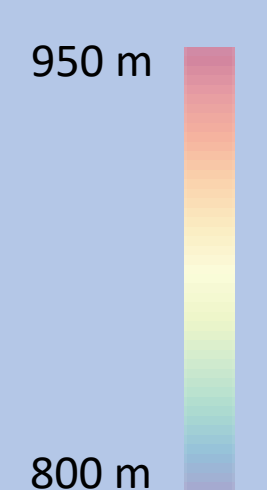
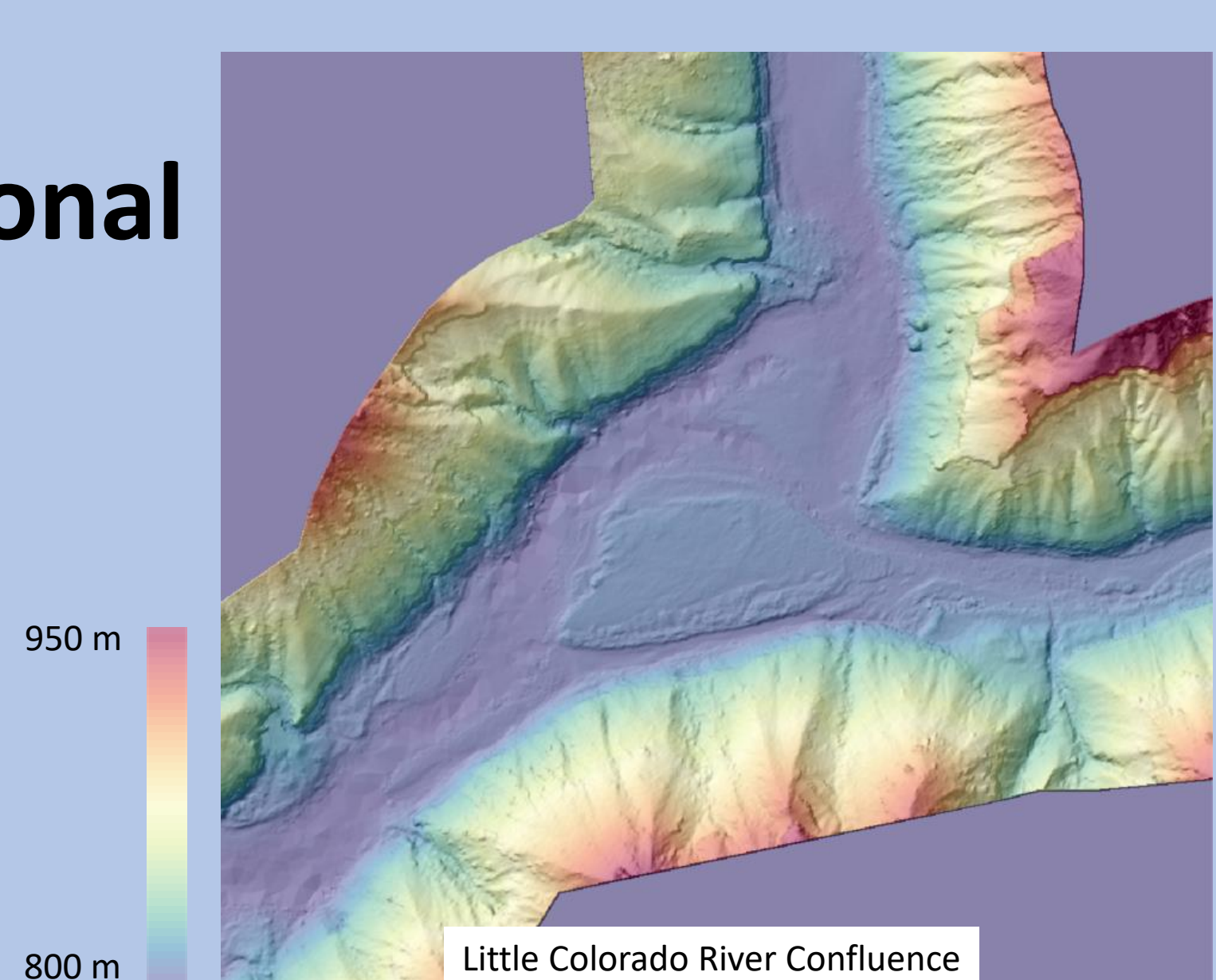
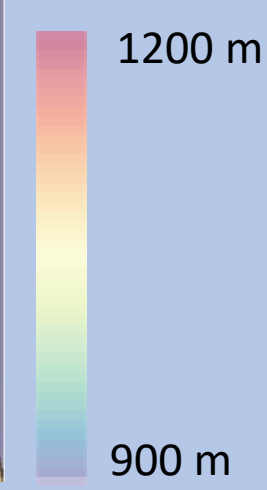
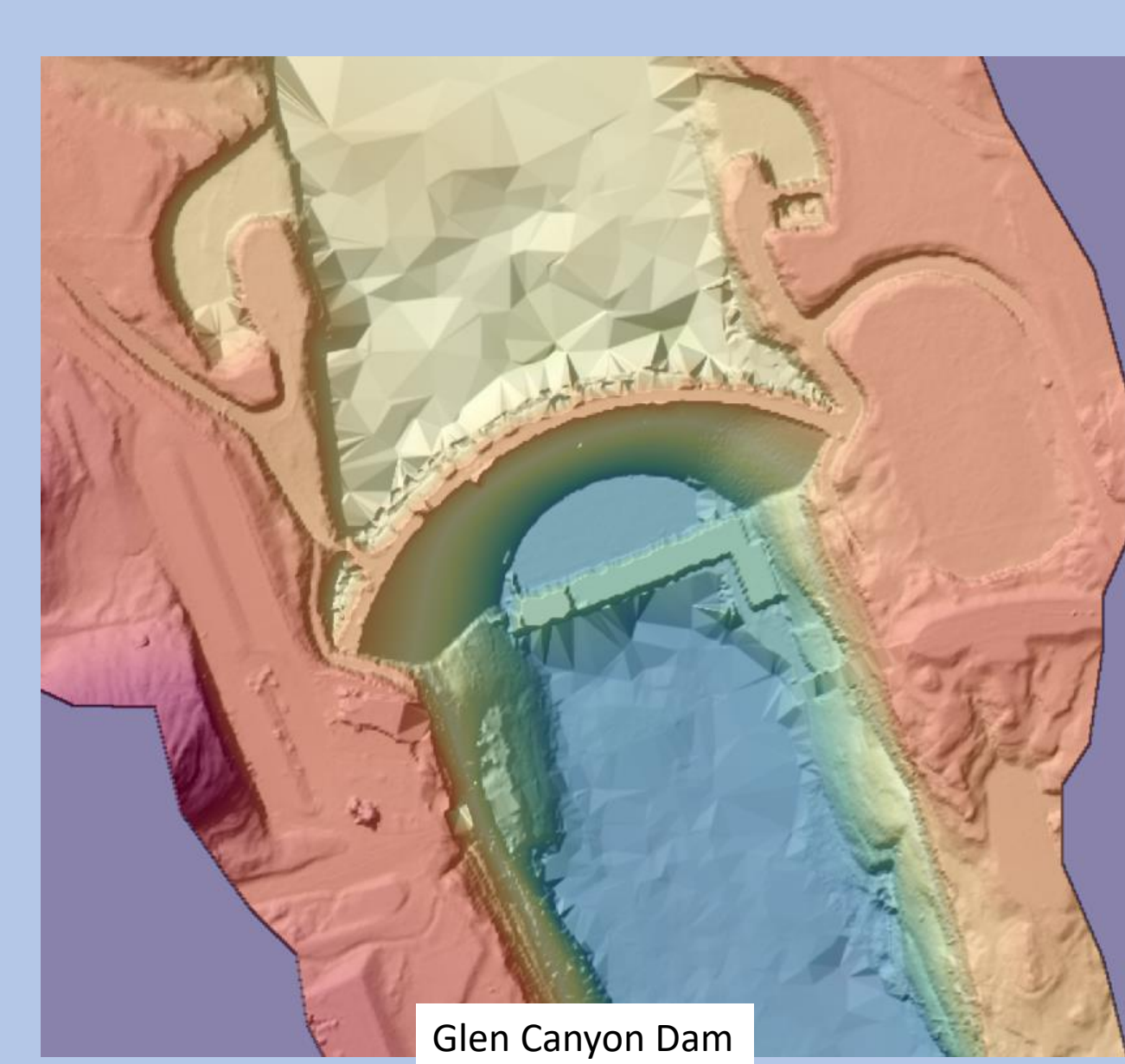


# Topographic Data from Airborne Image Acquisition of Colorado River Corridor in Grand Canyon National Park and Glen Canyon National Recreation Area: Digital Surface Models for 2002, 2009, 2013 and 2021 and Digital Elevation Model for 2021

Nat Bransky<sup>1,2</sup>, Joel Sankey<sup>1</sup>, Keith Kohl<sup>1</sup>, Tom Gushue<sup>1</sup>

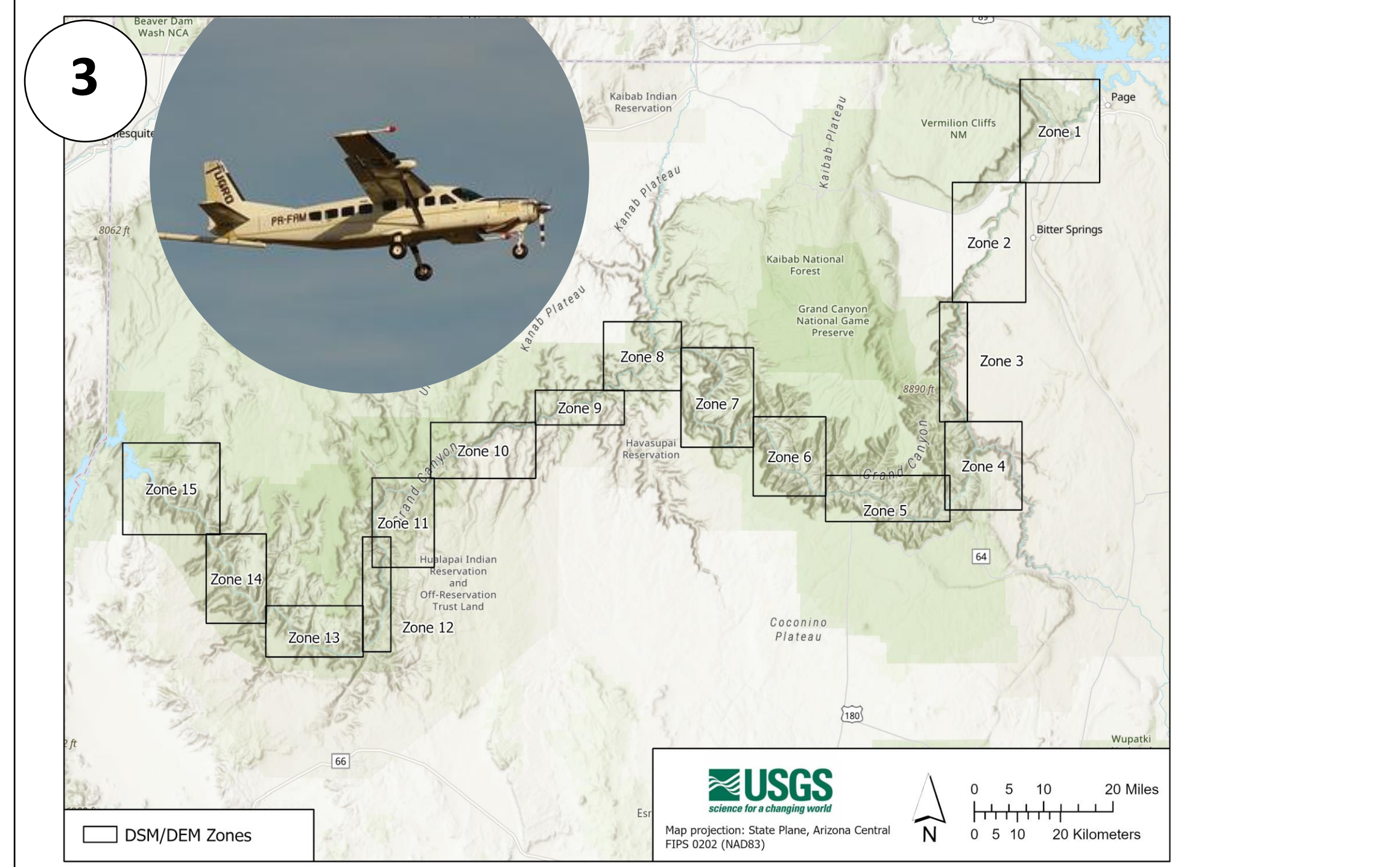
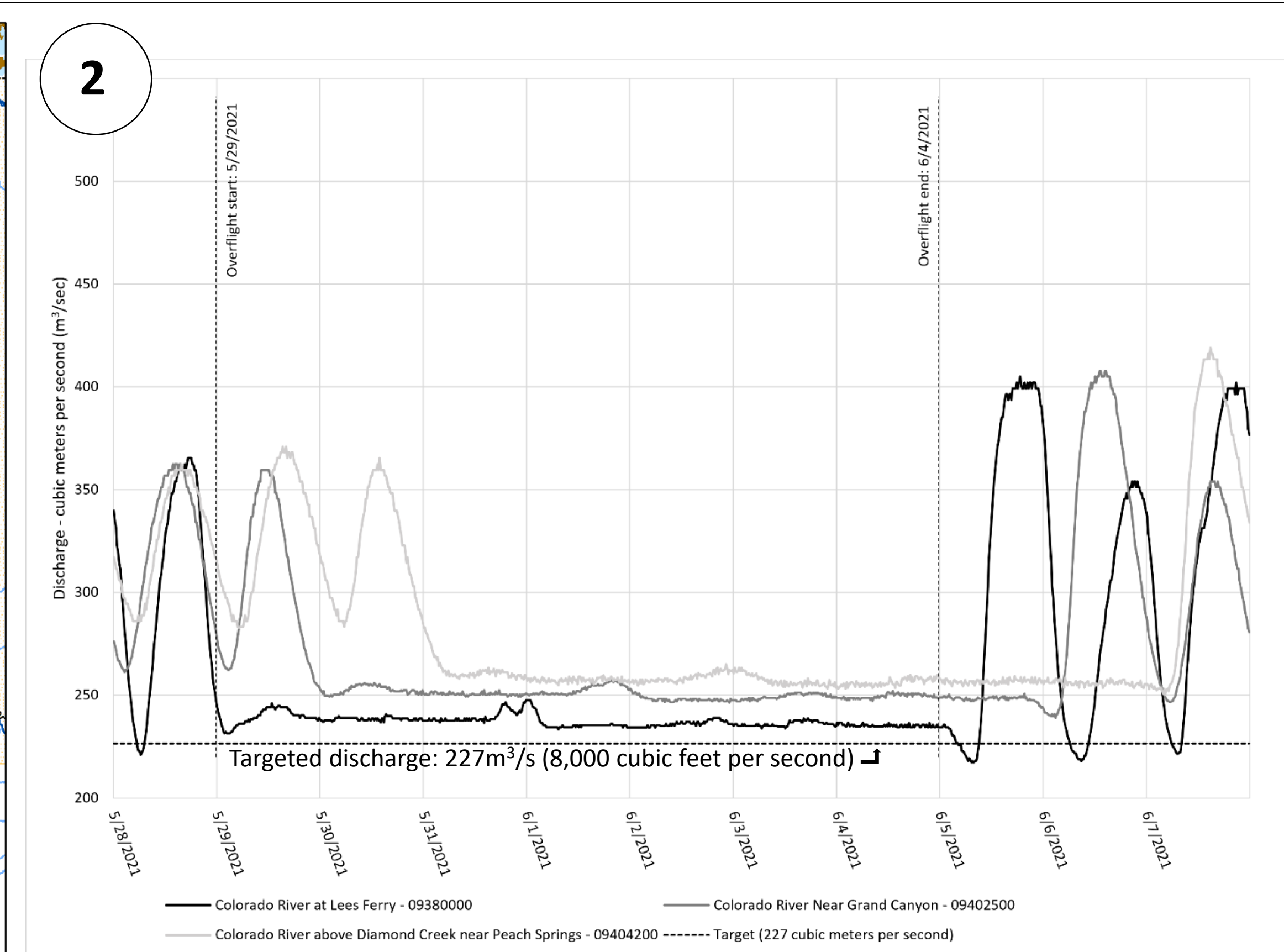
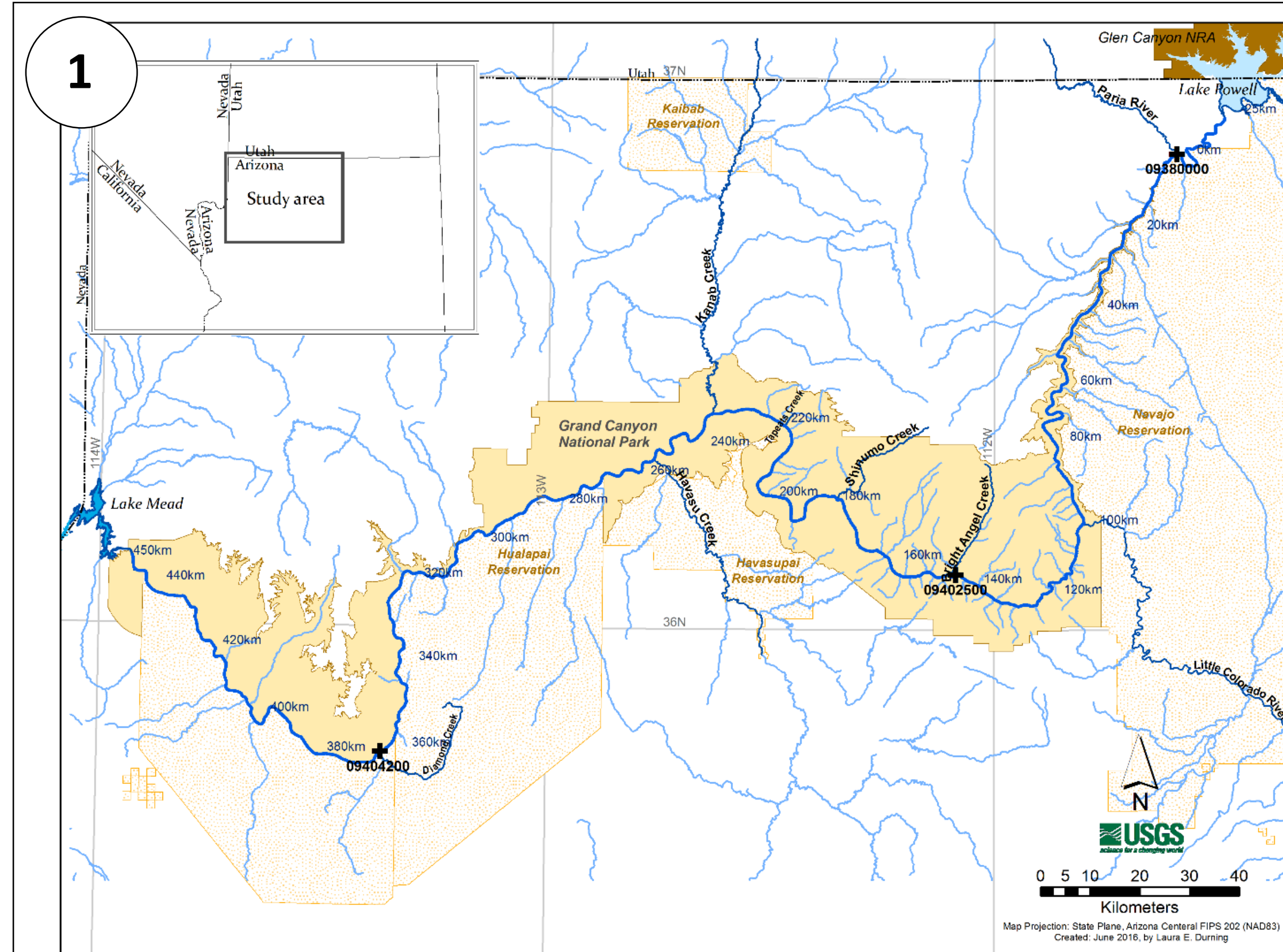
<sup>1</sup>U.S. Geological Survey Southwest Biological Science Center

<sup>2</sup>Northern Arizona University School of Informatics, Computing, and Cyber Systems



**Purpose**  
Topographic data were essential for orthorectification of multispectral images acquired during respective airborne data acquisition missions. They are also used for scientific monitoring and research, and production of GIS products such as topographic change detection, geomorphological analyses, and vegetation mapping.

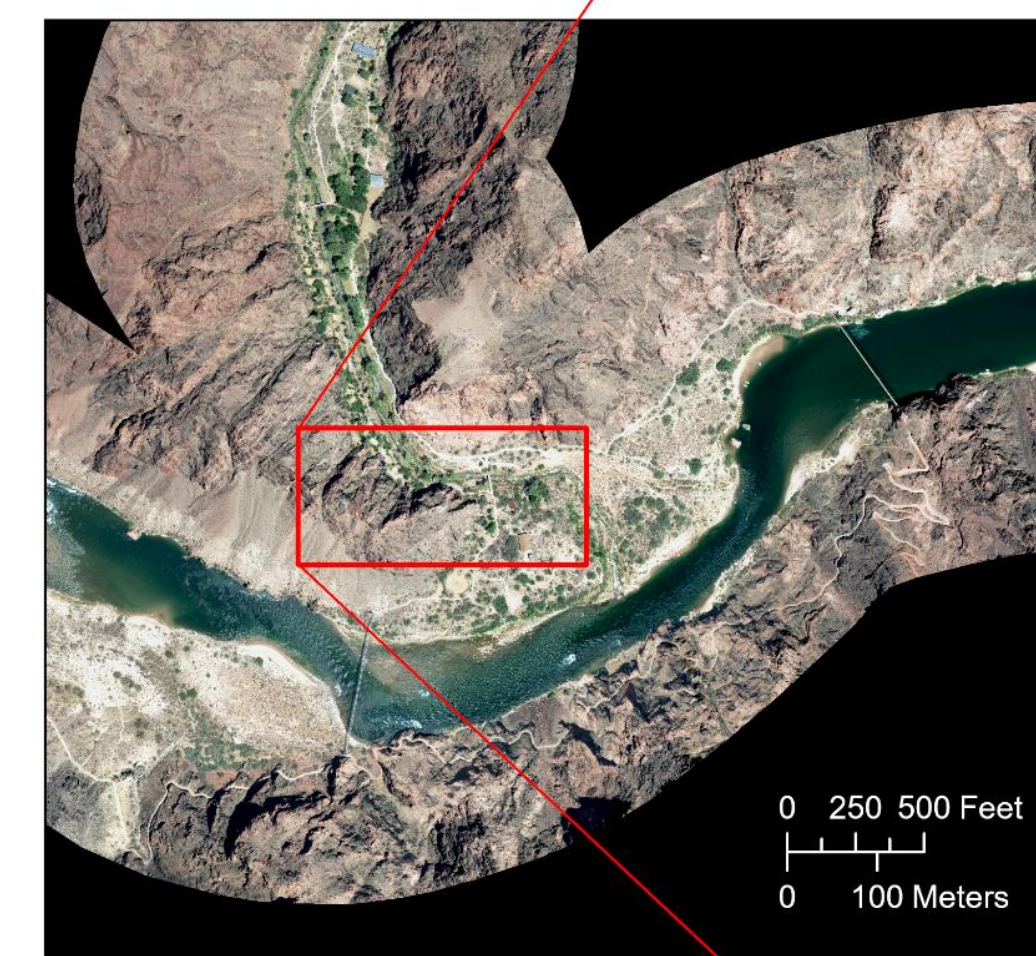
- Data Collection by contractor of the USGS Grand Canyon Monitoring and Research Center**
1. Collected from just upstream of Glen Canyon Dam (in Lake Powell) near Page, Arizona, downstream to Lake Mead's Pearce Ferry, Arizona, for a total length of 475 kilometers (km) at a width of about 500 meters (m) centered on the mainstem of the Colorado River and its seven primary tributaries: the Paria River, the Little Colorado River, Bright Angel Creek, Shinumo Creek, Tapeats Creek, Kanab Creek, and Havasu Creek
  2. Targeted river discharge of 227 m<sup>3</sup>/s (8,000 cubic feet per second)
  3. Topographic datasets produced in 15 spatially distinct zones



Mission	Sensor	Spatial reference	Flight Altitude above mean sea level	Dates of Acquisition	Contractor
2002	HRSC-AX push-broom sensor	NAD83(HARN)	5486 – 6400 m	May 24 – June 5, 2002	ISTAR
2009	Leica ADS40 SH 52 digital multi-spectral sensor	NSRS(2007)	1814 – 2743 m	May 25 – June 1, 2009	EarthData
2013	Leica ADS80/82 digital multi-spectral sensor	NAD83(2011)	2438 – 3353 m	May 25 – May 30, 2013	Fugro, Inc.
2021	Leica ADS100 digital push-broom multi-spectral sensor	NAD83(2011)	2438 – 3353 m	May 29 – June 4, 2021	Fugro, Inc.

## DSM and DEM Specifications

- 1 m spatial resolution
- Each pixel represents the elevation of the surface at that point referenced to Ellipsoid



Hillshade from 2021 DSM with transparent 2021 imagery over Phantom Ranch showing topography, vegetation, and buildings near Bright Angel Creek.

## Vertical and Horizontal Accuracy Assessment

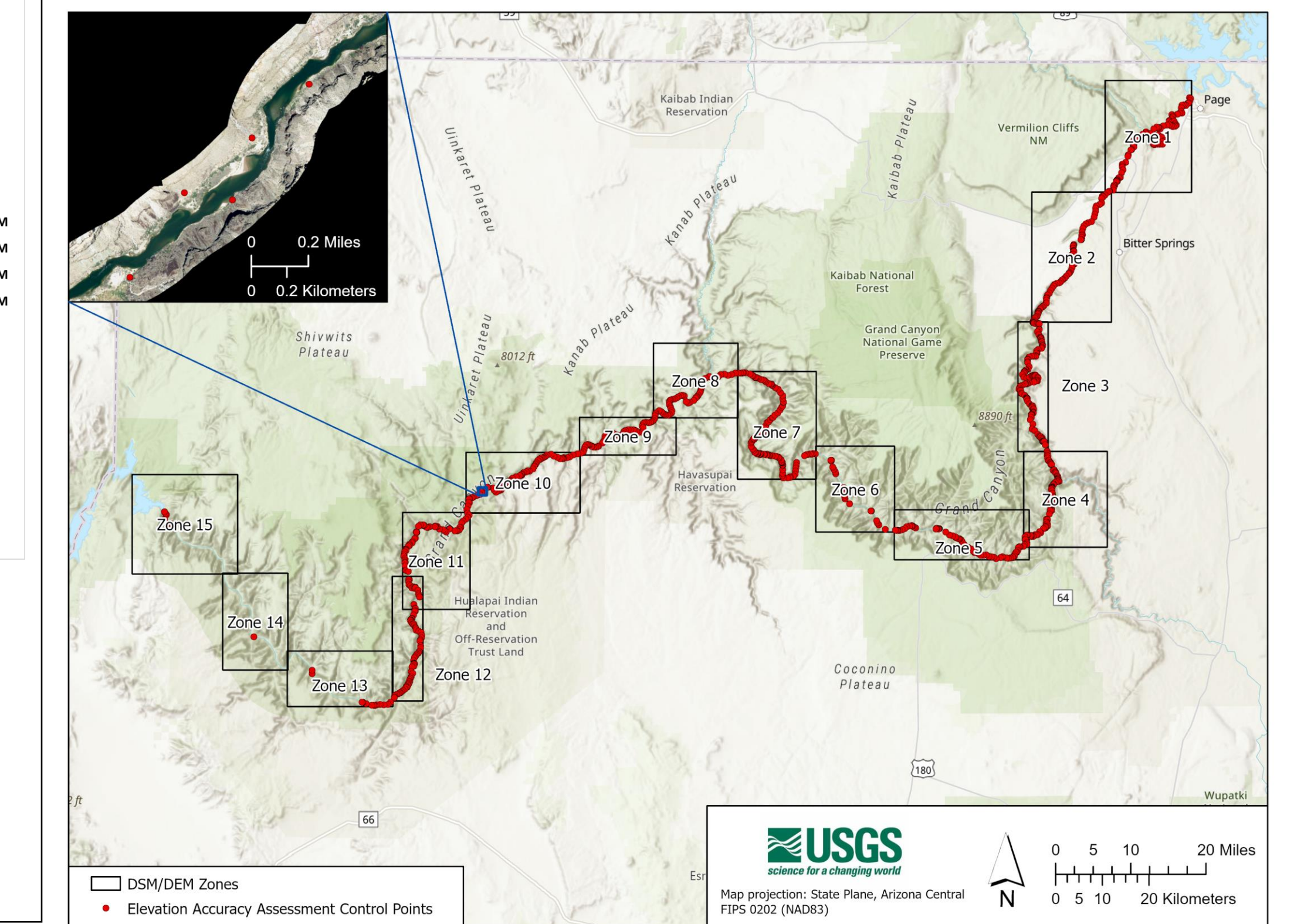
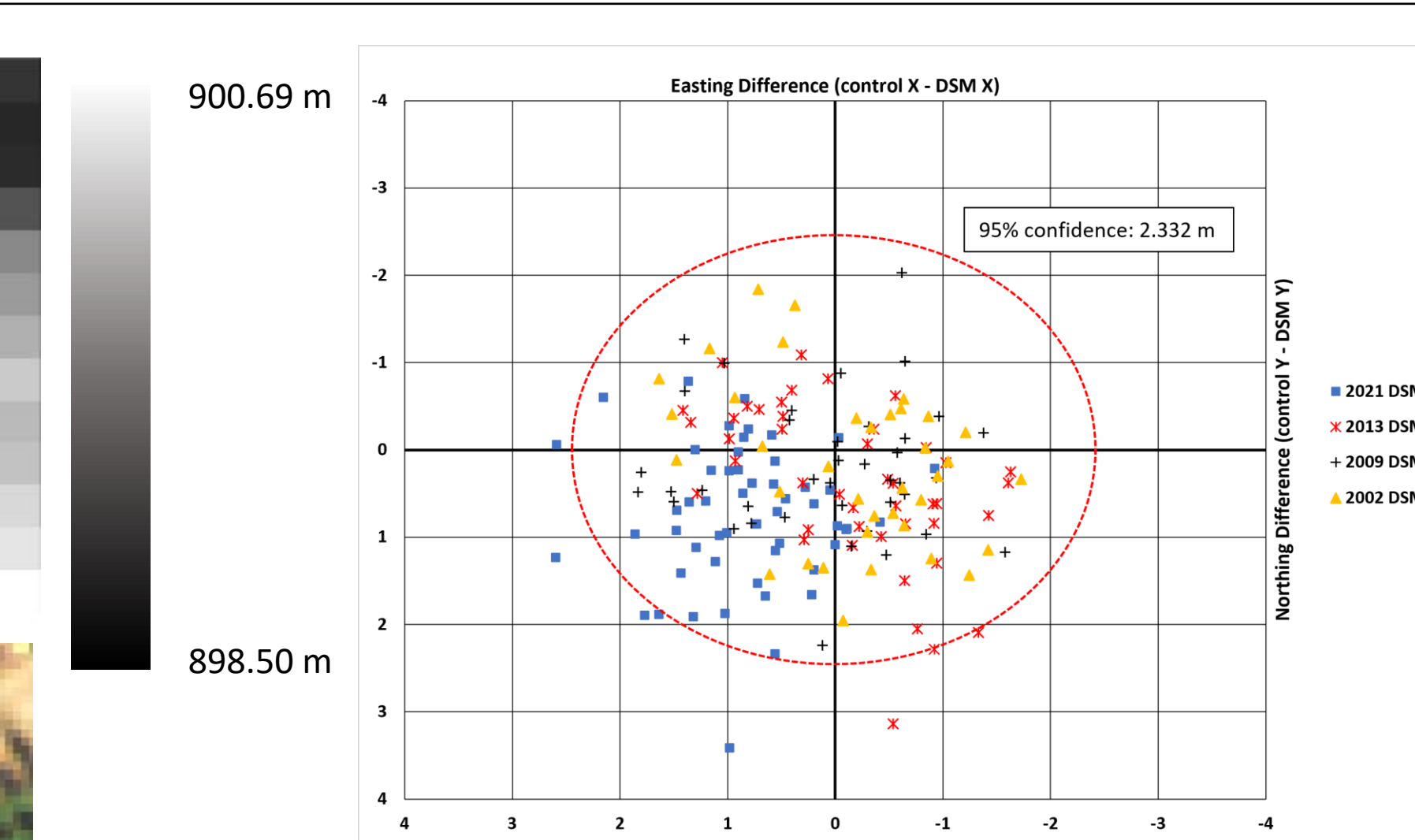
Vertical Accuracy calculated by finding the error between the Grand Canyon Monitoring and Research Center network of ground control point elevation values and the corresponding pixel elevation in the DSM

Horizontal Accuracy calculated by finding the error between the Grand Canyon Monitoring and Research Center network of surveyed "Hard Points" (e.g. corners of large, angular rock outcrops) and the same points identified in the DSM



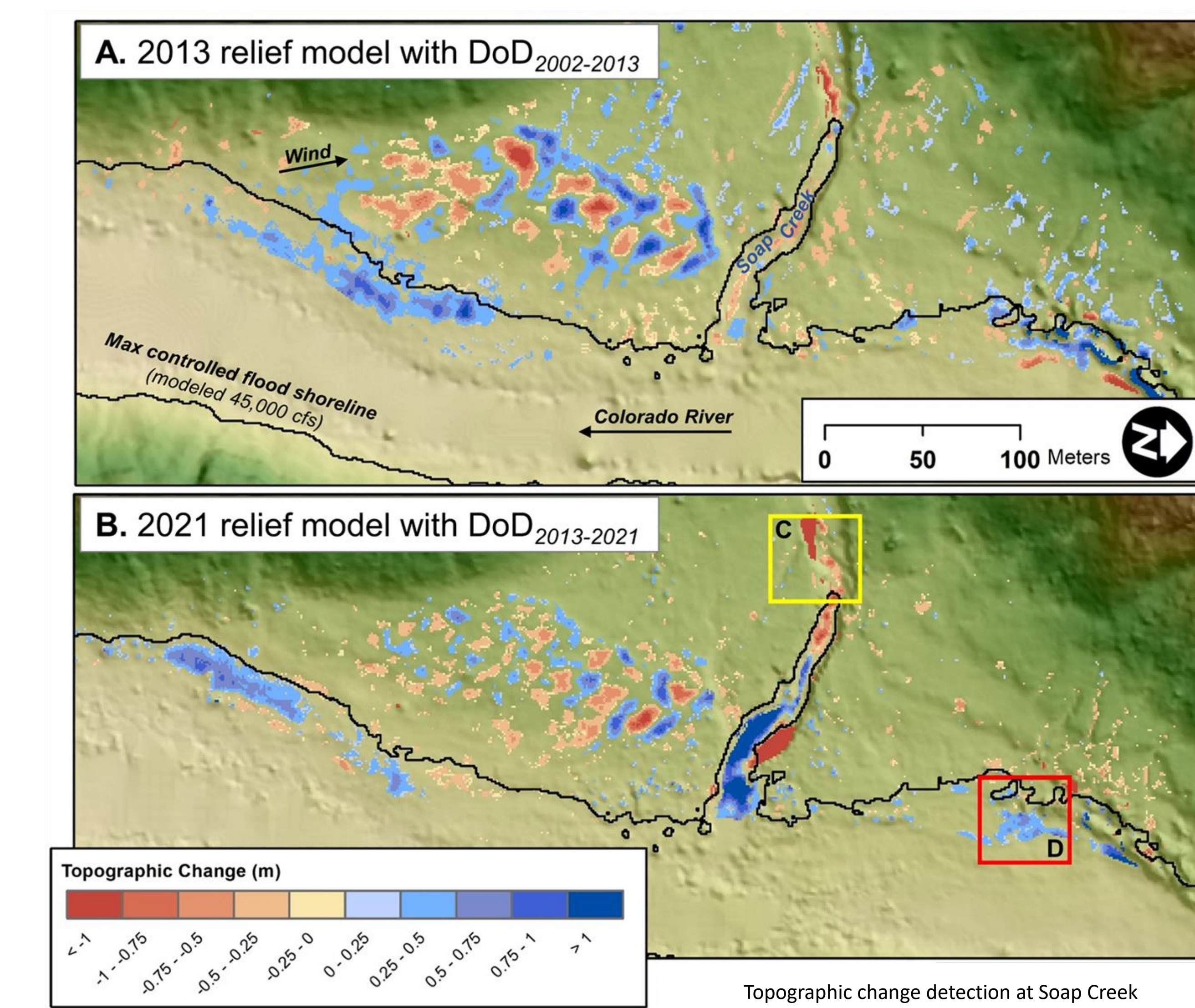
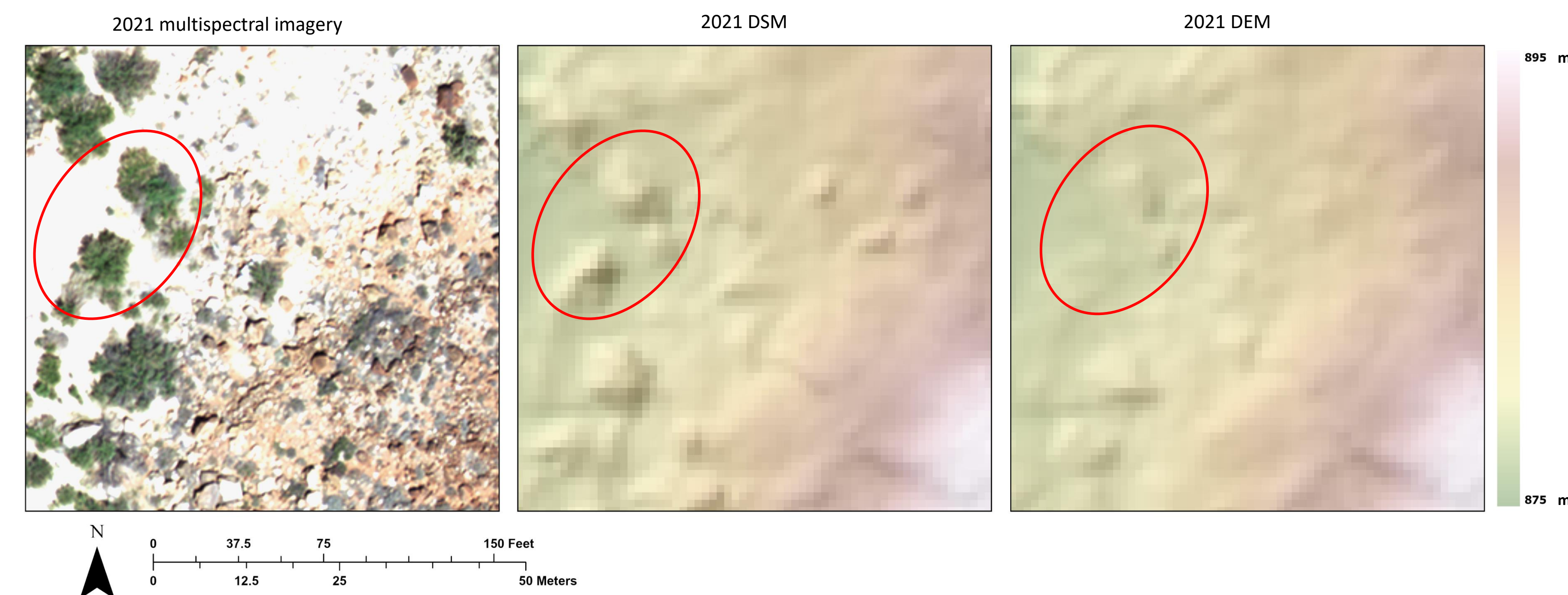
Horizontal error in 2021 DSM calculated at the hard point pictured above: 0.195 easting (x), 1.376 northing (y)

Topographic Dataset	Vertical accuracy at 95% confidence from N=926 control points
2002 DSM	1.5066
2009 DSM	1.3506
2013 DSM	1.3787
2021 DSM	1.3785
2021 DEM	2.9186



## Digital Surface Model (DSM) and Digital Elevation Model (DEM) Processing by Contractor

- Stereoscopic imagery from various view angles was autocorrelated to create a digital surface model (DSM)
- DSMs provide elevation data on open ground (e.g. bare soil, rocks) and on aboveground terrain features including buildings, trees, and vegetation that cover otherwise open ground
- 2021 DEM generated by removing the aboveground features from the DSM by filtering process



## What Comes Next

- **Topographic data publication in press**
  - Sankey, J.B., Kohl, K., Gushue, T., Bransky, N., Bedford, A., Durning, L., Davis, P.A., *In Prep.*, DSMs for Colorado River Corridor in Grand Canyon National Park and Glen Canyon National Recreation Area: 2002, 2009, 2013 and 2021 and DEM for 2021: U.S. Geological Survey data release.
- **Science and change detection**
  - Differencing two DSMs generates a Digital Surface Model of Difference (DoD) showing topographic changes that occurred during the inter-DSM time period
    - $DSM_{later} - DSM_{earlier} = DoD_{later - earlier}$
- **Future Grand Canyon overflights**
  - Previous, similar overflights: 2002, 2009, 2013
  - Potential future overflight: during the FY 2025-27 Triennial Work Plan

