BUREAU OF RECLAMATION

Flaming Gorge Reservoir
2022 Boat Ramps Survey

Colorado River Storage Project, Wyoming & Utah
Upper Colorado Basin Region

U.S. Department of the Interior
Bureau of Reclamation
Provo Area Office
Operations and Emergency Management Group
Provo, Utah

June 2022

Mission Statements

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Acknowledgements

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Cover: Flaming Gorge Reservoir, Mustang Ridge Boat Launch Area

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Flaming Gorge Reservoir 2022 Boat Ramps Survey

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1. Introduction

Flaming Gorge Reservoir spans approximately 91 miles along the Green River in Southwestern Wyoming and northeastern Utah, with the dam being about 32 river miles downstream from the Utah-Wyoming border. The dam and reservoir are operated by Reclamation as part of the Colorado River Storage Project.

Since 1999, the Colorado River Basin has experienced an extended drought. Lake Powell and Lake Mead storages have declined to record-low levels, and Lake Powell is at risk of declining below the minimum power pool elevation of 3490 feet. To help address declining Lake Powell levels, Reclamation has released additional water from Flaming Gorge, and is considering further releases. Reclamation desired to take measures to identify and quantify potential impacts that may result from declining water levels at Flaming Gorge. These measures included verifying the bottom elevations of 10 boat ramps and identifying bathymetric conditions below 3 marinas.

The Provo Area Office was asked to conduct the bathymetric survey of the facilities. The survey was performed from June 27, 2022, to June 29, 2022.

2. Reservoir Survey Methods and Extent

2.1. Survey Methods

During the survey, end-of-day reservoir water surface elevations as reported at usbr.gov varied from 6014.95 (6/26/2022) to 6015.15 (6/29/2022) feet Reclamation Project Vertical Datum (RPVD). The survey was conducted from a boat using a multibeam depth sounder to continuously measure water depths and a LiDAR unit to scan nearby shorelines, unsubmerged boat ramps, and floating infrastructure. The horizontal position of the moving vessel was continually tracked using real-time kinematic (RTK) GPS and later corrected using post-processing kinematic (PPK) GPS.

The survey of each boat ramp or marina was conducted along a series of survey lines determined in the field. A map of the surveyed areas is presented in Figure 1. Boat ramp survey lines were generally long, sweeping lines spaced closely enough to provide 50% overlapping coverage of adjacent lines from the multibeam depth sounder, or close enough that linear interpolation of data between survey lines would be adequate. Marina survey lines were generally tightly curving and spaced as docks, anchor cables, and other boats or features allowed; generally, full coverage was obtained.

The HYPACK hydrographic survey software was used to collect, combine, and export bathymetry and LiDAR data. A raster mesh was created in HYPACK and used when exporting the data for further processing in ArcGIS. For each raster mesh cell, the reservoir bottom elevation was assigned equal to the average elevation of all available data points within that raster cell. Raster meshes were composed of 1-ft square grid cells.

2.2. Survey Control, Datum, and Monuments

All bathymetry and GPS control measurements were collected in North American Datum 1983 (NAD83), State Plane Utah North-FIPS 4301, US survey feet and North American Vertical Datum 1988 (NAVD88, Geoid 18), US survey feet elevations. During processing, all bathymetry and GPS measurements were converted to Reclamation Project Vertical Datum (RPVD) for Flaming Gorge. A 2019 sedimentation survey determined the RPVD to be 4.61 feet lower than NAVD88 (Geoid 18). Results were inconclusive in confirming that the RPVD was equal to National Geodetic Vertical Datum 1929 (NGVD29). Therefore, 4.61 vertical feet were subtracted from all bathymetry and GPS points to convert them from NAVD88 to RPVD (Reclamation 2021).

To gather RTK quality GPS data, a GNSS base receiver (base station) was set up over a temporary point located near the boat ramps. The base station collected at least 2 hours of observations that were later submitted to OPUS to provide a survey-grade solution. Figure 1 shows base station locations utilized throughout Flaming Gorge Reservoir. Although only six locations are illustrated here, 9 of the 10 boat ramps had RTK-GPS corrections during the survey. The base station location at Brinegar Crossing was also used for Upper Marsh Creek, the base station location at Lucerne was also used for Antelope Flat, and the base station location at Mustang Ridge was also used for Cedar Springs. Due to technical difficulties with base station equipment, the GPS base station was not used at Buckboard boat ramp and marina.

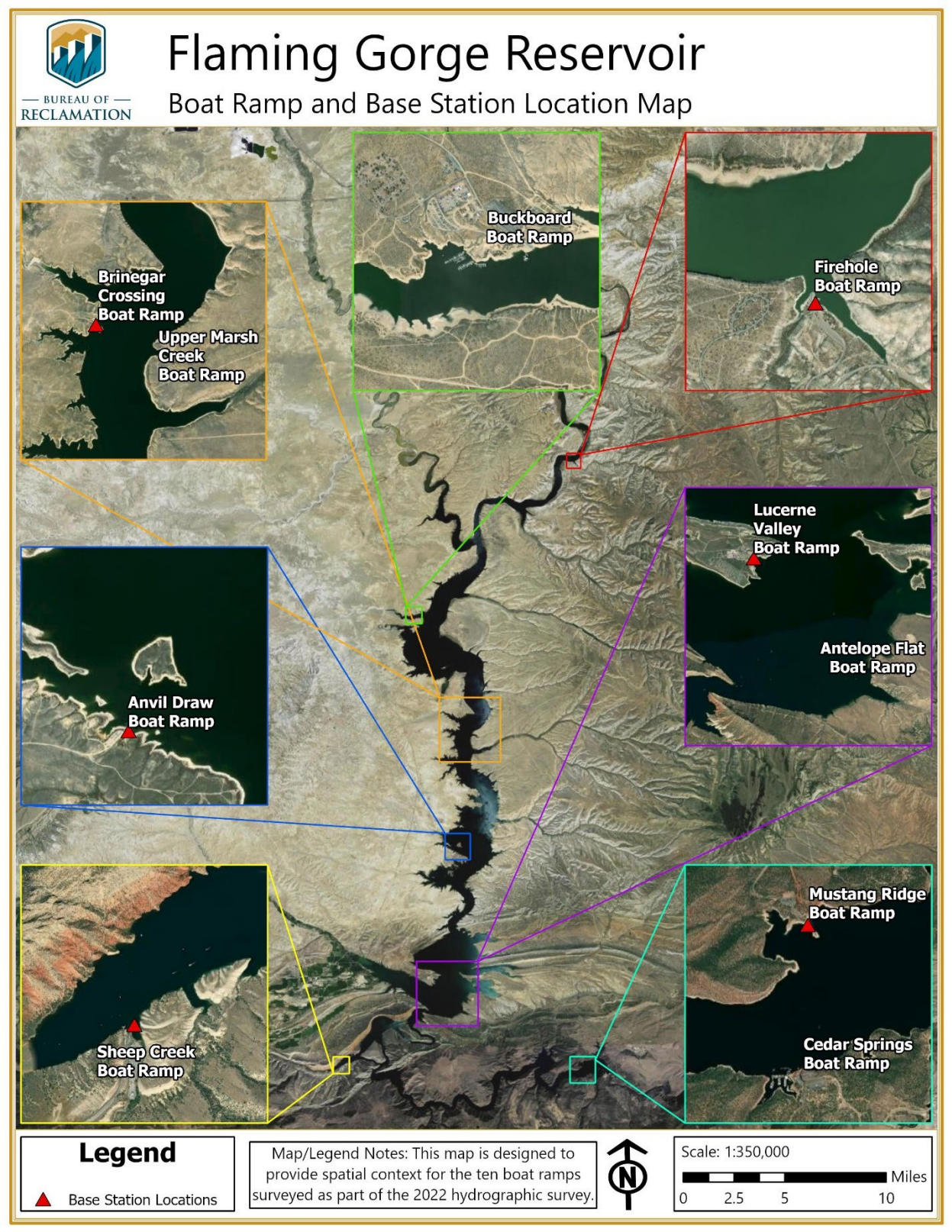

Figure 1. Map of bathymetric survey extents and data coverage

3. Reservoir Boat Ramps and Marinas

There are many variables that affect the quality and accuracy of hydrographic surveys—GPS from boat antennas, GPS from the base station, the type of motion reference unit, sound speed profiler, human judgement and error, and underwater vegetation, to name a few. Many steps have been taken to reduce the amount of error each variable has on the echosounder's depth measurement; however, it is impossible to remove every degree of uncertainty. Limitations and assumptions are part of the nature of bathymetric surveys. Below is a list of those included in this survey.

3.1. Limitations and Assumptions

Due to the number of variables affecting depth measurements, boat ramp bottoms were rounded to the nearest half-foot.

Many boat ramp bottoms were covered in sediment and other debris, making it difficult to precisely determine the ramp end. A range of possible ramp ends were provided along with a best estimate for a precise end at each location.

When estimating boat ramp bottom elevations, a conservative approach was taken, particularly for ramps whose ends were more difficult to distinguish. For instance, if the end of a boat ramp was covered in sediment and appeared to end between elevations 5932 and 5934 feet, the higher value—in this case, elevation 5934—was selected.

Echosounders can be used to penetrate some sediment and other debris to better detect the "true" ground. However, echosounders performing in this capacity operate at a low frequency—about 80 to 200 Hz. Lower frequencies reduce data resolution by increasing beam footprint size. The echosounder used in this survey operated at 400 Hz throughout the survey resulting in higher resolution, but no penetration of surface deposits.

Elevation differences from datum transformations tend to vary spatially with longitudinal or latitudinal movement. However, the original survey data was recorded in a project-specific vertical datum. To transform the 2022 survey data into the project vertical datum, a static elevation shift was applied to the final sonar and LiDAR datasets.

Several filters are applied during the data editing phase to expedite the time needed to remove data anomalies. Occasionally, actual elevations, whether from the reservoir terrain, a submerged structure, or so on, get removed.

3.2. Boat Ramp Bottom Elevations

The primary objective of this hydrographic survey was to verify bottom elevations of 10 boat ramps at Flaming Gorge Reservoir. After the survey data was collected and processed, boat ramp bottoms were determined by a combination of cross section lines along the boat ramps, cloud windows of the survey data, contour lines, aerial imagery, and photographs taken during the survey. Table 1 and

Figure 2 compare the US Forest Service ramp bottom elevation numbers with the bottom elevations measured from the 2022 survey (Heath 2022).

Additional information for each boat ramp and marina can be found in the appendices. Appendices are laid out similarly to Table 1 meaning they progress from upstream to downstream. Each appendix generally contains a colored bathymetry map, a cross section along the ramp down to the reservoir bed, and HYPACK cloud imagery of the processed sonar data. Some ramps were straight from top to bottom, others curved, and others changed direction sharply. To show these changes, images from Google Earth Pro timeline recorded during low water years were screen captured and included in some of the appendices.

Table 1. Flaming Gorge boat ramp bottom elevations

Boat Ramp	USFS (ft)[1]	2022 Survey[2] (ft)		
		Low	B.E.[3]	High
Firehole	5991	5995	5998.5	6001
Buckboard	5960	5971.5	5974	5979
Brinegar Crossing	5990	5991.5	5992	5998.5
Upper Marsh Creek	5997	5962	5966	5980
Anvil Draw	5995	6011	6011	6011
Lucerne Valley	5960	5915	5967	5968
Antelope Flat	5960	5960	5961	5962
Sheep Creek	5977	5981	5981.5	5983
Cedar Springs	5858	5856	5857	5859
Mustang Ridge	5929	5829.5	5934	5934

[1] Elevations noted in Forest Service documentation

[2] June 2022 surveyed elevations (to nearest half-foot)

[3] B.E. = Best Estimate

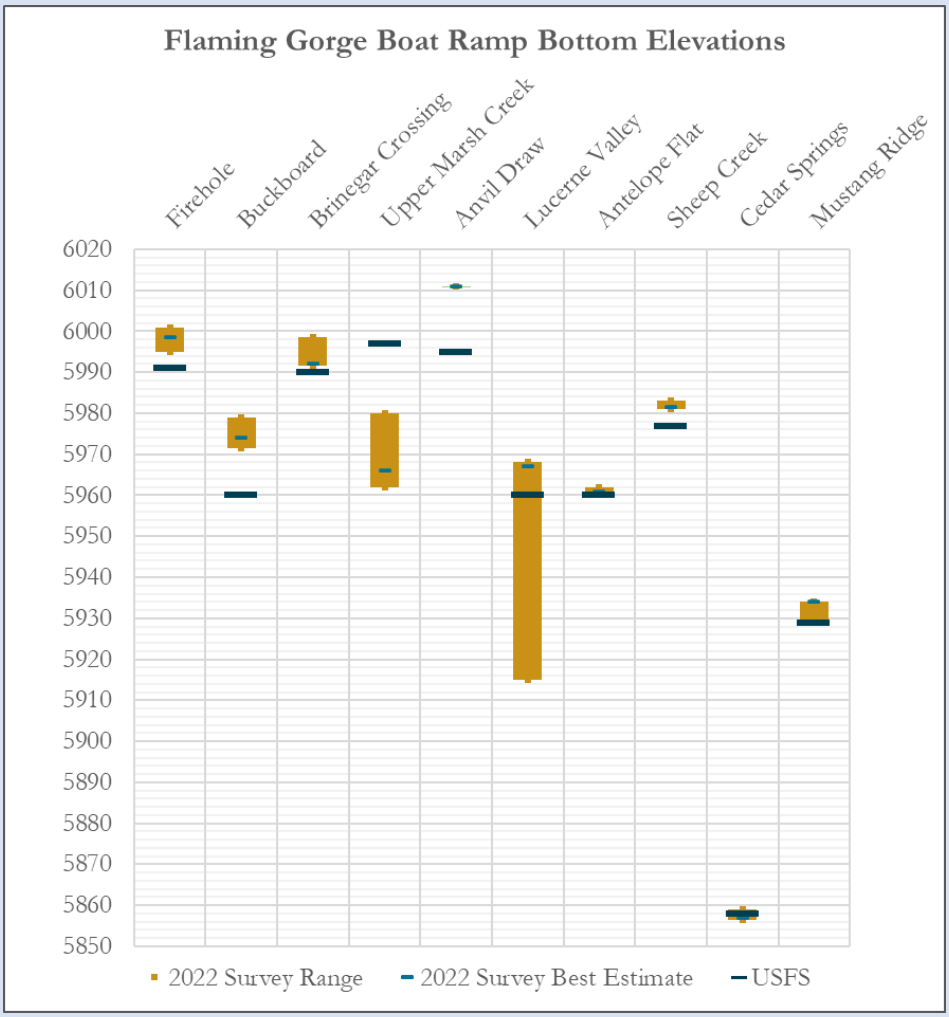

Figure 2. Graph of Flaming Gorge boat ramp bottom elevations

References

Heath, B. 2022. Email Correspondence from Brett Heath, Facility Operations Specialist, Forest Service, Ashley National Forest, Flaming Gorge Ranger District, February 9, 2022.

Reclamation. 2021. *Flaming Gorge 2019 Sedimentation Survey, Technical Report No. ENV-2021-111.* Denver: Bureau of Reclamation, Technical Service Center, Sedimentation and River Hydraulics Group.

Appendix A — Firehole

The Firehole Canyon boat launch area is approximately 30 miles southwest of Rock Springs, Wyoming. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data clearly show the west edge of the boat ramp down to elevation 6001 feet, with the centerline of the ramp continuing at a 10% slope and terminating at approximate elevation 5998.5 feet. Because of sediment buildup, it isn't clear if the ramp ends there or continues lower as the slope transitions to a 1% slope. The 1% slope below the transition elevation of 5995 feet suggests that the ramp does not extend down to elevation 5991 feet as noted in the Forest Service documentation—an elevation 7.5 feet lower than the 2022 survey approximation.

An elevation map (Figure 3) and cross section (Figure 4) of the boat ramp are below. Figure 5 is a screenshot taken from a 2013 Google Earth photo illustrating the boat ramp alignment changing direction. Figure 6 is a cross section taken from HYPACK along the LiDAR and sonar data; red dotted lines have been added to illustrate the change in slope between elevations 5995 and 5998.5 feet. Figure 7 is a screen capture of HYPACK cloud imagery detailing the ramp edges.

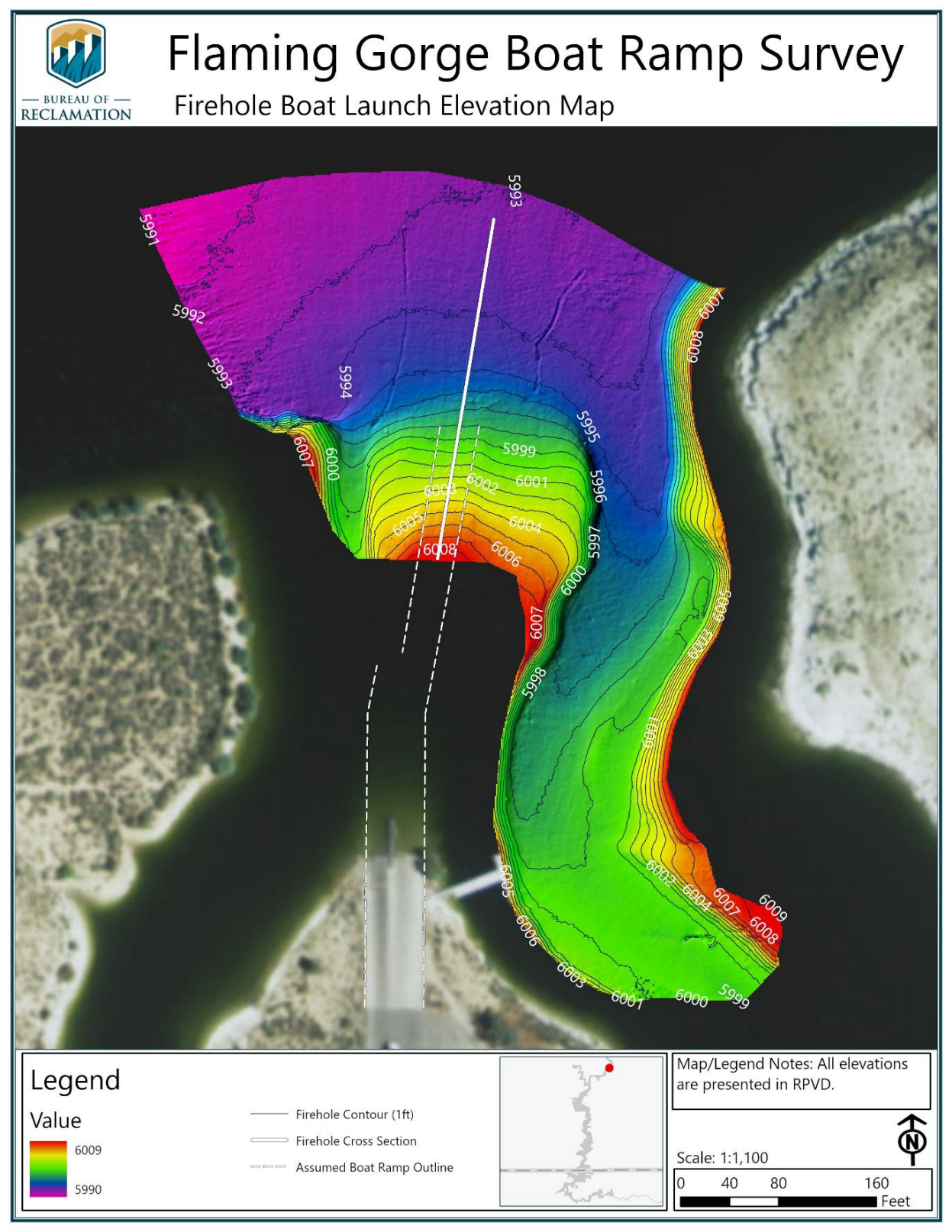

Figure 3. Elevation map of Firehole boat ramp and cross section alignment (Figure 4)

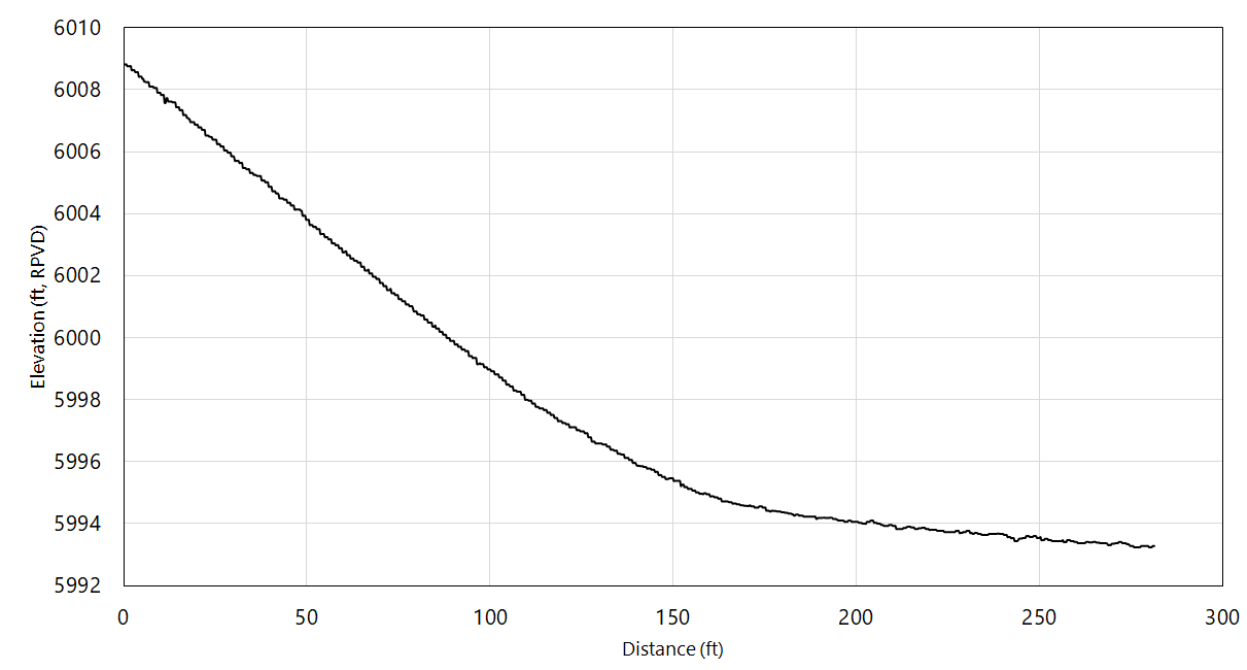

Figure 4. Cross section of Firehole boat ramp centerline

Figure 5. Firehole boat ramp from 2014 Google Earth Pro photo

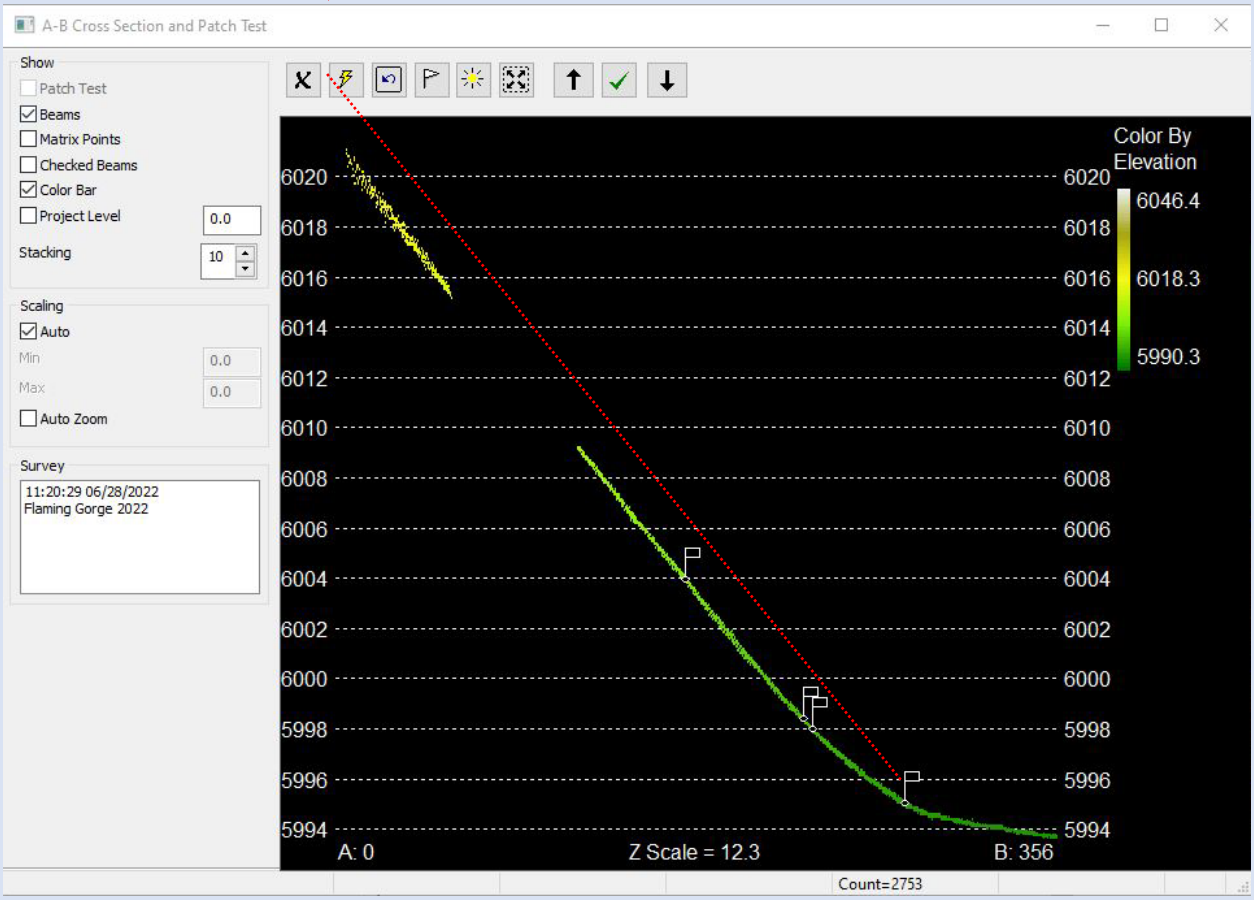

Figure 6. HYPACK cross section along LiDAR and sonar datasets

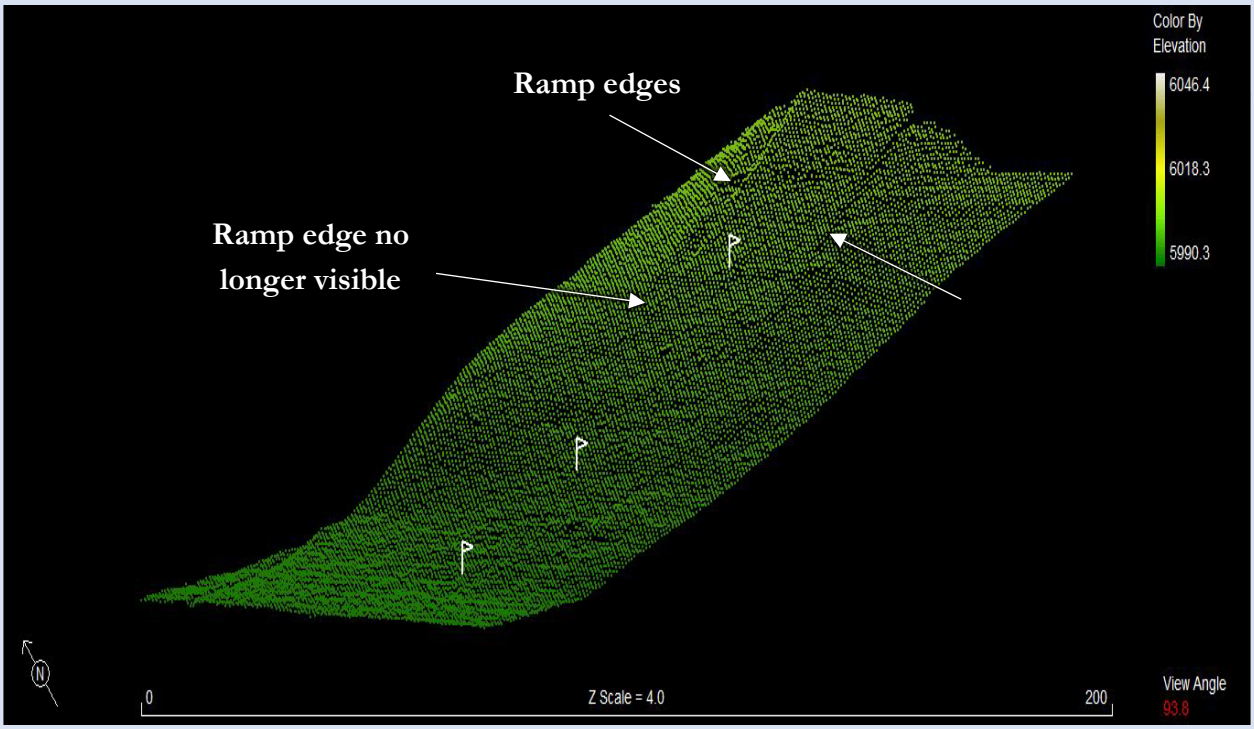

Figure 7. HYPACK cloud imagery of Firehole boat ramp

Appendix B — Buckboard

The Buckboard Boat Launch Area is approximately 27 miles southwest of Green River, Wyoming. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data show the sides of the ramp with the centerline of the ramp continuing at a constant 11% slope and terminating at approximate elevation 5974 feet. Because of sediment buildup, it isn't clear if the ramp ends there or continues lower as the slope transitions to a sub-1% slope. The sub-1% slope below elevation 5971.5 feet suggests that the ramp does not extend down to elevation 5960 feet as noted in the Forest Service documentation—an elevation difference 14 feet lower than the 2022 survey approximation.

An elevation map (Figure 8) and cross section (Figure 9) of the boat ramp are below. Surveys at each boat ramp used a combination of RTK and PPK GPS. However, an equipment failure prevented the use of RTK GPS during the Buckboard survey, so only a PPK solution was used. There were some striations along the sonar swath edges that were not observed in the other boat ramp surveys. Dotted white lines were added near the bottom of the survey data in Figure 8 to represent these anomalies.

Figure 10 is a cross section taken from HYPACK along the LiDAR and sonar data; red dotted lines have been added to illustrate the change in slope between elevations 5971 and 5976 feet. Figure 11 is a screen capture of HYPACK cloud imagery detailing sediment piles on or near the boat ramp and where the slope completely flattens.

The privately-operated Buckboard Marina, which is located immediately west of the boat ramp, and has on-water boat mooring, and other facilities, was entirely surveyed (see Figure 12).

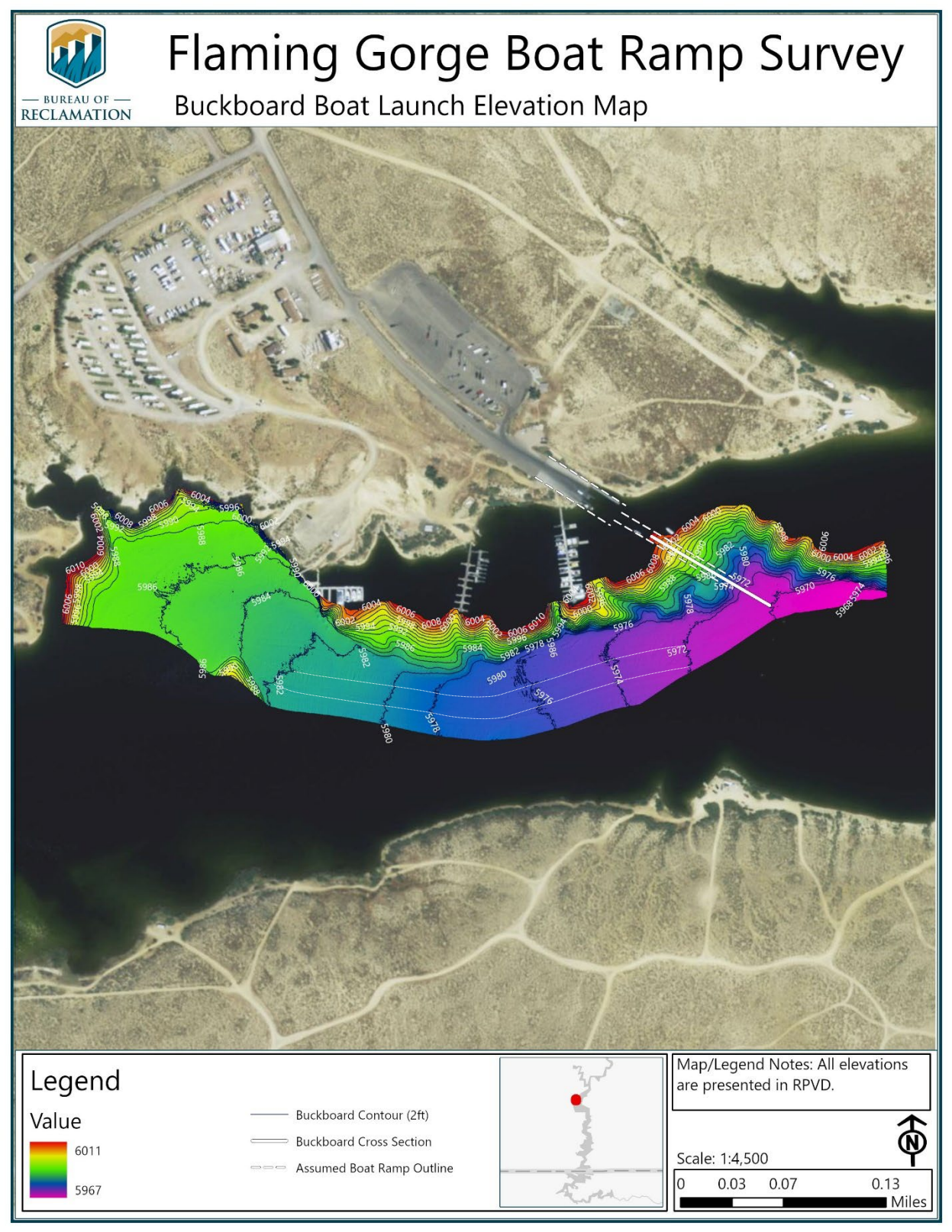

Figure 8. Elevation map of Buckboard boat ramp and cross section alignment (Figure 9)

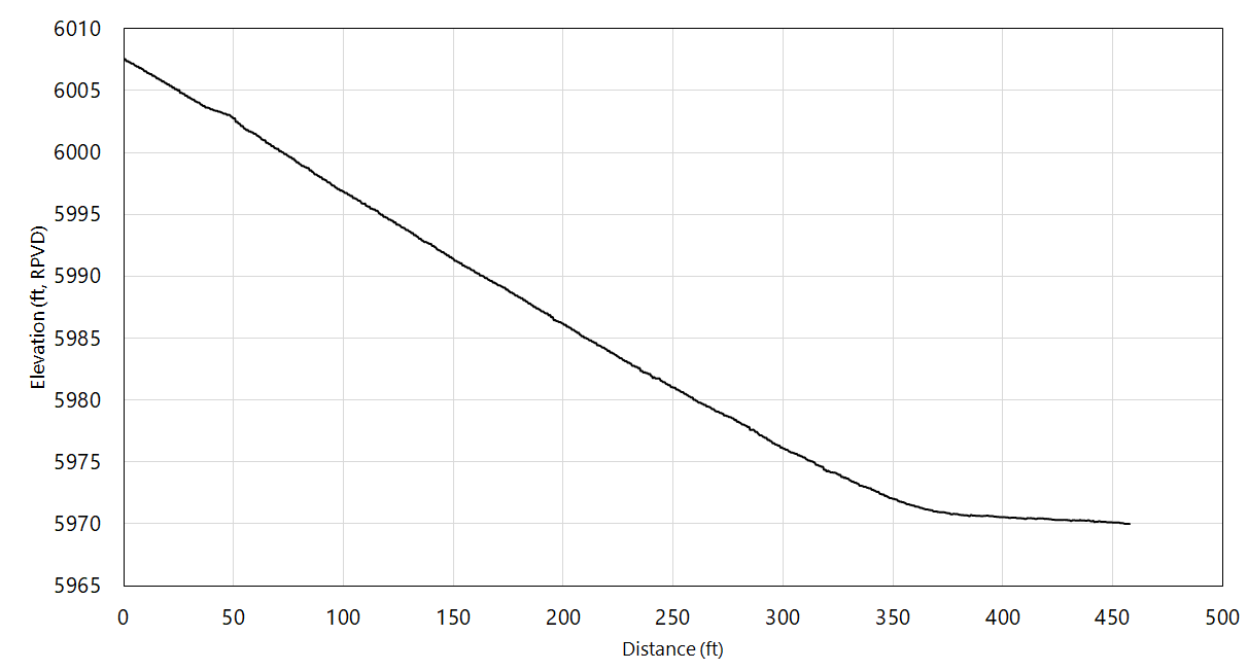

Figure 9. Cross section of Buckboard boat ramp centerline

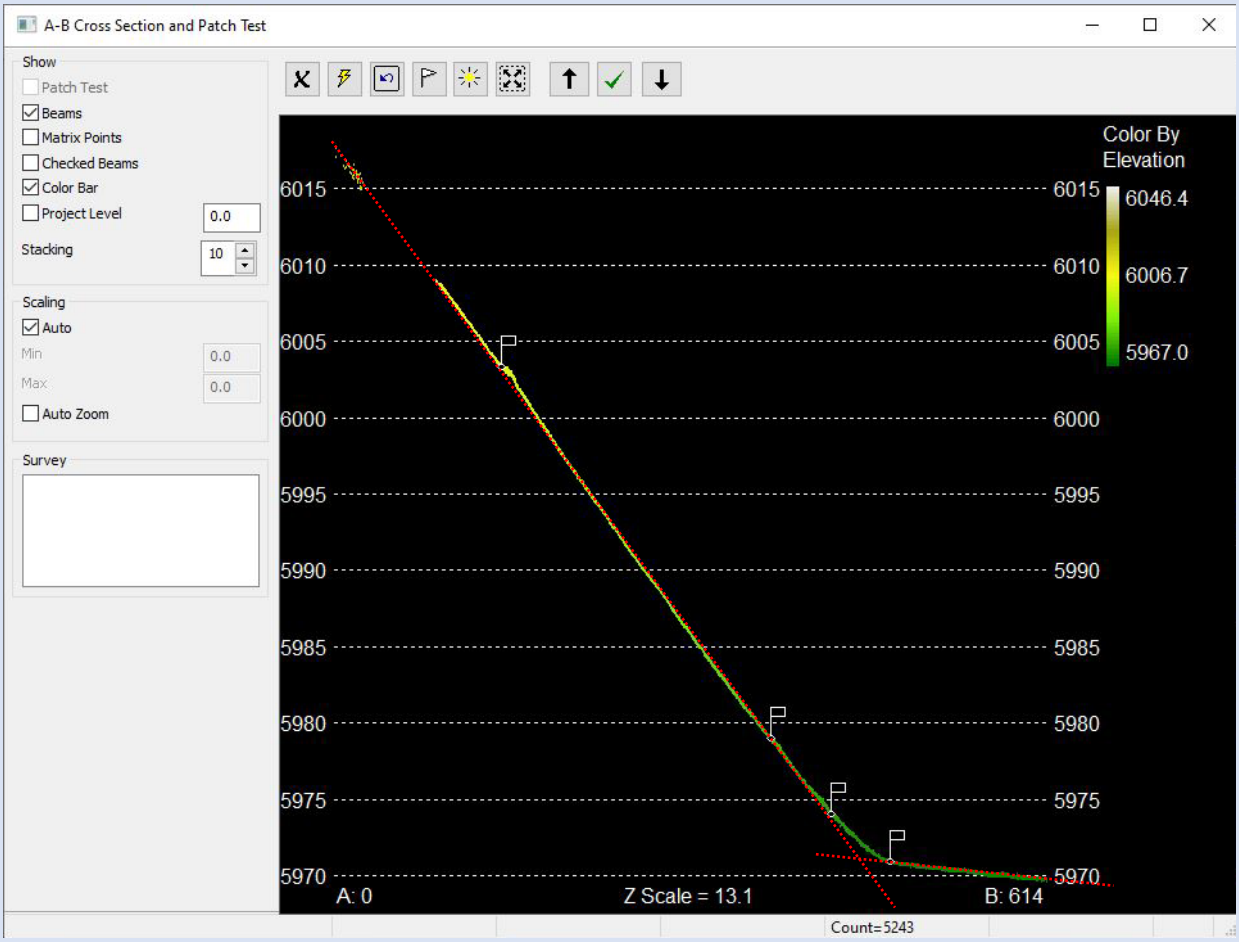

Figure 10. HYPACK cross section along LiDAR and sonar datasets

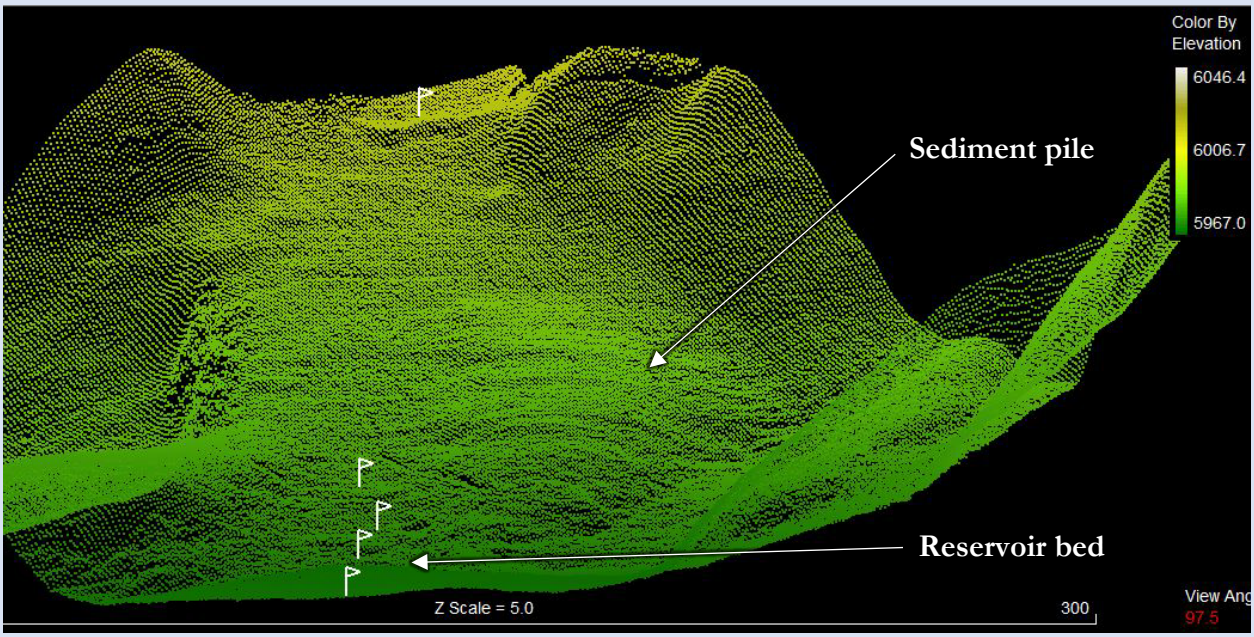

Figure 11. HYPACK cloud imagery looking up the Buckboard boat ramp

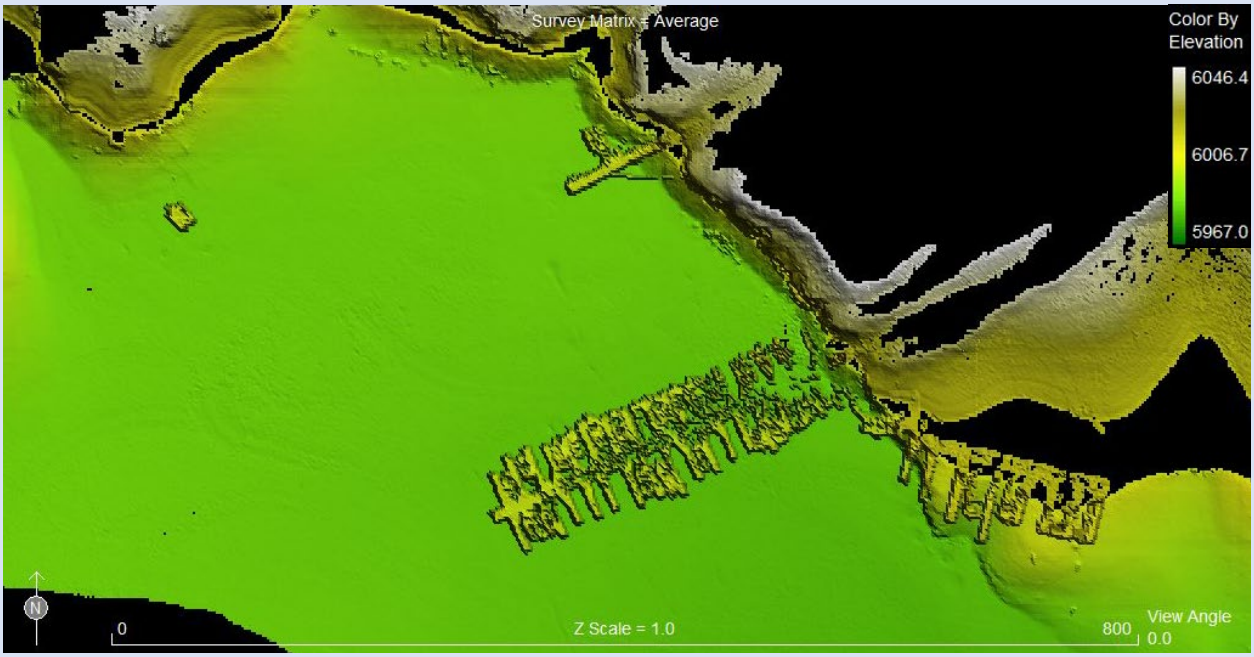

Figure 12. Map of Buckboard Marina boat mooring area

Appendix C — Brinegar Crossing

The Brinegar Crossing Boat Launch Area is approximately 35 miles south of Green River, Wyoming. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data show the centerline of the boat ramp continuing at a constant 10% slope and terminating at approximate elevation 5992 feet where the slope abruptly flattens to 4%. The 4% slope below the transition elevation of 5992 feet suggests that the ramp does not extend down to elevation 5990 feet as noted in the Forest Service documentation—an elevation 2 feet lower than the 2022 survey approximation.

An elevation map (Figure 13) and cross section (Figure 14) of the boat ramp are below. Figure 15 is a screenshot taken from a 2013 Google Earth photo illustrating the boat ramp alignment changing direction. Figure 16 is a cross section taken from HYPACK along the LiDAR and sonar data; red dotted lines have been added to illustrate the change in slope around elevation 5992 feet. Figure 17 is a screen capture of HYPACK cloud imagery looking along the reservoir bed and into the boat ramp; a ramp slope to bed slope white dotted line was added to illustrate the slope flattening. Figure 18 is another screen capture of HYPACK cloud imagery looking at the transition from boat ramp to reservoir bed from a side view.

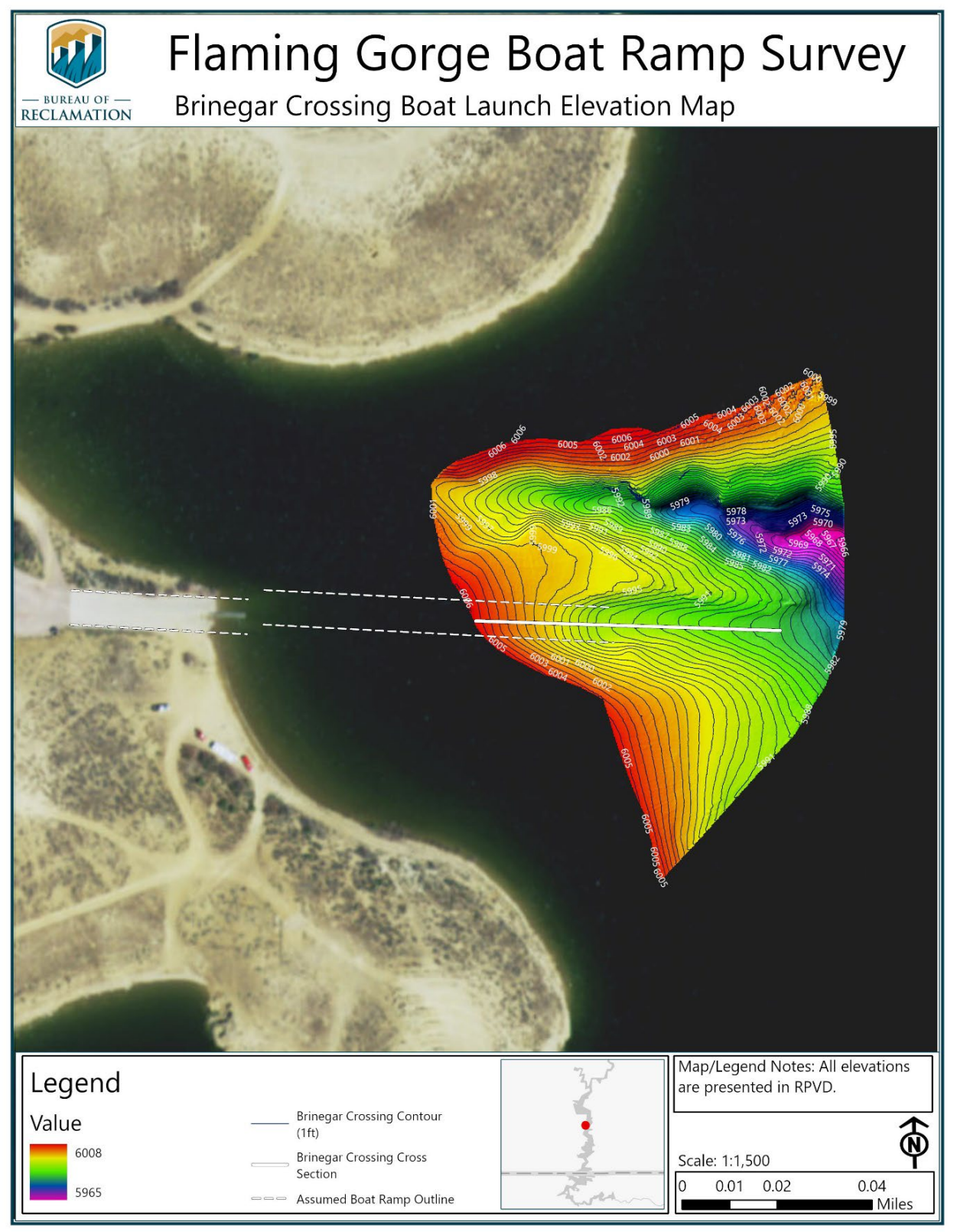

Figure 13. Elevation map of Brinegar Crossing boat ramp and cross section alignment (Figure 14)

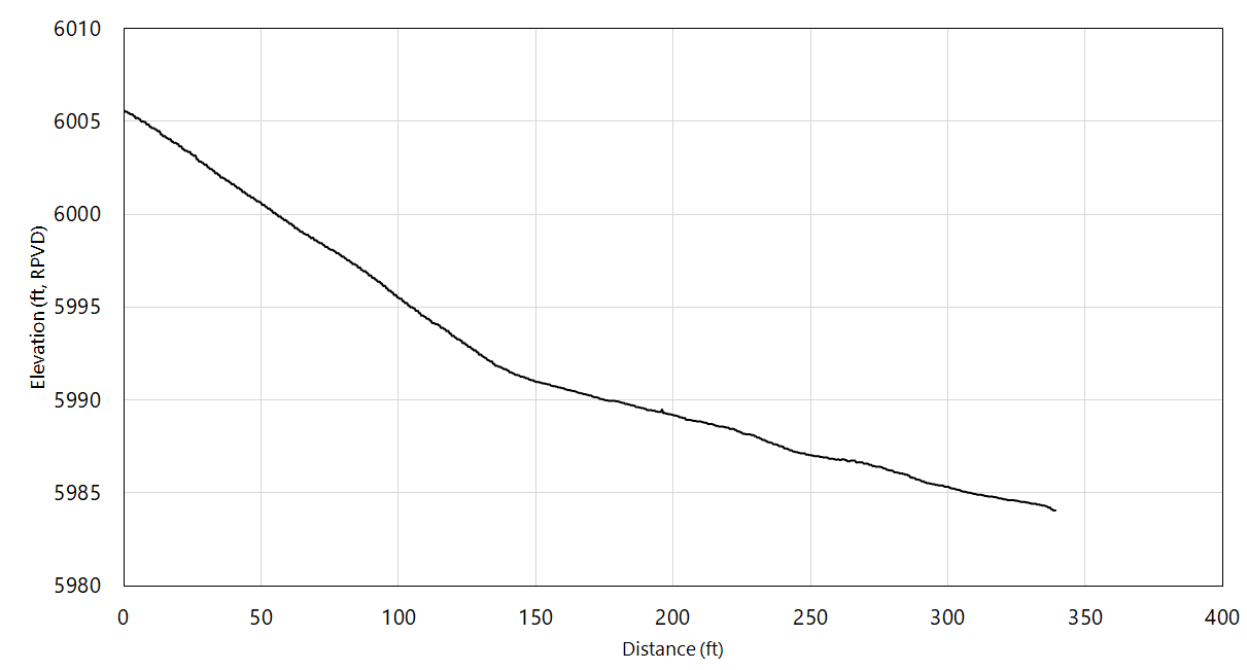

Figure 14. Cross section of Brinegar Crossing boat ramp centerline

Figure 15. Brinegar Crossing from 2013 Google Earth photo

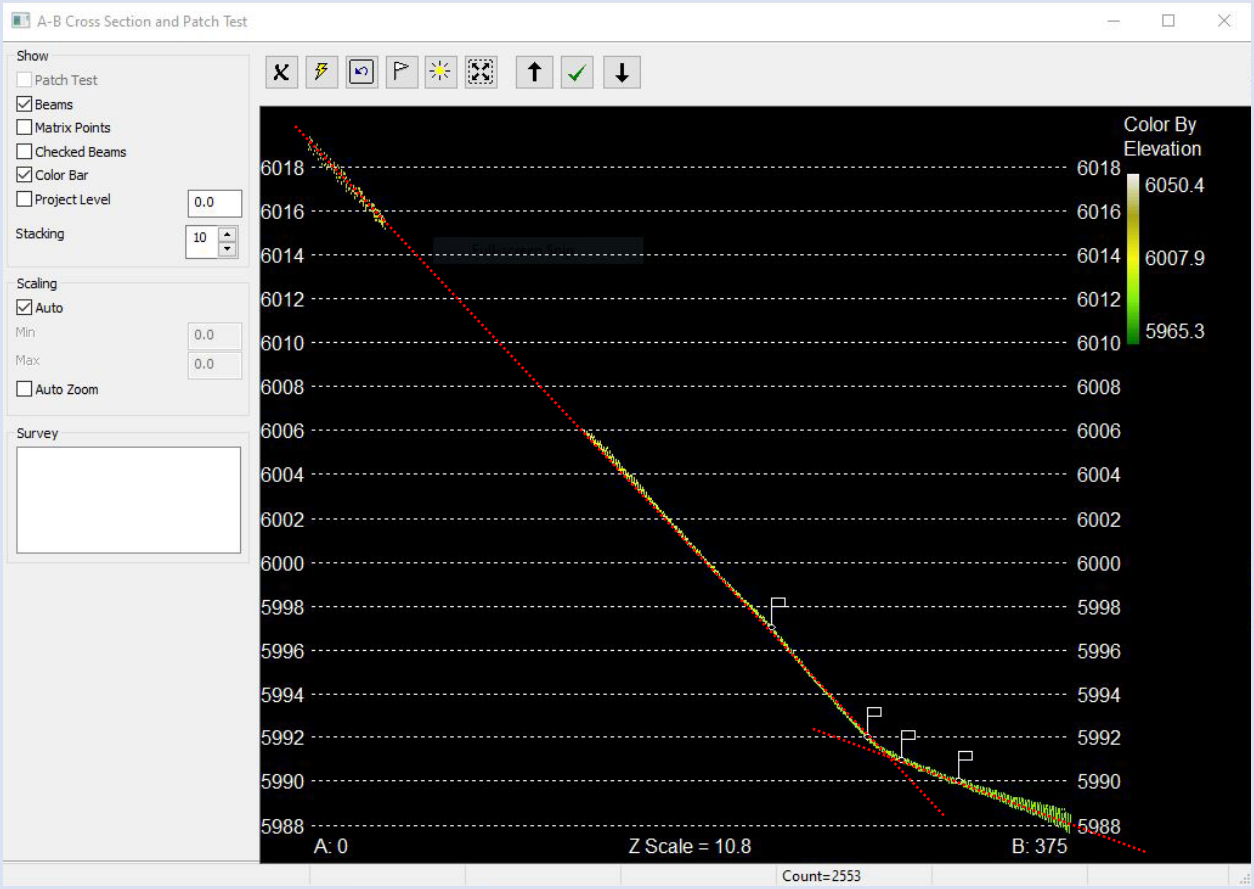

Figure 16. HYPACK cross section along LiDAR and sonar datasets

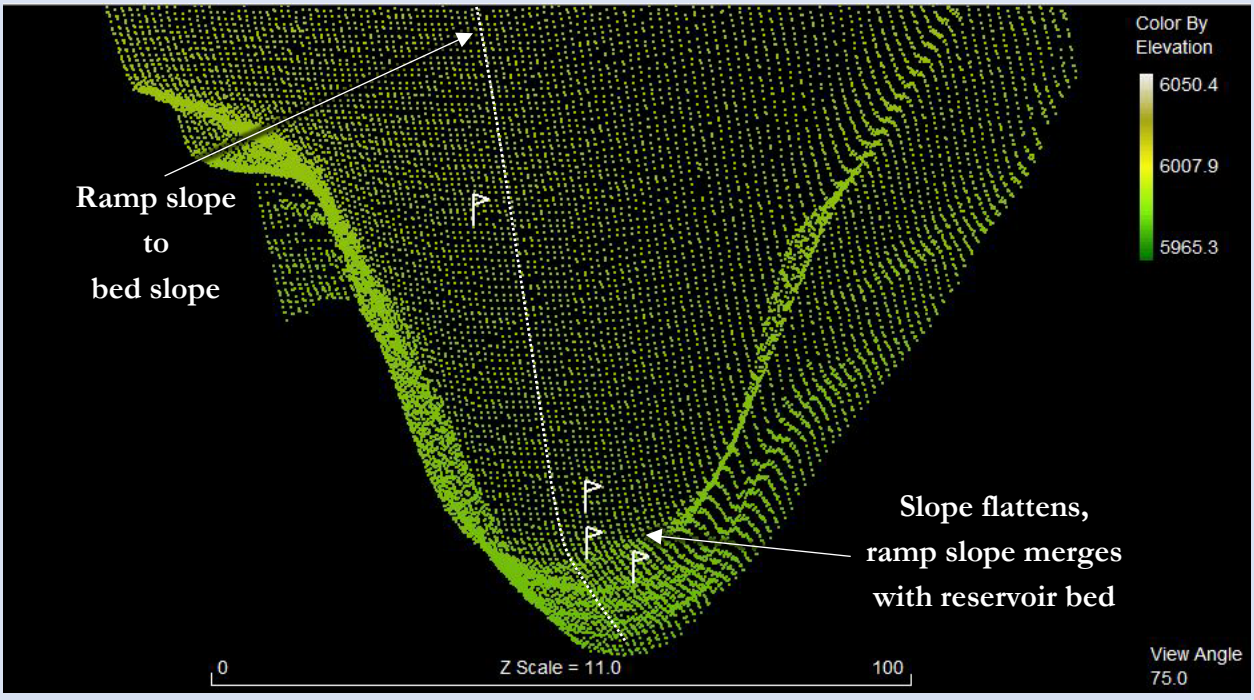

Figure 17. HYPACK cloud imagery looking along the reservoir bed and up the boat ramp

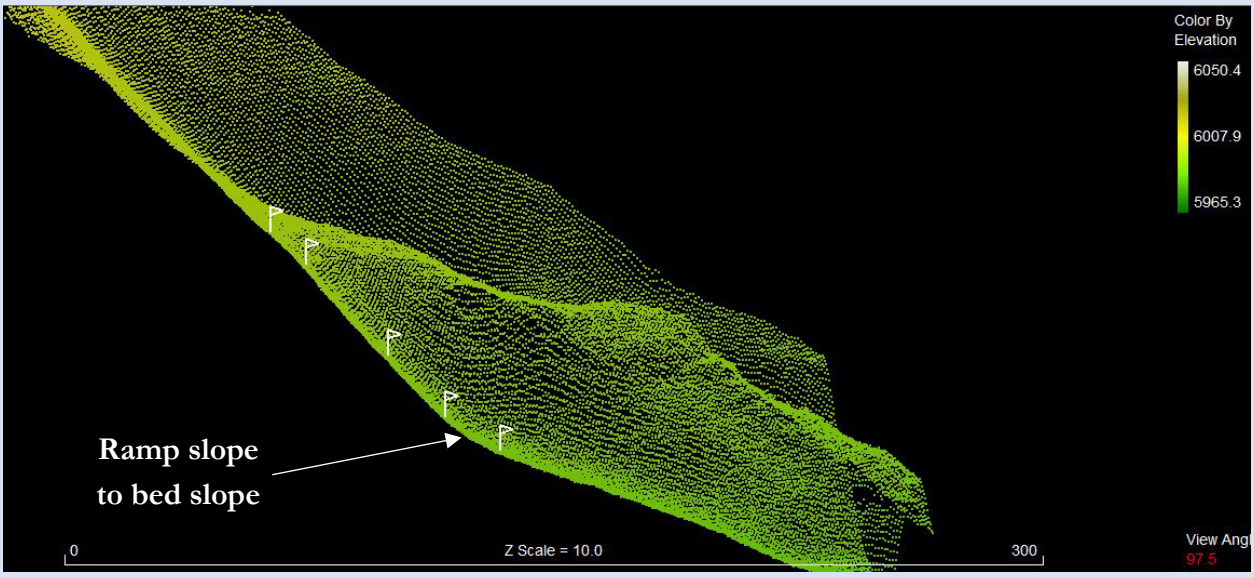

Figure 18. HYPACK cloud imagery looking into Brinegar Crossing boat ramp from a side view

Appendix D – Upper Marsh Creek

The Upper Marsh Creek Boat Launch Area is approximately 30 miles northwest of Dutch John, Utah. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data clearly show the north edge of the boat ramp down to elevation 5980 feet, with the centerline of the ramp continuing at a constant 12% slope and terminating at approximate elevation 5966 feet. The slope varies somewhat but continues at roughly 12% down to elevation 5962 feet, briefly flattens, then abruptly steepens to a 30%+ slope. The constant 12% slope to elevation 5966 feet suggests that the ramp extends far beyond elevation 5997 feet as noted in the Forest Service documentation—an elevation 31 feet higher than the 2022 survey approximation.

An elevation map (Figure 19) and cross section (Figure 20) of the boat ramp are below. Figure 21 is a cross section taken from HYPACK along the LiDAR and sonar data; a red dotted line has been added to illustrate the change in slope from the LiDAR to sonar data, and the abrupt slope change near elevation 5960 feet. Figure 22 is a screen capture of HYPACK cloud imagery looking up the boat ramp. Figure 23 is a photo taken during the survey showing sediments and rocks strewn across the above-water portion of the ramp, similar to what is depicted underwater in Figure 22.

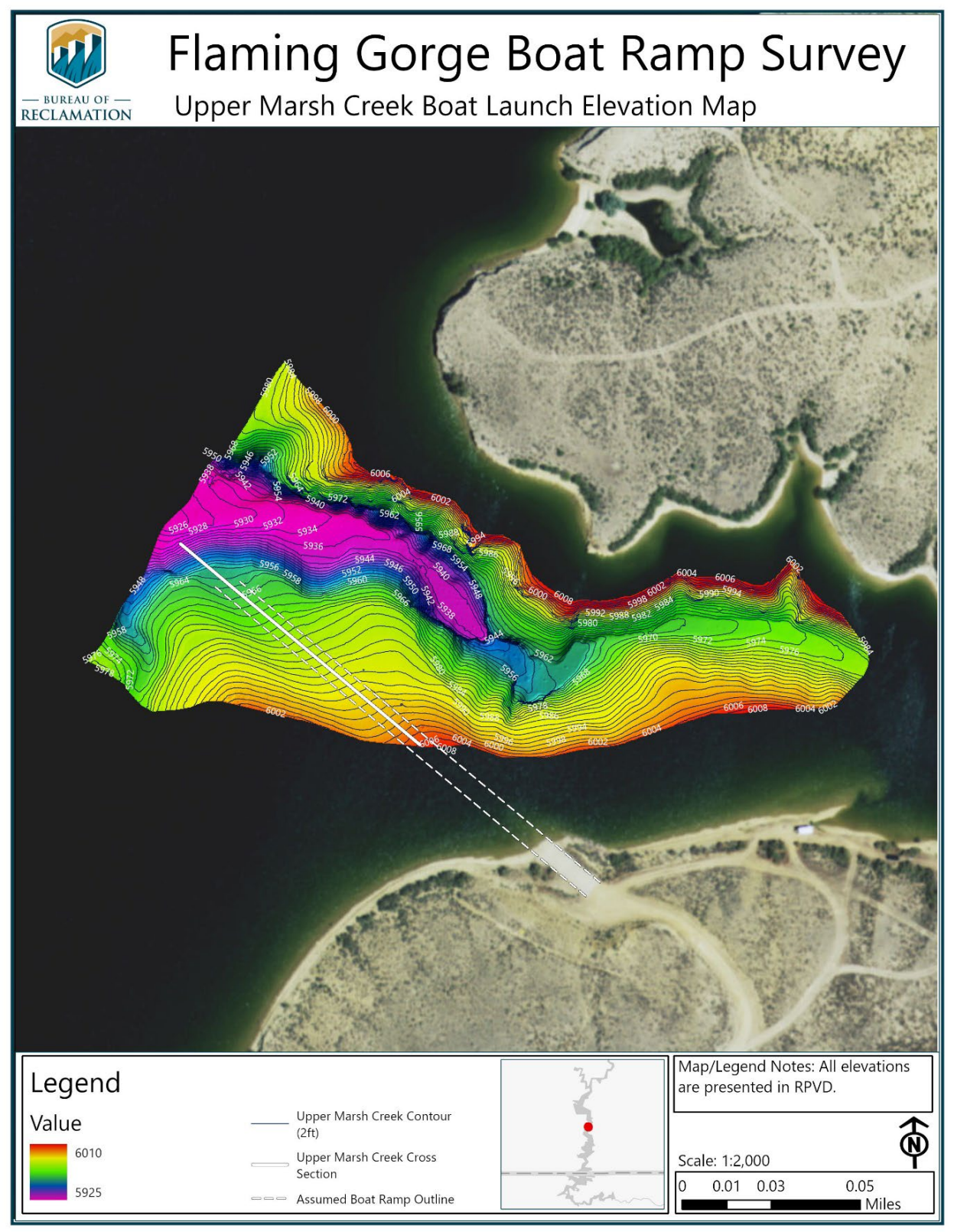

Figure 19. Elevation map of Upper Marsh Creek boat ramp and cross section alignment (Figure 20)

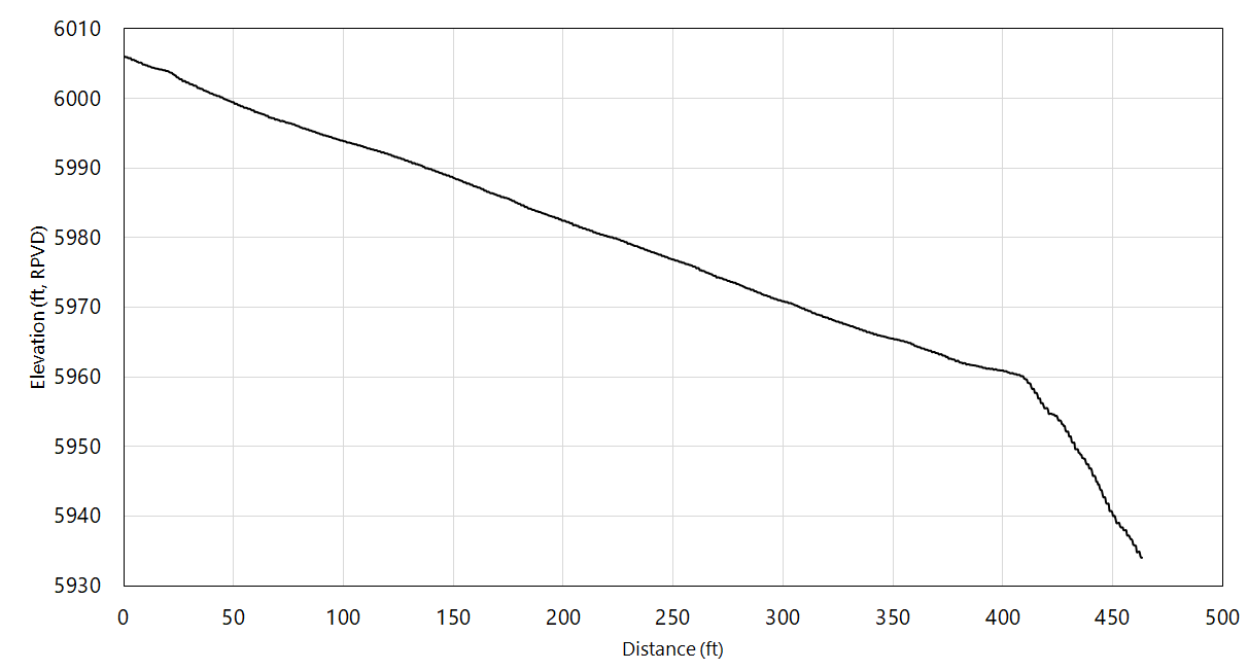

Figure 20. Cross section of Upper Marsh Creek centerline

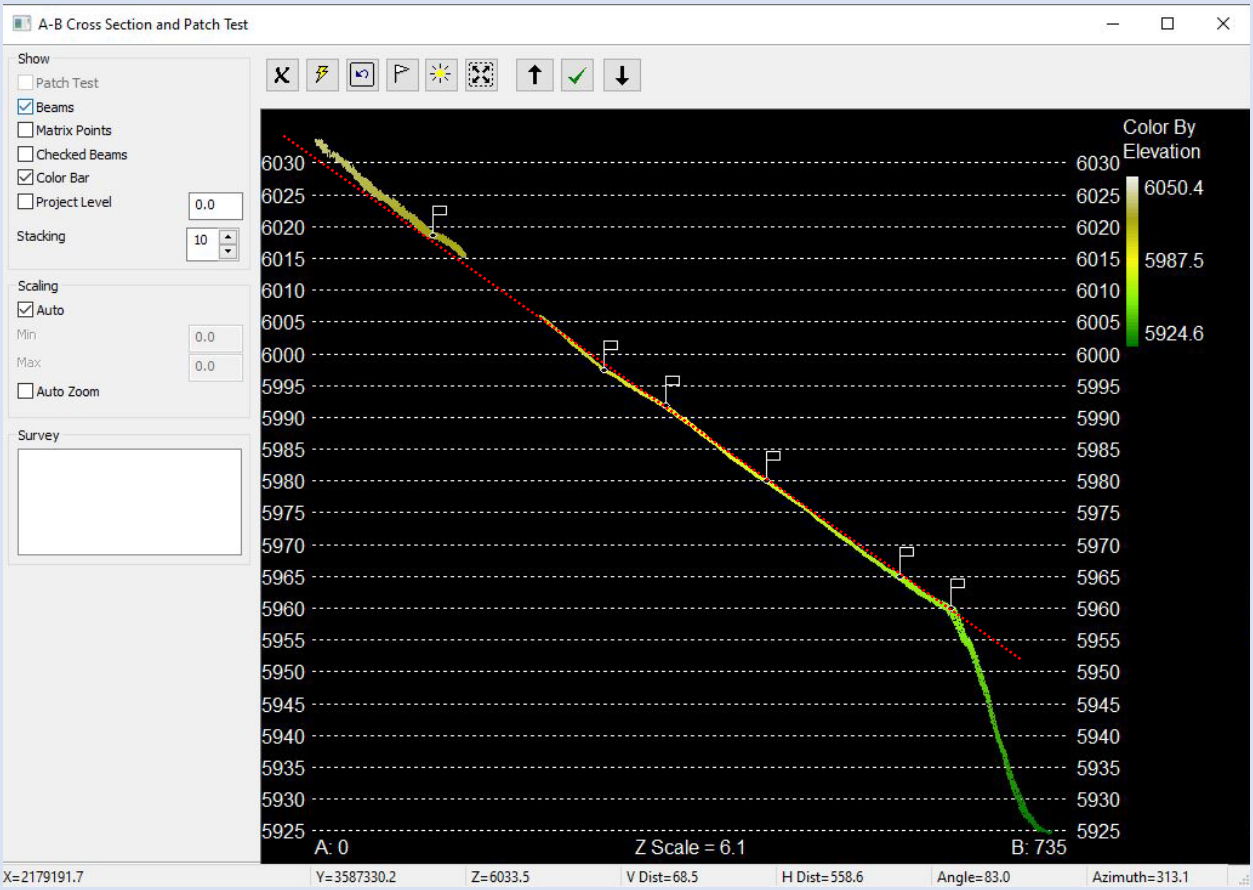

Figure 21. HYPACK cross section along LiDAR and sonar datasets

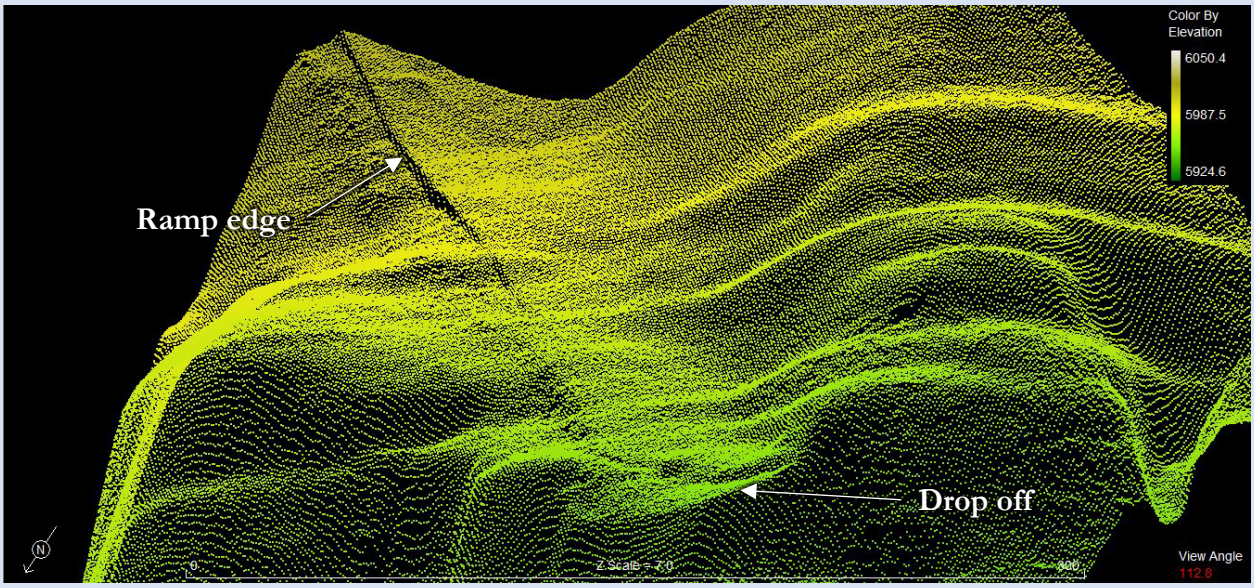

Figure 22. HYPACK cloud imagery looking up Upper Marsh Creek boat ramp

Figure 23. 2022 survey photograph showing sediments and rocks across the ramp face

Appendix E – Anvil Draw

The Anvil Draw Boat Launch Area is approximately 11 miles northeast of Manilla, Utah. The 2022 survey fully covered the submerged area near the boat ramp, but not the ramp itself.

The boat ramp could not be safely surveyed with the boat-mounted sonar because the ramp end was in too shallow water. Therefore, the Reclamation surveyor used a rod-mounted GPS rover to physically measure the end of the ramp which was visible from the launch pier. The precise ramp end elevation was at 6011 feet. The Forest Service documentation estimates the elevation at 5995 feet—an elevation 16 feet lower than the 2022 survey.

An elevation map (Figure 24) and cross section (Figure 25) of the boat ramp are below. Figure 26 is a cross section taken from HYPACK along the LiDAR and sonar data. Figure 27 is a photograph taken from the end of the launch pier showing both the ramp edge and ramp end. Figure 28 is a photograph of Derek McGovern (PRO-428) surveying the ramp bottom from the launch pier.

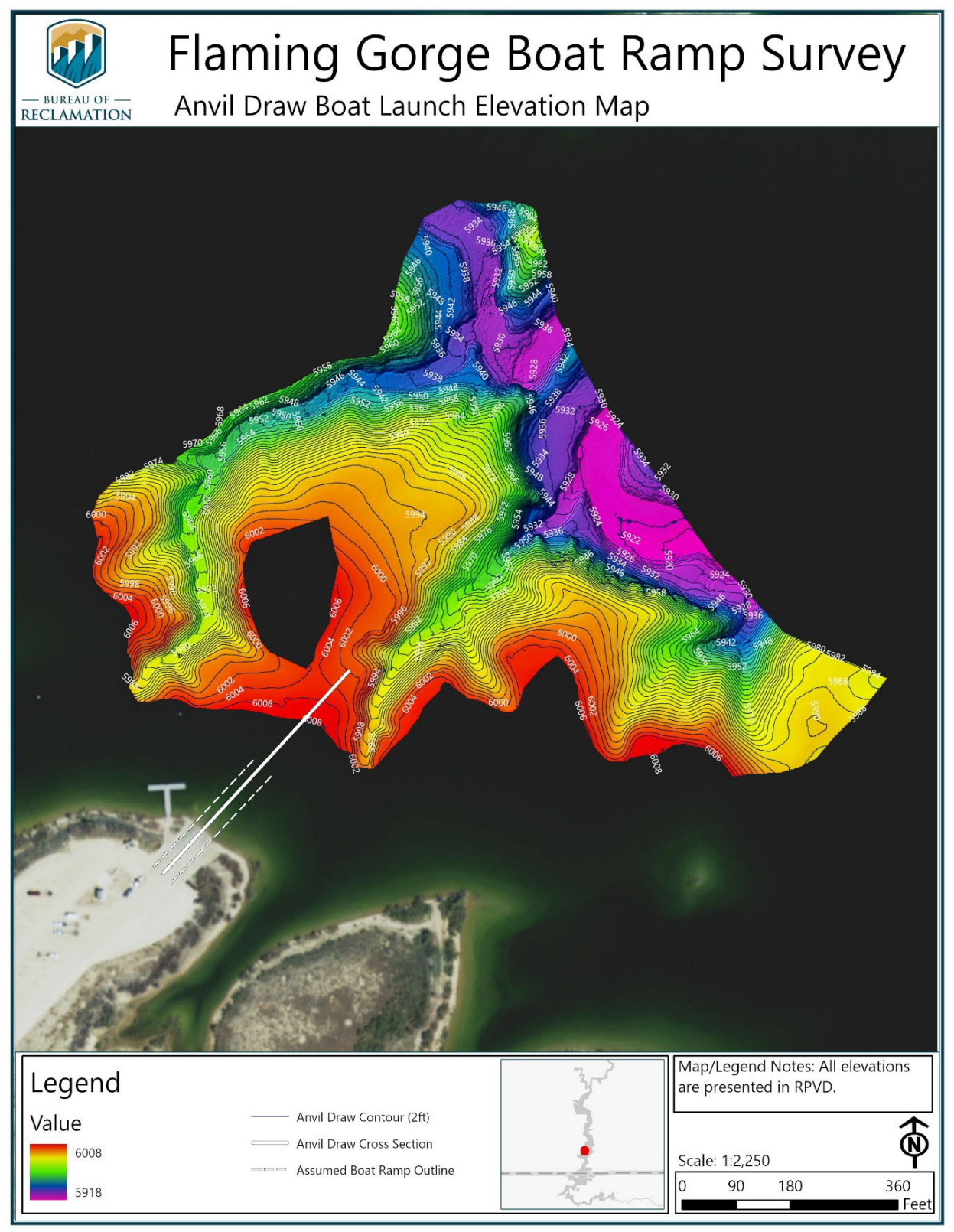

Figure 24. Elevation map of Anvil Draw boat ramp and cross section alignment (Figure 25)

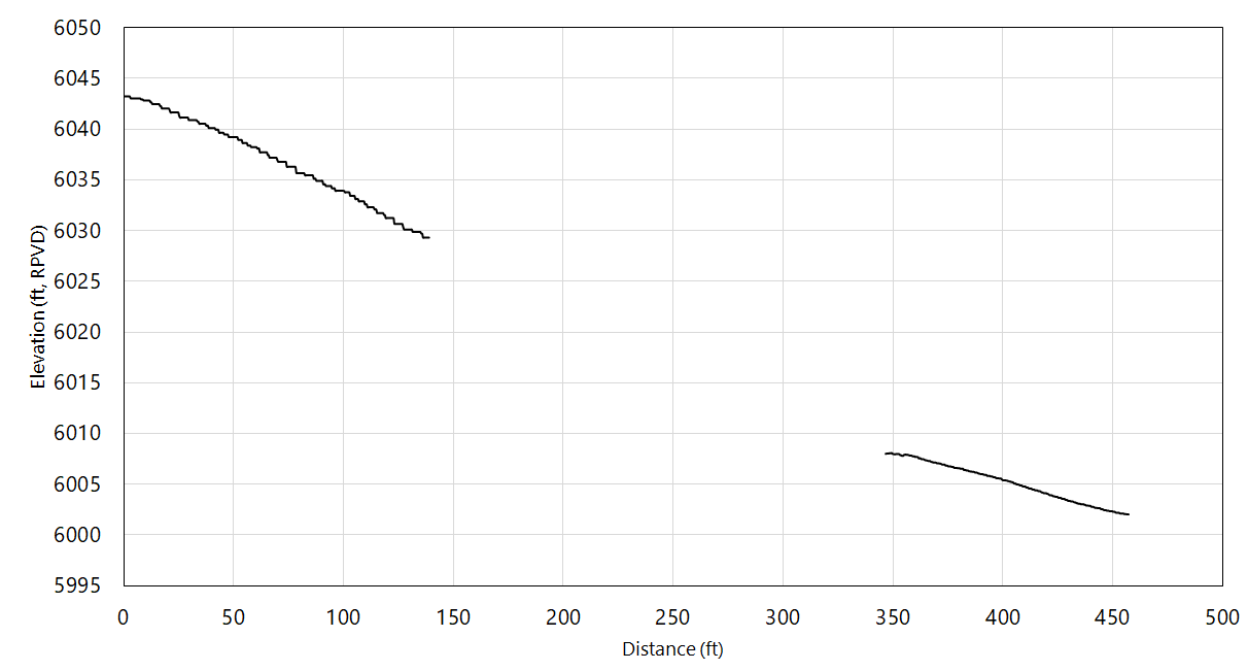

Figure 25. Cross section of Anvil Draw boat ramp centerline

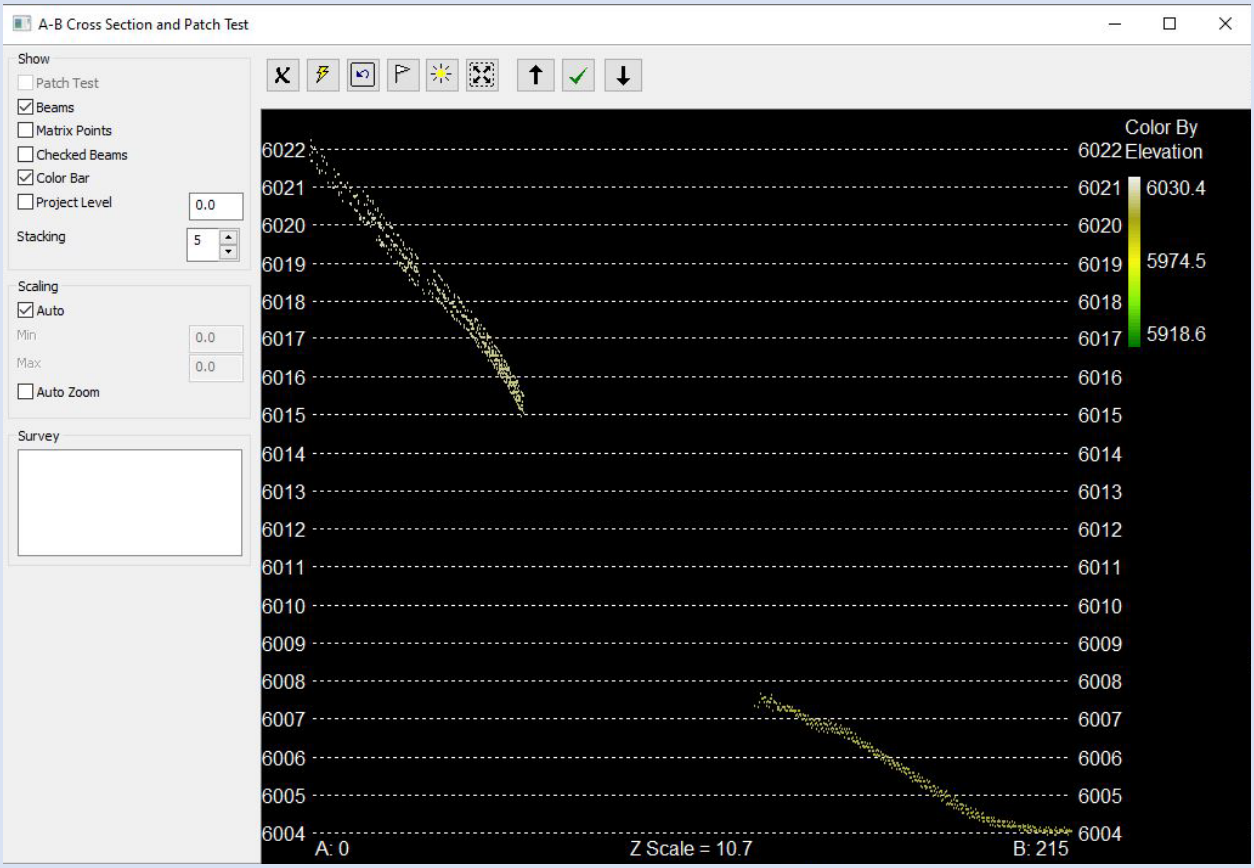

Figure 26. HYPACK cross section along LiDAR and sonar datasets (ramp end not shown)

Figure 27. Photograph of Anvil Draw boat ramp from the launch pier

Figure 28. Derek McGovern (surveyor) recording boat ramp end

Appendix F — Lucerne Valley

The Lucerne Valley Boat Launch Area is approximately 8 miles east of Manilla, Utah on the Utah-Wyoming border. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data show the alignment of the ramp curving to the south and passing below the two northernmost mooring slip sets at the marina, then curving east below the third set of mooring slips. The ramp slope continues at a fairly constant 12% slope to elevation 5915 feet. However, the ramp narrows significantly near elevation 5967 feet indicating the approximate end of the ramp and a possible transition to a narrower ramp or old road. The Forest Service documentation indicates the ramp end at elevation 5960 feet—an elevation 7 feet lower than the 2022 survey approximation.

An elevation map (Figure 29) and cross section (Figure 30) of the boat ramp are below. Figure 31 is a screen capture of HYPACK cloud imagery looking at the boat ramp as it transitions from approximately 80-feet wide to 40-feet near elevation 5967 feet; white dotted lines have been added to show the edges of the ramp/road. Figure 32 is another screen capture of cloud imagery looking near elevation 5915 feet where the narrowed ramp/road meets the reservoir bed; white dotted lines have also been added to show the edges.

The Lucerne Valley Marina, located immediately south of the boat ramp, has on-water boat mooring, boat fueling, water pumping, and other facilities. The entire boat mooring area was surveyed, see Figure 33. White dotted lines have been added to approximate the edges of the boat ramp and narrowed ramp/road with respect to the location of the boat mooring slips during the survey.

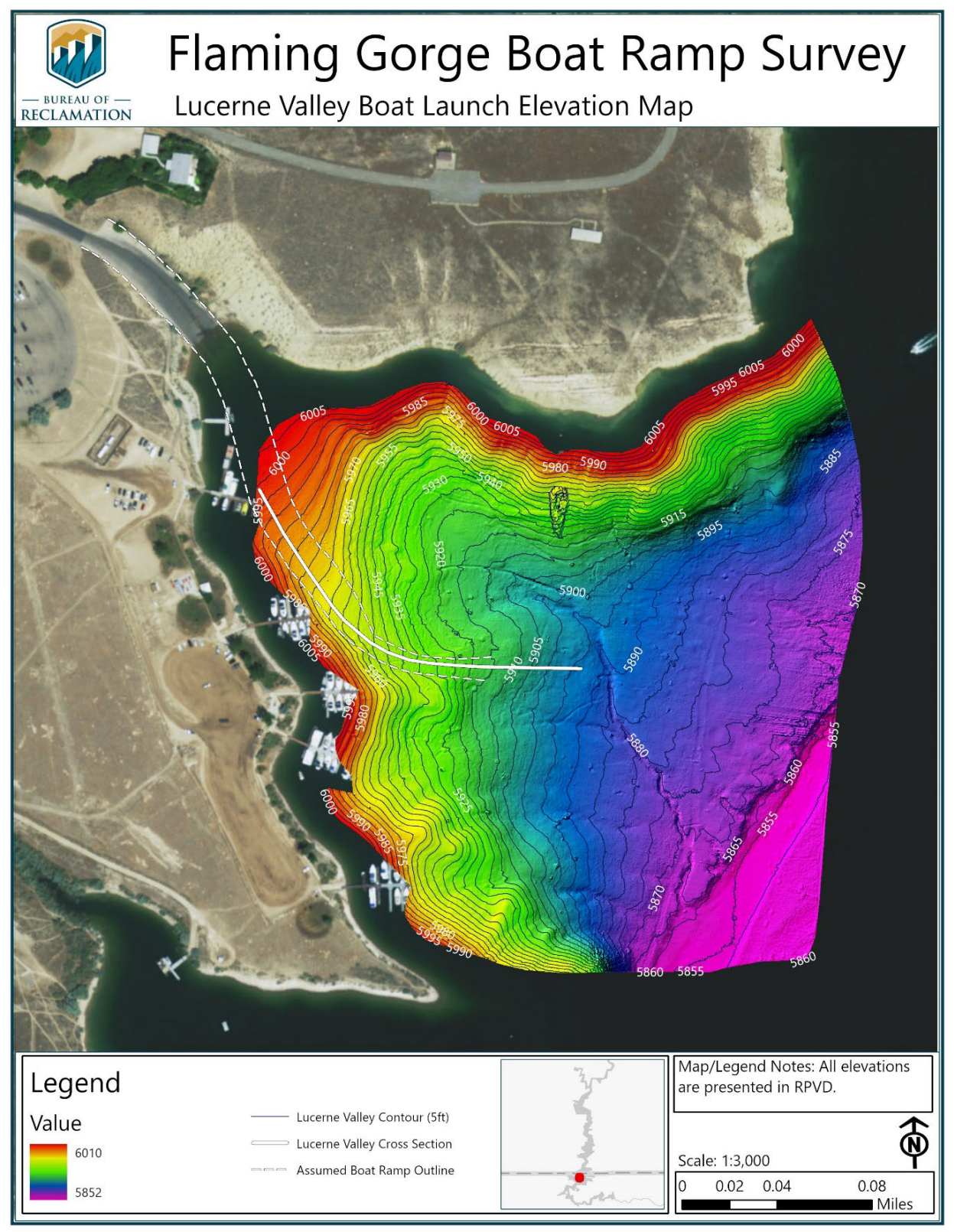

Figure 29. Elevation map of Lucerne Valley boat ramp and cross section alignment (Figure 30)

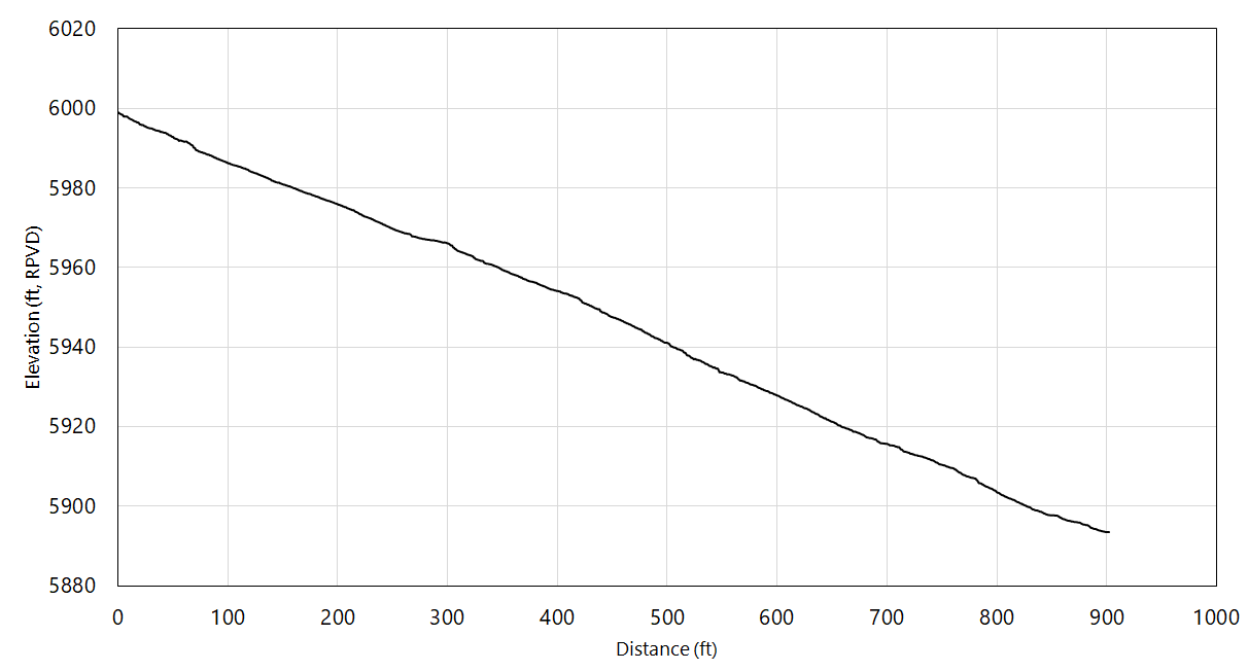

Figure 30. Cross section of Lucerne Valley boat ramp centerline

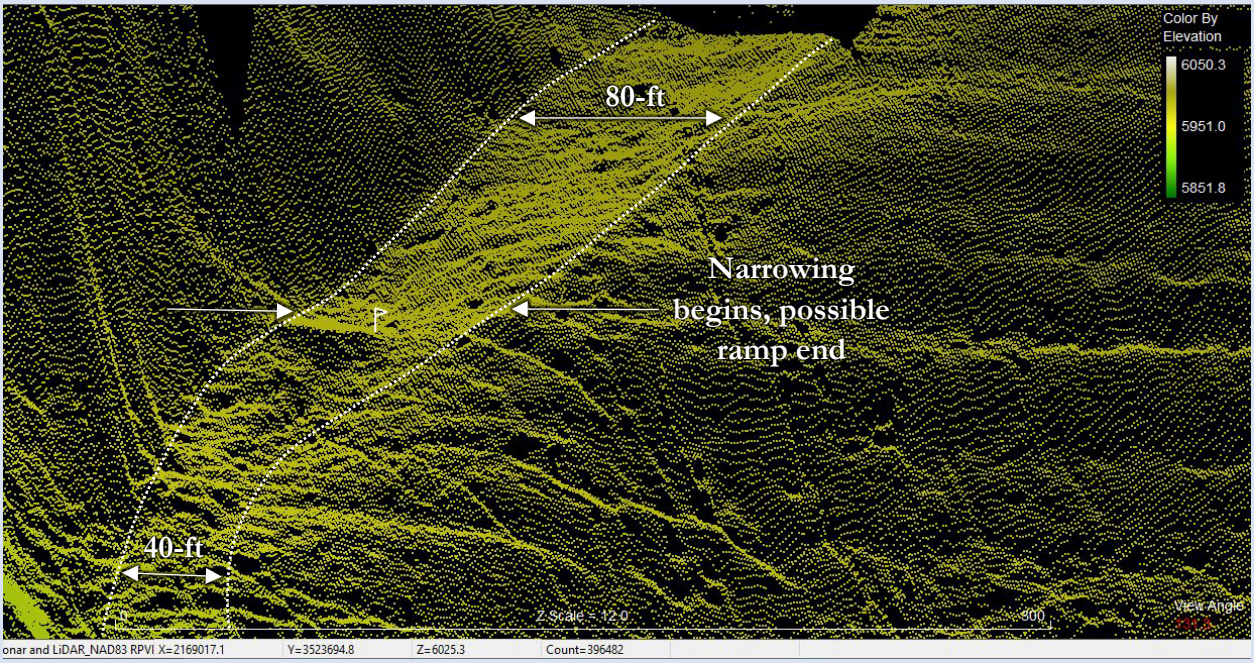

Figure 31. HYPACK cloud imagery looking at narrowing of boat ramp near elevation 5967 feet

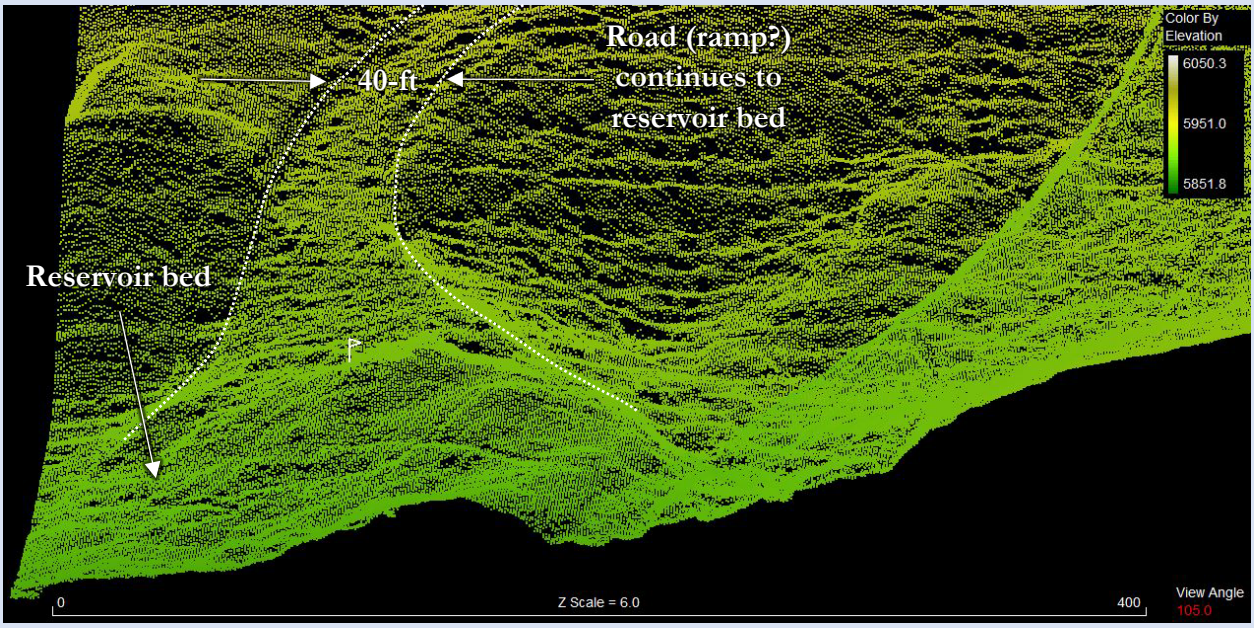

Figure 32. HYPACK cloud imagery near elevation 5915 feet near reservoir bed

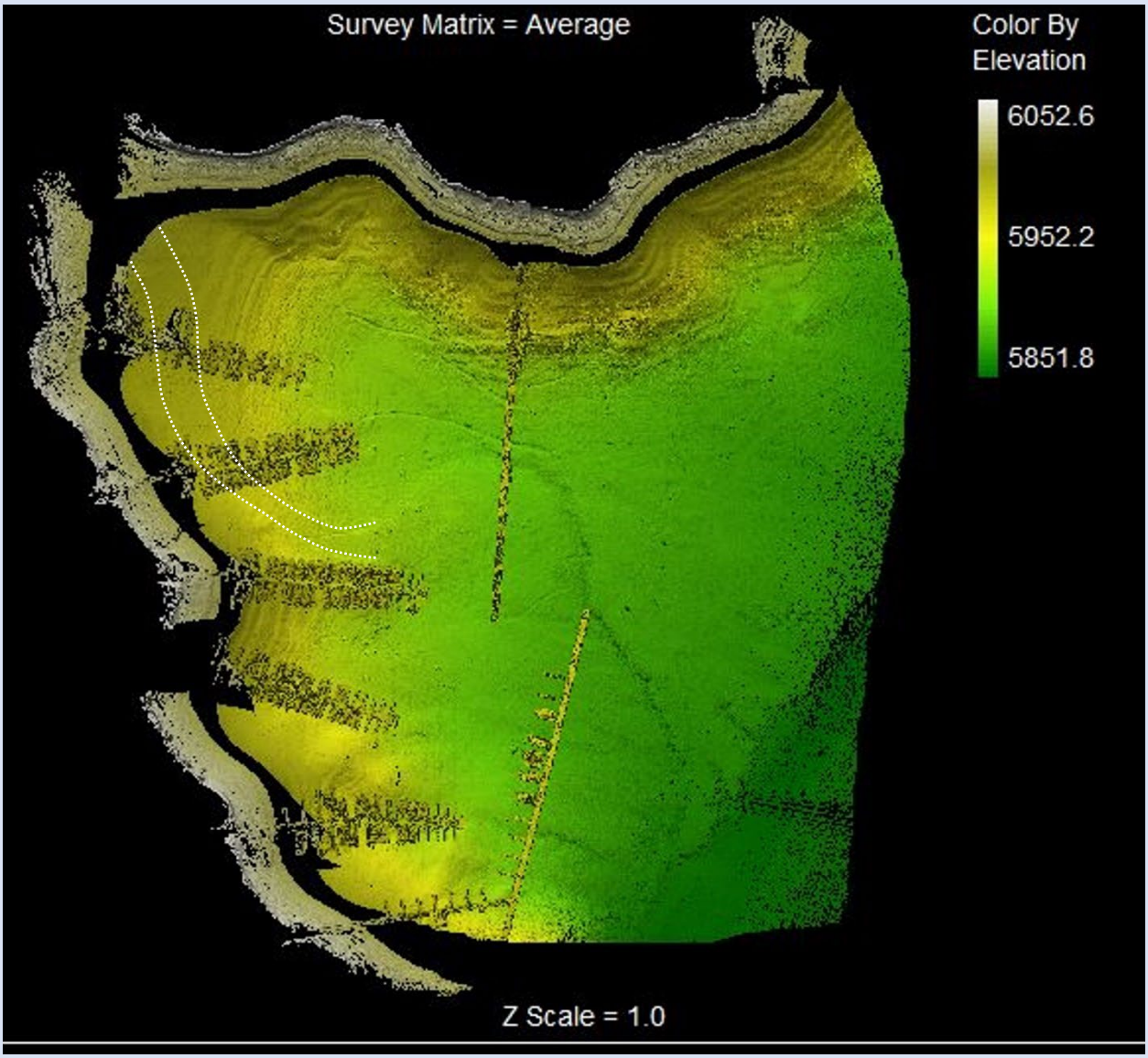

Figure 33. Map of Lucerne Valley Marina boat mooring area

Appendix G — Antelope Flat

The Antelope Flat Boat Launch Area is approximately 11 miles northwest of Dutch John, Utah. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data clearly show the entire ramp with the centerline of the ramp continuing at a constant 9% slope and terminating at approximate elevation 5961 feet. The survey data corroborate the ramp end elevation of 5960 feet as noted in the Forest Service documentation—an elevation 1 foot lower than the 2022 survey approximation. A narrower, 30-foot-wide road continues below the ramp at an 8% slope to elevation 5942 feet.

An elevation map (Figure 34) and cross section (Figure 35) of the boat ramp are below. Figure 36 is a cross section taken from HYPACK along the sonar data; a red dotted line was added to show the dip beneath and end of the boat ramp near elevation 5961 feet. Figure 37 is an aerial view of the sonar data clearly showing the ramp edges and end. Figure 38 is a screen capture of HYPACK cloud imagery looking up the end of the ramp.

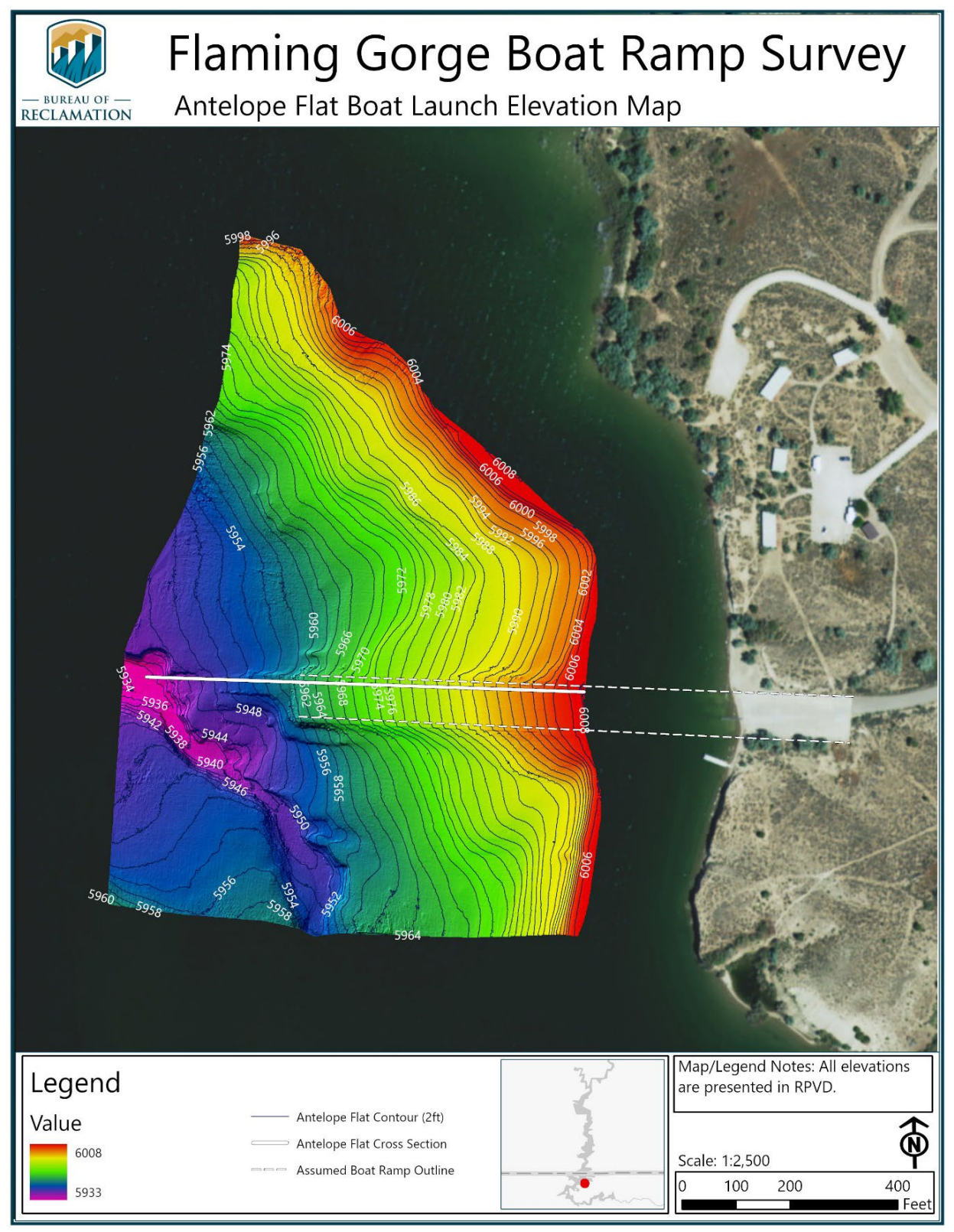

Figure 34. Elevation map of Antelope Flat boat ramp and cross section alignment (Figure 35)

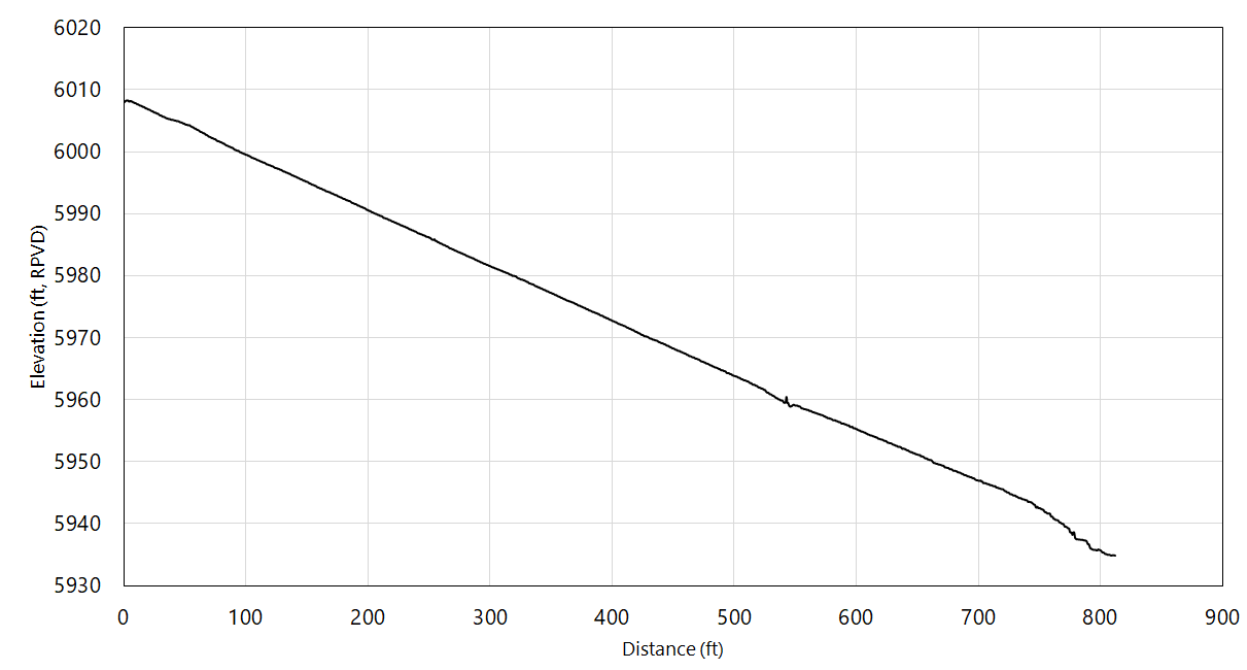

Figure 35. Cross section of Antelope Flat boat ramp centerline

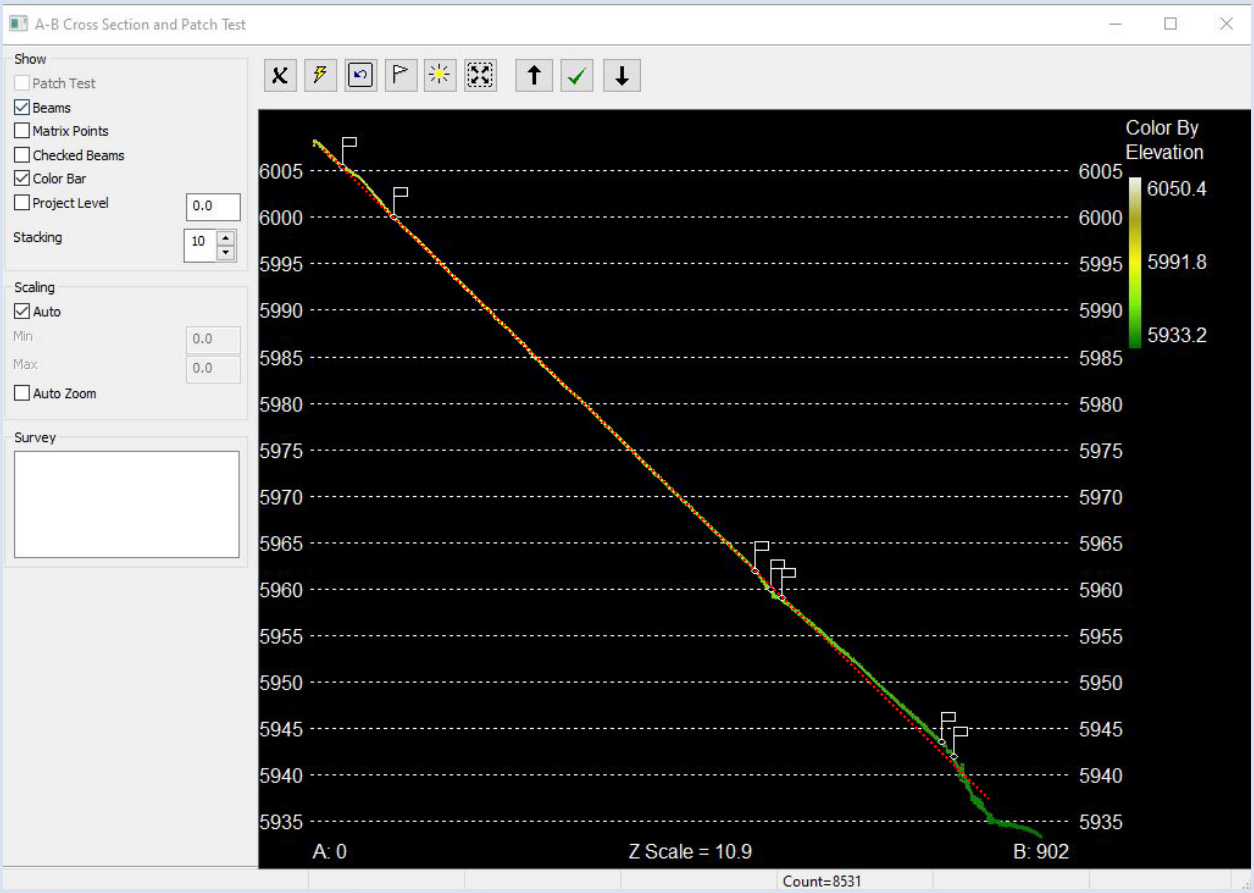

Figure 36. HYPACK cross section along sonar data

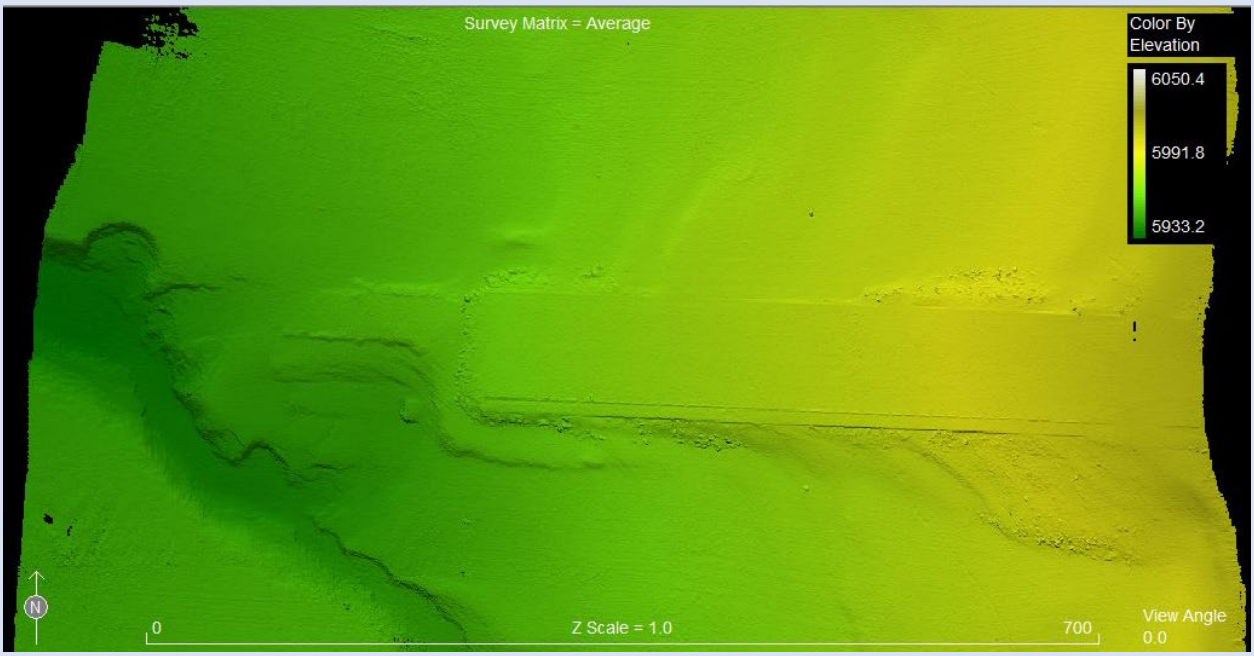

Figure 37. HYPACK aerial view of Antelope Flat boat ramp

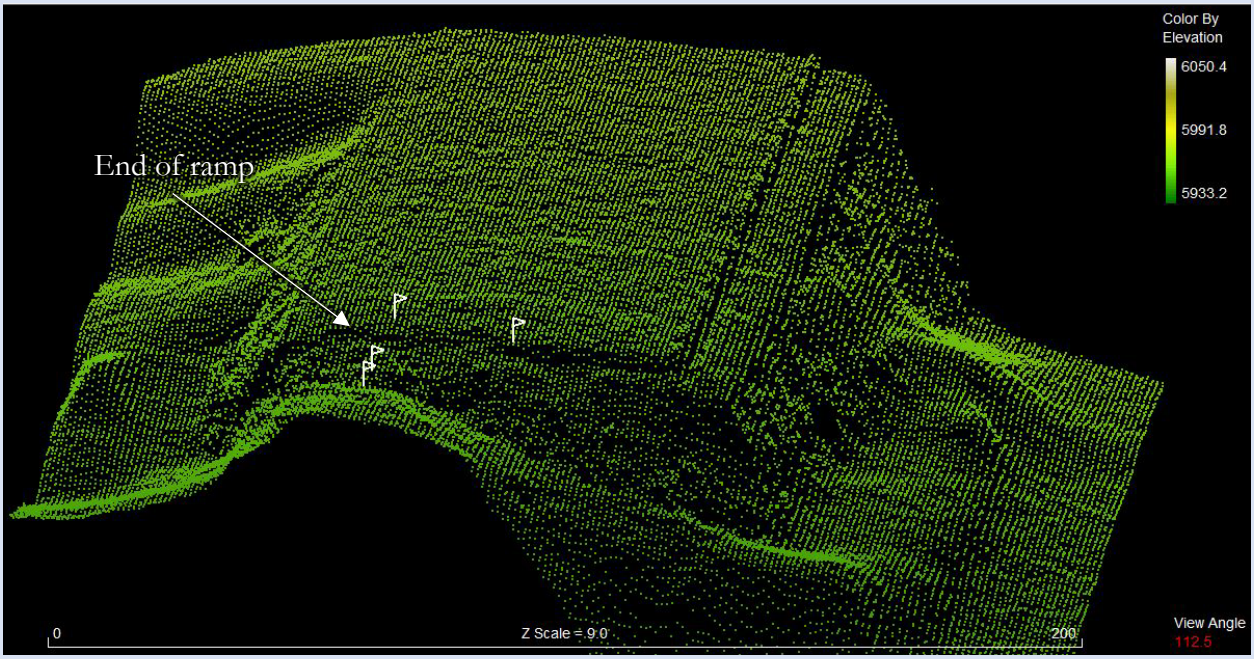

Figure 38. HYPACK cloud imagery showing ramp edges and end

Appendix H – Sheep Creek

The Sheep Creek Boat Launch Area is approximately 9 miles southeast of Manilla, Utah. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data show the centerline of the ramp continuing at a nearly constant 8-10% slope and terminating at approximate elevation 5981.5 feet where the slope abruptly transitions to 2%. The 2% slope below elevation 5981.5 feet suggests that the ramp does not extend down to elevation 5977 feet as noted in the Forest Service documentation—an elevation 4.5 feet lower than the 2022 survey approximation.

An elevation map (Figure 39) and cross section (Figure 40) of the boat ramp are below. Figure 41 is a cross section taken from HYPACK along the sonar data; a dotted red line was added along the ramp slope and extended below the connecting reservoir bed. Figure 42 is a screen capture of HYPACK cloud imagery looking up the boat ramp.

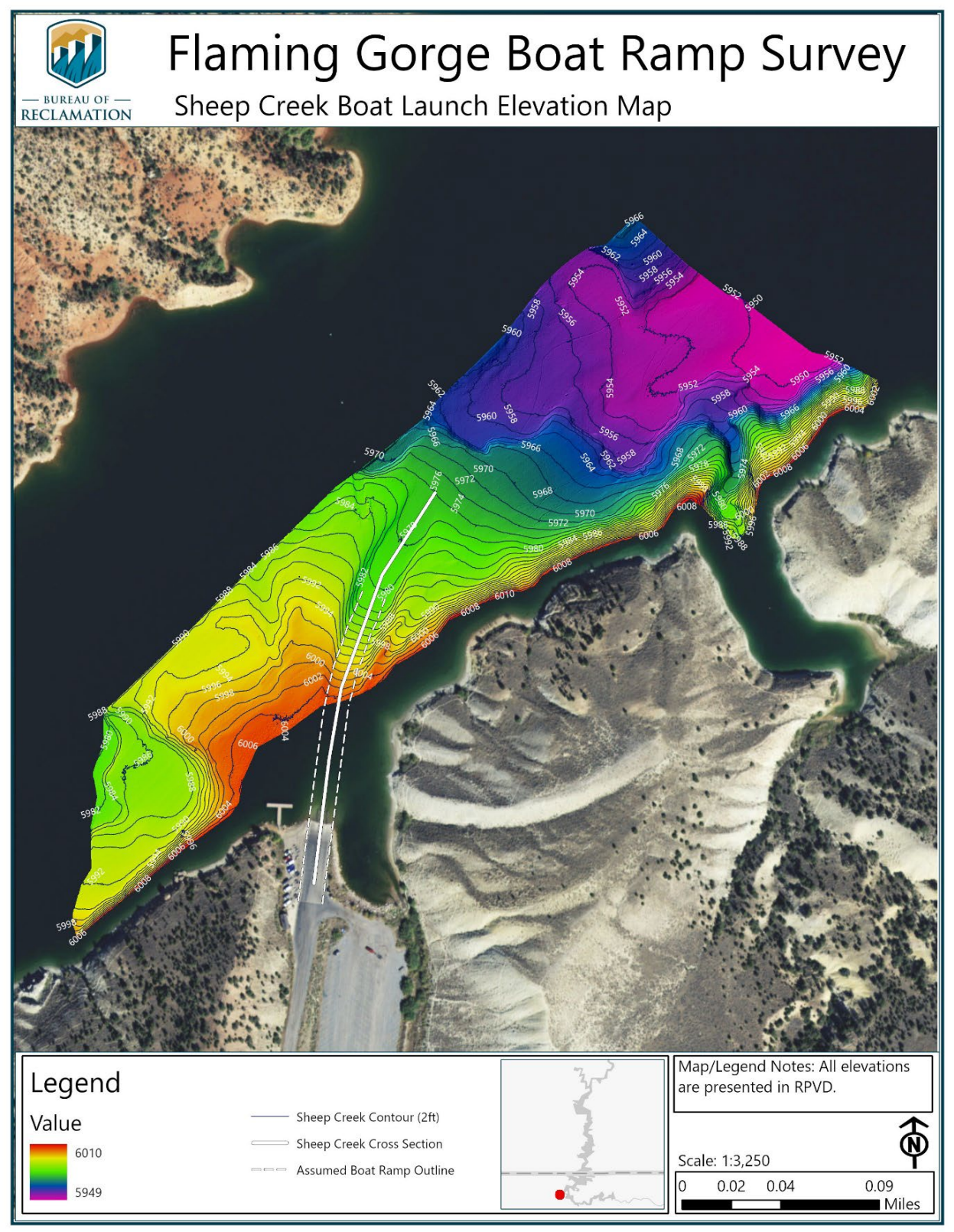

Figure 39. Elevation map of Sheep Creek boat ramp and cross section alignment (Figure 40)

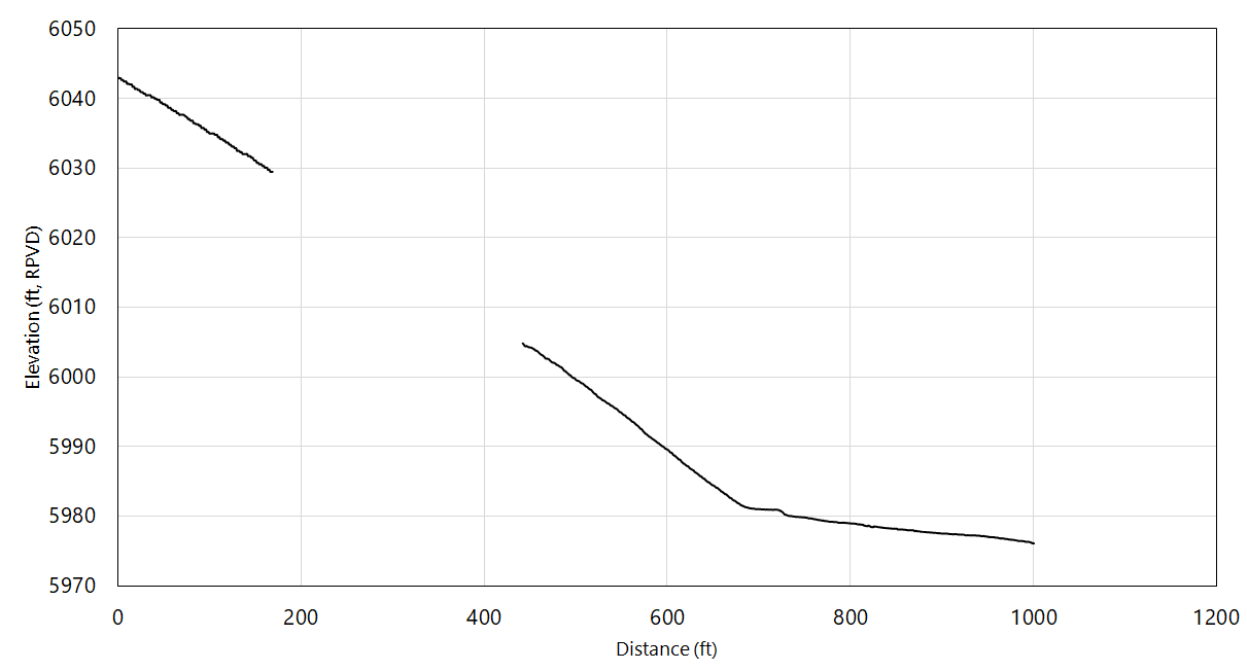

Figure 40. Cross section of Sheep Creek boat ramp centerline

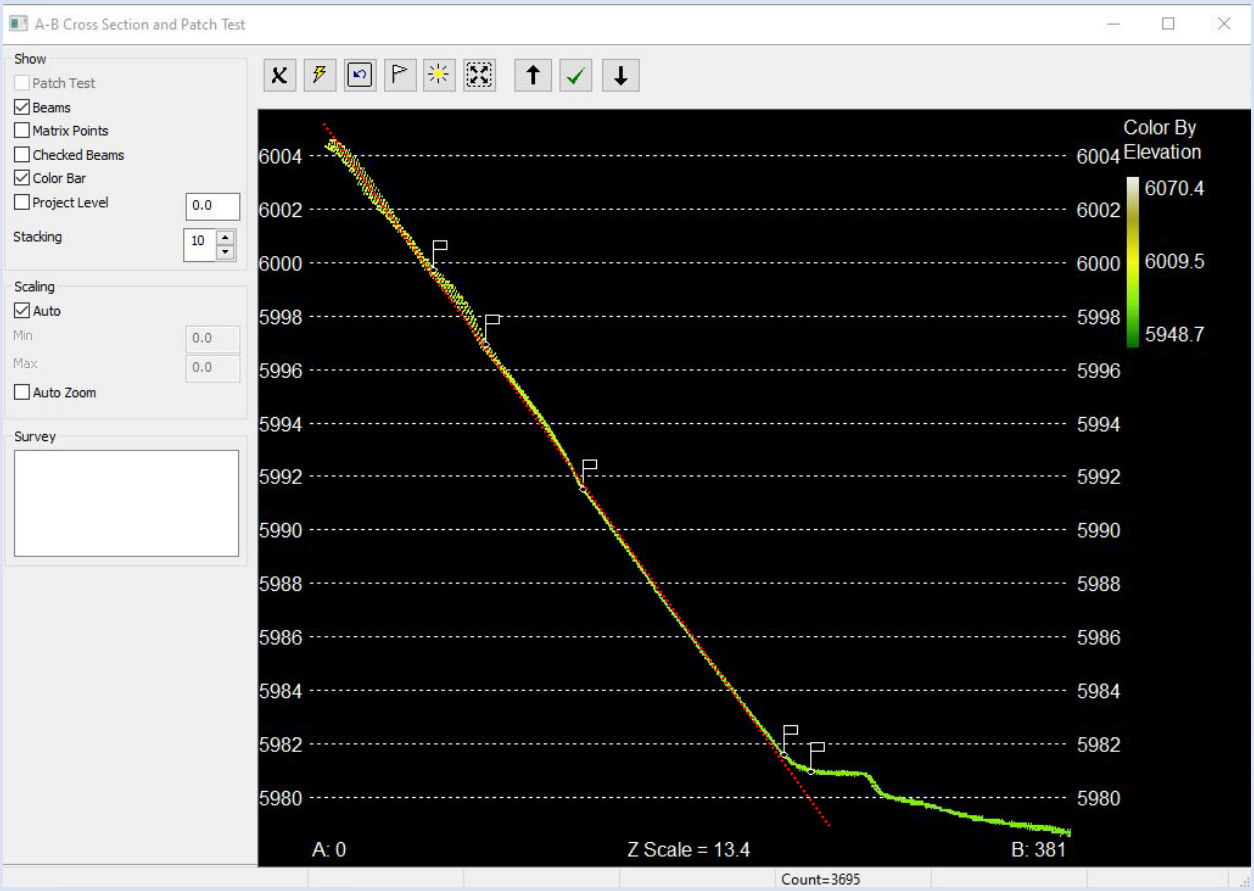

Figure 41. HYPACK cross section along sonar data

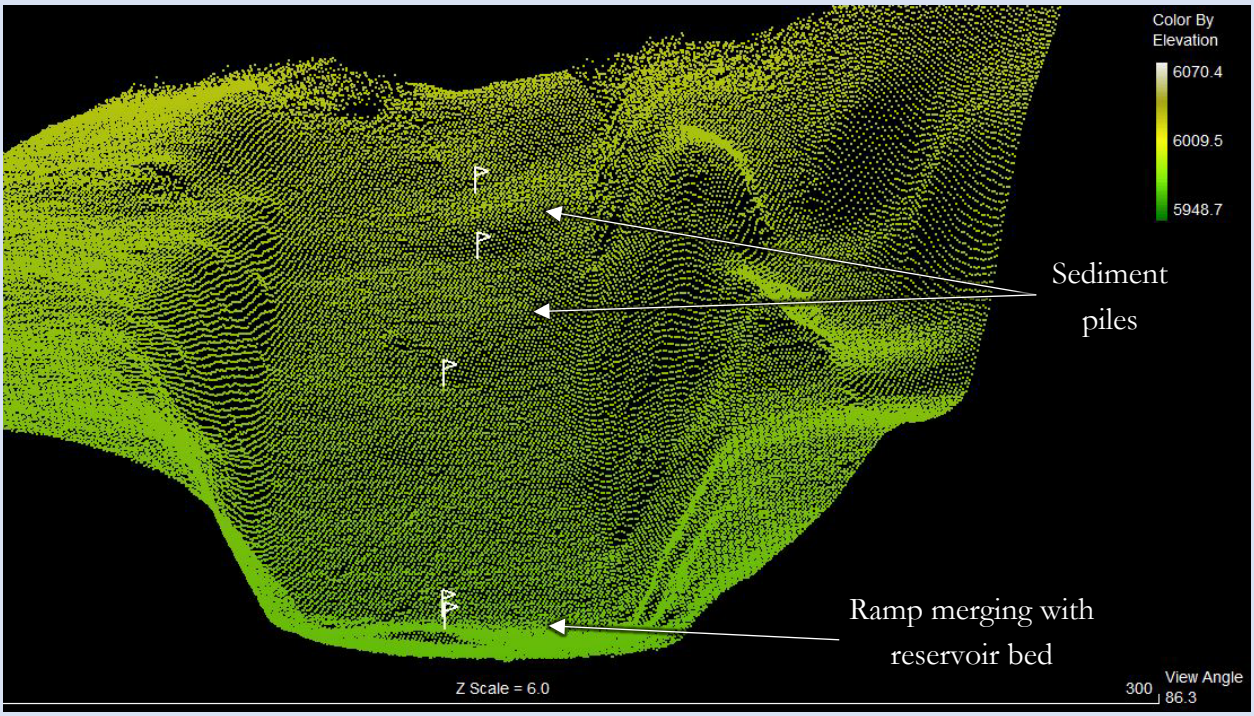

Figure 42. HYPACK cloud imagery looking up sheep creek boat ramp

Appendix I — Cedar Springs

The Cedar Springs Boat Launch Area is approximately 6 miles southwest of Dutch John, Utah. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data clearly show the entire ramp (which may be an old road) with the centerline of the ramp gradually curving northward, continuing at a nearly constant 10-12% slope. The ramp terminates at approximate elevation 5857 feet where the ramp abruptly transitions to a 30%+ slope. The survey data corroborate the ramp end elevation of 5858 feet as noted in the Forest Service documentation—an elevation 1 foot higher than the 2022 survey approximation.

An elevation map (Figure 43) and cross section (Figure 44) of the boat ramp are below. Figure 45 is a cross section taken from HYPACK along the sonar data; near the ramp bottom, a red dotted line was added along the ramp slope before the ramp ends and drops off. Figure 46 is a screen capture of HYPACK cloud imagery looking near the ramp bottom detailing the drop off after the ramp ends.

The Cedar Springs Marina, located immediately west of the boat ramp, has on-water boat mooring, and other facilities. The boat mooring area was surveyed, see Figure 47.

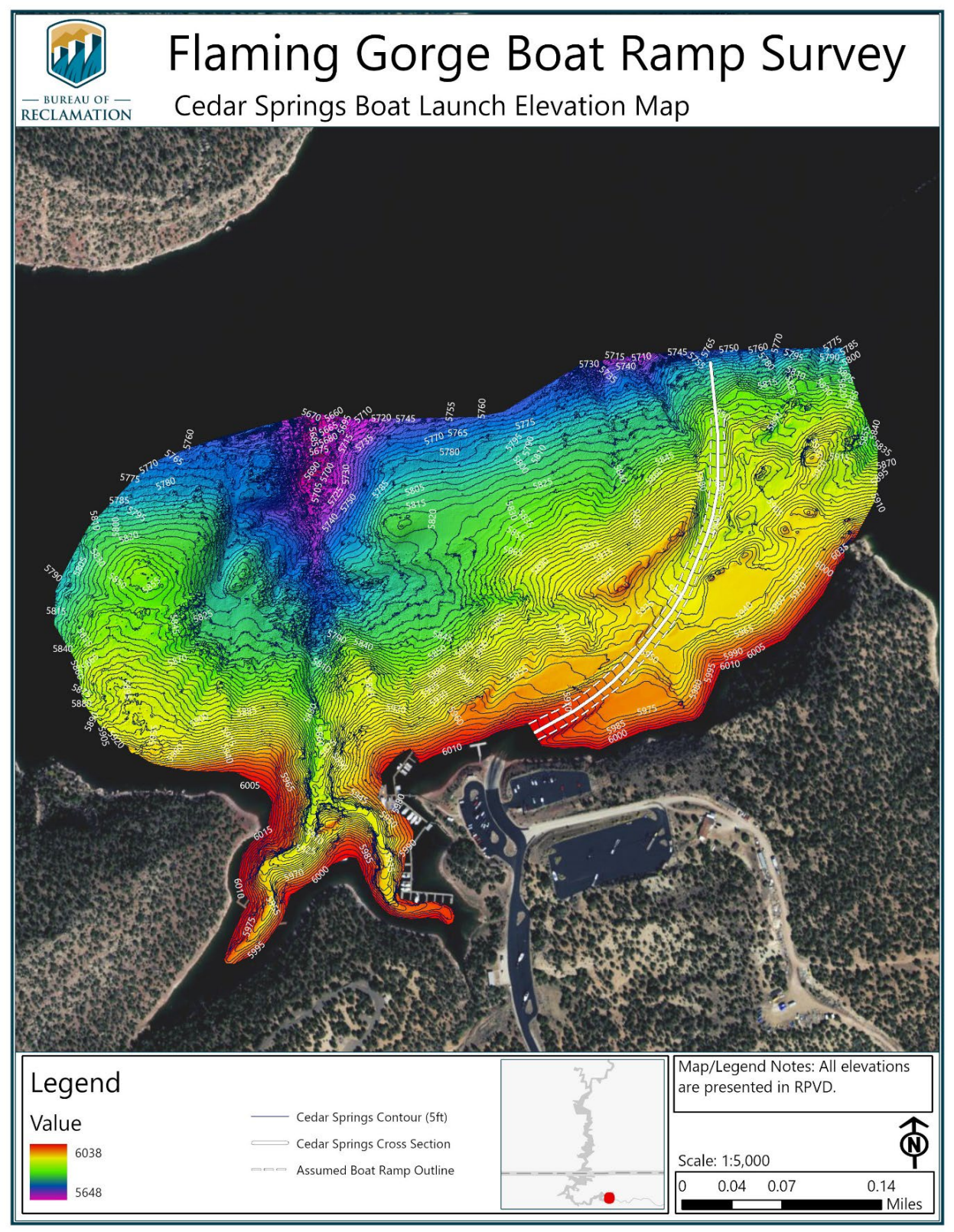

Figure 43. Elevation map of Cedar Springs boat ramp and cross section alignment (Figure 44)

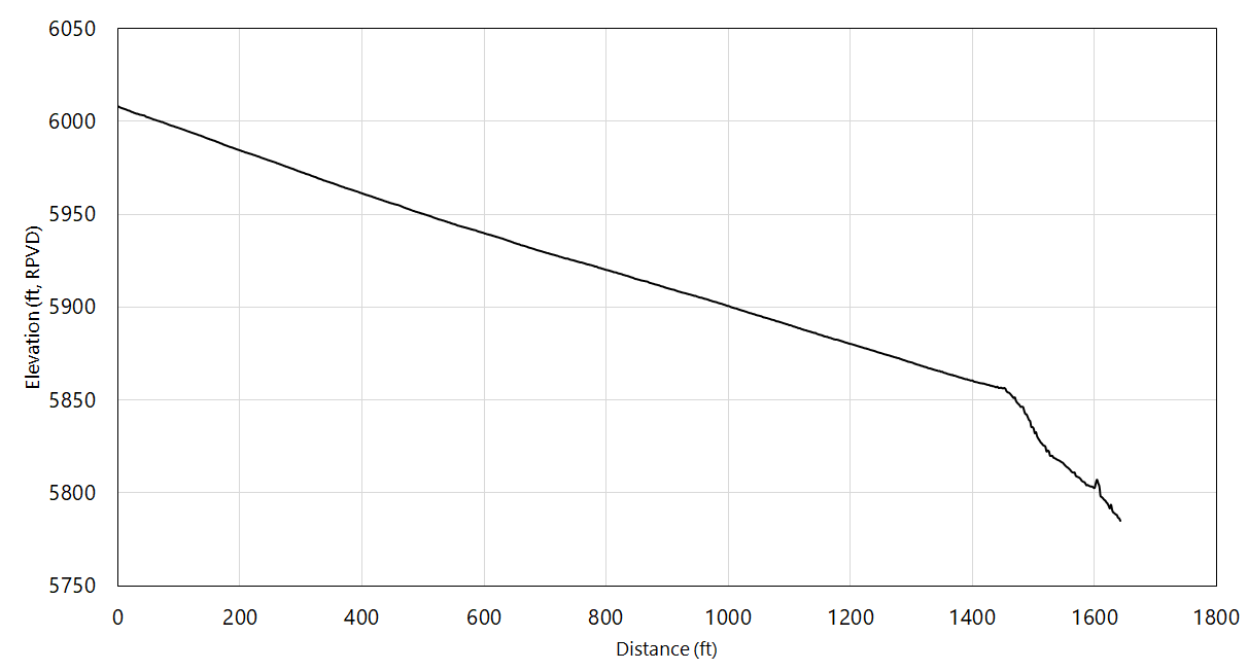

Figure 44. Cross section of Cedar Springs boat ramp centerline

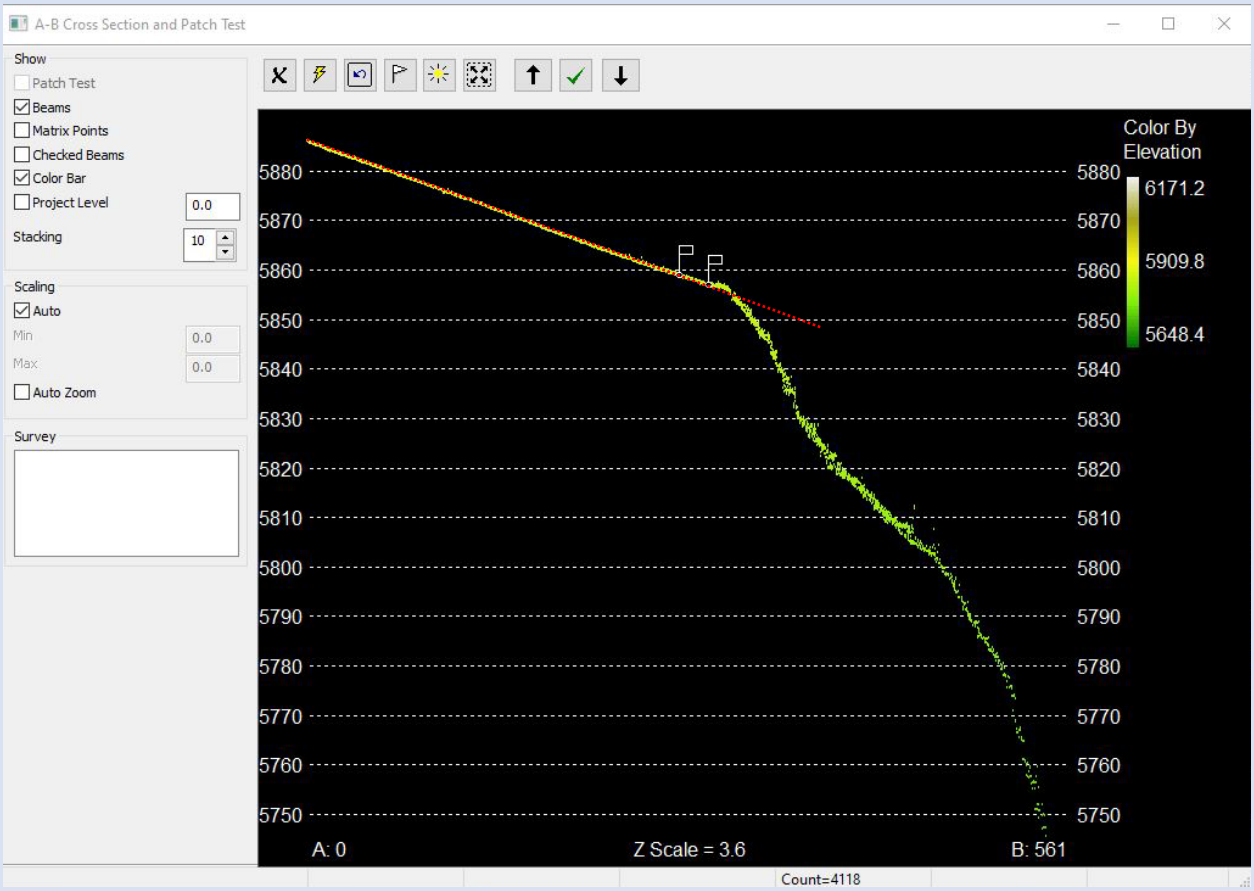

Figure 45. HYPACK cross section along sonar data near ramp end

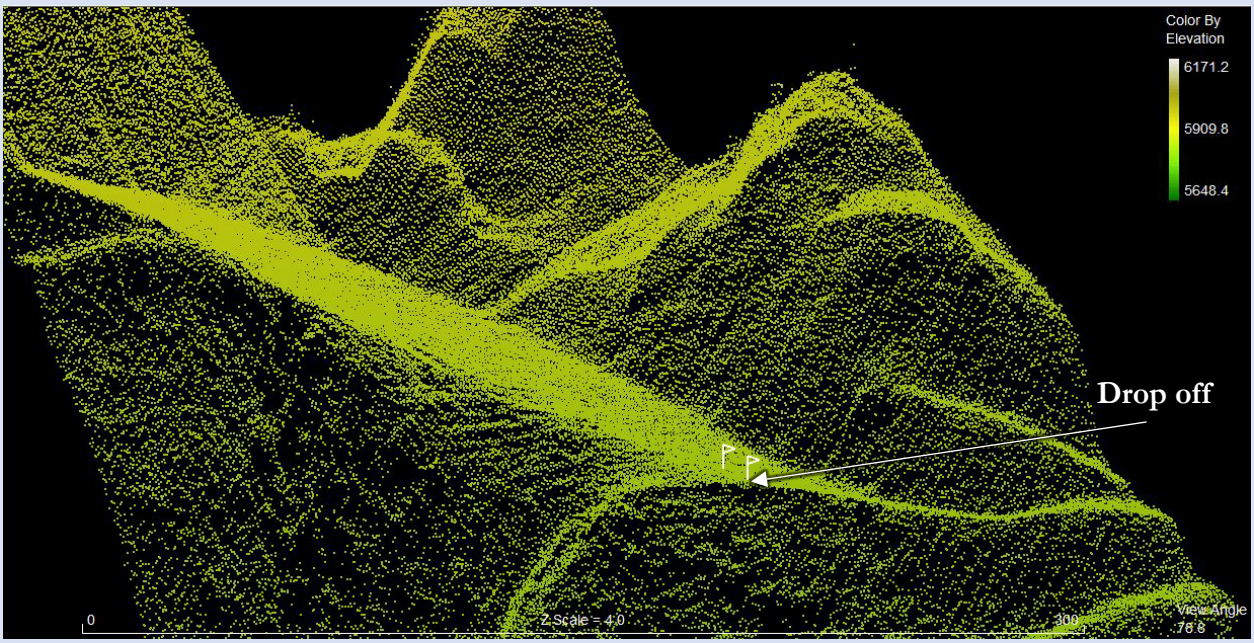

Figure 46. HYPACK cloud imagery looking near the boat ramp end

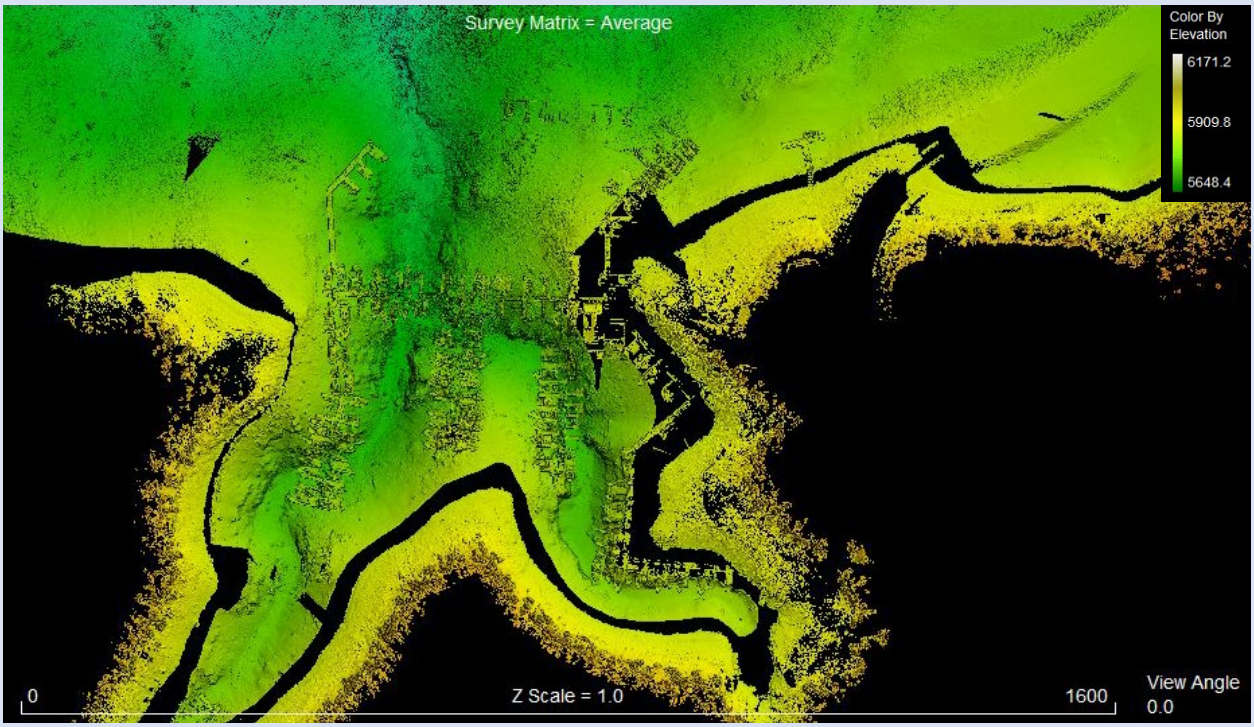

Figure 47. Map of Cedar Springs Marina boat mooring area

Appendix J — Mustang Ridge

The Mustang Ridge Boat Launch Area is approximately 6 miles west of Dutch John, Utah. The 2022 survey fully covered the submerged portion of the boat ramp.

The survey data clearly show the entire ramp with the centerline of the ramp gradually sweeping eastward, continuing at a constant 13% slope before terminating at approximate elevation 5934. The ramp narrows to 25 feet at elevation 5954 feet and continues to elevation 5934. It is possible the ramp is only covered with sediment and may continue down to elevation 5929.5 feet. The slope abruptly steepens around elevation 5928 feet, which corroborates the elevation 5929 ramp end noted in the Forest Service documentation—an elevation 5 feet lower than the 2022 survey approximation.

An elevation map (Figure 48) and cross section (Figure 49) of the boat ramp are below. Figure 50 is a cross section taken from HYPACK along the sonar data near the ramp bottom; a dotted red line was added along the ramp slope and extended beyond the drop off near elevation 5928. Figure 51 is an aerial view of the ramp zoomed in around the end, clearly illustrating the ramp narrowing, ramp edges, and ramp drop off. Figure 52 is a screen capture of HYPACK cloud imagery looking up the boat ramp near the ramp bottom.

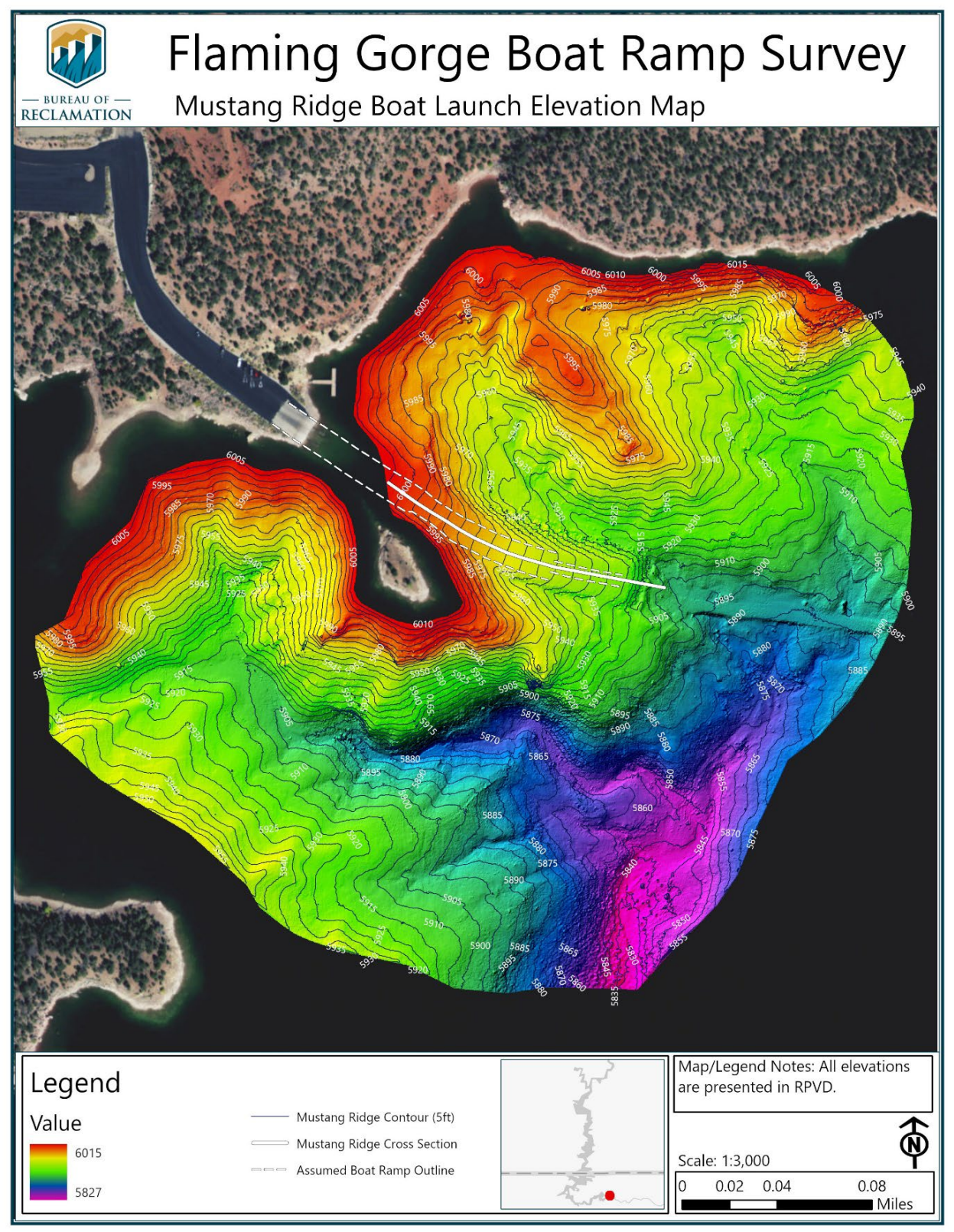

Figure 48. Elevation map of Mustang Ridge boat ramp and cross section alignment (Figure 49)

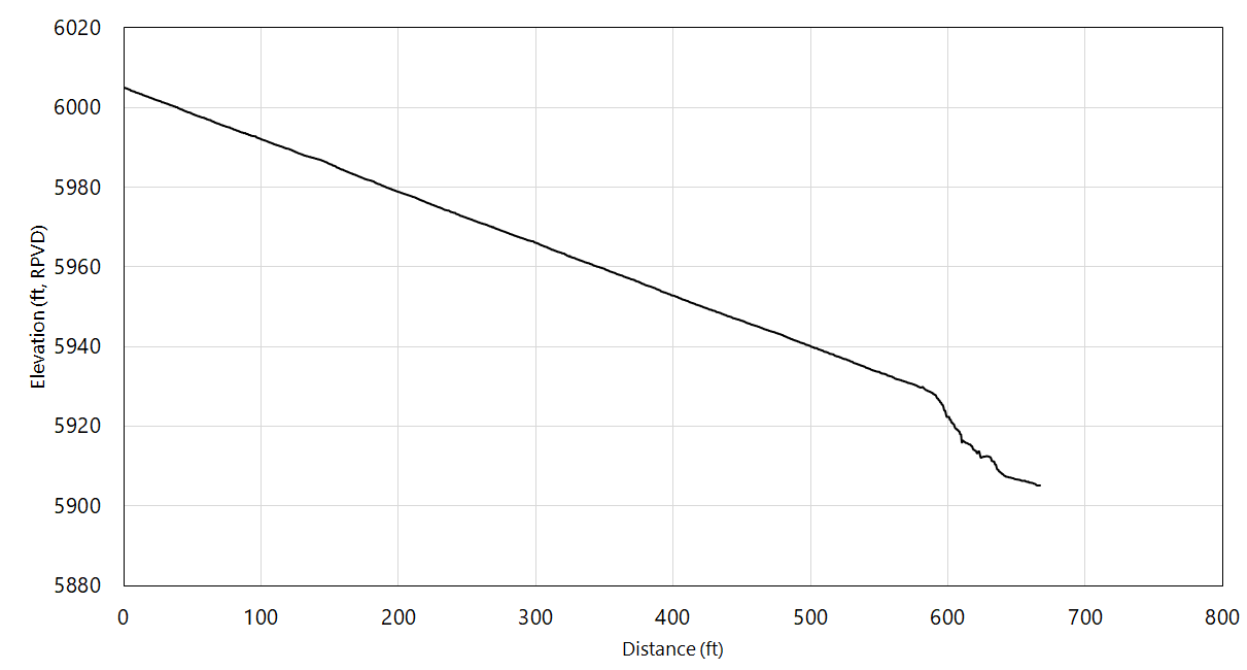

Figure 49. Cross section of Mustang Ridge boat ramp centerline

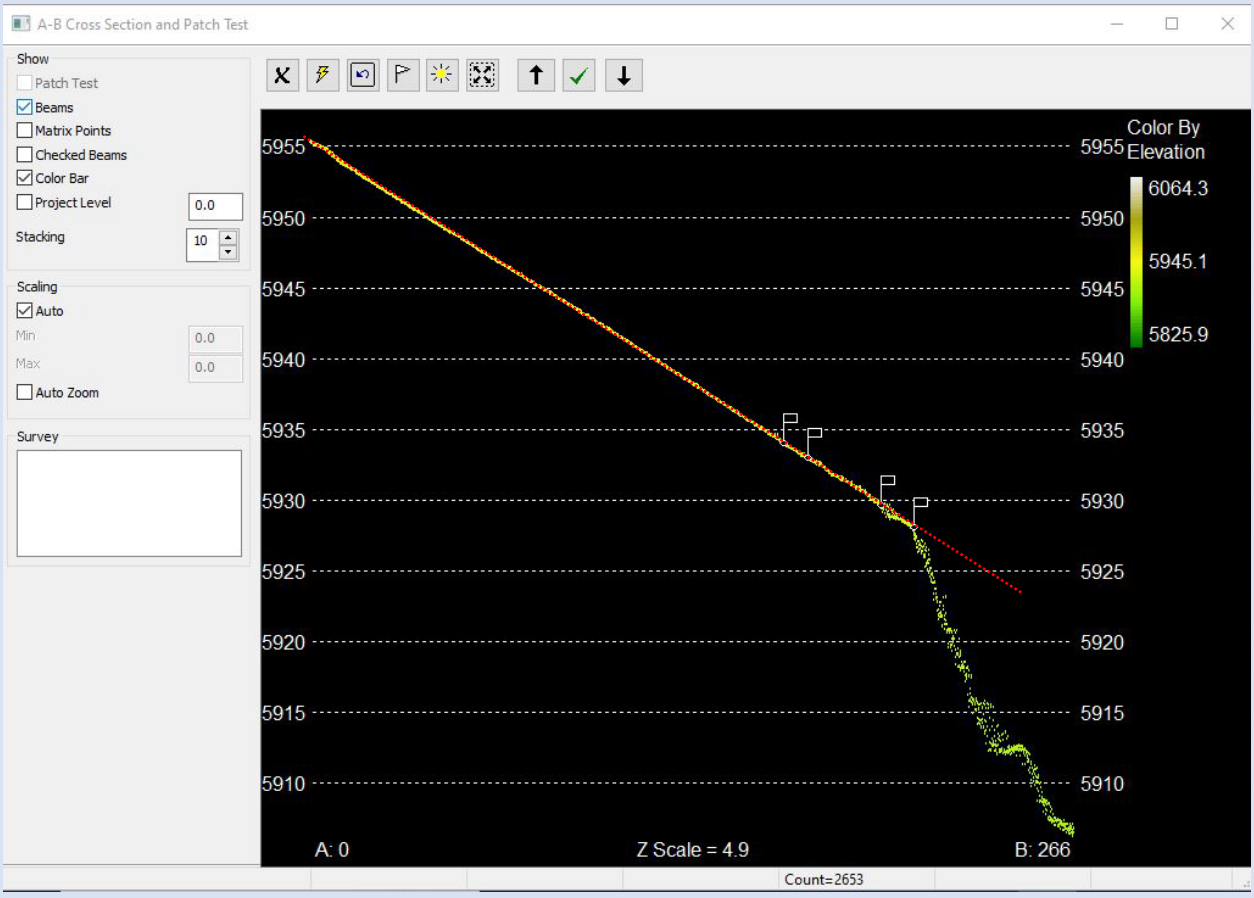

Figure 50. HYPACK cross section along sonar data near ramp end

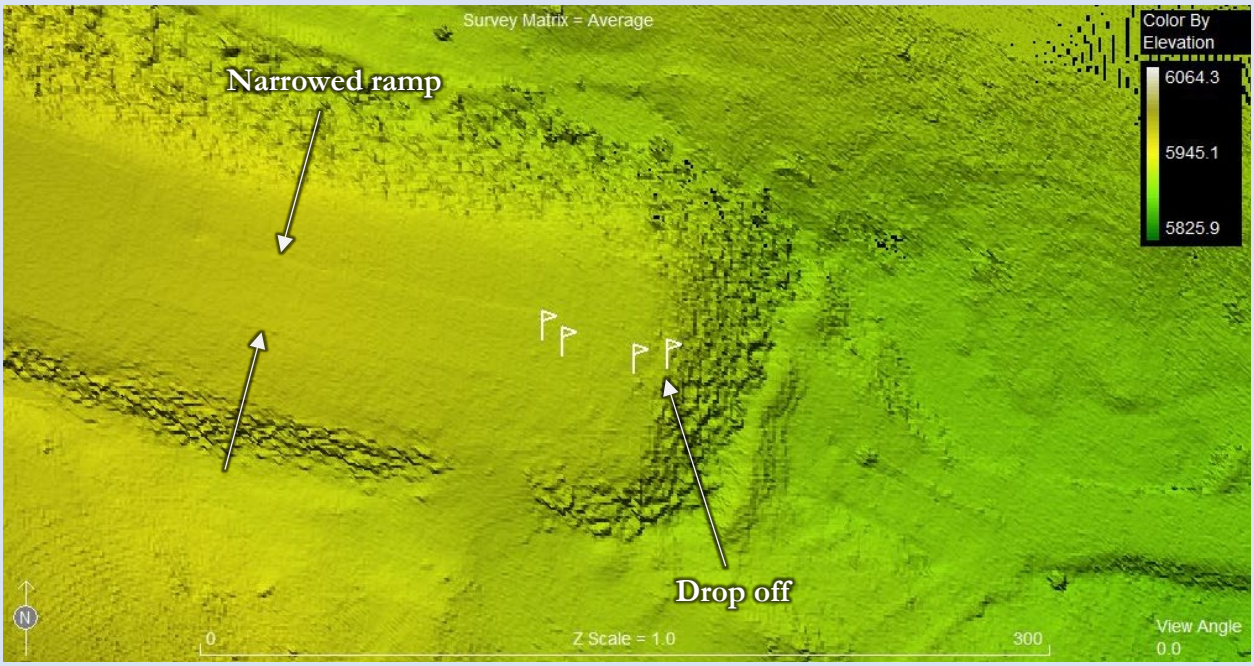

Figure 51. HYPACK aerial view of Mustang Ridge boat ramp end

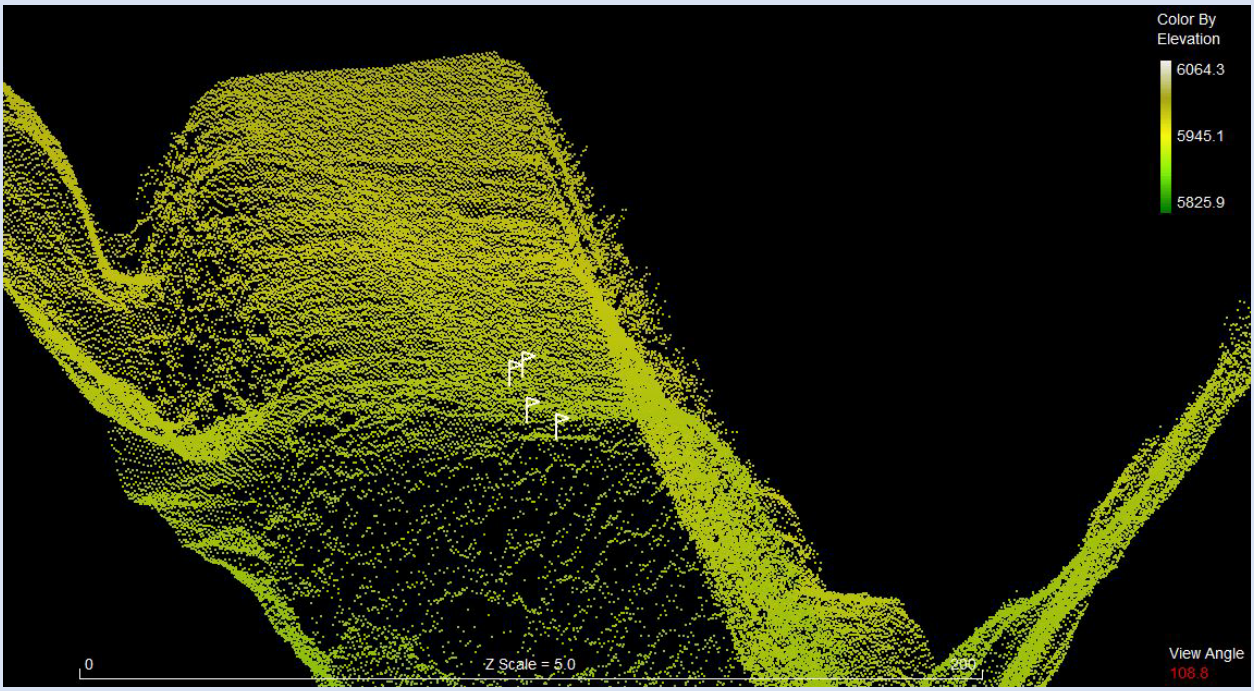

Figure 52. HYPACK cloud imagery looking up the boat ramp near the ramp bottom