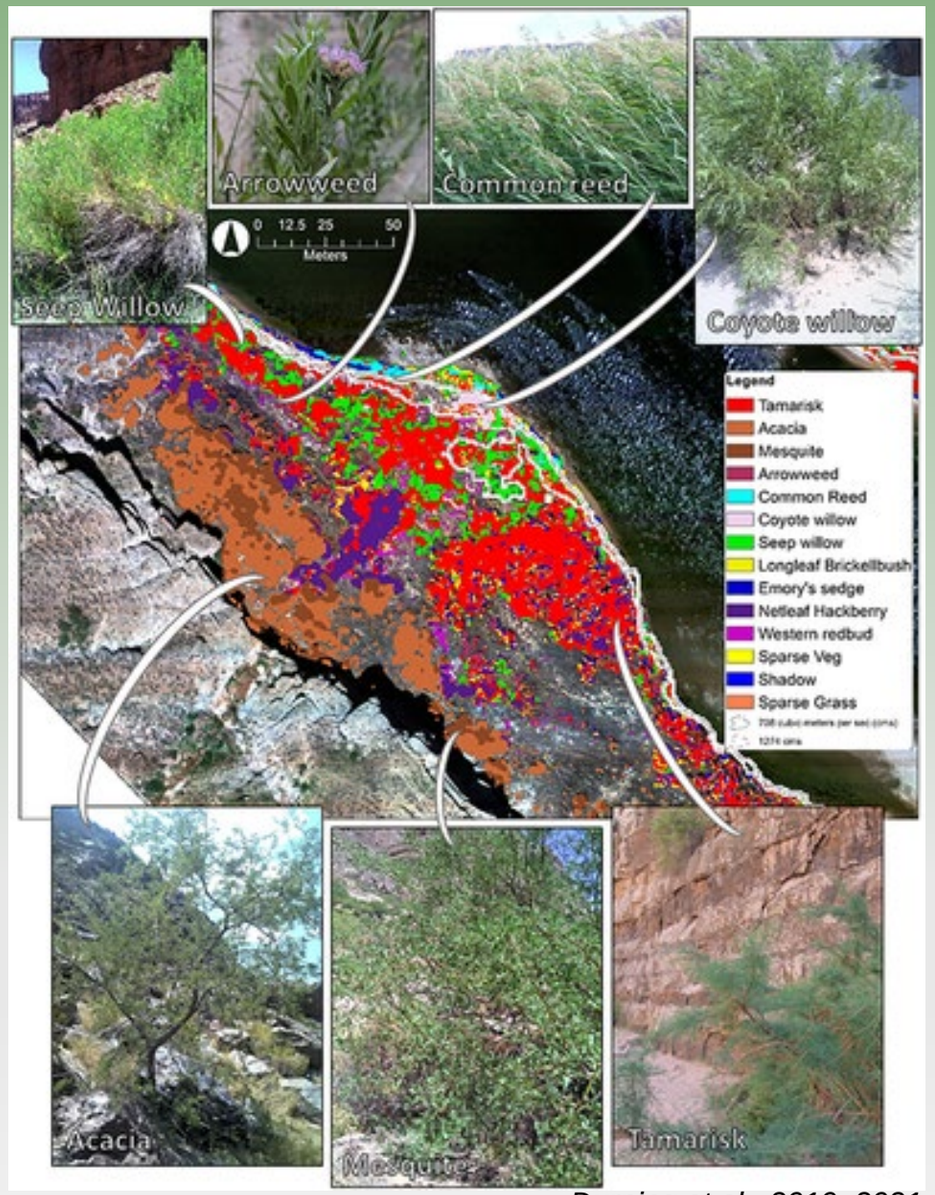
May 2021 Overflight Imagery Final Modifications

- Reducing shadows
- Smoothing cutlines
- Fixing vegetation smear
- **Removing geologic ripple effect**



Summary and Next Steps

- The 2021 overflight was an extremely successful data collection effort in FY21
- Project L Overflight Remote Sensing is on schedule in FY22 and FY23 to:
  - Publish 2021 DSM/DEM (topography) USGS data release
  - Finish 2021 Orthomosaic (imagery) final modifications and publish USGS data release
  - Produce 2021 overflight data landcover classification maps



Durning et al., 2019, 2021

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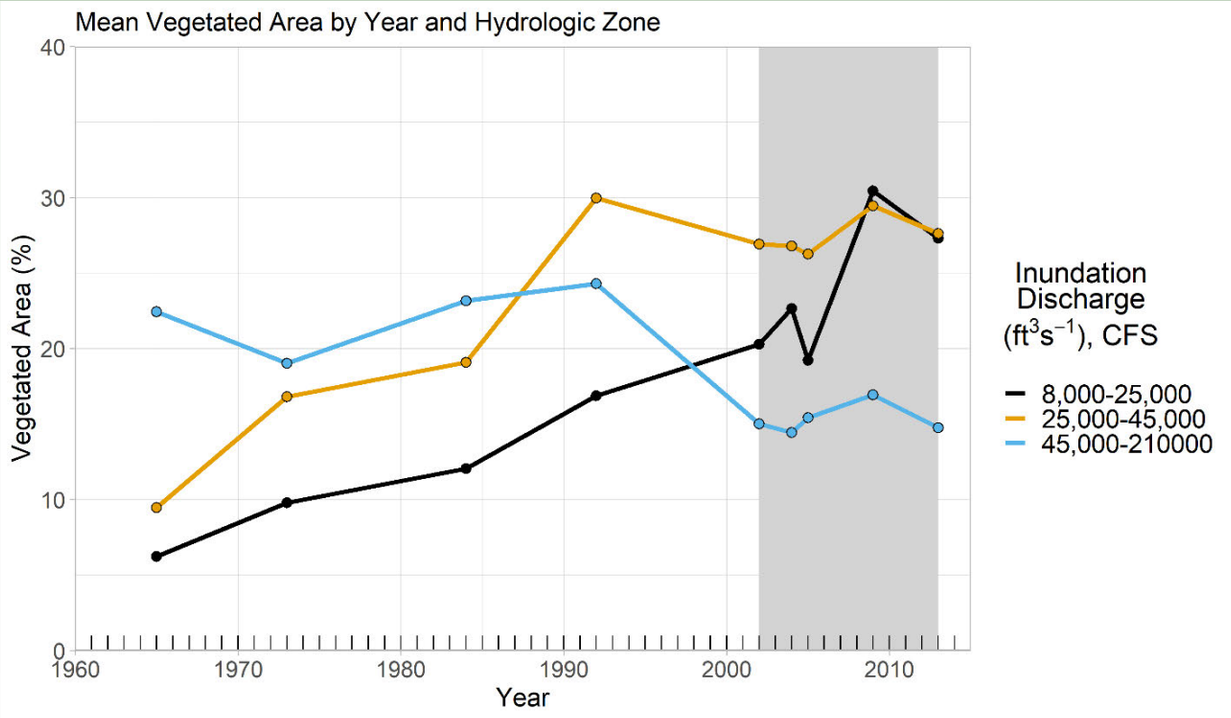
Summary and Next Steps

- The 2021 overflight imagery, topography, and landcover classification map datasets can be used with archive from previous decades of aerial imagery to track changes of the Colorado River in the Grand Canyon and answer science questions:
    - *How has landcover changed in the Colorado River Ecosystem (CRe) 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?*



Sankey et al., 2015; Durning et al., 2021

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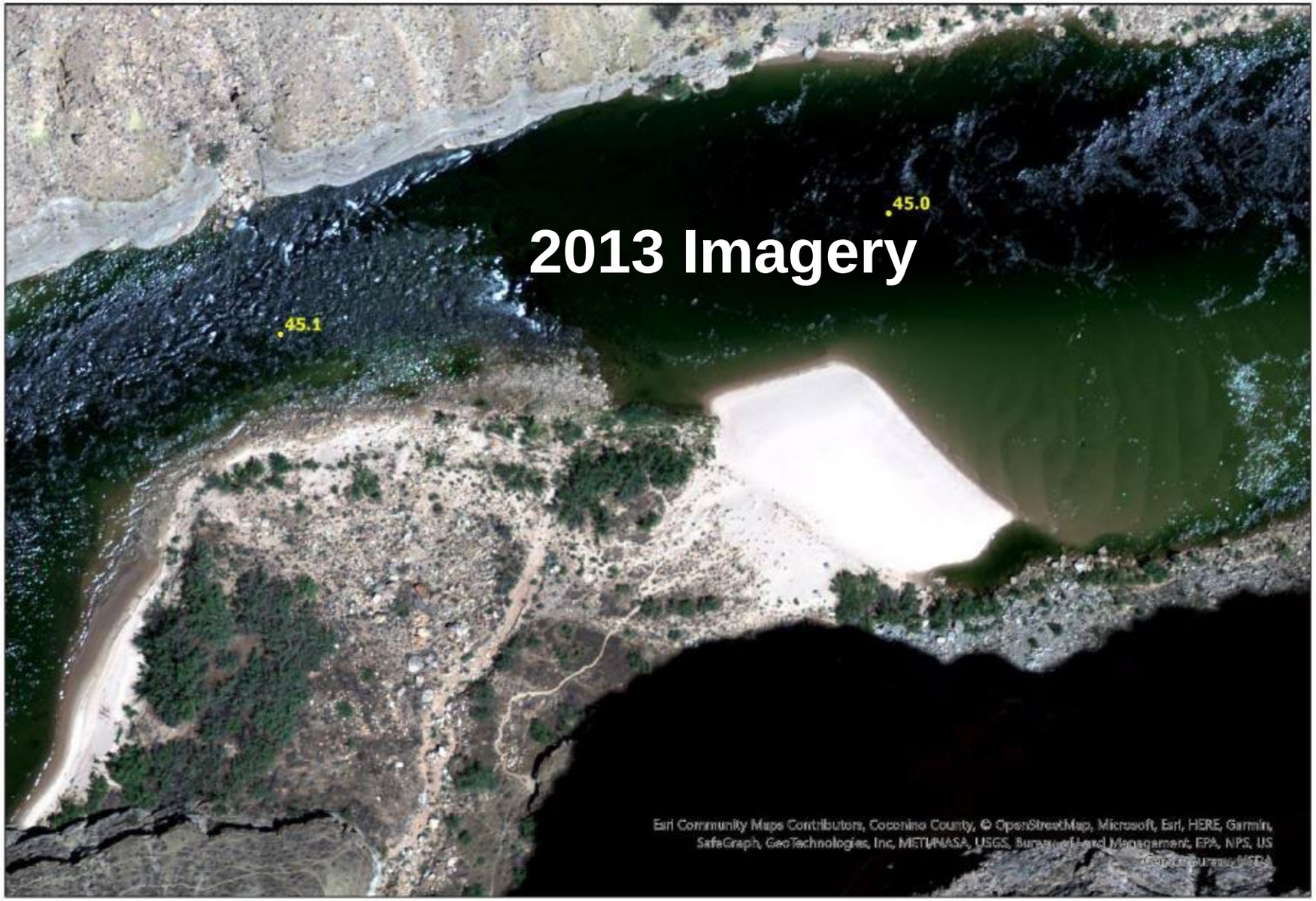
Assessing long-term changes with the 2021 orthomosaic (example)

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



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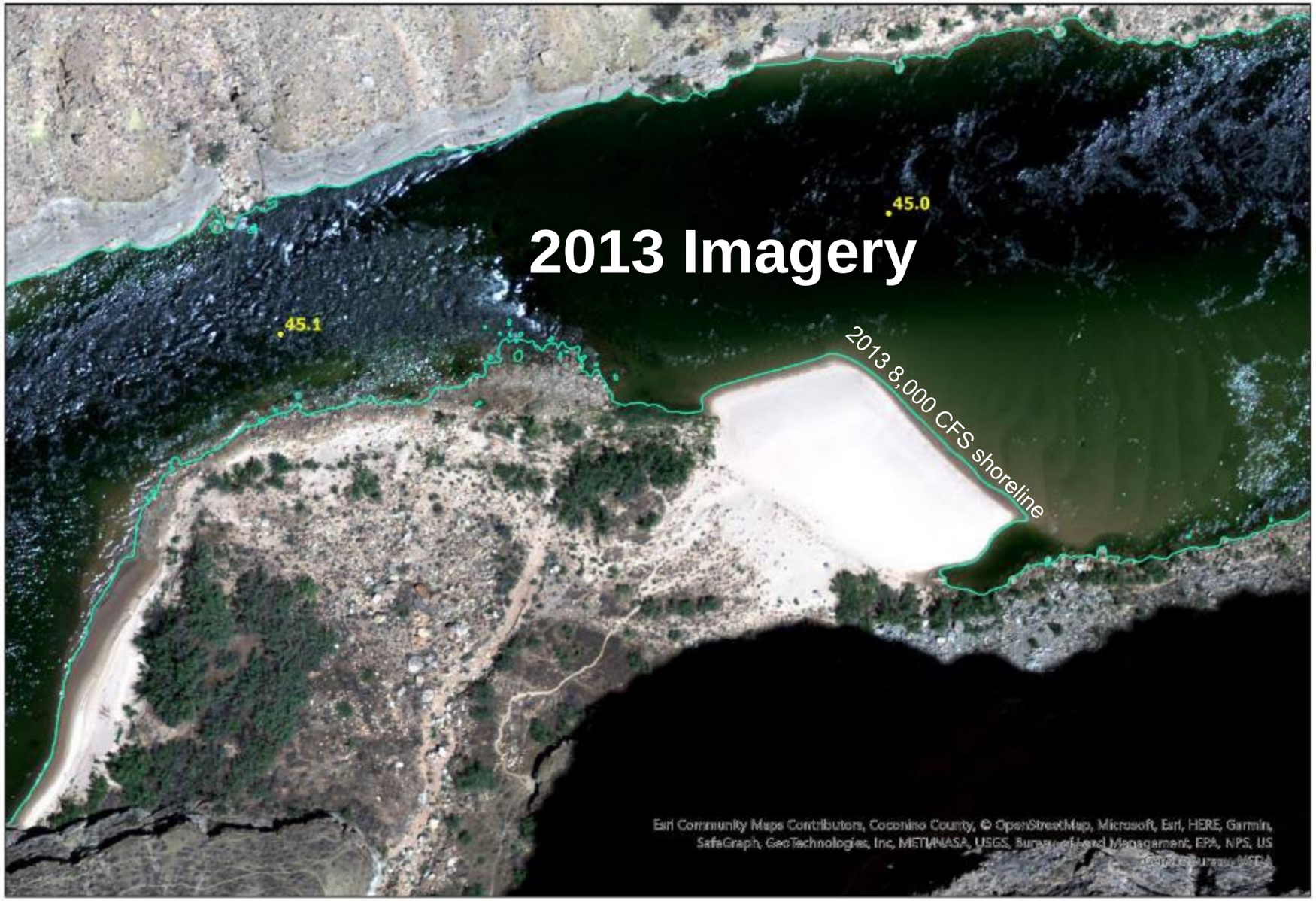

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Assessing long-term changes with the 2021 orthomosaic (example)

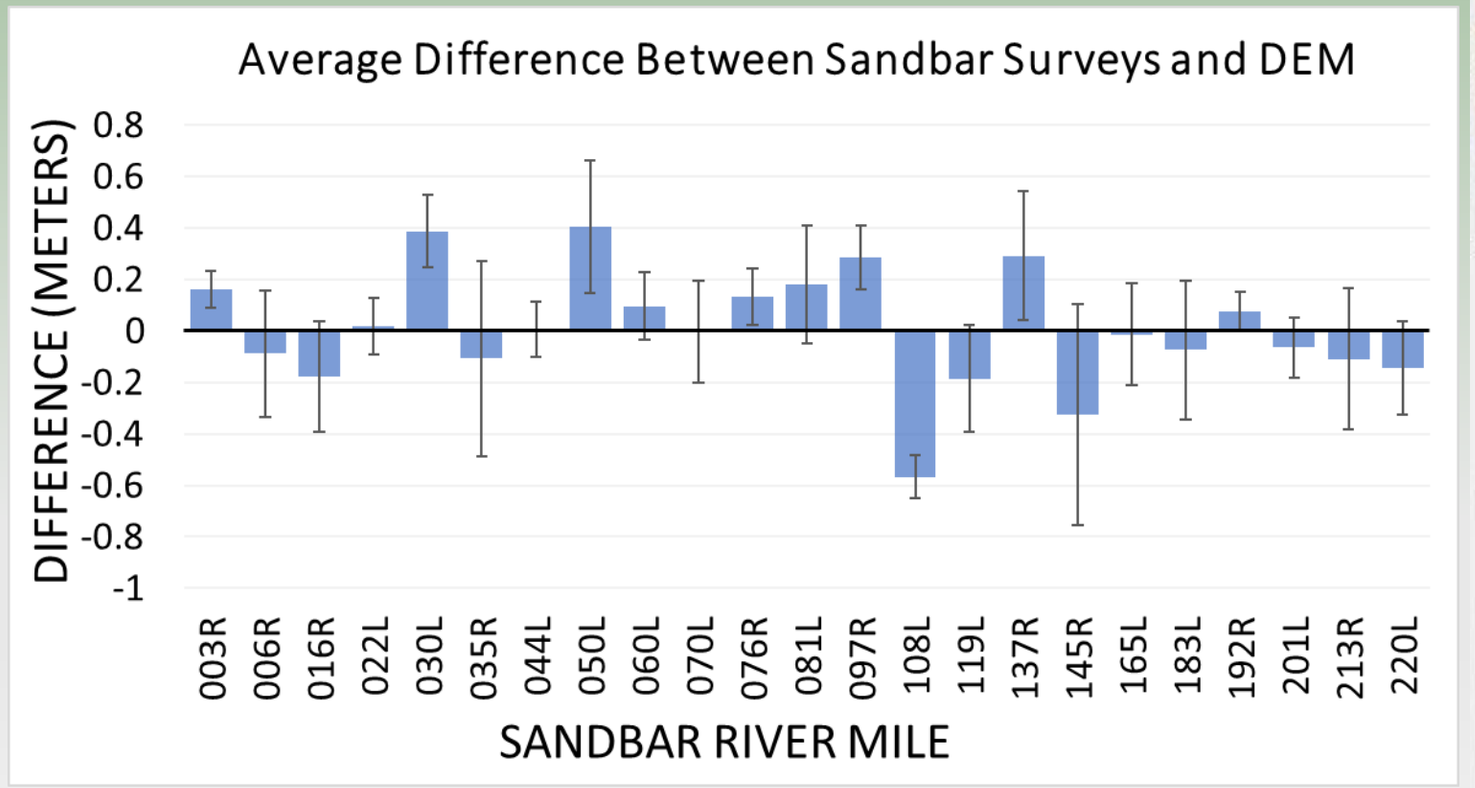
Assessing long-term changes with the 2021 orthomosaic (example)

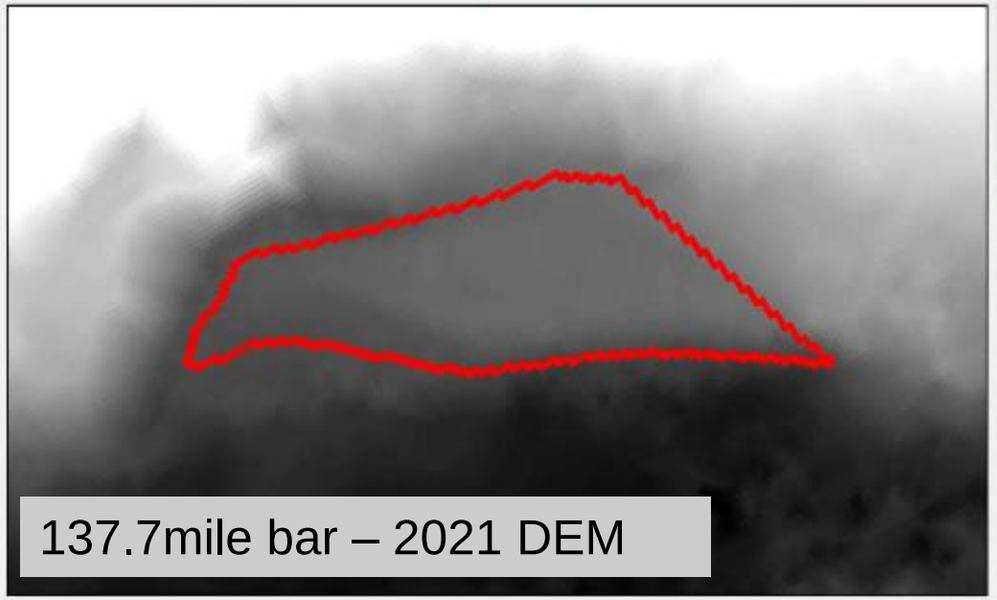
Assessing long-term changes with the 2021 orthomosaic (example)

Preliminary data – do not cite

Measurement of sandbar topography 2021 DEM (example)

- 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.





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

The End

Thanks for listening and remember it is not too early to begin planning for the next overflight which could occur in 2025 or 2026 during the next Triennial Workplan!

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

Bureau of Reclamation

National Park Service

NAU Northern Arizona University