High Resolution Topography and Geomorphology of Select Archeological Sites in Glen Canyon National Recreation Area, Arizona

Brian Collins[1] (bcollins@usgs.gov), Skye Corbett[1], Joel Sankey[2], and Helen Fairley[2]

[1]US Geological Survey, Geology Minerals Energy and Geophysics Science Center, [2]US Geological Survey, Grand Canyon Monitoring and Research Center

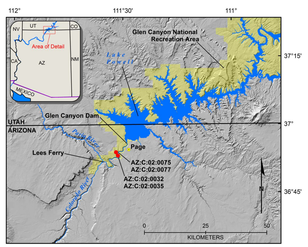
OVERVIEW:

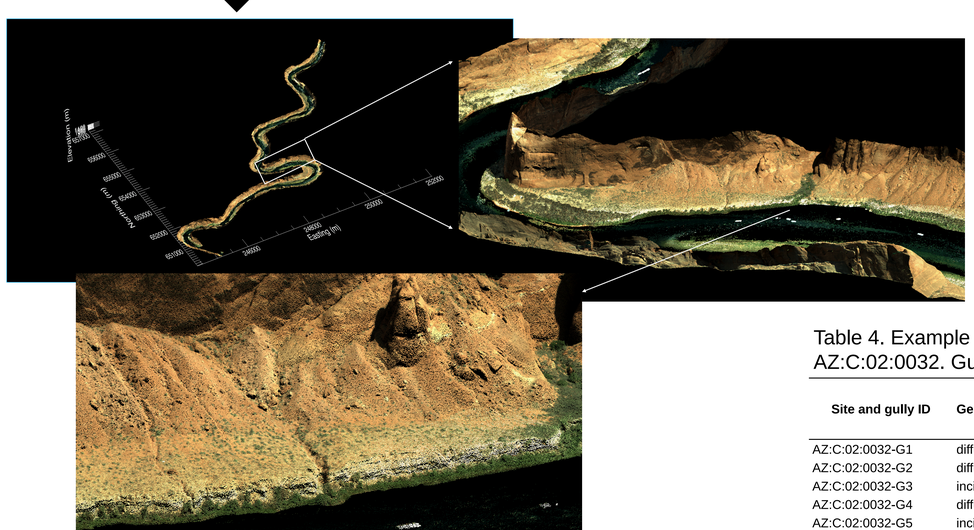
- HIGH RESOLUTION DIGITAL TOPOGRAPHIC DATA IS VALUABLE FOR DETECTING AND MONITORING EROSION AND GEOMORPHIC CHANGE WITHIN ARCHAEOLOGICAL SITES
- IN FALL 2012 AND 2013 TERRESTRIAL LIDAR DATA WERE COLLECTED AT FOUR ARCHAEOLOGICAL SITES WITHIN GLEN CANYON NATIONAL RECREATION AREA (GLCA)
- IN SUMMER 2013 AIRBORNE LIDAR DATA WERE COLLECTED ALONG APPROXIMATELY 8 MILES OF THE COLORADO RIVER WITHIN GLCA, INCLUDING THE FOUR ARCHAEOLOGICAL SITES ALSO COVERED BY TERRESTRIAL LIDAR
- THIS POSTER PRESENTS ONGOING WORK THAT IS EXAMINING THE CAPACITIES OF THESE DIFFERENT DATA SETS, WHEN USED INDEPENDENTLY AS WELL AS IN COMBINATION, TO ACCURATELY DESCRIBE TOPOGRAPHY FOR THE GOAL OF CHARACTERIZING GEOMORPHIC CHANGE

COMPLETED DATA COLLECTION INCLUDES:

- SEPTEMBER 2012 TERRESTRIAL LIDAR AT FOUR ARCHAEOLOGICAL SITES
- JULY 2013 AIRBORNE LIDAR FOR 8.5 RIVER MILES (-6 TO -14.5) OF ENTIRE CANYON BOTTOM AND 21 ARCHAEOLOGICAL SITES
- NOVEMBER 2013 REPEAT TERRESTRIAL LIDAR AT FOUR ARCHAEOLOGICAL SITES
- INFILTRATION MEASUREMENTS AND SUBSTRATE MAPPING AT FOUR ARCHAEOLOGICAL SITES

Helicopter-based airborne lidar acquisition





Examples from the airborne lidar point cloud dataset for the ~ 8 river mile collection area in Glen Canyon National Recreation Area. The upper left panel shows an overview of the entire lidar collection; the uppermost endpoint of the data collection area is ~ 1 mile from Glen Canyon Dam and the lowermost is ~ 6 miles from Lee's Ferry. The other 2 panels show examples in the vicinity of the "Nine Mile" terrace area.

COMPLETED DATA ANALYSIS INCLUDES:

- HIGH RESOLUTION THREE-DIMENSIONAL SURFACE MODELS OF FOUR ARCHEOLOGICAL SITES FOR THE SEPTEMBER 2012 AND JULY 2013 LIDAR DATA SETS
- GEOMORPHOLOGICAL ANALYSIS SUMMARIES OF FOUR ARCHAEOLOGICAL SITES
- DETECTION OF GULLIES >1-METER IN WIDTH FOR 14.5 RIVER MILES USING 1-METER PHOTOGRAMMETRIC DIGITAL SURFACE MODELS (DSM) TO DETERMINE DEGREE OF EROSION IN GLEN CANYON
- DATA ACCURACY AND RESOLUTION ASSESSMENT FOR ARCHAEOLOGICAL SITE MONITORING

Table 1. Vertical accuracy and point density comparison of terrestrial and airborne lidar point data. Vertical accuracy of 1-m resolution airborne digital surface model (DSM) data from GCMRC remote sensing overflight is also provided for comparison

Survey panel #	Archaeological site	Terrestrial lidar – total station ΔZ (cm)	Airborne lidar – total station ΔZ (cm)	Airborne DSM – total station ΔZ (cm)	Airborne lidar – terrestrial lidar ΔZ (cm)	Terrestrial lidar ground point density (points/m²)	Airborne lidar ground point density (points/m²)
P1	AZ:C:02:0075	4.1	4.9	38.7	0.8	661	15
P2	AZ:C:02:0075	3.7	4.6	29.4	0.9	87	19
P3	AZ:C:02:0077	7.5	8.5	25.1	1.0	2609	18
P4	AZ:C:02:0077	2.7	3.7	23.6	1.0	183	13
P5	AZ:C:02:0035	2.7	6.7	2.0	4.0	319	14
P6	AZ:C:02:0035	3.0	7.2	19.3	4.2	2013	12
P7	AZ:C:02:0032	1.3	5.2	15.9	3.9	842	27
P8	AZ:C:02:0032	3.0	7.3	19.4	4.3	1192	28
	AVERAGE	3.5	6.0	21.7	2.5	988	18

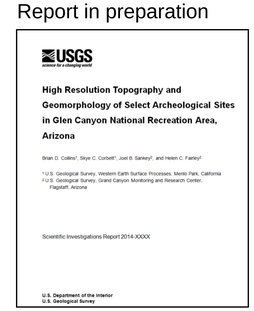
Table 2. Error assessment for maximum errors in terrestrial lidar point data

Error type	Laser error (cm)	Registration error[1] (cm)	Georef. error (cm)	Total station survey. error (cm)	Control network error (cm)	Total relative error (cm)	Total absolute error (cm)
Horizontal	0.3	0.9	2.2	1.4	6.2	2.6	6.7
Vertical	0.7	0.6	1.5	1.9	10.8	2.6	11.1

Table 3 . Error summary for maximum errors in airborne lidar point data reported by the contractor and equipment specifications

Error type	Total relative error (cm)	Total absolute error (cm)
Horizontal	5.0	8.0
Vertical	5.0	5.0

Report in preparation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[1]U.S. Geological Survey, Western Earth Surface Processes, Menlo Park, California
[2]U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

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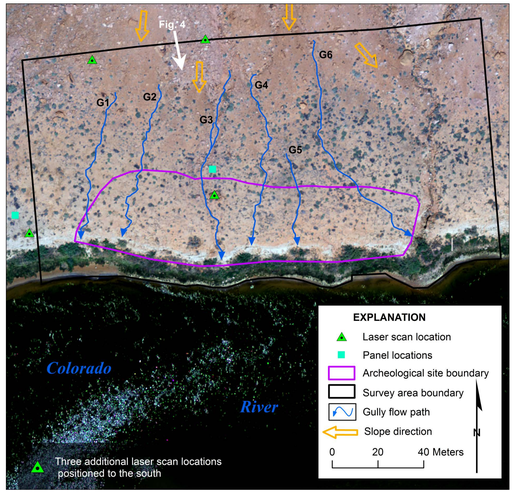
Table 4. Example summary of gully topography determined from lidar datasets at site AZ:C:02:0032. Gullies numbered G1 through G6 are shown in figures (above right)

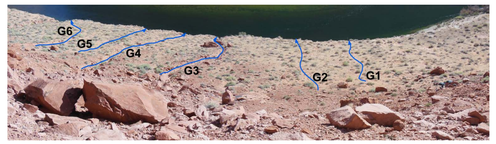
Site and gully ID	General description	Approx. gully incision depth at terrace edge[2] (m)	Approx. maximum width[1] (m)	Approx. maximum depth[1] (m)	Location of gully head
AZ:C:02:0032-G1	diffuse	1.1	n/a	n/a	mid-talus
AZ:C:02:0032-G2	diffuse	5.2	n/a	n/a	mid-talus
AZ:C:02:0032-G3	incised with vertical banks	4.8	1.60	0.60	top of talus
AZ:C:02:0032-G4	diffuse	4.0	n/a	n/a	top of talus
AZ:C:02:0032-G5	incised with sloping banks	3.1	2.00	0.40	alluvial fan
AZ:C:02:0032-G6	diffuse	3.6	n/a	n/a	top of talus

[1] Gully dimensions (with +/- 5 cm accuracy) are measured only within the site boundary. "n/a" indicates gully is not incised or channelized within the site boundary.

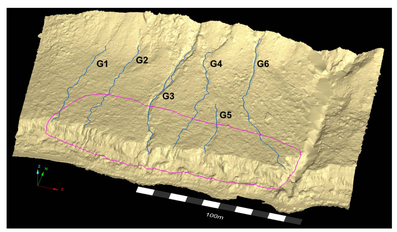
[2] Gully incision at terrace edge (with +/- 10 cm accuracy) is defined as the elevation difference from the terrace surface to the point where each gully drains over a vertical edge greater than 2 m in height.

HIGH RESOLUTION SURFACE MODELING FOR GEOMORPHOLOGICAL CHARACTERIZATION AND CHANGE DETECTION

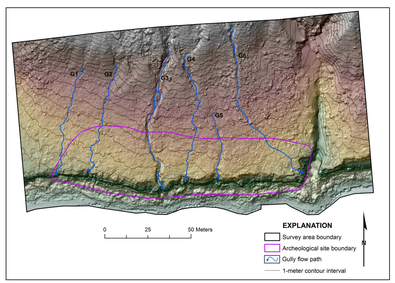




5-CM TRIANGULATED IRREGULAR NETWORK (TIN)



5-CM 2D DIGITAL ELEVATION MODEL (DEM) GRID



FUTURE DATA ANALYSIS INCLUDES:

- CENTIMETER-SCALE CHANGE DETECTION AT FOUR ARCHAEOLOGICAL SITES TO DETERMINE SHORT-TERM EROSION RATES
- DETECTION OF GULLIES <1-METER IN WIDTH FOR 8.5 RIVER MILES USING 10 CM POINT SPACING AIRBORNE LIDAR TO IDENTIFY DEGREE OF EROSION IN GLEN CANYON
- LANDSCAPE-SCALE GEOMORPHOLOGICAL MODELING AT FOUR ARCHAEOLOGICAL SITES TO DETERMINE LONG-TERM EFFECTS OF CLIMATE VERSUS DAM OPERATIONS ON FLUVIAL TERRACE EROSION

(Preliminary Data from Collins, Corbett, Sankey and Fairley, Do Not Cite)