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DEWBERRY RESPONSE TO USGS FISH SPRINGS TOPOBATHYMETRIC LIDAR

Produced for U.S. Geological Survey

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1. 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 Fish Springs Topobathymetric Lidar Project.

The lidar data were processed to bare-earth/bathymetric bottom digital terrain models (DTM). Bare-earth/bathymetric bottom digital elevation Models (DEMs) were produced for the project area.

Deliverables for this project included classified point cloud data, bare earth topobathymetric digital elevation models, intensity images, refraction extents, void polygons, control points, metadata, project report, flightline index and project extent shapefiles.

The Stakeholders review of the final data resulted in three questions, listed below. Each question is discussed in more detail in the Response section of this document.

1. “Image 1 provides a clear look at a submerged channel (using the 10cm ortho imagery). The second image shows this channel as a higher elevation in the DEM.”
2. “The remaining images demonstrate our confusion at how the Refraction polygons were created (and used) as they do not seem encapsulate what can be easily photo-interpreted in the 10 cm imagery as open water. Are we missing something here in terms of the green laser technology? We also included a CIR image from the same date captured from Sentinel 2 imagery which helps delineate standing water. Adding to the confusion is these polygons seem to directly influence the las point classification. Some open water pools are excluded while many dry channels (with vegetation) and clear upland areas are included. We would have expected the large dry basins on the north end of the refuge to be classed as ground.”

3. "The last example also shows another instance where the refraction extent is drawn considerably different and its effects on the las point classification. This does not make sense to us. While the overall DEM surfaces look good and the surveys indicate the accuracy is acceptable, we have these concerns which we can't square up."

2. Project Area

Data was formatted according to tiles with each tile covering an area of 1,000 m by 1,000 m. A total of 98 tiles were produced for the project encompassing an area of approximately 29.5 sq. miles.

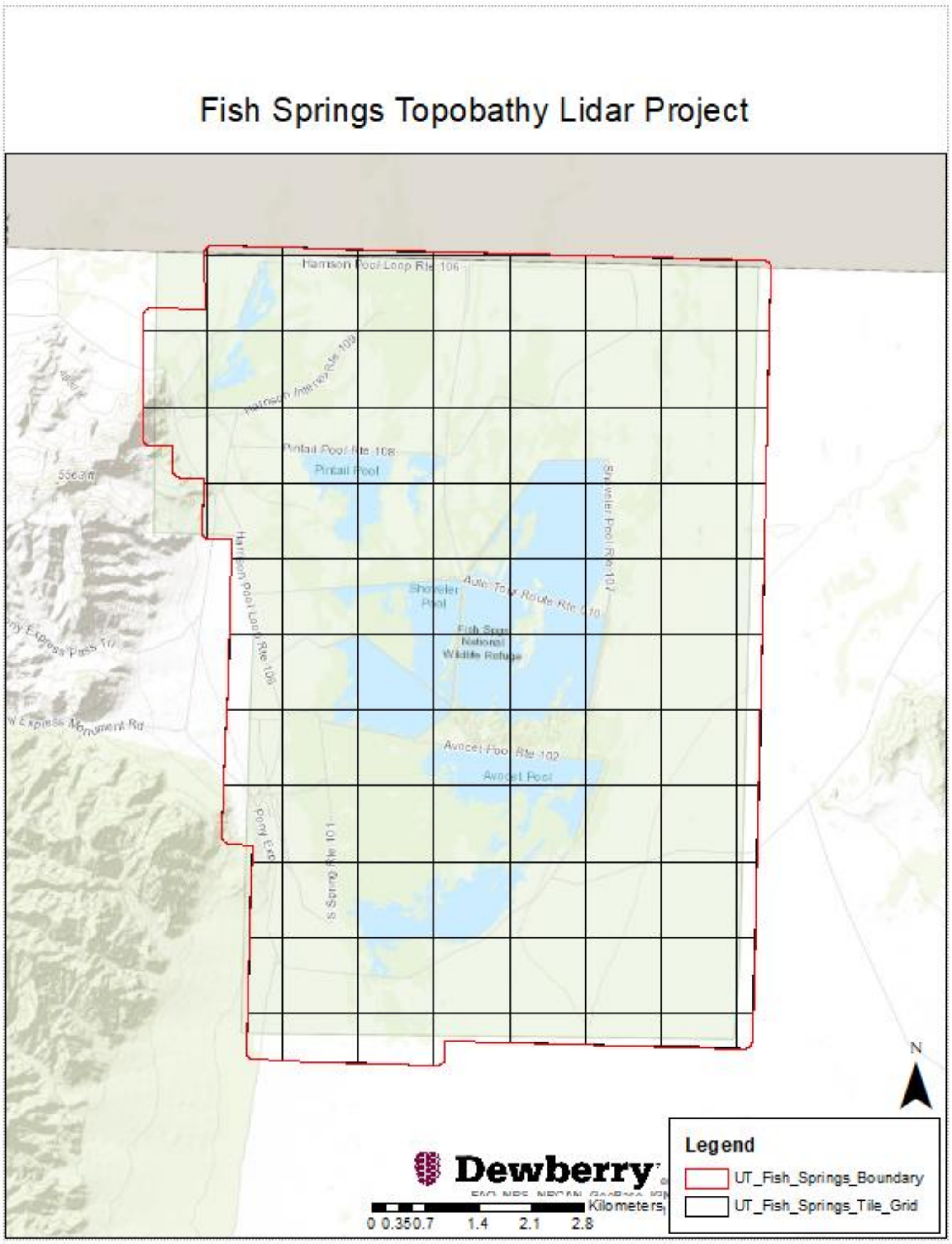


Figure 1. Project Map

3. Response

The Stakeholders had three remaining questions as outlined below.

Question 1

“Image 1 provides a clear look at a submerged channel (using the 10cm ortho imagery). The second image shows this channel as a higher elevation in the DEM.”

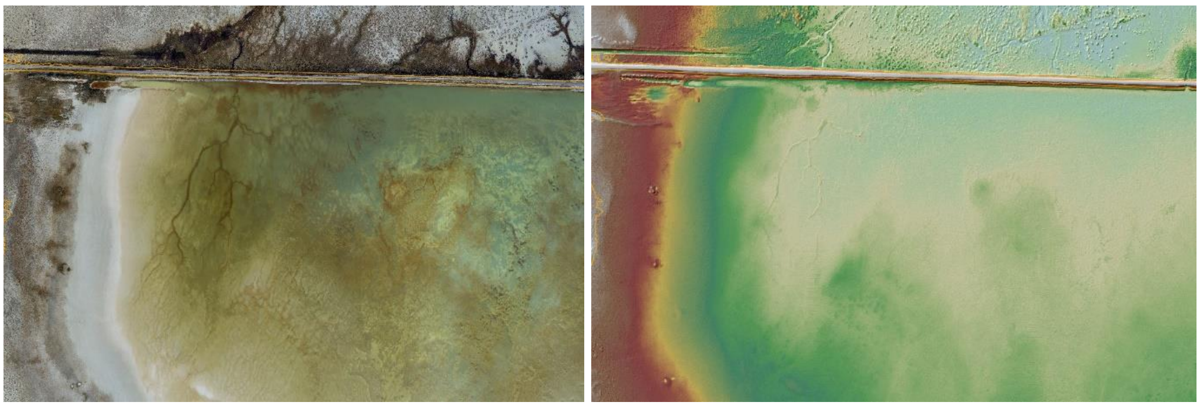


Figure 2. Images 1 and 2 from Stakeholder, showing channel in question via orthoimagery (left image) and the delivered topobathymetric DEM (right image).

The feature in Figure 2 is located in tile 12STK980190. The US Fish and Wildlife Service (USFWS) identified a channel that appeared higher in elevation in the digital elevation model (DEM). The point cloud shows a consistent, well-modeled feature, which is why Dewberry had originally classified it as bathy bottom (class 40). Dewberry investigated this channel further and verified that this feature has always been raised/elevated in all versions of data; the higher elevations were not introduced from refraction correction, or any other processing performed by Dewberry. From imagery, it appears as though the channel could be vegetated, but the point cloud does not represent variations in lidar returns typically associated with vegetation, even low vegetation. There is a potential that algae or some other smooth aquatic vegetation was present in the channel at the time of collect.

Dewberry requested a field check be conducted at this area to better quantify the area in question. Dewberry classified the channel to reflect field verification and/or client preferences which had the feature in question reclassified to water column, and to interpolate across the feature rather than void out in the DEM. Figures 3 and 4 compare the channel as delivered, modeled in bathy bottom, to a topobathymetric DEM and lidar point cloud profile of the channel when the elevated feature is reclassified to water column.

FWS did go out and get eyes on the area in question- the Gadwall drainage area, however “wind/wave action and turbid water made if difficult to get pictures of the exact area in question. It was determined that the bulk of the feature is vegetated, mostly with spiral ditchgrass, a submerged aquatic plant that is seen throughout the refuge. Tellingly, it grows in dense patches in drainages and ditches. That would align with FWS’s contention of what this feature is on the ground. Figure 5 shows the vegetation in question, but without a drone mounted camera- which is not allowed within the restricted airspace, this is all that could be provided at this time. The vegetation in question is both dense beneath the surface, and floating to the surface in patches.”

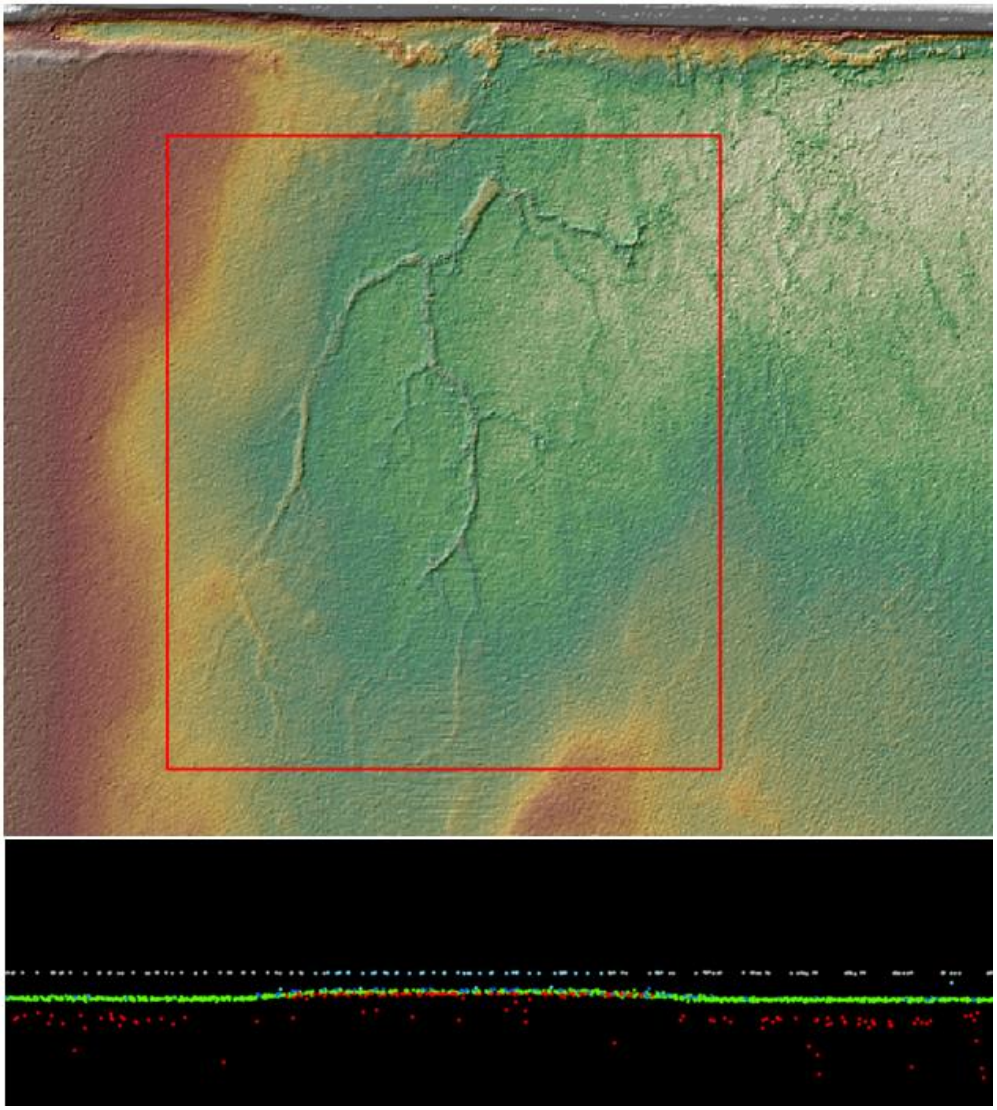


Figure 3. A lidar cross-section of the feature in question shows that the bathymetric ground surface is raised in the initial delivery. Profile shows a gradual and natural elevation gradient with no obvious indication of vegetation. Class 1 (unclassified) is shown in grey, class 7 (low noise) is shown in red, class 40 (bathymetric ground) is shown in green, class 41 (water surface) is show in light blue, and class 45 (water column) is shown in dark blue.

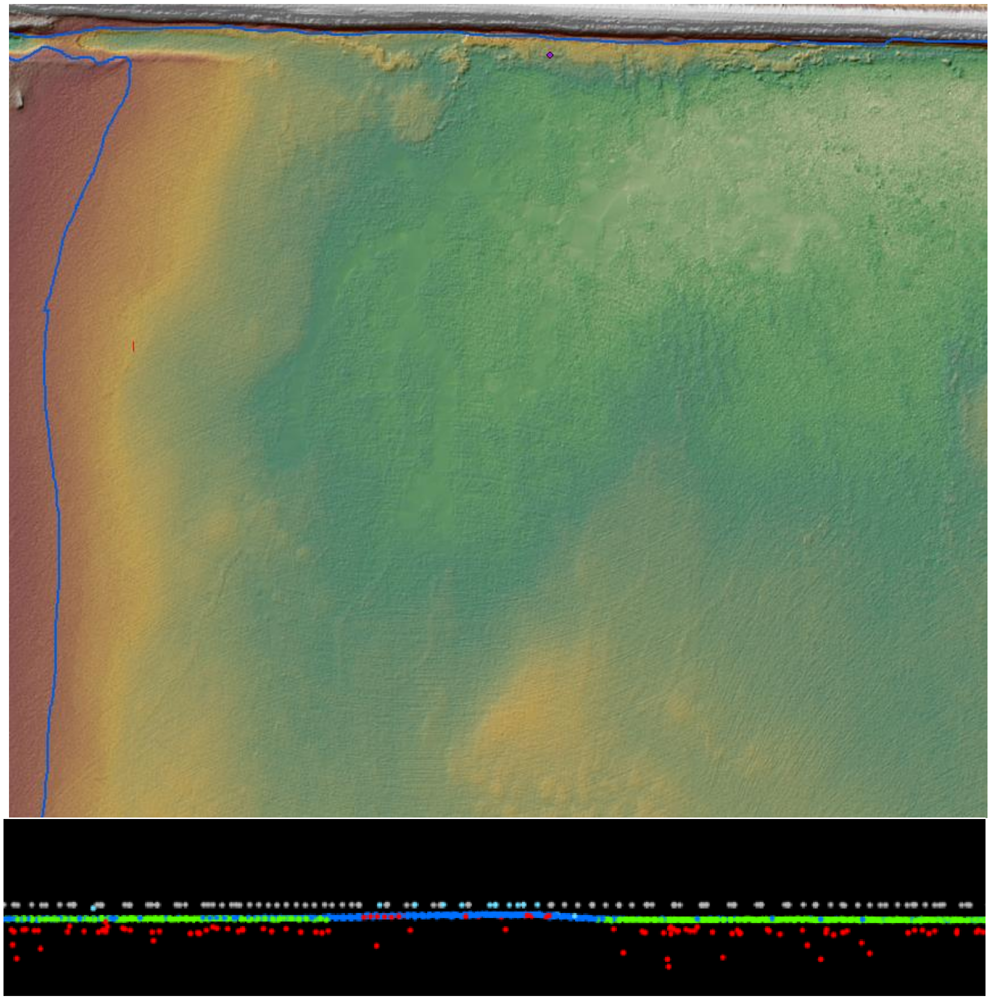


Figure 4. A lidar cross-section of the feature in question shows the results when bathymetric ground classification is adjusted to remove the slightly raised area. Additional voids are introduced in the DEM due to a lack of sufficient bathy bottom coverage. This lack of coverage is based on the assumption that the raised area is part of some sort of algae or aquatic vegetation and there does not appear to be any surface beneath to indicate bathy bottom coverage was acquired for this particular area. Class 1 (unclassified) is shown in grey, class 7 (low noise) is shown in red, class 40 (bathymetric ground) is shown in green, class 41 (water surface) is show in light blue, and class 45 (water column) is shown in dark blue.

Figure 5. FWS image of spiral ditchgrass within the Gadwall drainage.

Question 2 & 3

Questions 2 and 3 are related.

Question 2: "The remaining images demonstrate our confusion at how the Refraction polygons were created (and used) as they do not seem encapsulate what can be easily photo-interpreted in the 10 cm imagery as open water. Are we missing something here in terms of the green laser technology? We also included a CIR image from the same date captured from Sentinel 2 imagery which helps delineate standing water. Adding to the confusion is these polygons seem to directly influence the las point classification. Some open water pools are excluded while many dry channels (with vegetation) and clear upland areas are included. We would have expected the large dry basins on the north end of the refuge to be classed as ground." See Figures 5-6.

Question 3: "The last example also shows another instance where the refraction extent is drawn considerably different and its effects on the las point classification. This does not make sense to us. While the overall DEM surfaces look good and the surveys indicate the accuracy is acceptable, we have these concerns which we can't square up." See Figures 7-8.

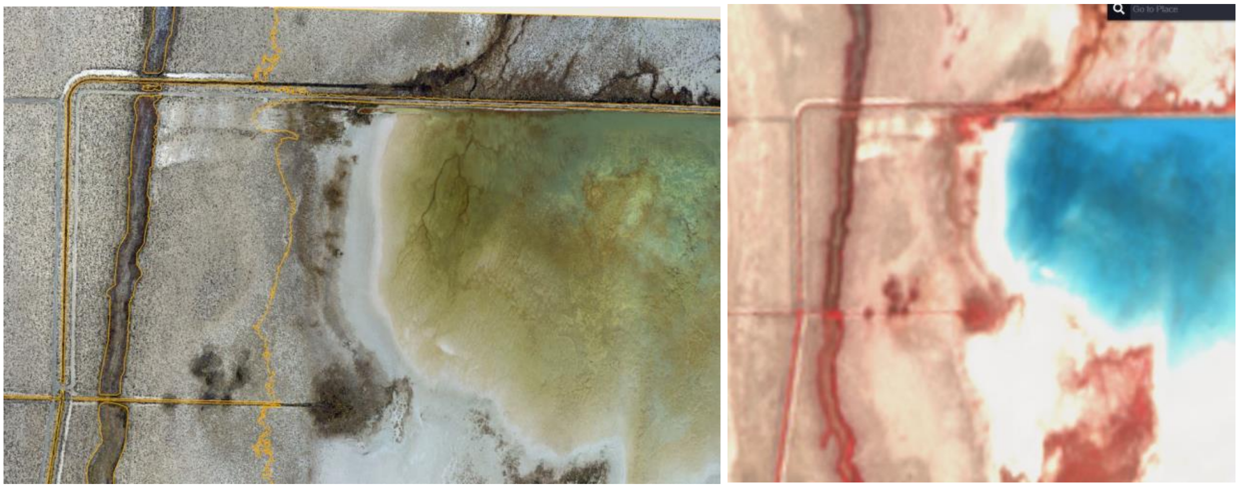


Figure 6. Images 3 and 4 from Stakeholder.

Figure 7. Image 5 from Stakeholder.

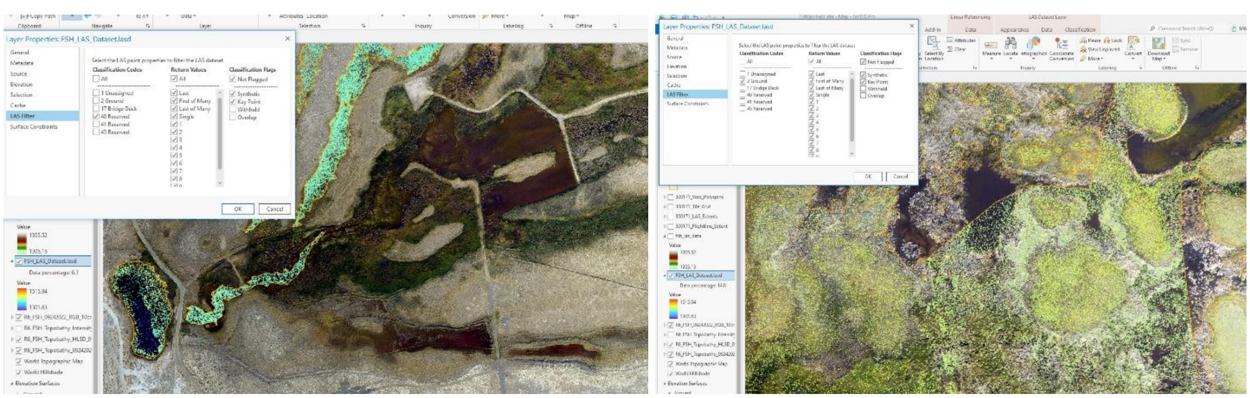


Figure 8. Images 6 and 7 from Stakeholder, showing bathy bottom (class 40) classified points within refraction extents (left image) and ground (class 2) classified points outside of refraction extents (right image).

Dewberry's refraction extent polygons are intended to show the extent of where refraction correction was applied and are used to delineate ground- class 2 vs. bathy bottom- class 40 classification in the final point cloud.

Upon further review it was determined that an incorrect, earlier version of the refraction extents was used for the final classification and delivered to USGS (Figure 9). Dewberry generates a couple different versions of refraction extents throughout our production process. The first version, incorrectly delivered, is a much more expansive version of "potential" areas requiring refraction correction. This version is used to help us determine where water may be present. This version is then reviewed and revised, using a combination of DEMs, ortho imagery, intensity, Max Height Separation Raster (MHSR), difference rasters, and additional ancillary datasets, to reflect the actual extent of bathy bottom deep enough to require refraction correction. Priority is given to substantial areas that were clearly wet or could be perceived as wet. Some nominal areas of potentially wet ground were not collected when perceived dense vegetation was also present (Figure 10). These vegetated areas often appear as darker features in the intensity but do no correlate well to the ortho imagery and/or MHSR. In addition, Dewberry did not include areas that could be perceived as dry or mostly dry floodplains as they did not meet the depth criteria for refraction corrections, nor could they be clearly perceived as wet (Figure 11).

Lastly, Dewberry applies ground (class 2) and bathy bottom (class 40) classifications based on the refraction extents so that all grounded points within the refraction extents are classed to class 40 and all grounded points outside of the refraction extents are classed to class 2.

Dewberry has verified that the refraction correction was correctly applied to the Fish Springs lidar point cloud, but that the incorrect version of refraction extents was used for the final classification steps. Dewberry has updated the lidar point cloud classification to match the correct, final version of refraction extents (Figure 12 and Figure 13). The updated lidar point cloud and correct version of refraction extents will be redelivered. The redelivered refraction extents and updated point cloud resolves questions 2 and 3. This correction does not impact the delivered topobathymetric DEMs.

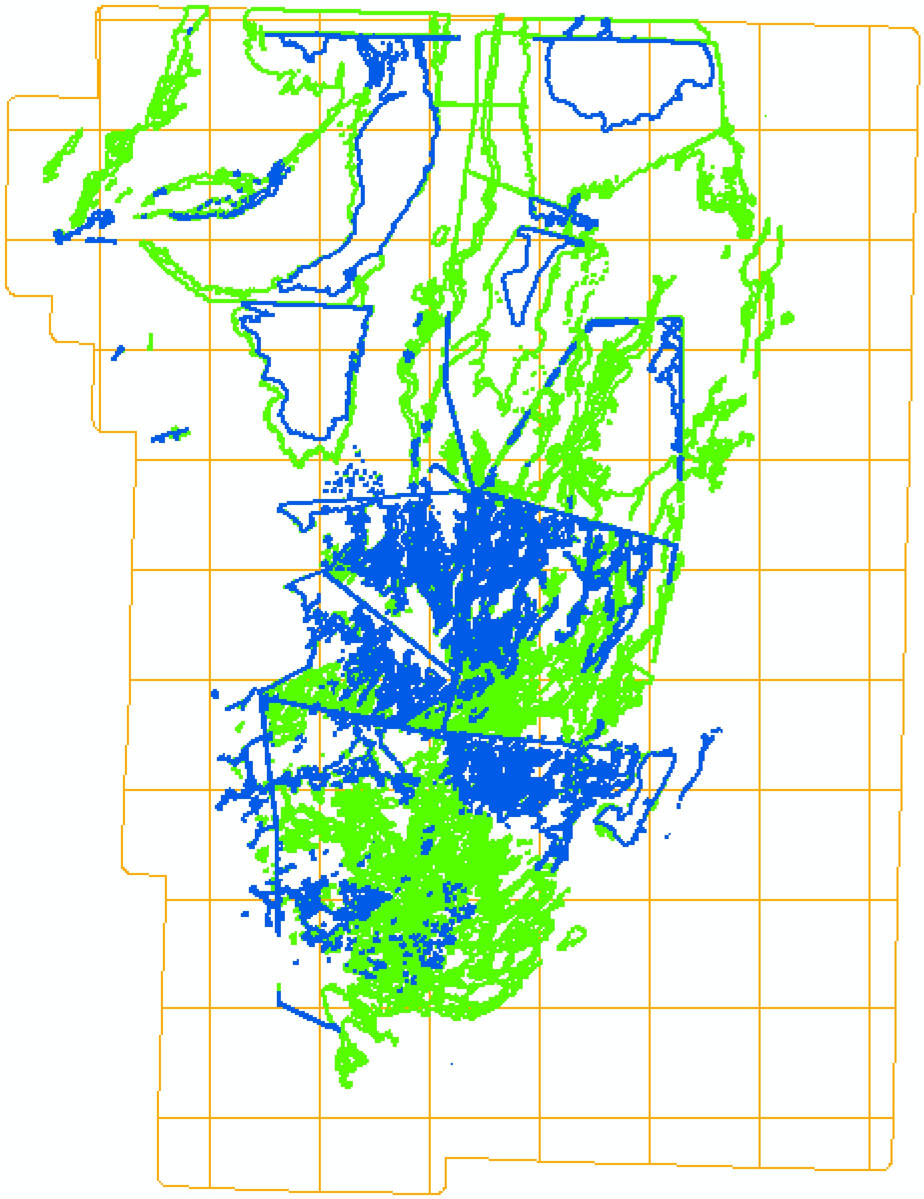


Figure 9. An overview showing the difference between the initially derived and delivered refraction extents (green) compared to the final version of refraction extents (blue). The initial set of refraction extents (green) were generated and were to only be used internally by Dewberry to help identify areas that were potentially wet. The set of refraction extents in blue show the true areas where refraction corrections took place and includes areas that could be clearly perceived as wet.

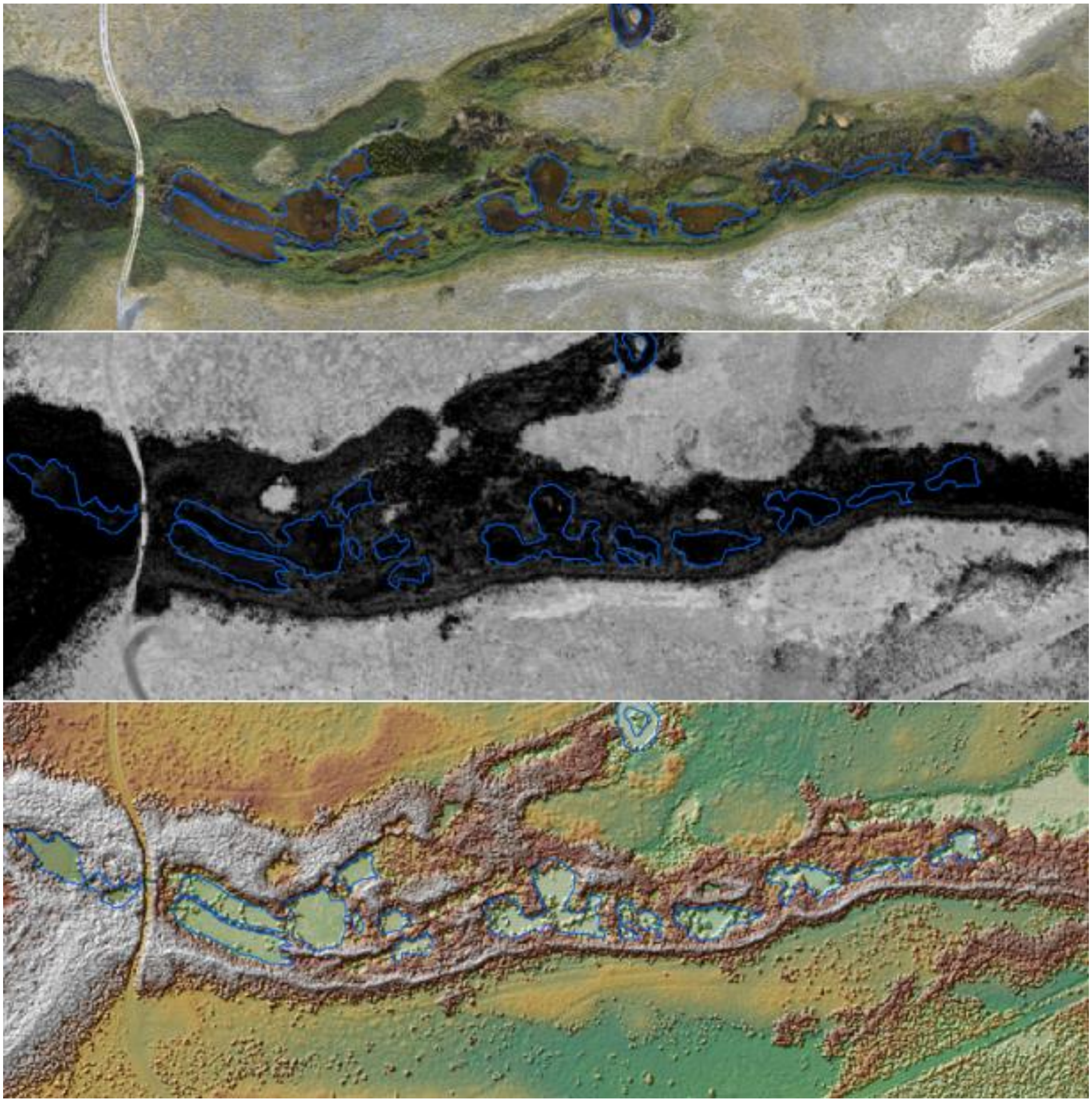
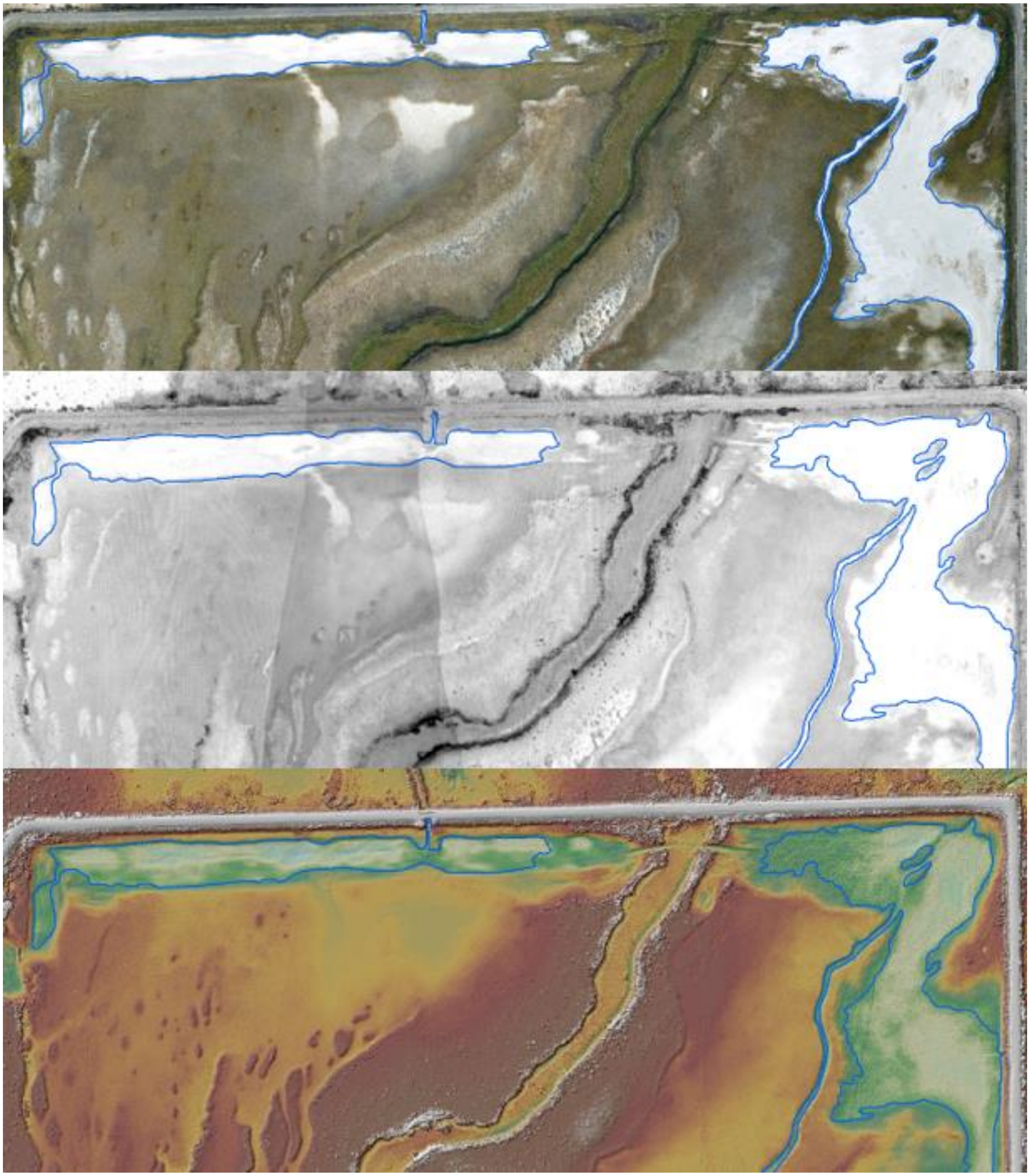


Figure 10. An example of a nominal area of potentially wet ground, as suggested by the intensity, that was not collected in the refraction extents (blue polygons) due to the perceived dense vegetation. Only the “pools” of open water containing bathy bottom and detected water surface points were refracted.



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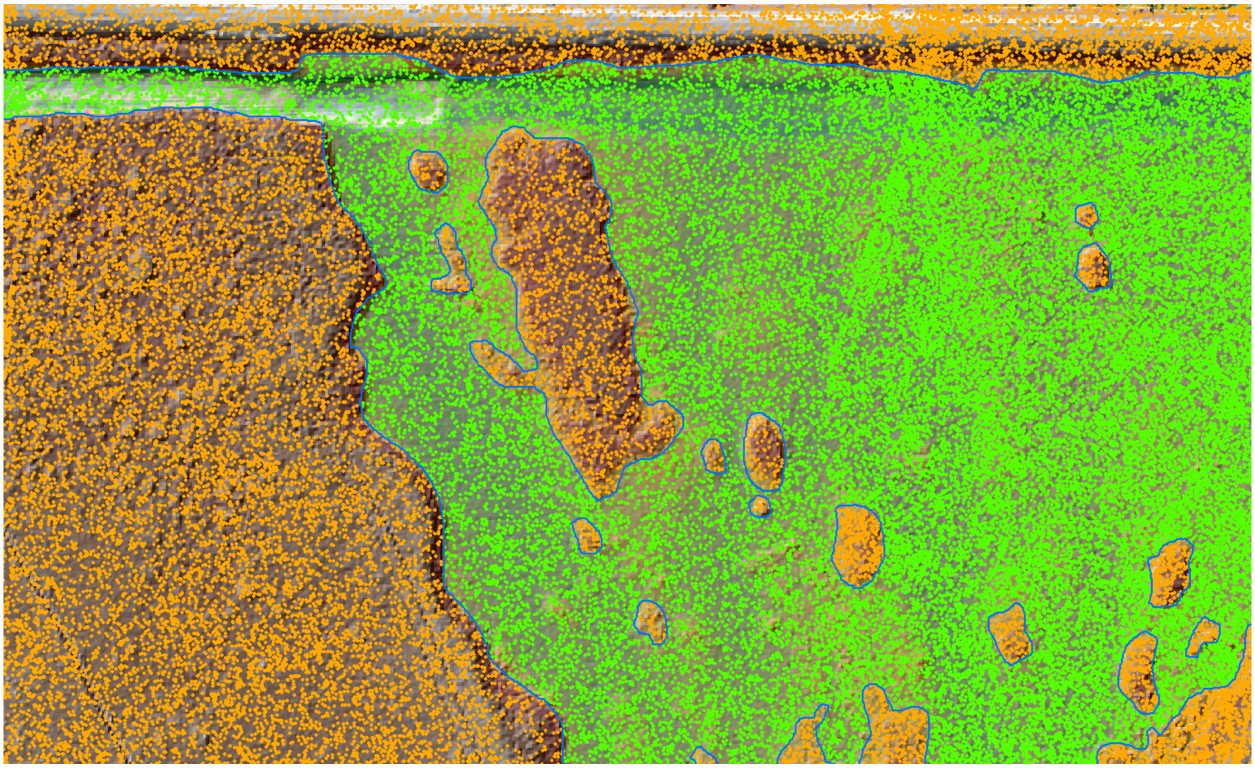

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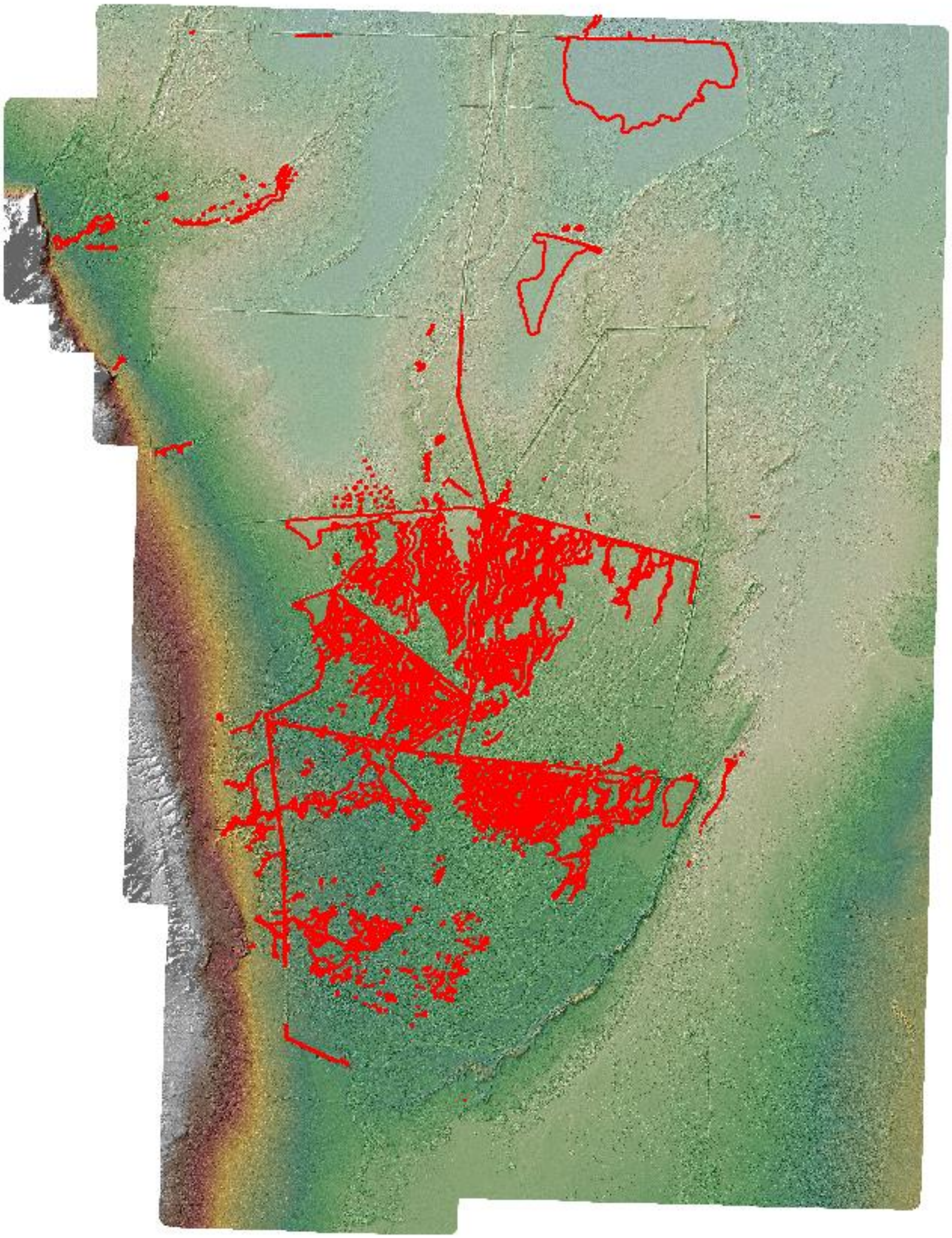

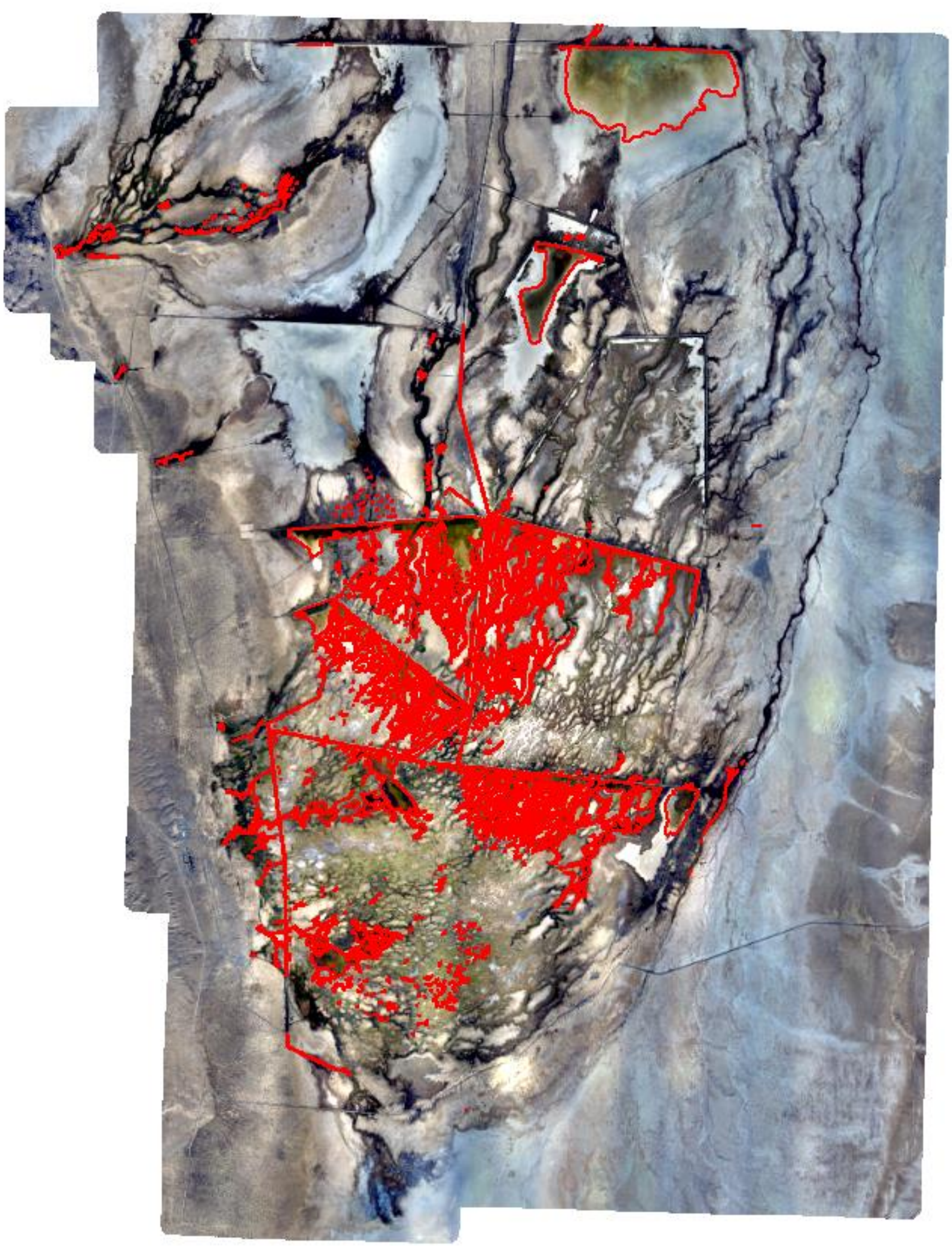

Figure 13. Final set of refraction extents for the full AOI. The top image has the refraction extents overlaid on top of the DEM, the bottom image the refraction extents overlaid on top of the ortho-imagery.

Ortho Imagery Review

It was noted that there were several areas on the orthoimagery that contained smearing or other anomalies. The original orthos were created utilizing lidar that was not 100% finalized in order to meet the delivery deadline. Some of the above ground features that had not been completely classified out resulted in a surface that caused these anomalies. All orthos were reprocessed with the finalized lidar, which corrected the noted smears and anomalies (Figure 14).

Figure 14. An example of area that was impacted by the surface anomaly. Top image shows the warp caused by the powerlines and in the bottom image it is repaired.

There is one area of seamlines that did not color balance and blend as well in the reprocessing (Figure 15). Due to the nature of seamlines in such a vast open and flat area such as the desert or over open water there are often visible edges similar to this. Since all orthos were reprocessed it is also not possible to use the old tiles for this area as they would not match perfectly along the edges leading to visible pixel mismatch along the edges of the tiles.

Figure 15. Area affected by seamline visibility.

There is one void in the orthos that was previously noted as well (Figure 16). Dewberry proposed to patch in some older imagery in order to have a seamless dataset. This void is noticeable as there are temporal, color balance, and resolution differences. It was determined that the imagery could be accepted this way as the void is outside of the preserve boundary.

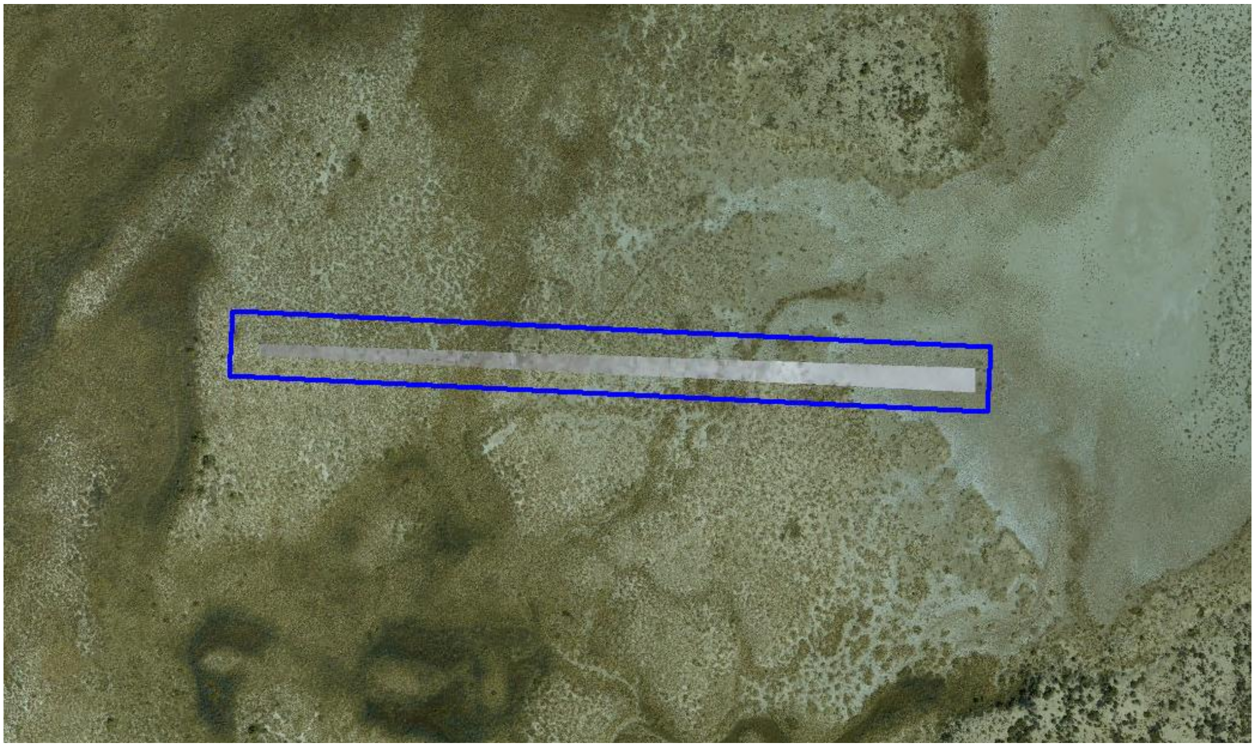

Figure 16. Area affected by void with patched in data.