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Dewberry Response to USGS Review of the NRCS Maryland LiDAR Processing Project

Produced for U.S. Geological Survey

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Table of Contents

Executive Summary

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the USGS NRCS Maryland LiDAR Project Area.

The LiDAR data were processed to digital surface models (DSM) and bare-earth digital terrain models (DTM). Detailed breaklines and bare-earth digital elevation Models (DEMs) were produced for the project area.

Deliverables for this project included raw point cloud data, classified point cloud data, first return digital surface models, bare earth not hydro-enforced digital terrain models, bare earth hydro enforced digital elevation models, intensity images, breaklines, control points, metadata, project report, and project extent shapefiles.

The USGS review of these deliverables resulted in six calls to remove bridges or bridge related artifacts, three calls to replace culverts, one call to add road bank points to ground, two general classification calls, one call to modify the elevation of a tidal area, four calls to collect and flatten additional hydro features, and one general LAS call for missing min/max scan angles and system IDs.

PROJECT AREA

Data was formatted according to tiles with each tile covering an area of 1500m by 1500m. A total of 833 tiles were produced for the project encompassing an area of approximately 605 sq. miles.

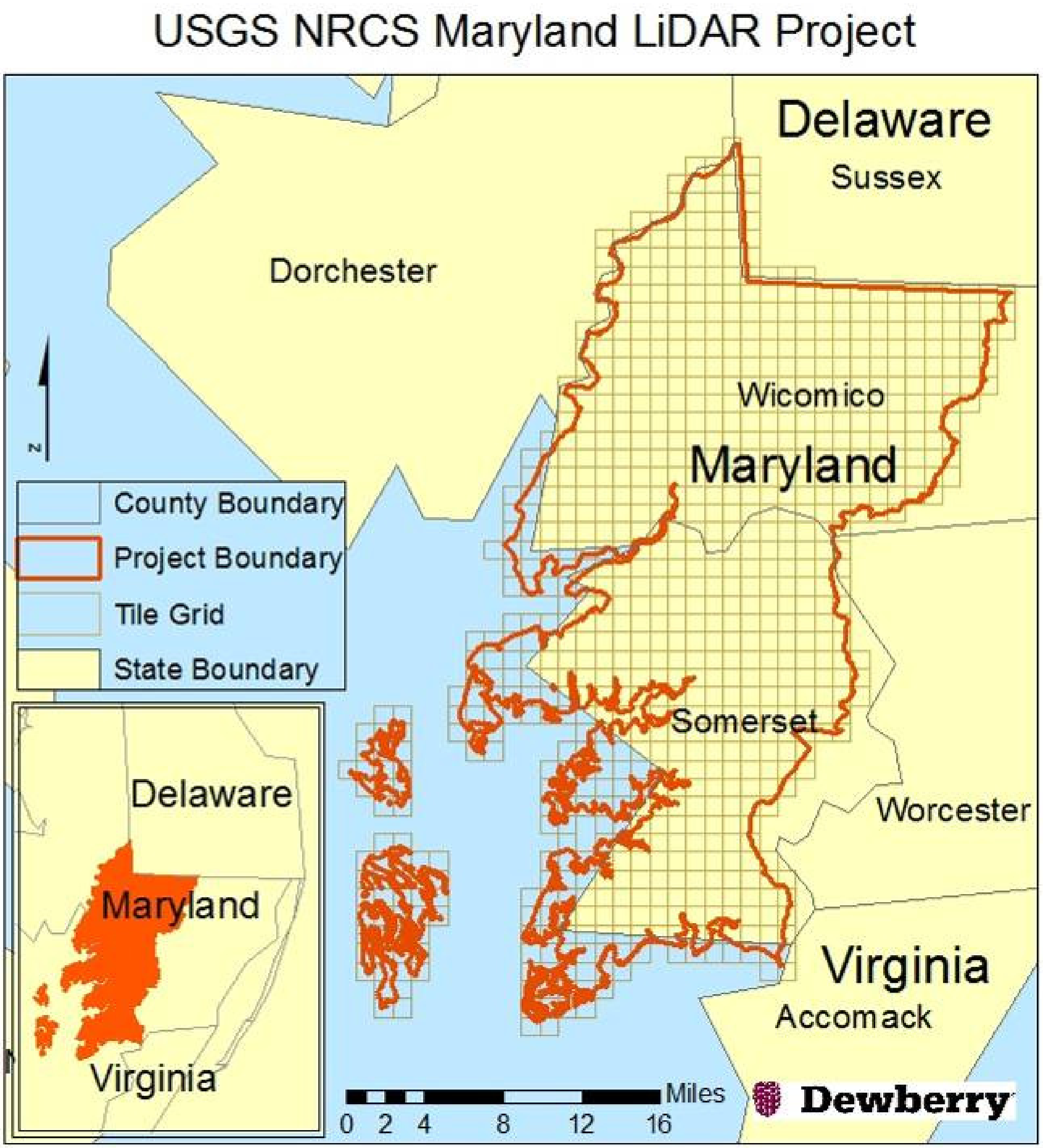

Figure 1- Project Map

Edit Calls

METADATA

Though it was not requested for this delivery, intensity metadata has been delivered based on comments received for other recent USGS projects.

ACCURACY TESTING

USGS' report states that the USGS accuracy testing yielded different results than Dewberry's accuracy testing. However, the Dewberry values stated in the USGS report do not fully match the values Dewberry stated in its metadata and final project report. Some of this confusion may have occurred because Dewberry tests the vertical accuracy of the data at three different stages in the overall process and all three different accuracies are reported in the different metadata files and in the final project report.

The first vertical accuracy Dewberry calculates is the FVA on the raw swath data. The acquisition provider will perform their own accuracy calculations, but Dewberry will verify the accuracy of the raw swath data with independent check points. This FVA value is reported in the swath metadata.

The second vertical accuracy Dewberry calculates is FVA, CVA, and SVA on the final classified LiDAR tiles. The USGS report lists the Dewberry reported SVA for tall weeds and crops and forested areas fully covered by trees as 0.215 m and 0.275 m, respectively. However, Dewberry's metadata and final project report list forest as 0.215 m and weeds/crops as 0.275 m. These two SVA values were reversed in USGS' report. Dewberry's calculated values are listed in the LAS and project metadata files and found in Table 13 in the final project report.

Dewberry then re-calculates the FVA, CVA, and SVA on the final DEM products. The vertical accuracy testing on the LiDAR ensures the source data meets project specifications and the vertical accuracy testing on the bare-earth DEMs ensures the final derived surface also meets project specifications. USGS' report lists Dewberry DEM accuracy values as the same as the LiDAR accuracy values. However, Dewberry DEM metadata and Table 16 in the final project report show that the DEM accuracy values are slightly different than the LiDAR accuracy values. The difference in the two sets of vertical accuracy values occurs because the DEMs are created by averaging several LiDAR points within each pixel to attain one elevation value per pixel. This elevation is then compared to the survey checkpoint located within the specified pixel. The elevation of LiDAR at a specified location, however, is derived by a linear interpolation between the three closest discrete LiDAR points. The different interpolation methods may result in slightly different accuracy values.

Additionally, the USGS report states that Dewberry used 59 checkpoints in our accuracy testing but Dewberry only used 58 checkpoints in the accuracy testing. Out of the sixty four checkpoints received from the surveyor, one was determined to be unusable by the surveyor. Five were not used in the final vertical accuracy testing done by Dewberry due to the presence of dense organic debris at the survey site. The surveyor's antenna rod was able to penetrate the debris at these sites while the LiDAR was not. The resulting difference in elevation, though only a few centimeters, was significant enough to justify the omission of these points. The checkpoints that were not included in the accuracy testing done by Dewberry are listed in the final project report along with photos of each location.

Below are Tables 13 and 16 from Dewberry's final project report. When Table 16, Dewberry's vertical accuracy results for the DEM deliverables are compared to USGS' accuracy results from the DEM deliverables, the biggest difference between the two calculated vertical accuracy sets is 0.002 m (assuming USGS reported values for the weeds/crops and forest land cover categories have been reversed as happened in the Dewberry reported values). Thus, Dewberry calculated vertical accuracies and USGS calculated vertical accuracies are either identical or nearly identical.

Land Cover Category	# of Points	FVA – Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=0.182 m	CVA – Consolidated Vertical Accuracy (95th Percentile) Spec=0.269 m	SVA – Supplemental Vertical Accuracy (95th Percentile) Target=0.269 m
Consolidated	58		0.267	
Open Terrain	21	0.157		
Grass Weeds Crops	19			0.275
Forest	18			0.215

FVA, CVA, and SVA Vertical Accuracy calculated from the classified LiDAR tiles (Table 13 in the final project report)

Land Cover Category	# of Points	FVA – Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=0.182 m	CVA – Consolidated Vertical Accuracy (95th Percentile) Spec=0.269 m	SVA – Supplemental Vertical Accuracy (95th Percentile) Target=0.269 m
Consolidated	58		0.260	
Open Terrain	21	0.157		
Grass Weeds Crops	19			0.264
Forest	18			0.252

FVA, CVA, and SVA Vertical Accuracy calculated from the bare-earth DEM deliverables (Table 16 in the final project report)

LAS TILES

USGS was unable to view min/max scan angle and system ID information for the LAS files. While scan angles are verified by Dewberry prior to delivery, all LAS tiles were re-verified that they contained appropriate scan angle information. USGS resolved the min/max scan angle issue as it was resulting from an issue with the set-up of their software or quality checks. The system ID information for all LAS tiles has been added and all tiles have been redelivered. USGS identified artifacts and missing water features in the delivered data. These calls resulted in the modification of seventeen LAS tiles. The seventeen modified LAS tiles have also been redelivered.

BRIDGE REMOVAL

There were three locations where Dewberry interpreted a feature as a culvert and included it in the ground surface. USGS identified these features as bridges, not culverts. Dewberry has modified the points and removed these features from the ground surface.

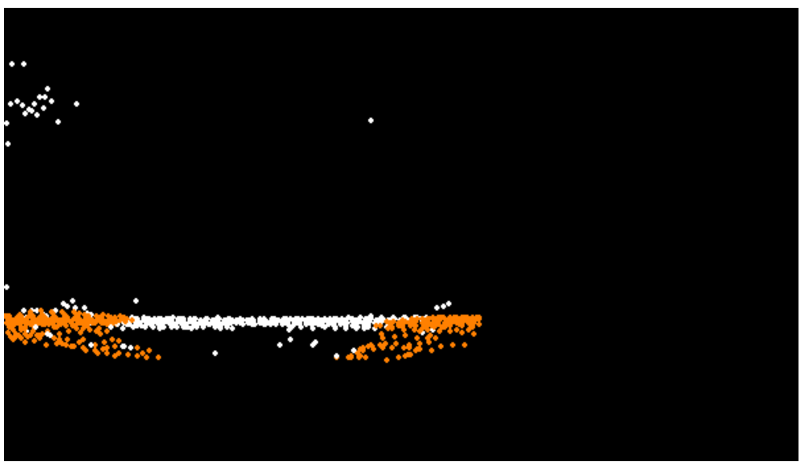

Figure 2- Tile 18SVH284403. Bridges have been removed from ground (orange) and reclassified to class 1 (white)

BRIDGE REMOVAL ARTIFACTS

There were three locations where USGS made calls regarding visual artifacts. The DEM surface models are created from TINs or Terrains. TIN and Terrain models create continuous surfaces from the inputs. Because a continuous surface is being created, the TIN or Terrain will use interpolation to triangulate across a bridge opening from legitimate ground points on either side of the actual bridge. This can cause visual artifacts or “saddles.” These “artifacts” are only visual and do not exist in the LiDAR points or breaklines. No points were modified in these locations.

Figure 3-Tile 18SVH479493. No additional points can be removed from ground classification. Bridge "saddles" are a visual artifact resulting from interpolation of a continuous surface.

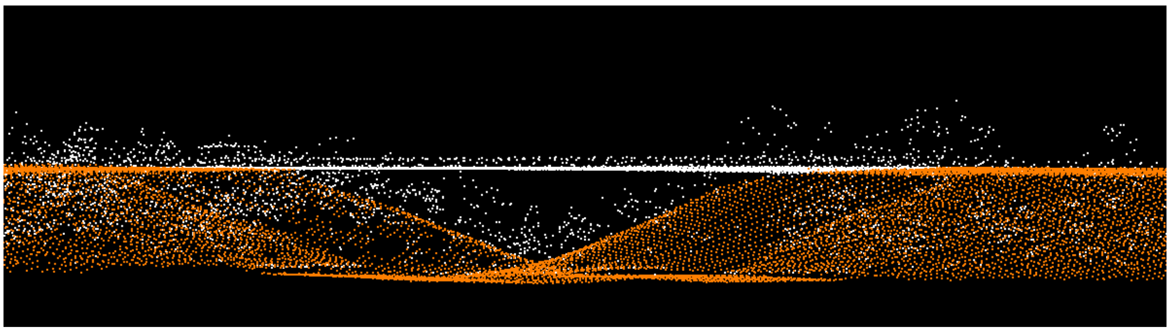

Figure 4-Tile 18SVH494493. No additional points can be removed from ground classification. Bridge "saddles" are a visual artifact resulting from interpolation of a continuous surface.

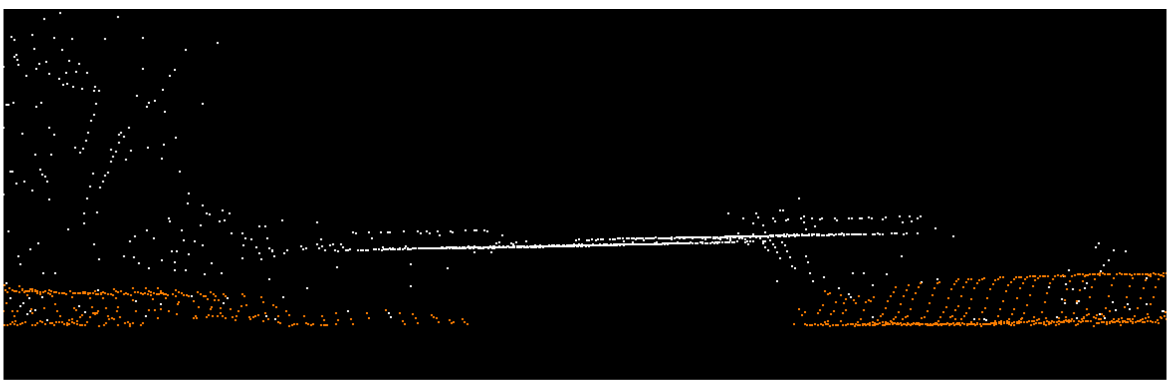

Figure 5-Tile 18SVH389298. No additional points can be removed from ground classification. Bridge "saddles" are a visual artifact resulting from interpolation of a continuous surface.

CULVERT REPLACEMENT

There were three locations where Dewberry interpreted a feature as a bridge and removed it from the ground surface. USGS identified these features as culverts, not bridges. Dewberry has modified the points and added these features to the ground surface. An example is shown below.

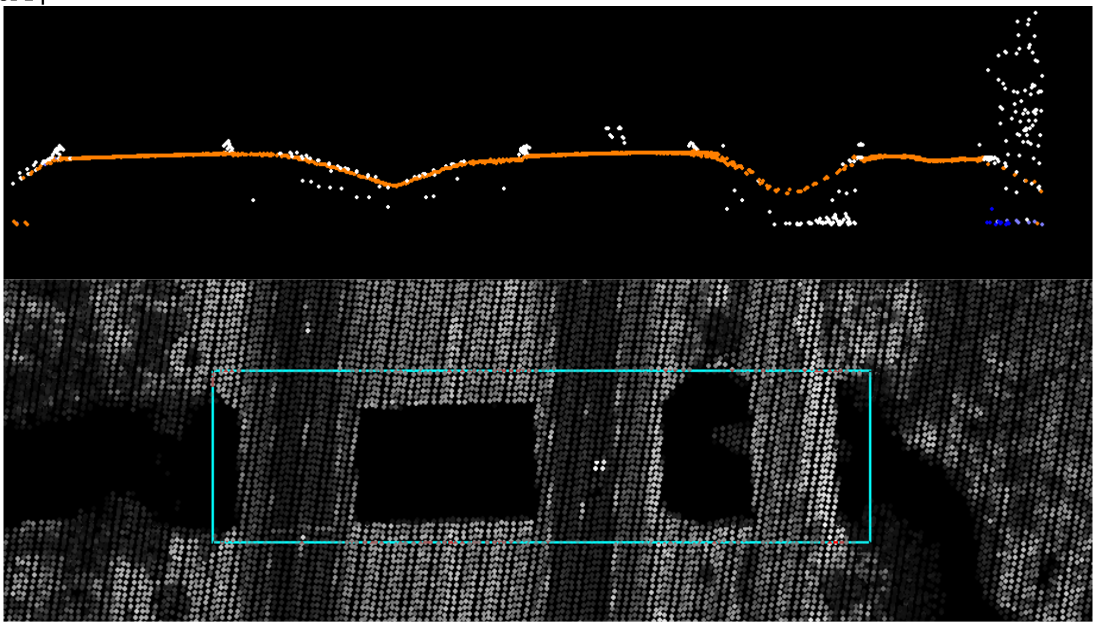

Figure 6-Tile 18SVH389238. Culverts have been reclassified from class 1 (white) to ground (orange).

ARTIFACTS

There were two calls to remove features from the ground surface. At first glance these areas may resemble vegetation. However, as the profile shows, the vegetation has been removed and the small mounds are correctly left in the ground. There was one call to add points to ground along a road bank. Points were modified and additional points were added to the ground surface. Examples are shown below.

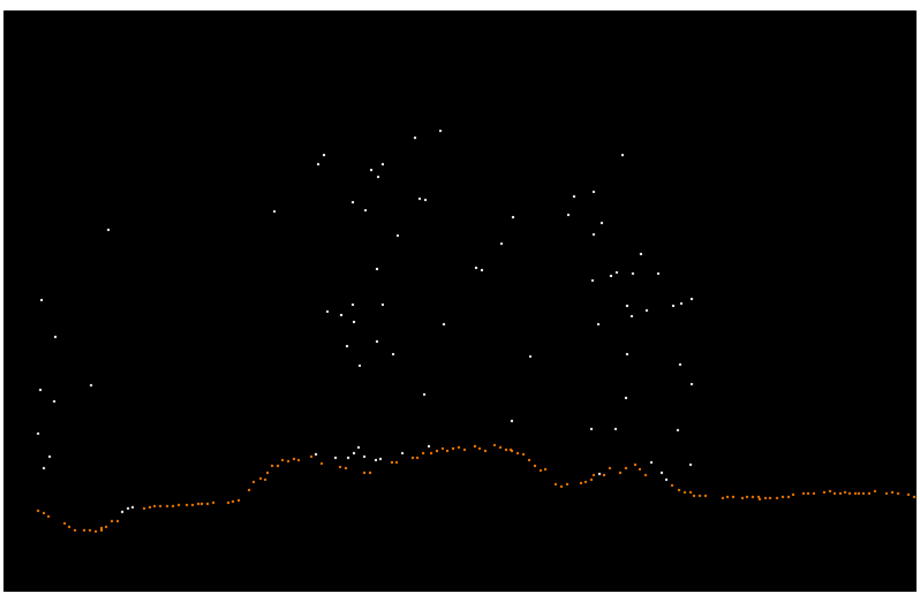

Figure 7-Tile 18SVH494553. All vegetation points have already been removed from ground (orange). No modification required as mounds are legitimately part of the ground surface.

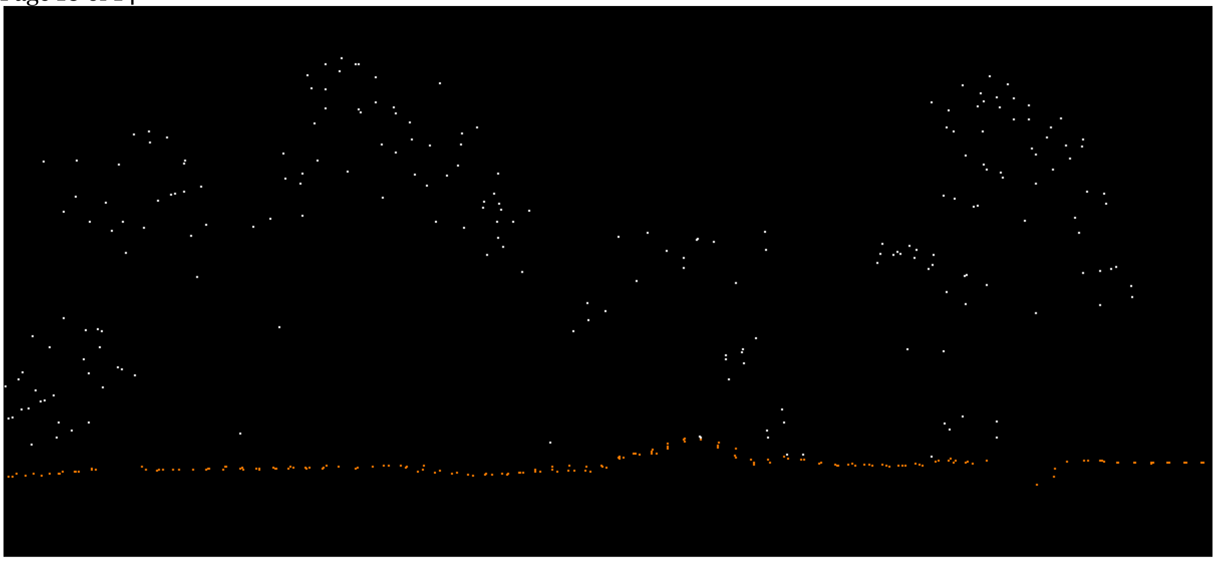

Figure 8-Tile 18SVH374538. All vegetation points have already been removed from ground (orange). No modification required as mounds are legitimately part of the ground surface.

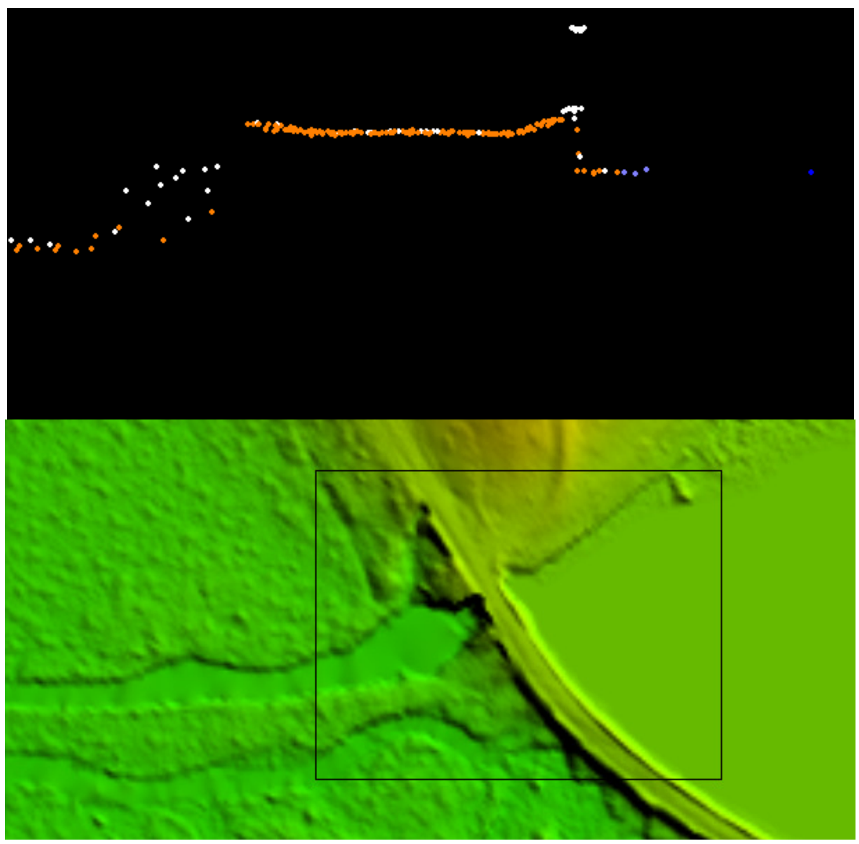

Figure 9-Tile 18SVH344568. Additional points have been added to the ground (orange)to fully model the road feature in the redelivered DEM.

BREAKLINE ADJUSTMENTS

There were four locations where USGS identified areas of water that were not included in the collected breaklines. While the interpretation of the feature may be questionable in the intensity imagery, Dewberry agrees with all four calls after reviewing color imagery and the available LiDAR points. There is one location called out by USGS where the elevation of the breaklines was too low. After reviewing the LiDAR, Dewberry confirmed that the elevation was not accurate and modified the elevation of the breaklines up stream of the structure/ spillway.

Figure 10 - Tiles 18SVH299583, 18SVH314583, 18SVH299568, and 18SVH314568. An additional pond breakline has been collected for this feature and used to flatten the feature in the redelivered DEM. The LAS have been corrected to reflect the addition of this feature.

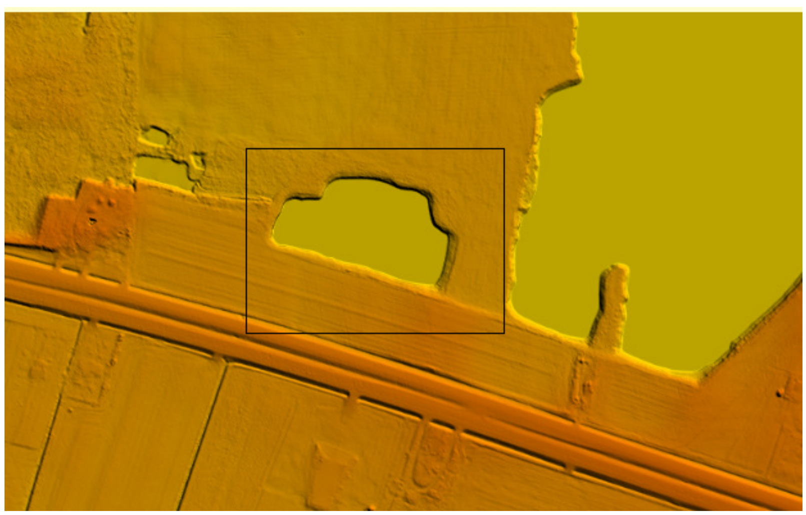

Figure 11 – Tiles 18SVH359553 and 18SVH374553. An additional pond breakline has been collected for this feature and used to flatten the feature in the redelivered DEM. The LAS have been corrected to reflect the addition of this feature.

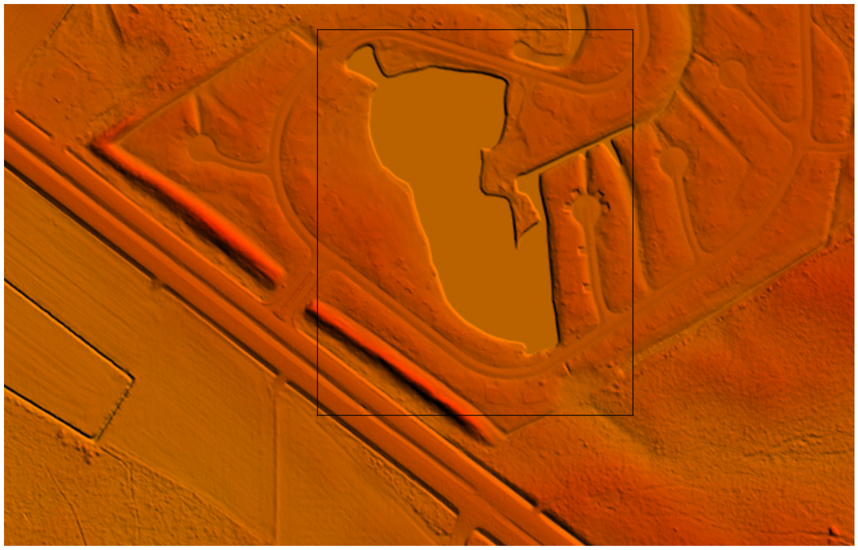

Figure 12 – Tile 18SVH389538. An additional pond breakline has been collected for this feature and used to flatten the feature in the redelivered DEM. The LAS has been corrected to reflect the addition of this feature.

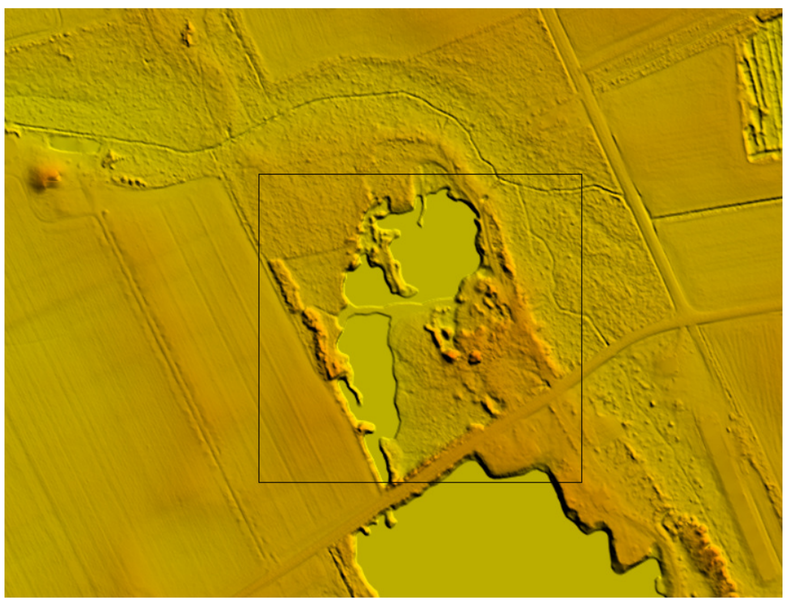

Figure 13 – Tile 18SVH359508. An additional pond breakline has been collected for this feature and used to flatten the feature in the redelivered DEM. The LAS has been corrected to reflect the addition of this feature.

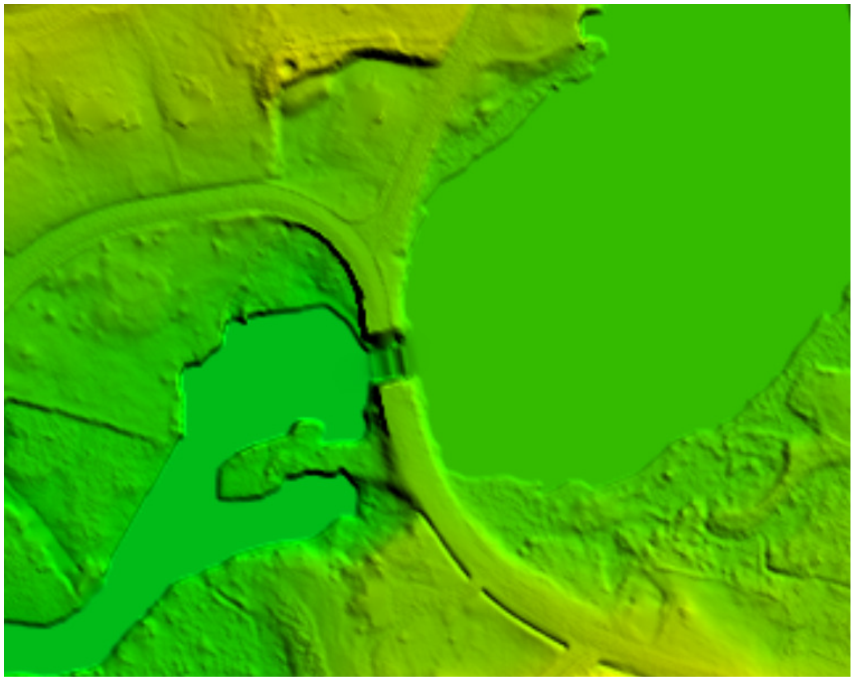

Figure 14 - Tile 18SVH389373. Elevation of breakline has been raised upstream of the spillway and stepped down to the lower tidally influenced area, as shown in the DEM above.

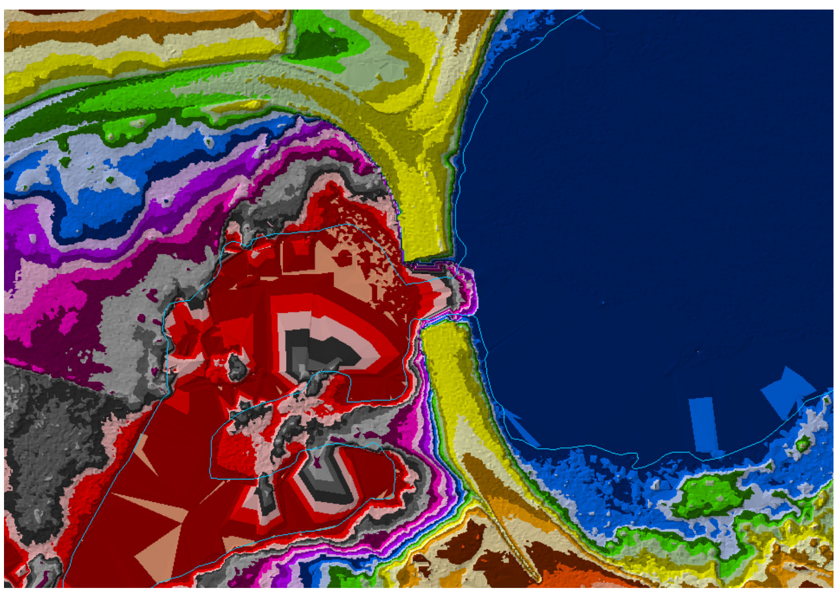

Figure 15 – Tile 18SVH389373. The terrain shows the sudden drop in elevation at the spillway and why Dewberry stepped the elevations to tie the higher elevations upstream of the spillway to the lower elevation downstream of the spillway.

Summary of Edit Calls

- Intensity ortho metadata has been created and delivered.

- There was one call regarding the accuracy testing.
  - The difference in accuracy testing results is likely due to confusion between the LiDAR accuracy results and the DEM accuracy results. Please see explanation in the above section.

- One general LAS call for missing scan angles and missing system IDs.
  - All 833 classified LAS tiles have been redelivered with corrected system IDs.
  - The scan angle issue was determined by USGS to be an issue with their software and not an issue with the data itself. No changes were made to the scan angles.

- There were six calls to remove bridges or bridge related artifacts.
  - Three of these issues have been corrected.
  - There were three calls where no changes were necessary because the artifacts are only visual and do not exist in the data itself.

- There three calls to replace culverts.
  - All available points have been added back to ground at these three locations.

- There was on call to add road bank points back to ground.
  - This issue has been corrected.

- There were two calls to remove artifacts from ground.
  - No changes were necessary in these areas as the features are legitimate ground features.

- There was one call to modify the elevation of a tidal area.
  - The breakline elevations have been corrected in this area.

- There were four calls to modify breaklines.
  - All four of these issues have been corrected.