APPENDIX F – TOPOBATHYMETRIC DEM DEVELOPMENT FOR MFLS MODELING FOR LAKE PREVATT, ORANGE COUNTY, FLORIDA

INTRODUCTION

A topobathymetric digital elevation model (DEM) was produced to support the Minimum Flows and Levels (MFLs) determination and assessment for Lake Prevatt. This involved the compilation of data from several sources and disparate data types. The bathymetric portion (blue in Figure F-1) was interpolated using a set of elevation points compiled from a number of sources (see below for details); to ensure accuracy and spatial consistency, all bathymetric elevation data were compared to survey data from the St. Johns River Water Management District (SJRWMD) Bureau of District Projects and Construction. The upslope portion (brown area in Figure F-1) was derived from the 2018 - 2019 statewide United States Geological Survey (USGS) Light Detection and Ranging (LIDAR) data (hereafter referred to as "USGS LIDAR") and was adjusted for vegetation interference using MFLs terrestrial survey data (see below for details). The LIDAR flight collection dates occurred between December 4, 2018 and April 12, 2019.

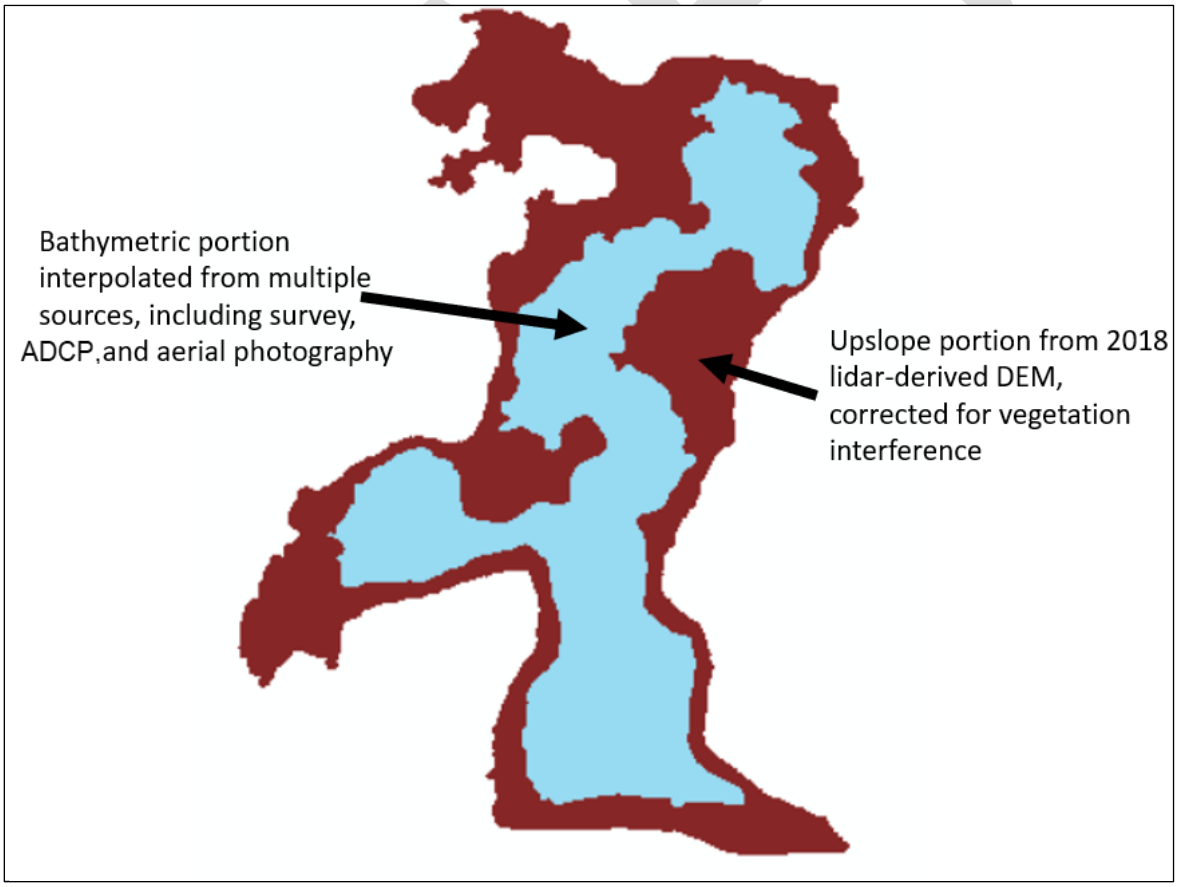

Figure F-1. Lake Prevatt topobathymetric digital elevation model overview. The boundary between the bathymetric portion (blue) and the upslope portion (brown, derived from the USGS LIDAR-derived DEM) is the hydroflattened edge extracted from the USGS DEM; the blue area is the same as the area that was hydroflattened in the USGS DEM due to poor returns over water.

All geospatial work was completed in Esri ArcMap 10.8.1. The final DEM is a 0.76200152 by 0.76200152- meter grid (2.5 by 2.5 feet) with spatial reference system NAD1983_HARN UTM_Zone_17N. Horizontal units are in meters (US). All original (pre-interpolation, surveyed and derived) elevation data are in vertical units of feet (NAVD88). Two DEMs were produced, one in vertical units in feet, the other in meters.

BATHYMETRY

The bathymetric portion (blue area in Figure F-1; Panel A in Figure F-2) was developed by interpolation combining bathymetry datasets that were either acquired or derived using different methodologies. All lines (contours, digitized water edge) were converted to points for interpolation. All data were validated against elevation survey data provided by the Bureau of District Projects and Constructions (Survey) and/or the MFLs program to determine spatial compatibility of all data sources.

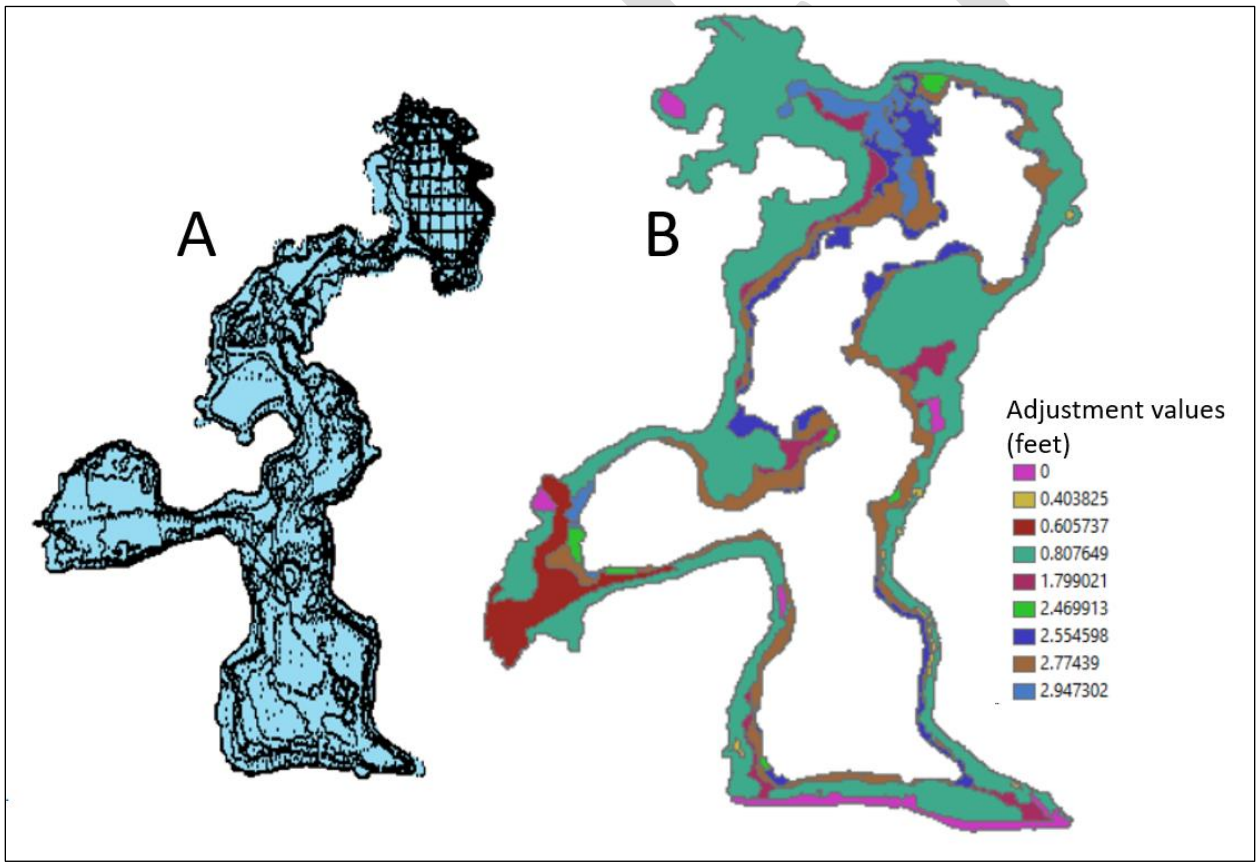

Figure F-2: Details of the final topobathymetric DEM for Lake Prevatt. Panel A displays all elevation points used for interpolation of the bathymetric portion of the DEM. Panel B displays the upslope vegetated LIDAR-derived portion of the DEM with adjustment factors (Vertical Datum NAVD88).

Bathymetric data list

The datasets used for the bathymetric DEM include the following:

1) Survey
    a. Survey transects collected by the Bureau of District Projects and Constructions January 11, 2016.
    b. Survey (soundings) collected by MFLs team in 2021.
    c. Survey collected ca. 2022 by MFLs field team.
    d. Three survey transects (bathymetry and topographic) collected by MFLs field team.
2) Acoustic Doppler Current Profiler (ADCP) data collected in 2015; cleaned to remove vegetation signals and thinned.
3) Bathymetric vegetation linework delineated ca. 2022 converted to points. Elevations were assigned by survey points (i.e., vegetation polygons that were delineated when water level was lower than when the USGS LIDAR was flown. The hydroflattened area of the USGS DEM is the region where water was present during the LIDAR collect).
4) "Heads up" digitized shoreline from aerial photographs (source: SJRWMD and Google Earth). Linework was converted to points; elevation values were assigned by a set of nearest survey data for each year.
    a. 2011
    b. 2014
    c. 2015
    d. 2016
    e. 2017
    f. 2018 (Hydroflattened edge from USGS LIDAR raster)

Bathymetric Data Processing

The 2016 survey data were collected by the Bureau of District Projects and Construction in anticipation of MFLs re-evaluation for Lake Prevatt. Additional elevation data were collected by the MFLs team in 2021 and 2022 by collecting depth soundings or using standard survey techniques with rod and transit level. These two datasets represent the standard for elevation (bathymetry) estimated for the lake and all additional elevation datasets (digitized aerial photography linework, ADCP data, vegetation polygon linework) were validated or assigned elevation as needed in comparison to these survey data.

A large dataset of points (depth soundings) was collected using ADCP methods in 2015 by the District's Bureau of Water Resource Information. During collection of these data, standard survey depth measurements were conducted as QAQC. This dataset was cleaned to remove outliers (likely due to vegetation). Due to the large amount of data, the dataset was thinned to remove superfluous data and thereby reduce the total number of points, which ensured the interpolation was not overly influenced by the ADCP data. Additional survey campaigns were undertaken by the MFLs team to fill in gaps in 2021 and 2022.

Digitization of the lake edge using five years of aerial photography flown when the lake level was lower than 2018-2019 (when LIDAR data was collected) was completed by "heads up" digitizing in ArcMap; these lines were assigned elevation values based on the nearest set of survey points and then converted to points for interpolation.

The hydroflattened areas of LIDAR-derived DEMs are assigned an elevation value during the processing of the lidar point cloud data; hydroflattening is a requirement for areas with standing water because there is a lack of returns. The edge of the hydroflattened area for Lake Prevatt is the physical lake edge at the time the LIDAR was flown. Importantly, this line is the common edge between the bathymetric and upslope portions of the DEMs (Figure F-1; Panels A and B in Figure F-2; Figure F-3) which plays a role when the two portions of the DEM are mosaiced together (described below). Additionally, the lake polygon edge was converted to points to be included in the interpolation which reinforces the common elevations between the two rasters (bathymetric and upslope). The total dataset used for interpolation is 35,062 points.

Interpolation of Bathymetric Data

Bathymetric points were interpolated to a raster surface (DEM) using the Natural Neighbor method. Natural Neighbor was chosen due to its fidelity to the elevation values of the input data, strict adherence to the range in elevation of the input data, and for its comparatively simple algorithm compared to other interpolation methods.

LIDAR PORTION AND ADJUSTMENT FACTOR DEVELOPMENT

The upslope portion of the Lake Prevatt DEM (brown area in Figure F-1) was extracted from the USGS LIDAR DEM. Due to extensive vegetation interference, adjustment factors were required based on vegetation community type. A detailed vegetation map was developed by MFLs staff based on 2021 conditions (described in Appendix C). The vegetation map was extended to reach the outer boundary of the final topobathymetric DEM (boundary determined by MFLs).

To develop the adjustment factors shown in Panel B of Figure F-2, 331 survey points were collected in eight vegetation classes. Table F-1 displays the calculation of the adjustment factors and the area of each vegetation class. Minor alteration to the vegetation map was required to align with 2018 conditions when the LIDAR was flown. Before adjustment, the difference between survey and USGS DEM elevation was 2.56 feet (mean). Vegetation polygons were assigned the correction values and applied to the upslope DEM. After applying the adjustment factors the mean difference between survey and the adjusted DEM was 0.07 feet (aggregated DEM version, described in next section).

A small set of upslope survey points was not used in the adjustment factor development and were then used to evaluate the adjustment factors applied to the USGS LIDAR collection

(Oak Hammock; 21 points). There were no issues with the adjustment factors applied in these areas thus supporting the adjustment factor approach.

The method used for adjusting LIDAR data for Lake Prevatt is an extension of the method used by the SJRWMD in the 2012 Water Supply Impact Study (Fox et al. 2012). Additional references for adjusting terrestrial LIDAR are available upon request.

Table F-1. Adjustment factors by vegetation type. Entries marked with * indicate adjustments derived from Oak Hammock based on 2018 aerial photography.

Vegetation Classes	Adjustment Factor (ft NAVD88)	Number of Survey Points	Adjusted Area (acres)
Anthropogenically disturbed	0	5	3.22
Low vegetation adjacent to Oak Hammock	0.4038245	*	0.52
Mixed Hardwood / Oak Hammock	0.6057368	*	4.93
Oak Hammock	0.8076490	83	51.1
Shallow Marsh	1.7990210	33	3.81
Willow Scrub-shrub	2.4699130	28	0.99
Deep Marsh – Emergent	2.5545980	30	6.94
Buttonbush Shrub	2.7743900	144	11.66
Deep Marsh – Floating/Emergent	2.9472020	8	3.5
Total		331	86.67

MOSAIC TO NEW RASTER

To ensure a smooth spatial transition (no gaps) between the bathymetry interpolation and the LIDAR-derived DEM at the lake edge, a 5-meter area of overlap between the two rasters was added to the bathymetry raster. The “Mosaic to new raster” function in the Data Management Toolset in ArcMap was used to create the DEM (Figure F-3). Additionally, a smoothing function in ArcMap was employed (aggregation) to avoid or diminish a stairstep appearance in the final raster output when adjacent areas in the vegetated area (polygons) have significant difference in adjustment factors (Figure F-4). The final topobathymetric DEM for Lake Prevatt is shown in Figure F-5.

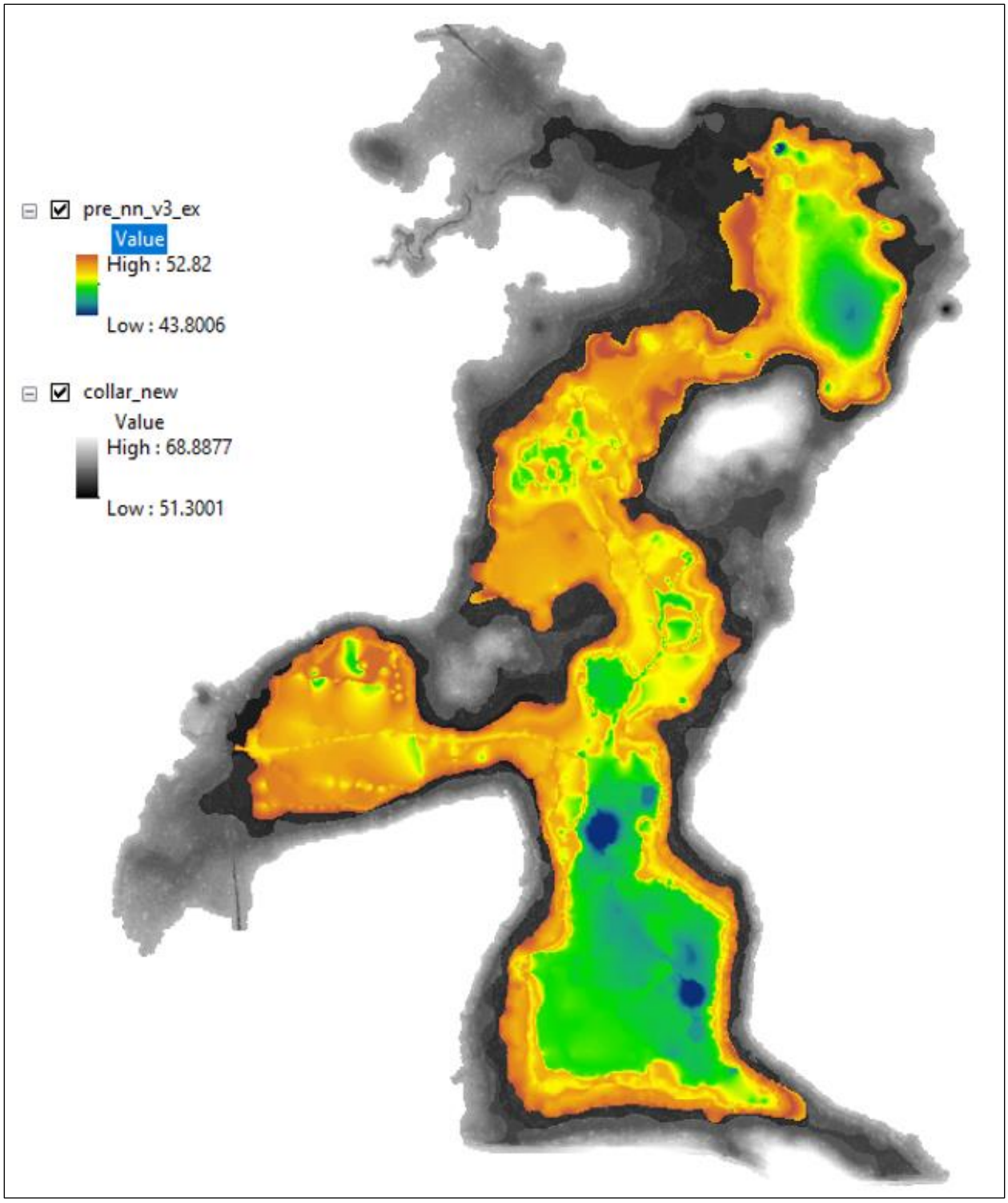

Figure F-3: The two rasters prior to the “Mosaic to new Raster” function. The bathymetric raster is in color and the upslope USGS LIDAR-derived raster is in gray scale.

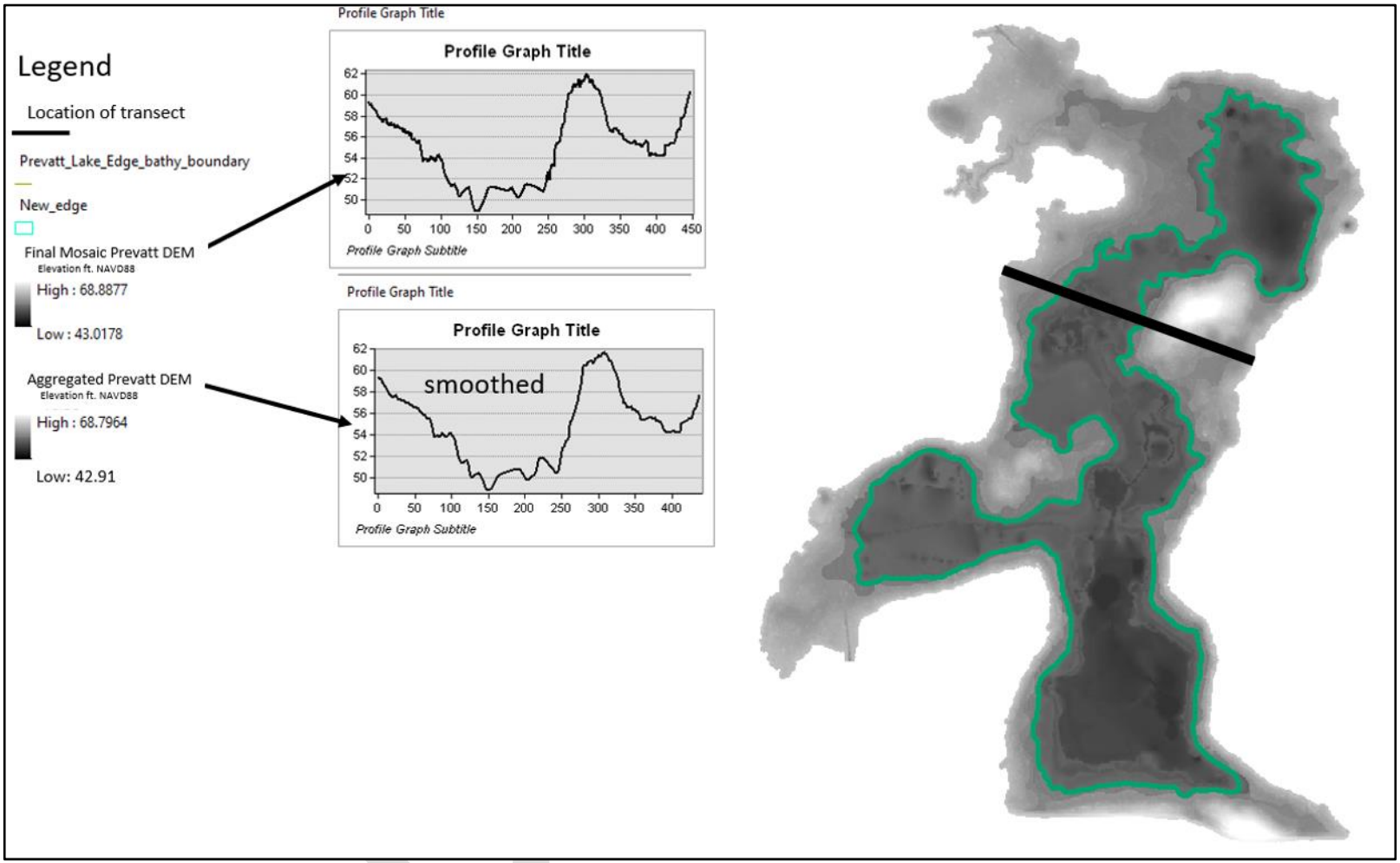

Figure F-4. Comparison of before (top plot) and after (bottom plot) the smoothing function that removes stairstep result of the raster mosaic of the two rasters and from adjacent LIDAR adjustment polygons with different adjustment factors. The heavy black line on the DEM (right) is the location of the cross section. The area inside the green line represents the area entirely derived from interpolation of bathymetric data.

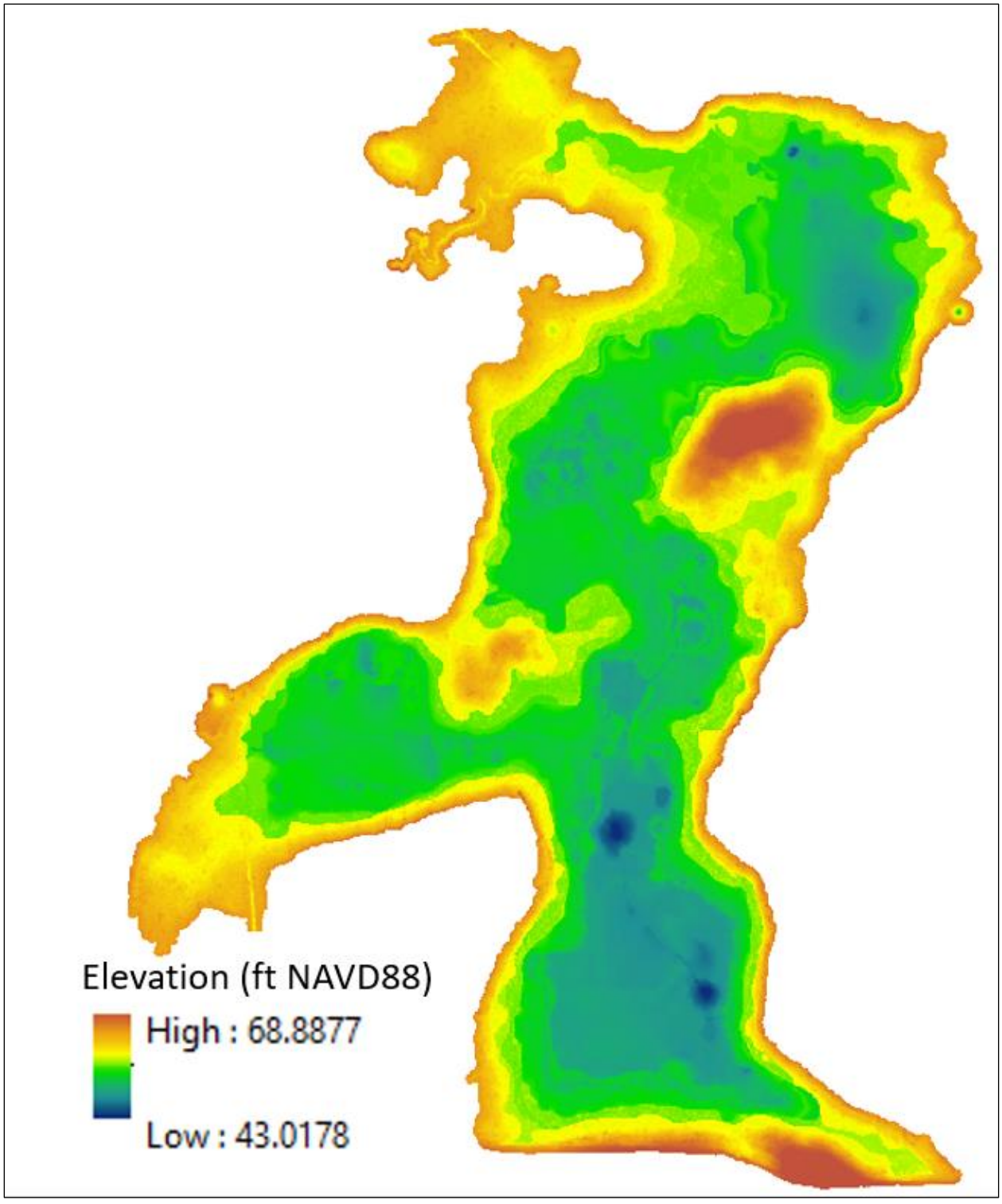

Figure F-5. The final FY23 topobathymetric DEM for Lake Prevatt.

REFERENCES

Fox, Sandra, Palmer Kinser, Lawrence Keenan, Clay Montague and Debra. Hydorn. 2012. Chapter 10, Appendix D. Hydroperiod Tool Analysis of St. Johns River Segment 7. SJ2012-1_Appendix10-D.pdf