Deliverable: QA Report for Mobile County, AL Lidar

Project 15: Elevation and Inundation

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Jamie Carter

The Baldwin Group, Inc.
Contract #EA133C-13-NC-0616
National Oceanic and Atmospheric Administration

Deliverable Summary

I. Staff involved in developing deliverable and their roles

This deliverable was completed by Rebecca Mataosky, Eric Morris, and Jamie Carter.

Rebecca Mataosky and Eric Morris performed the vertical accuracy determination and reviewed a sampling of the las files. Jamie Carter provided initial guidance and reviewed the document.

II. Description and timeframe of how the deliverable was accomplished

An agreement letter was signed between the City of Mobile, Alabama and the NOAA Office for Coastal Management (OCM) on November 18, 2013. The agreement provided the City of Mobile with a quality assurance (QA) report and in return, OCM would receive a final copy of the lidar data . The data would be publicly available via NOAA's Digital Coast.

However, during a phone call on October 27, 2014, the City of Mobile indicated that the USGS had become involved in the project with the intention of performing a full quality assurance assessment for this data set. The City of Mobile indicated that OCM would no longer need to provide an assessment. However, OCM had already received a copy of the lidar data. The federal task lead asked that a basic assessment of the data still be completed and would be acceptable as the deliverable. This task would serve as an internal development opportunity for the lidar team members. The assignment introduced team members to the level of effort needed for a task such as this, increased familiarity with lidar and the elevation accuracy assessment software in place (MARS 7.1) and provided exposure to vertical accuracy determination techniques.

Work began in early November and continued through November and was completed in December.

III. Who has reviewed the deliverable document and associated products?

Jamie Carte, Eric Morris, and Kirk Waters reviewed the deliverable document.

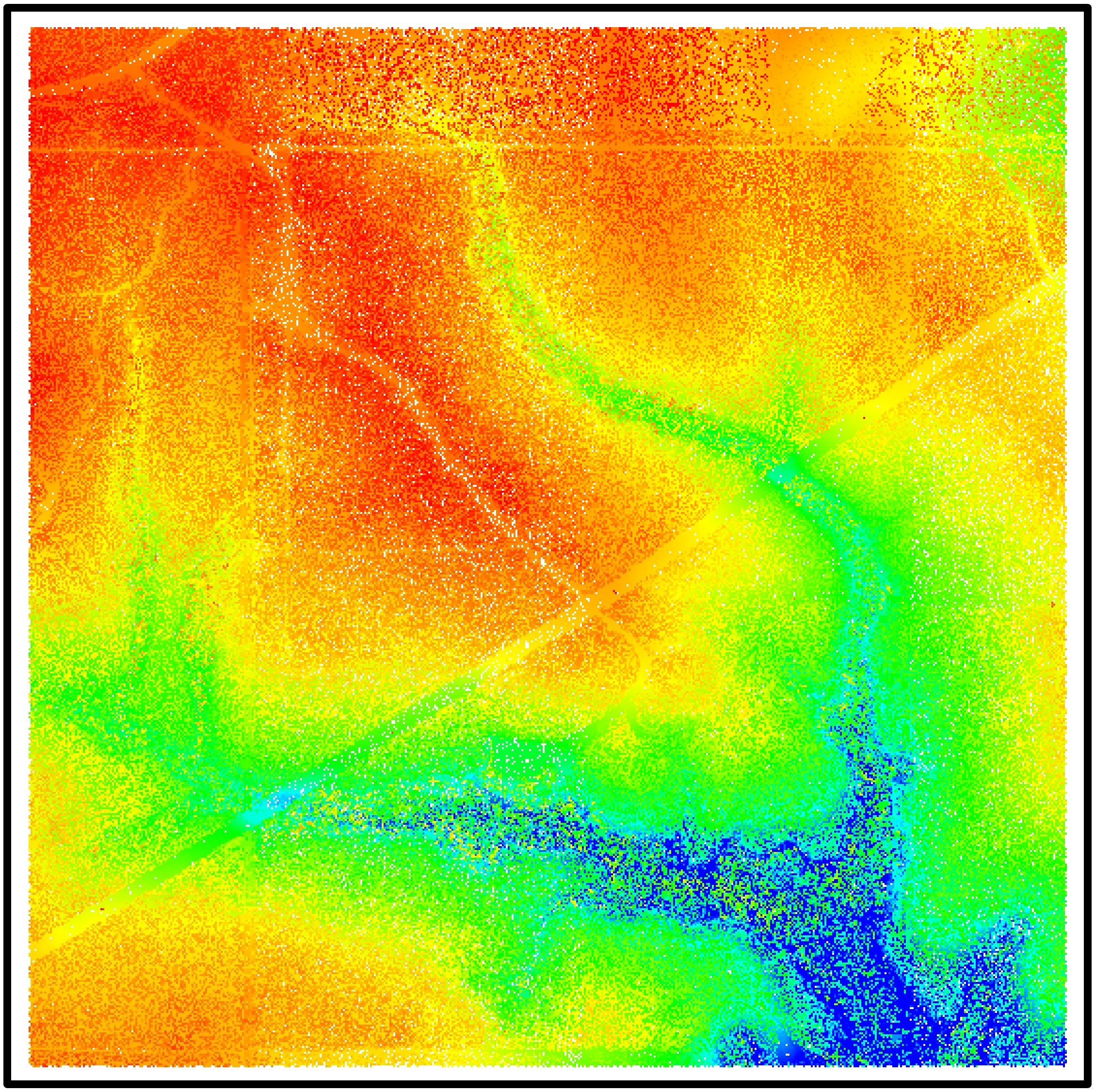
IV. What are the next steps?

Even though this deliverable was not needed as an external document, lidar team members learned how to use the MARS software to determine a vertical accuracy value for a lidar data set and what information needed to be included in the associated report.

V. Where does the associated deliverable product "live"?

This deliverable document will be used by lidar team members as a guide for future lidar vertical accuracy determinations and will be accessible internally.

Topographic Lidar QA Report: 2013 Mobile County, Alabama



Quality Assurance Review (Basic)
The Baldwin Group, Inc. on behalf of NOAA Office for Coastal Management
December 2014
(revised January 2015)

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Executive Summary

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Introduction

This report describes the general assessment of the 1123 lidar files (collected in 5 areas) for Mobile County, Alabama (see Figure 1) and provides a determination of whether the fundamental vertical accuracy (FVA) met the contracted value in open terrain areas (non-vegetated). The basic goal of an accuracy assessment is to measure known points on the ground (ground control points, or GCPs) and compare those with points generated from the lidar data. This is often carried out separately for points that fall into different ground cover types. Bare-earth (classified ground) lidar errors for open areas are likely lower than the lidar errors derived from points within forests, for example. The most common land cover types are bare earth, forest, shrub, urban, and weeds or crops. Ground points are used to judge the overall quality of data collection because these points typically require very little classification processing and are usually the most accurate for comparing to control points.

In practice, independent measurements (points collected in the field) are compared with a surface created from the lidar points. A generated surface is used because the lidar points, in most cases, will not fall exactly on the spot where the field measurements were collected. The test surface generated from lidar points is typically created using the triangulated irregular network (TIN) method, which has the least amount of “smoothing.” As a result, the lidar elevation is actually a best representation using the three nearest points (i.e., the three points on the triangle). It is important that the area being tested not be sloped or irregular; a sloped or irregular surface could potentially bias the elevations. Similarly, the points should be collected in areas where there is a reasonable chance that the lidar can penetrate to the ground (open to the sky). Lastly, the location and soil characteristics of open terrain points should be collected in areas with little possibility of change, such as a maintained park or an established parking lot.

Once the values have been compared and the error values generated, several statistical formulas and descriptive terms are used to provide an overview of the data quality. The Mobile County lidar project specifications were to meet USGS Quality Level 2 requirements, as designated at the time of this project. This translates to a vertical Root Mean Square Error (RMSEz) of less than or equal to 9.25 cm (0.303 ft). The vertical assessment used 25 open terrain control points. The data met the requirement.

The lidar were tested (with 25 open terrain control points) and met the required specifications with an RMSEz value of 9.14 cm (0.30 ft).

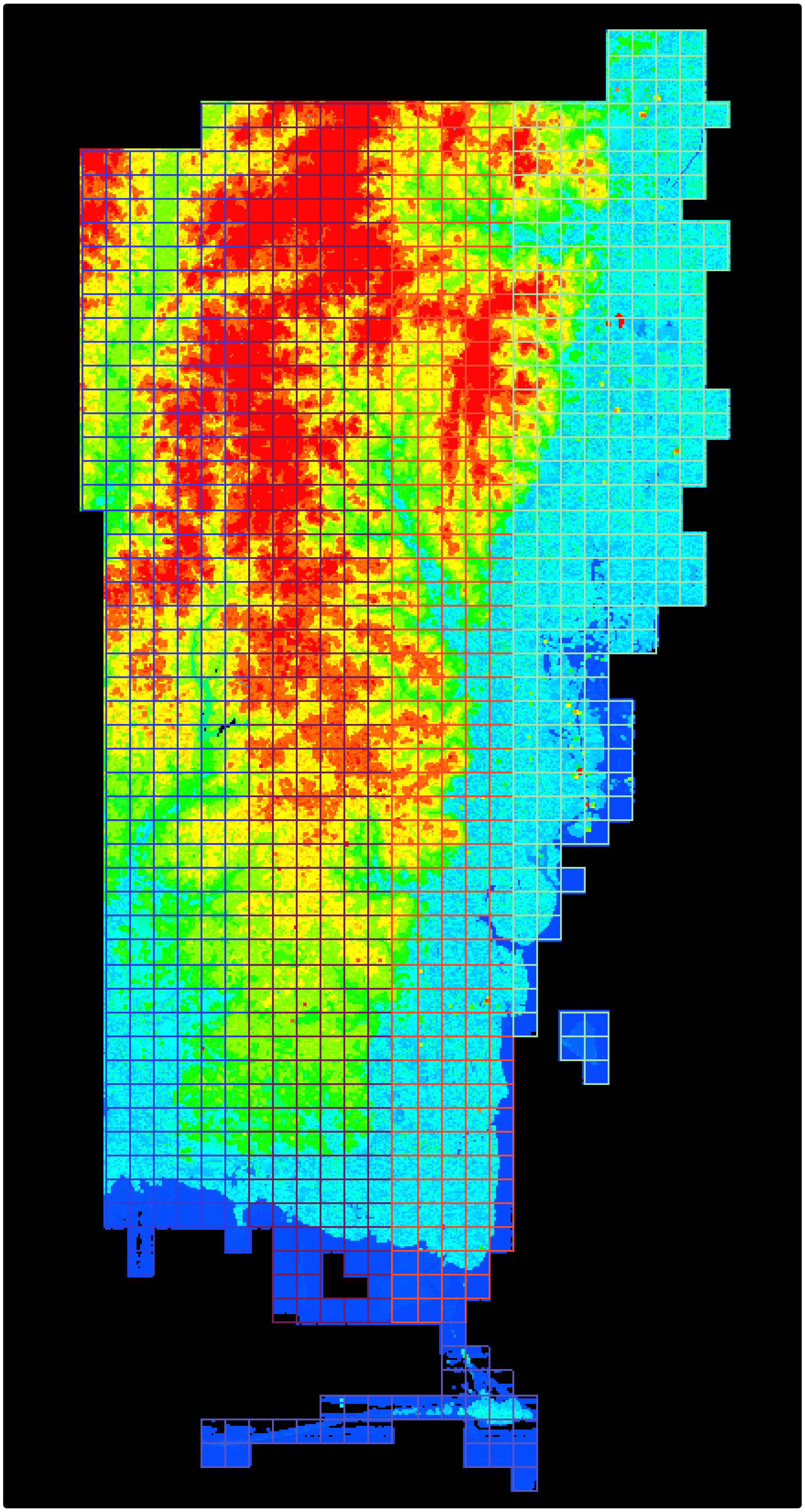


Figure 1. Lidar elevation point data for Mobile County, AL

Deliverables Received

1. 1123 LAS files
2. Control Point Report in pdf format
3. LAS Metadata - xml and html formats
4. Lidar Acquisition Report
5. Ancillary/supplemental shapefiles

Data Collection Specifications (from metadata and Acquisition Report)

1. Lidar meets USGS QL2 specifications ($RMSE_z$ less than or equal to 9.25 cm, nominal point spacing less than or equal to 0.7 m (or greater than or equal to 2 pts/m2))
2. Horizontal Datum: North American Datum of 1983
3. Coordinate System: State Plane Alabama West Zone (FIPS 0102)
4. Vertical Datum: North American Vertical Datum of 1988
5. Horizontal and Vertical Units: US Survey Feet

Software Used

The following software were used in the assessment of this data:

1. LAStools - available at http://www.cs.unc.edu/~isenburg/lastools/
    a. lasinfo
    b. lasvalidate
2. Global Mapper v15.1
3. Merrick MARS v7.1
4. ArcGIS 10.2.2
5. Microsoft Office 2010
6. USGS Geospatial Metadata Validation Service 'MP' (http://mrdata.usgs.gov/validation/)

Qualitative Assessment

In this section are the results of a basic qualitative review of the data. This review included the following:

1. The las files were run through two of the tools in the LAStools software suite. The first is LASInfo which reports the contents of the header and a short summary of the points. The second is lasvalidate which reports if LAS files conform to the ASPRS LAS 1.0 to 1.4 specifications.
2. General observations of LAS files
    a. Coverage of data
    b. Classification in different land cover areas
    c. Classification issues
3. Review of individual las files
4. Review of metadata (xml)

LASInfo Results

1. All 1123 LAS files are in 1.2 format
2. All 1123 LAS files - 0.508 m point spacing (all classes)
3. Density - 2.94 pt/m2 (all classes)
4. Minimum and Maximum z values
   a. Area A (292 files) - Min z value: -644.26 ft, Max z value: 2841.05 ft
   b. Area B (299 files) - Min z value: -697.65 ft, Max z value: 2919.77 ft
   c. Area C (251 files) - Min z value: -736.79 ft, Max z value: 2963.04 ft
   d. Area D (249 files) - Min z value: -757.80 ft, Max z value: 2850.50 ft
   e. Area E (32 files) - Min z value: -601.22 ft, Max z value: 2700.25 ft
5. Classifications - 1, 2, 3, 7, 9, 10; not every file has all classes
6. Number of files that have Class 9 (water) points: 732
7. Total number of point classifications
   a. Total number of points: 14,940,594,184 (100%)
      i. Number of unclassified (1) points: 10,908,058,078 (73%)
      ii. Number of classified points: 4,032,536,106 (27%)

LASValidate Results

1. Area A - 292 files: 292 files pass, 0 files have warnings, 0 files fail
2. Area B - 299 files: 262 files pass, 37 files have warnings, 0 files fail
   a. Same warning for all 37 files: System Identifier - empty string, first character is '\0'
3. Area C - 251 files: 234 pass, 17 files have warnings, 0 files fail
   a. Same warning for all 17 files: System Identifier - empty string, first character is '\0'
4. Area D - 249 files: 249 files pass, 0 files have warnings, 0 files fail
5. Area E - 32 files: 32 files pass, 0 files have warnings, 0 files fail

General Observations of LAS files

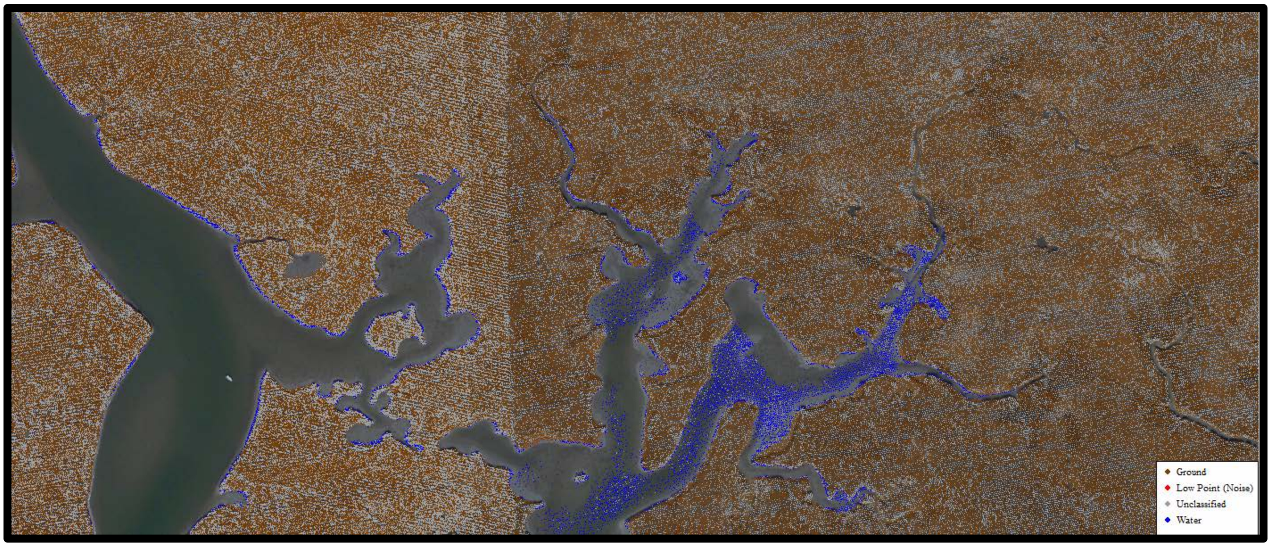
Coverage of Data

Lidar data covers all 1123 files with no data voids, see Figure 1.

Classification in Different Land Cover Areas

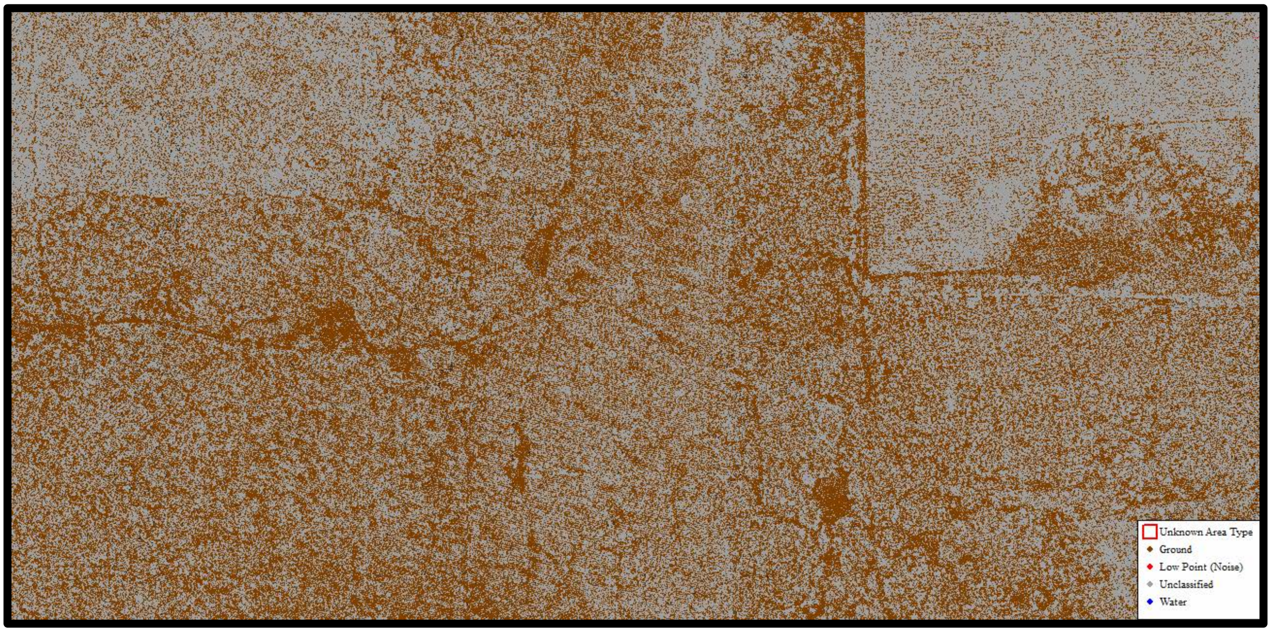
A random sampling of a few las files were examined for classification accuracy. In general, for the few tiles that were reviewed, the points seemed to be well classified. A few examples are provided.

a. Classification in undeveloped, open tidal marsh area (Area A, 1680144C.las)

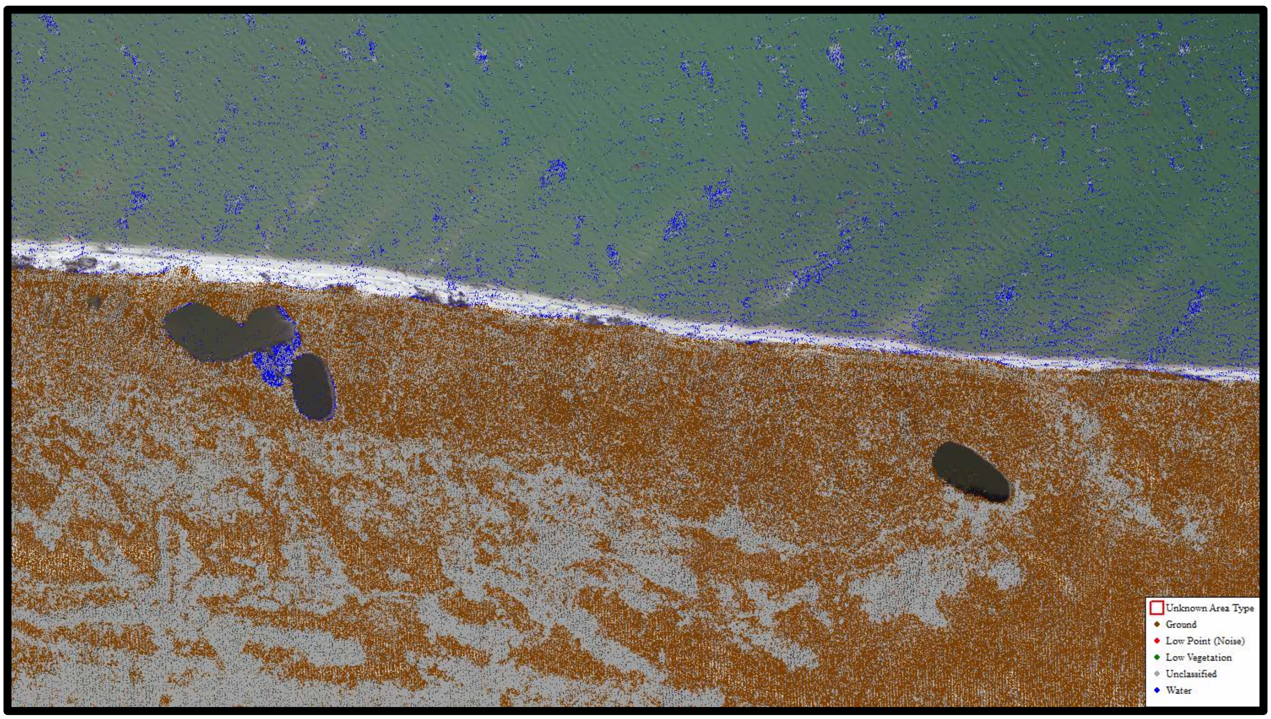


b. Classification in developed area (Area C, 1776270A.las)

c. Classification in forested area (Area E, 1680276C.las)



d. Classification in coastal/barrier island area (Area E, 1710090C.las)



Classification Issues

There were a few minor classification issues discovered during the review.

a. Files mainly in Area E (Dauphin Island) had points in water that were mis-classified as 3 (low vegetation). These points are colored green in Figure 2. There are 12,588,501 points classified as 3 (low vegetation).

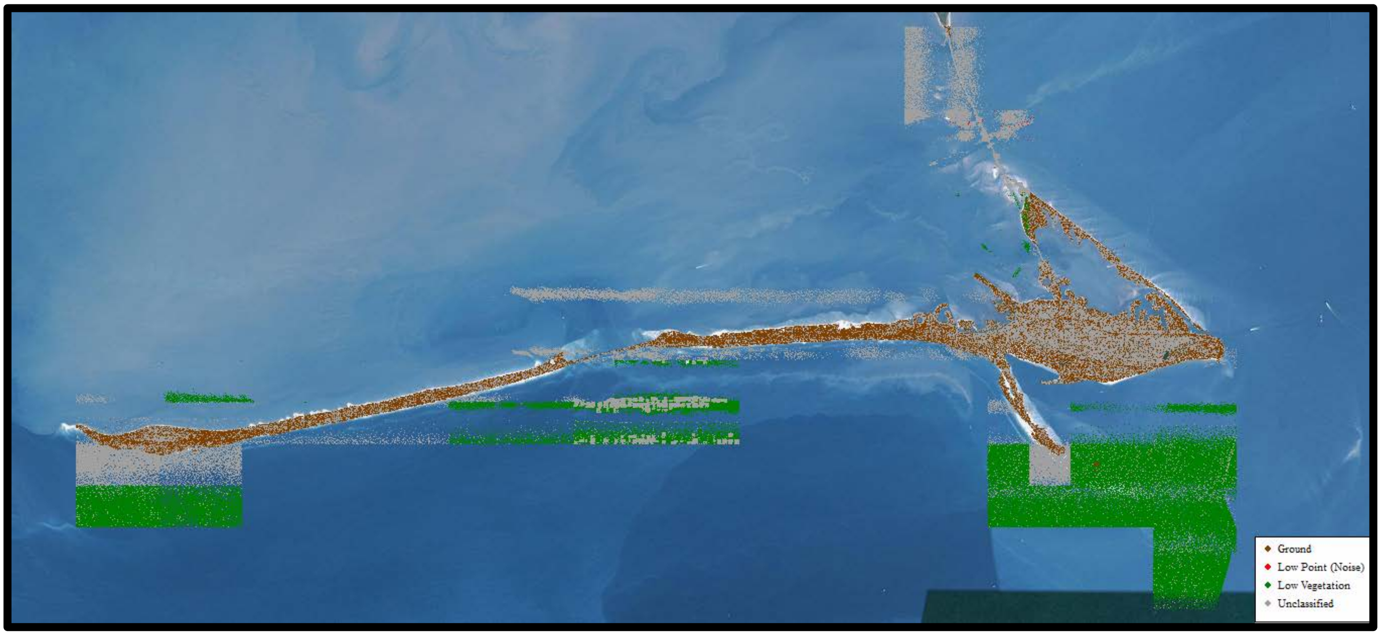


Figure 2. Classification of points as 3 (low vegetation), in green, Area E (Dauphin Island)

b. There are 28 points classified as Class 10 (railroad) in file 1722246A.las. These points are colored yellow in Figure 3.

Figure 3. Classification of points as 10 (uncertain), in yellow

Review of Individual Tiles

Area A - 1680372C.las

- good ground penetration (5 returns in some areas, all points have return number and classification)
- good ground classification, looks in dense canopy
- scan angles seem a little high (-40, 30)
- error (or "air") points above 1,000 ft, 4x the actual highest elevation in the tile

Area B - 1734300A.las

- elevation values look good
- data parameters as specified: Alabama State Plane West Zone (FIPS 0102); North American Vertical Datum of 1988; Horizontal and Vertical Units: US Survey Feet
- tile includes areas of vegetation, water, buildings, roads, and cleared land; classification looks good
- area of 3 flight lines, there is flightline overlap
- returns 1-5, all points have return number and classification

Area C - 1770372C.las

- elevation values look good
- data parameters as specified: Alabama State Plane West Zone (FIPS 0102); North American Vertical Datum of 1988; Horizontal and Vertical Units: US Survey Feet
- tile includes area of vegetation, water, and cleared land; classification looks good
- area of 3 flight lines, there is flightline overlap
- returns 1- 5, all points have return number and classification

Area D - 1806390C.las

- elevation values look good
- data parameters as specified: Alabama State Plane West Zone (FIPS 0102); North American Vertical Datum of 1988; Horizontal and Vertical Units: US Survey Feet
- tile includes area of vegetation, water, and cleared land; classification looks good
- powerlines are captured, are correctly classified as unclassified
- area of 3 flight lines, there is flightline overlap
- returns 1- 5, all points have return number and classification

Area E - 1764096C.las

- ground classification is adequate for this area
- water classed well

Review of Metadata

Both an html and xml versions of the las metadata were provided. The xml version was run through the USGS Geospatial Metadata Validation Service (mrdata.usgs.gov/validation/) to determine FGDC compliance. The test resulted in 19 metaparser (mp) errors, 16 missing, 3 bad value. The errors are listed in Figure 4.

```
Error (line 2): Theme_Keyword_Thesaurus is required in Theme
Error (line 2): Type_of_Source_Media is required in Source_Information
Error (line 2): Source_Citation_Abbreviation is required in Source_Information
Error (line 2): Source_Contribution is required in Source_Information
Error (line 2): Improper value for Publication_Time
Error (line 5): Attribute_Accuracy_Report is required in Attribute_Accuracy
Error (line 5): Attribute_Accuracy_Value is required in Quantitative_Attribute_Accuracy_Assessment
Error (line 5): Attribute_Accuracy_Explanation is required in Quantitative_Attribute_Accuracy_Assessment
Error (line 5): Attribute_Accuracy_Value is required in Quantitative_Attribute_Accuracy_Assessment
Error (line 5): Attribute_Accuracy_Explanation is required in Quantitative_Attribute_Accuracy_Assessment
Error (line 6): Vertical_Positional_Accuracy_Report is required in Vertical_Positional_Accuracy
Error (line 6): Horizontal_Positional_Accuracy_Report is required in Horizontal_Positional_Accuracy
Error (line 6): Improper value for Metadata_Future_Review_Date
Error (line 6): Improper value for Grid_Coordinate_System_Name
Error (line 6): Altitude_Resolution is required in Altitude_System_Definition
Error (line 6): Entity_Type_Definition_Source is required in Entity_Type
Error (line 6): Entity_and_Attribute_Overview is required in Overview_Description
Error (line 6): Entity_and_Attribute_Detail_Citation is required in Overview_Description
Error (line 6): Standard_Order_Process requires at least one of Non-digital_Form or Digital_Form
19 errors: 16 missing, 3 bad_value
```

Figure 4. Listing of mp errors for Mobile_County_LiDAR_metadata.xml

Quantitative Assessment

The following section summarizes the results of the statistical comparison between the provided control points and the ground classified lidar point data. The assessment was based on the provided 25 open terrain control points. The analysis was performed using Merrick MARS v7.1 and Microsoft Office 2010. In the MARS vertical accuracy determination, the ground classified point cloud data are used to construct a triangulated irregular networks (TIN) which is compared against the open terrain control points. This process produces statistics that can be used to quantify the vertical accuracy of the dataset.

During this process, it was noted that many of the open terrain control points were collected at NGS survey markers. Using GoogleEarth to look at these locations, it looked like many of the markers are in locations that are not ideal (i.e., not on flat, level terrain) for control point location. The distribution of the control points generally covered the entire county, except for the southern extent of the data on Dauphin Island (Area E).

Vertical Assessment (25 open terrain control points)

See Figure 5 for control point locations and Appendix A for control point vertical accuracy information.
From the contractor supplied metadata, the data specifications called for the lidar data to meet USGS Quality Level 2 requirements. This translates to a Root Mean Square Error (RMSEz) of less than or equal to 9.25 cm (0.303 ft). The data were tested with 25 open terrain control points. The data met the requirement.

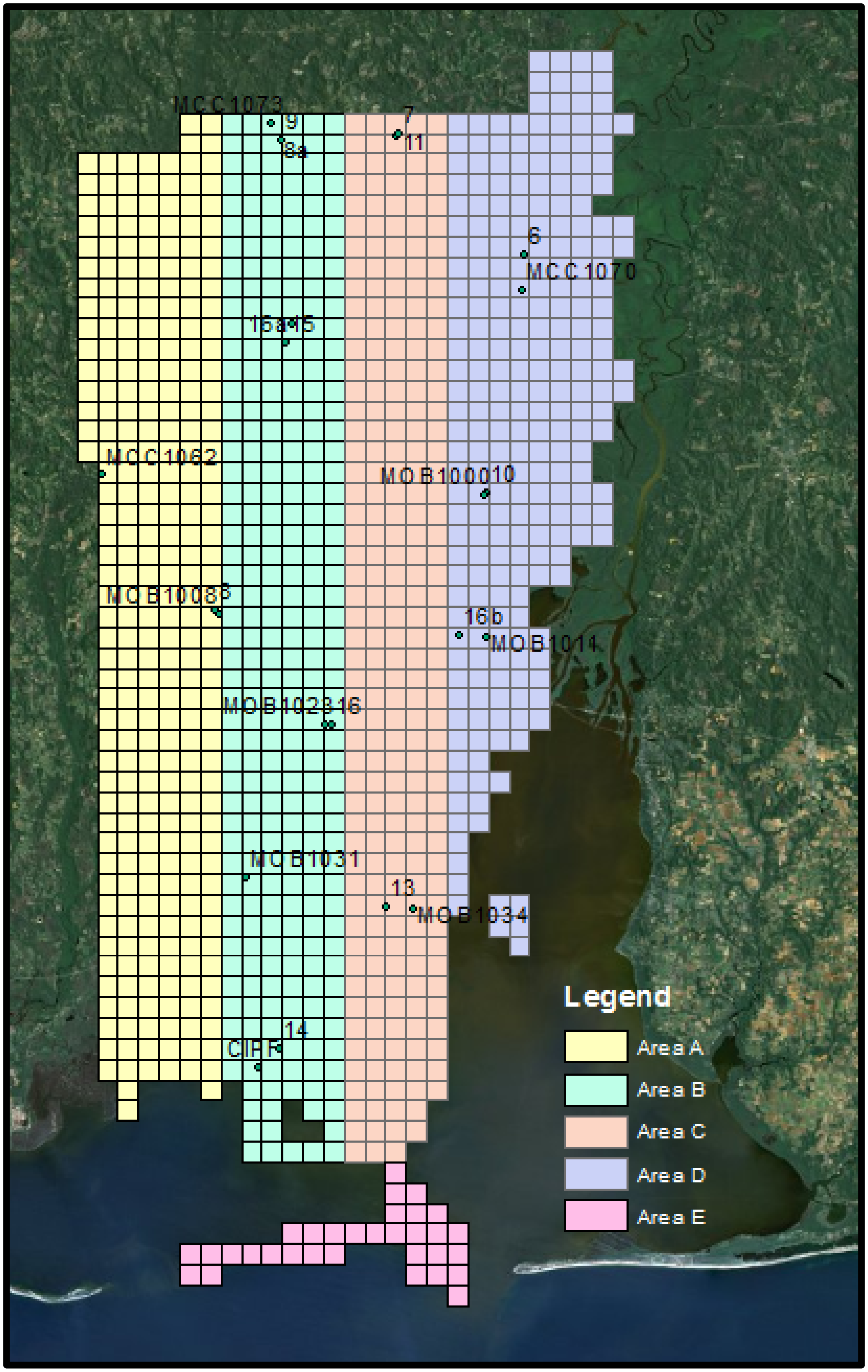


Figure 5. Open Terrain Control Point (25) Locations

The lidar were tested (with 25 open terrain control points) and met the requirement with an RMSEz value of 9.14 cm (0.30 ft). See Table 1.

Vertical Accuracy Objective	Feet	
Requirement Type	RMSE(z)	
RMSE(z) Objective	0.303	
Control Points in Report	25	
Elevation Calculation Method	Interpolated from TIN	
Control Points with LiDAR Coverage	25	
Average Control Error Reported	-0.02	
Maximum (highest) Control Error Reported	0.56	
Median Control Error Reported	0.07	
Minimum (lowest) Control Error Reported	-0.54	
Standard deviation (sigma) of Error for sample	0.3	
RMSE of Error for sample (RMSE(z))	0.3	PASS
NSSDA Achievable Contour Interval	1	
ASPRS Class 1 Achievable Contour Interval	0.9	
NMAS Achievable Contour Interval	1	

Table 1. MARS vertical accuracy results
(using 25 open terrain control points)

Conclusions

This basic and preliminary assessment of the quality of the 2013 Mobile County, Alabama lidar data set determined that the data passed the contract specified quality level, USGS QL2, with an $RMSE_z$ of 9.14 cm and 2.94 pt/m^2. The data covers the complete survey area and for the few las files reviewed, appears to be well-classified except for a few minor mis-classifications. This data should be suitable for use in sea level rise studies and coastal zone management, as well as forest resources management and natural resource conservation.

According to the MARS results (Table 1), this data meets the National Standard for Spatial Data Accuracy (NSSDA), American Society for Photogrammetry and Remote Sensing (ASPRS), and National Map Accuracy Standards (NMAS) specifications for supporting 1 ft contours.

Appendix A: Open Terrain Control Points

Table 2 includes the vertical accuracy information for all 25 open terrain control points. There were 5 points that had the same ID. During the vertical accuracy determination process these points were renamed to help avoid confusion. There were 3 points with an ID of 16 and 2 points with an ID of 8.
These points were renamed 16, 16a, 16b, 8, 8a.

Control Point Id	Control Point X	Control Point Y	Control Point Z	Z from LiDAR	Z Error
15	1735281	352697.2	187.4725	186.93	-0.54
MCC1070	1804220	368142.6	48.822	48.34	-0.48
6	1804571	378510.4	42.7338	42.28	-0.45
16b	1785396	267440.9	31.3017	30.92	-0.38
16a	1735281	352697.2	187.269	186.92	-0.35
11	1767602	413447.5	291.0394	290.74	-0.3
7	1767796	413977.5	299.4522	299.16	-0.29
8a	1733726	411821.1	281.775	281.5	-0.27
MOB1034	1772108	187682.9	28.612	28.47	-0.14
MOB1000	1793058	308182	17.98	17.87	-0.11
10	1793853	308910.7	17.0138	16.9	-0.11
13	1764577	188471.7	46.726	46.68	-0.05
9	1733727	411812.9	281.7611	281.83	0.07
14	1733350	147041.7	6.6157	6.71	0.09
8	1714069	274604.7	226.4208	226.56	0.14
MOB1011	1793632	266929.2	27.588	27.78	0.19
MCC1062	1681688	314135.1	84.308	84.5	0.19
CIPF	1726923	141470.5	2.722	2.92	0.2
16	1748559	241328.3	115.9413	116.14	0.2
MCC1073	1731082	416813.5	215.885	216.09	0.21
MCC1072	1768020	413813.7	300.531	300.75	0.22
MOB1008	1715439	273862.2	224.56	224.88	0.32

MOB1023	1746380	241213.1	117.797	118.12	0.32
MCC1067	1737082	358599.3	128.378	128.73	0.35
MOB1031	1723489	196897.7	147.378	147.94	0.56

Table 2. Open Terrain Control Points (detailed)