QUALITY CONTROL REPORT

July 6, 2012

Submitted To:

Mississippi Department of Environmental Quality
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Submitted By:

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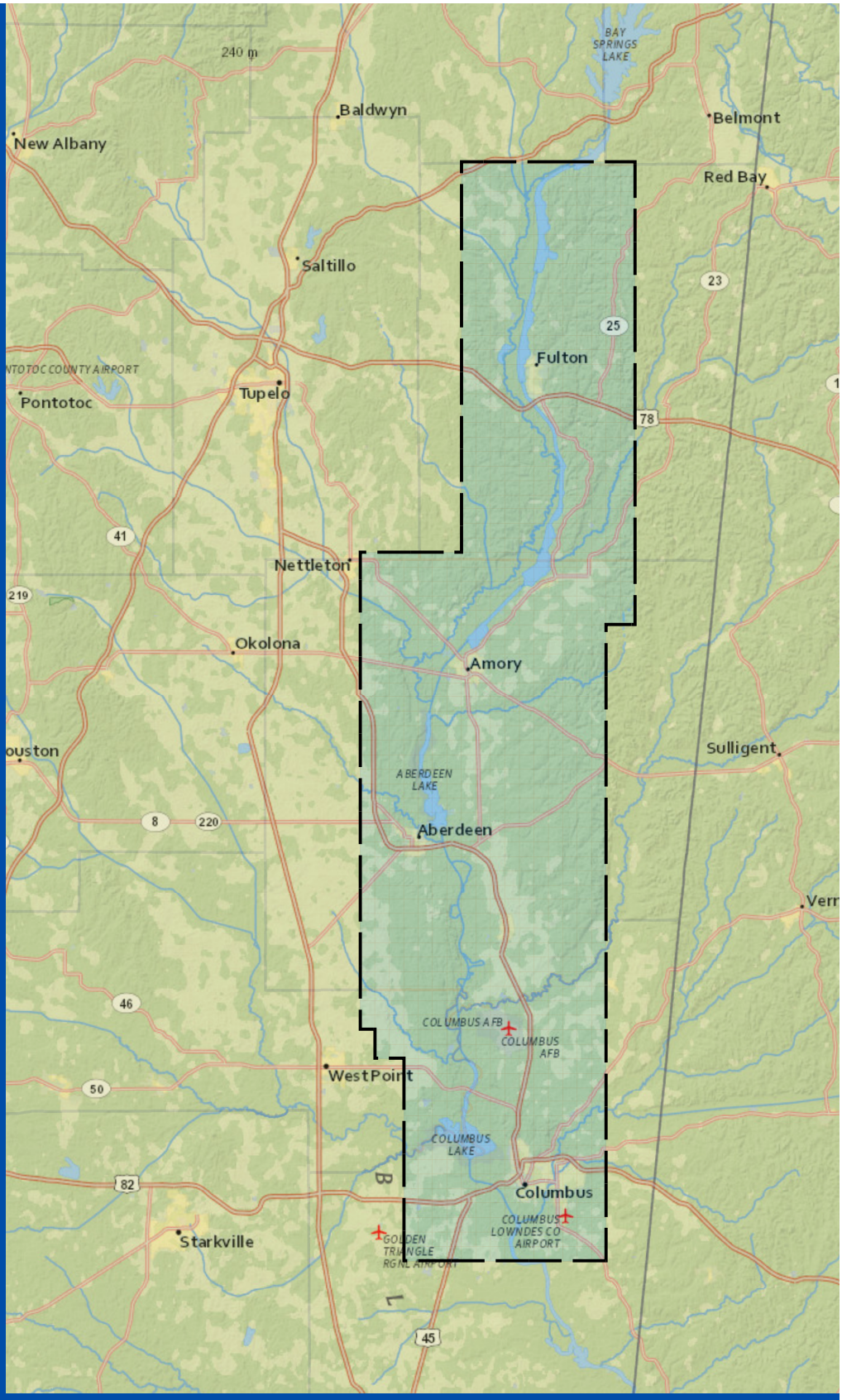

Independent Quality Control Report

TENNESSEE-TOMBIGBEE WATERWAY LIDAR

Work Order Number 108

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Tennessee-Tombigbee Waterway Independent Quality Control Report

1 Project Overview

1.1 Tennessee-Tombigbee Waterway LiDAR

In support of the Mississippi Digital Earth Model (MDEM) initiative and FEMA's program for flood map modernization, the Mississippi Department of Environmental Quality (MDEQ) tasked light detection and ranging (LiDAR) data for portions of Clay, Itawamba, Monroe, and Lowndes County in northeast Mississippi. The project was to adhere to mapping guidelines and specifications of FEMA's Appendix A and Procedure Memorandum No. 61.

1.2 Contractual Stakeholder's

It is the understanding of the URS Corporation (URS) that this project was initiated, planned, and executed with the following contractual stakeholders.

- The State of Mississippi Department of Environmental Quality
- Mississippi Geographic Information, LLC
- The Atlantic Group, LLC
- URS Corporation

1.3 Project Description

Collection of high-density elevation point data derived from multiple-return LiDAR measurements for use in supporting topographic analysis, including applications such as flood plain mapping. The project area of interest (AOI) covered approximately 948 square miles in northeast Mississippi which covers portions of Clay, Itawamba, Monroe, and Lowndes County, Figure 1.

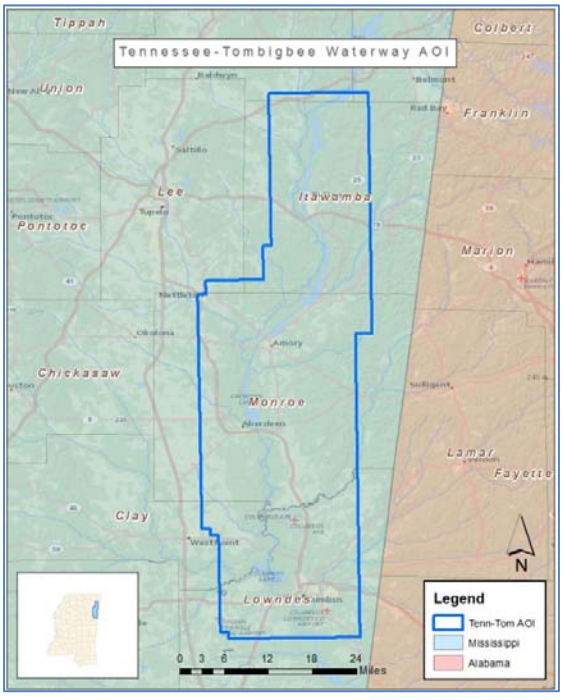

Figure 1 – Tennessee-Tombigbee Waterway AOI Overview

Project deliverables received by URS for QA included the following items:

- Classified LiDAR data (LAS 1.2 format)
    - 1.2 points per m²
- Bare Earth Digital Elevation Model (GeoTiff format)
- Hydro breaklines (ESRI readable format)
- Intensity Imagery (GeoTiff format)
- 2 foot contours (ESRI readable format)
- FDGC compliant metadata (XML format)

The LiDAR classification followed FEMA's Appendix A and Procedure Memorandum No. 61 guidelines which recommend the following classes be utilized.

- Class 1 – processed, but unclassified
- Class 2 – bare-earth ground
- Class 7 – noise
- Class 9 – water
- Class 10 – ignored
- Class 11 – withheld

All project scope identified the georeferencing details as follows:

- Horizontal Datum – NAD83
- Project - Mississippi State Plane Zone 2301
- Vertical Datum – NAVD88
- Geoid – 2009
- Units – US Feet

1.4 Project Mapping Vendor

The Atlantic Group, LLC (Atlantic) was tasked with LiDAR data acquisition and data processing.

Atlantic Point of Contact (POC):

Paul R. Weyant, Jr
Atlantic Group
Director of Internal Operations

2223 Drake Avenue SW
Suite 200
Huntsville , AL 35805

256-971-9991 Work
prweyant@theatlgrp.com

1.5 Project Quality Assurance (QA) Vendor

The Independent Quality Control for the Mississippi Department of Environmental Quality, as part of Work Order No. 108, was performed by URS Corporation (URS) to validate LiDAR data quality for the purposes of supporting the FEMA flood map modernization program. URS completed this work as a subcontractor to Mississippi Geographic Information, LLC (MGI).

MGI POC:

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1.6 Overview of QA Services

This document details the quality assurance review that was completed on the above mentioned AOI. The report covers QA services on an initial data delivery to URS received on March 16, 2012 as well as 4 re-deliveries of corrections applied to the LiDAR data, contour data, breakline data, DEM, and metadata, received on April 11, 2012, May 16, 2012, June 08, 2012 and June 20, 2012.

The QA services were performed in two phases, a macro review and a micro review.
The macro QA checks were performed on 100% of the deliverable tiles delivered and included the following checks:

- Verification of coverage compared to tasked AOI
- Readability of the data
- Data format and structure
- LAS header conformance to FDGC standards and specifications
- Correct tile name
- Correct georeferencing
- No data gaps
- Nominal post spacing conformance to project specification
- Gross anomaly identification
- Accuracy assessment review
- Metadata conformance to FGDC standards and specifications

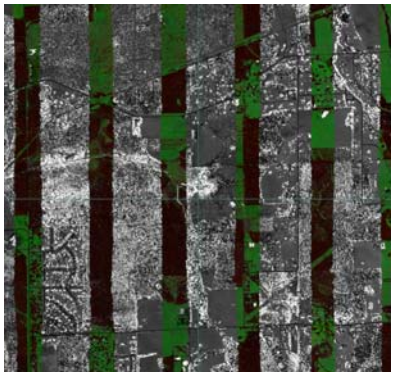


Figure 2 – Sample of macro check of flight line swath differences – colored bands are areas of overlap ground points between flight lines

The micro QA checks were performed on 25% of the deliverable tiles and included the following checks:

- Visual review for data anomalies and data gaps
- LiDAR classification checks
- Hydro breakline topology and completeness checks
- Bare Earth DEM review using manual and automated tools
- First return DEM review using manual and automated tools

The 25% data coverage to be reviewed as part of the micro QA process was selected by identifying every fourth tile within the deliverable tile layout, Figure 3.

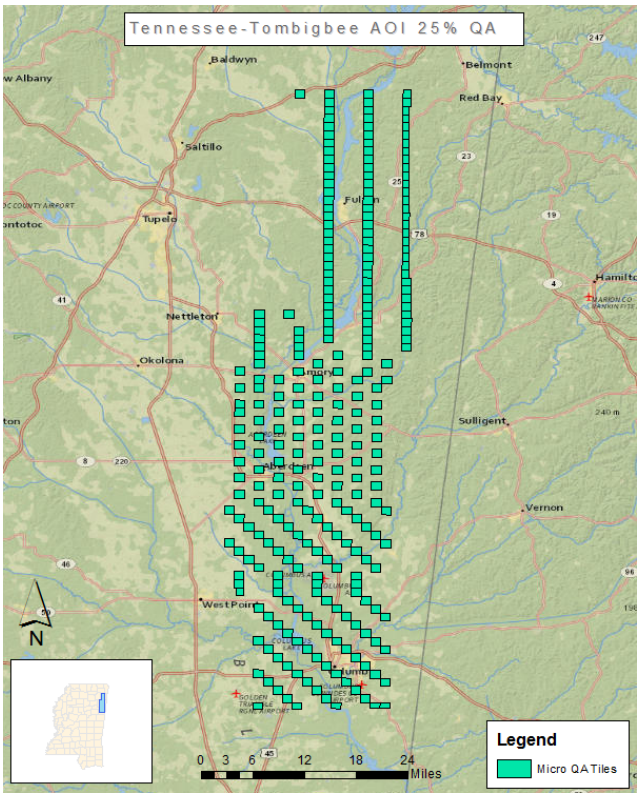


Figure 3 – 25% Tiles Selected for Micro QA Review

2 QA Timeline of Events

The below table expresses the QA timeline of significant events for this project. QA results were returned as an email summarizing the edit calls and included a shapefile of edit calls with corresponding screenshots.

Date Received	Delivery Method	QA Results Returned	Corrections Received
04/11/12 (full dataset)	hard drive	03/27 (macro) 04/26 (micro)	05/16/12
05/16/12 (only corrections)	hard drive	05/24/12	06/08/12
06/08/12 (only corrections)	ftp	06/12/12	06/20/12
06/20/12 (only corrections)	ftp	06/21/12	n/a

Table 1 – Timeline of QA Events

3 Final QA Report

The following summary of edit calls were addressed in subsequent deliveries until all the reviewed data had passed the QA process on June 21, 2012. The March 27 macro QA calls and the April 26 micro QA calls represent the first round of QA calls on the original delivered data set. The subsequent dates represent QA calls on redeliveries.

3.1 March 27, 2012 – Macro QA Edit Calls

Summary of edit calls

1. Minor data gaps identified in flight swaths (reviewed by URS/MGI/Atlantic and deemed non-issue).
2. Georeferencing information missing from LAS headers.
3. Metadata did not pass the USGS parser.

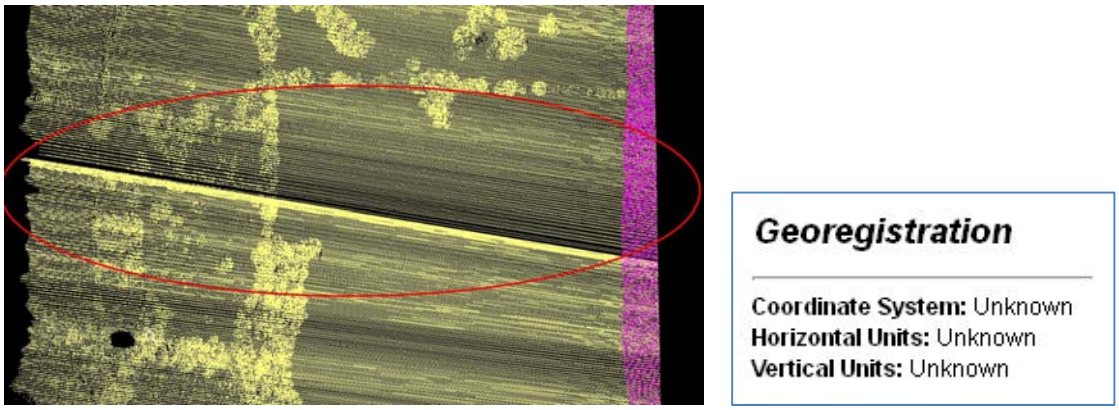


Figure 4 – Example of data gap call and the missing georeferencing information

3.2 April 26, 2012 – Micro QA Edit Calls

Summary of edit calls

1. Vertical Datum – the LAS data was delivered in Geoid 03 instead of Geoid 09.
2. Micro QA Edit Calls – 23 edit calls were identified. Issues range from minor data gaps, classification issues, missing breaklines, and missing hydrologic features.
3. Breakline Topology – The topology check identified 358 topology errors, including breaklines with dangles and multi-part features.
4. DEM – DEM tile coverage incomplete compared to the LAS deliverable (40 tile difference). One DEM tile was identified with a data gap.
5. Metadata – Redelivered metadata passes USGS parser. However, some comments on metadata (attached as word documents) should be addressed.

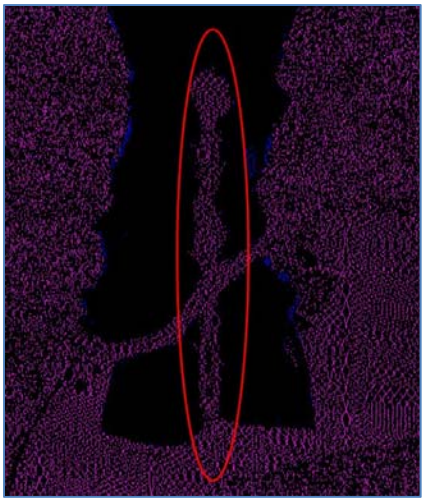


Figure 5 – Example of classification edit call – ground points in water

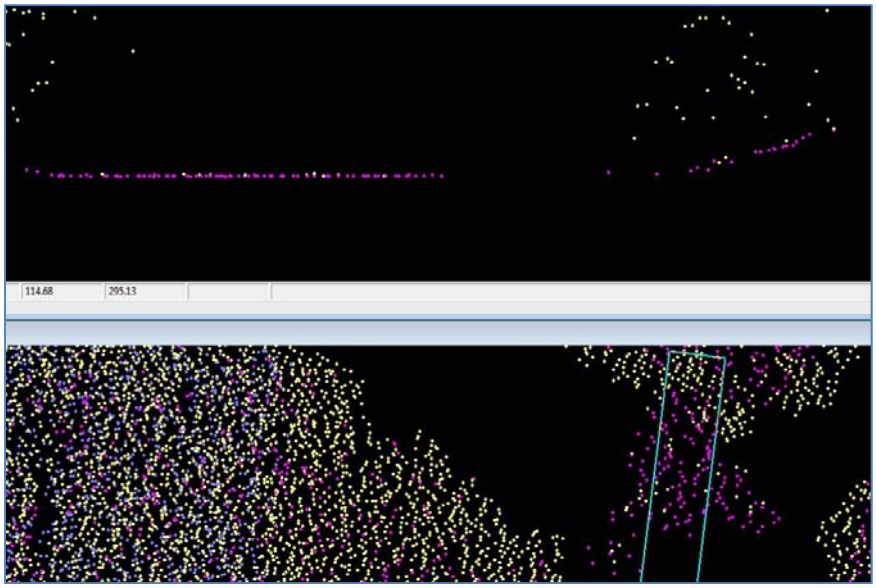


Figure 6 – Example of missing hydrologic feature edit call – points classified as ground should be water

3.3 May 24, 2012 - Edit Calls

Summary of edit calls

1. Edit Calls – 3 edit calls from round one (April 26th) were not corrected. All three calls were water points classified as ground.
2. Metadata – most round one issues resolved, however, a small syntax error is still causing the files to fail the USGS parser.
3. Contours – Numerous small (<50 ft) contours were observed in the dataset. The data passed QA but URS recommended that the small contours be removed to improve the overall quality of the final data set.
4. DEM – Review of the final DEM identified one seam issue in the bare earth surface not previously identified.
5. Breaklines – the breakline polylinez file did not have a vertical datum assigned

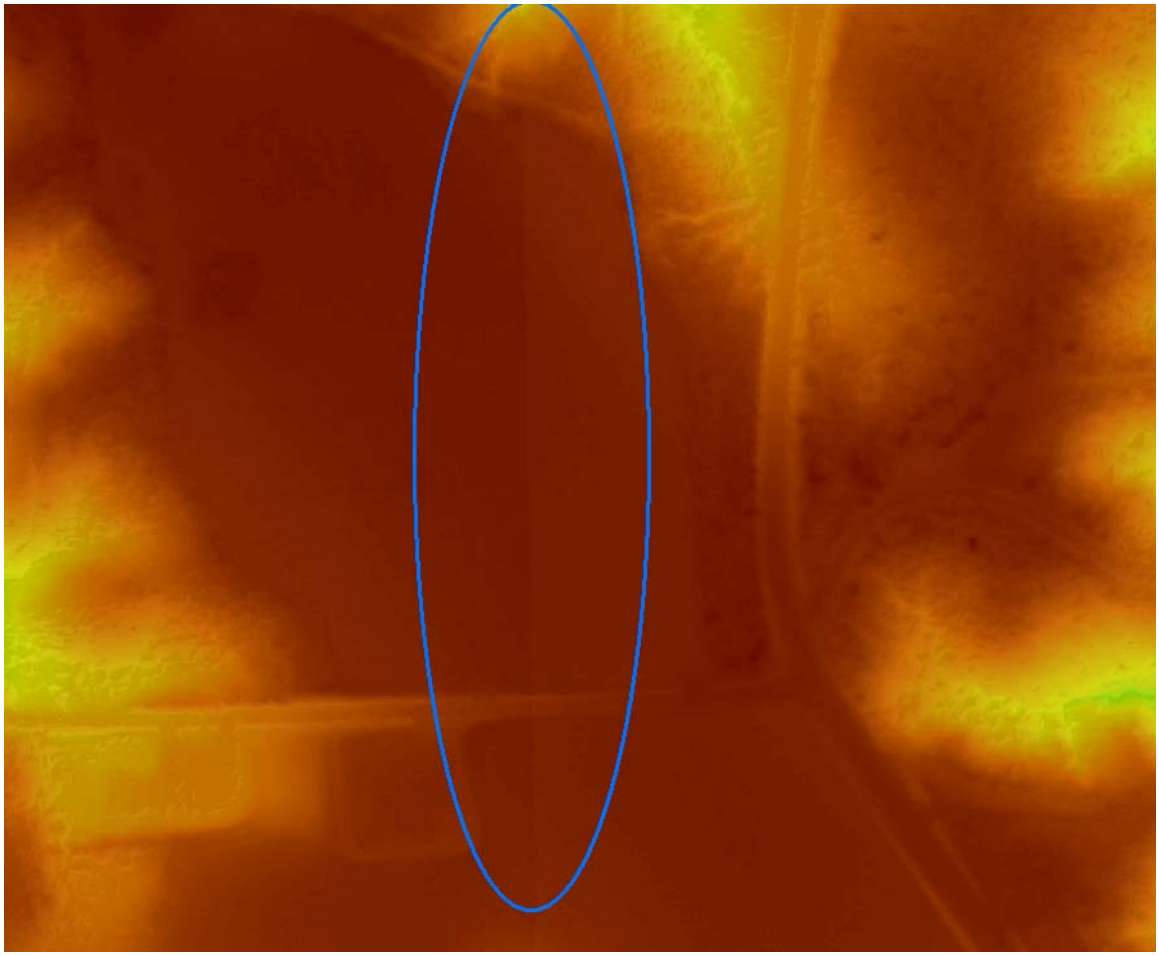


Figure 7 – Screenshot of seamline seam identified

3.4 June 12, 2012 – Edit Calls

Summary of edit calls

1. A correction for tile 1328 was not received. The 4/26 QA shapefile errantly listed tile as 1341 in its attributes, should have been 1328, however the geo-reference of the QA call did fall in tile 1328. It is believed that delivery of tile 1341 could have been a mix up in copying over the delivery tile due to the attribute mislabel.
2. Four tiles received did not have georeferencing information in the header.
3. The breakline shapefile did not contain a reference to the vertical coordinate system.

3.5 June 21, 2012 – No Edit Calls

The final re-delivery of corrected data was received from Atlantic on 6/20. URS reviewed the data and found that all edit calls had been addressed and there were no additional edit calls. Acceptance of this data delivery completed the 100% macro and 25% micro review process.

3.6 Accuracy Assessment

URS received from MGI a set of 60 QA control points. These control points represented three distinct land cover categories as specified by FEMA Appendix A, bare earth, urban, and forest, Figure 8.

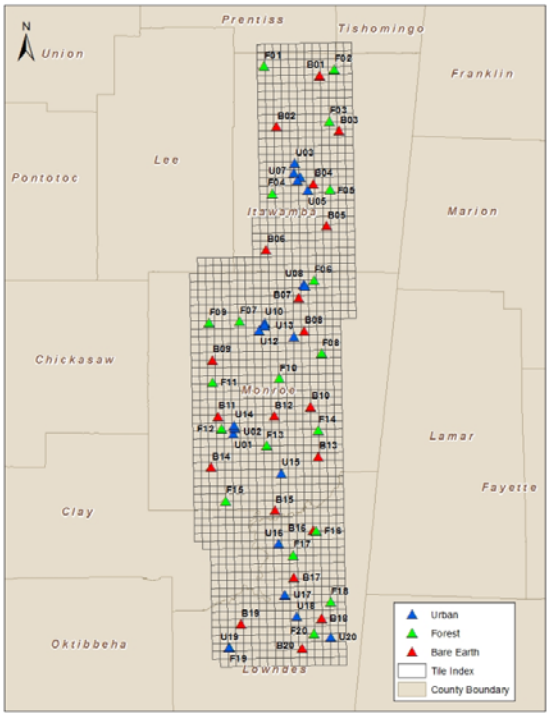


Figure 8 – Accuracy assessment ground control

In order to be fully accepted the LiDAR data set was contractually obligated to meet a Fundamental Vertical Accuracy (FVA), Consolidated Vertical Accuracy (CVA), and a Supplemental Vertical Accuracy (SVA) as defined by the National Digital Elevation Program (NDEP) and the American Society of Photogrammetry (ASPRS). The NDEP defines the FVA, CVA, and the SVA in the following manner.

The fundamental vertical accuracy of a dataset must be determined with check points located only in open terrain, where there is a very high probability that the sensor will have detected the ground surface. The fundamental accuracy is the value by which vertical accuracy can be equitably assessed and compared among datasets. Fundamental accuracy is calculated at the 95-percent confidence level as a function of vertical RMSE. – NDEP Guidelines for Digital Elevation Data, Version 1.0, Section 1.5.3.1

In addition to the fundamental accuracy, supplemental or consolidated accuracy values may be calculated for other ground cover categories or for combinations of ground cover categories. Because elevation errors often vary with the height and density of ground cover, a normal distribution of error cannot be assumed and, therefore, RMSE cannot be used to calculate the 95-percent accuracy value. Consequently a nonparametric testing method (95th Percentile) is

employed for supplemental and consolidated accuracy tests. – NDEP Guidelines for Digital Elevation Data, Version 1.0, Section 1.5.3.2

Utilizing the above mentioned guidelines the State of Mississippi Department of Environmental Quality defined the following project accuracy specifications.

Project Accuracy Specifications			
NDEP/ASPRS Methodology			
FVA<=	24.5	cm	ACCz 95% (12.5 cm RMSEz)
CVA<=	36.3	cm	95th Percentile
SVA<=	36.3	cm	95th Percentile

Table 2 – Accuracy Specifications

URS ran a z-probe analysis using the QA checkpoints and the LiDAR data set and returned the following accuracy assessment results.

Vertical Measurements/Calculations						
Point Number	**Ground Cover Classification**	**MISSISSIPPI STATE PLANE- ZONE 2301,(NAD83)**		**NAVD88 Survey Z (US Ft)**	**LIDAR-Z (US Ft)**	**ΔZ (cm)**
		Easting-X (US Ft)	**Northing-Y (US Ft)**			
QA_B01	Bare Earth	1126097.763	1792213.383	453.438	450.146	-3.292
QA_B02	Bare Earth	1099236.569	1760314.530	312.513	314.708	2.195
QA_B03	Bare Earth	1138162.240	1757663.762	525.751	532.639	6.888
QA_B04	Bare Earth	1122184.686	1724549.716	401.722	405.715	3.993
QA_B05	Bare Earth	1130452.207	1698280.556	427.499	436.704	9.205
QA_B06	Bare Earth	1092668.635	1683223.565	279.082	282.374	3.292
QA_B07	Bare Earth	1113107.208	1653264.164	282.005	284.169	2.164
QA_B08	Bare Earth	1116336.011	1632467.664	374.636	379.543	4.907
QA_B09	Bare Earth	1058970.110	1614271.683	274.566	280.540	5.974
QA_B10	Bare Earth	1120444.841	1585300.657	382.146	380.927	-1.219
QA_B11	Bare Earth	1062671.465	1579237.877	243.811	237.959	-5.852
QA_B12	Bare Earth	1097610.675	1579351.447	242.206	236.872	-5.334
QA_B13	Bare Earth	1125306.303	1554015.941	369.486	367.139	-2.347
QA_B14	Bare Earth	1058365.234	1547181.341	260.091	252.227	-7.864
QA_B15	Bare Earth	1098016.151	1520396.599	210.026	211.916	1.890
QA_B16	Bare Earth	1122264.573	1507768.426	265.780	258.770	-7.010
QA_B17	Bare Earth	1109982.007	1478332.358	205.063	201.009	-4.054
QA_B18	Bare Earth	1127120.554	1452801.282	186.817	195.260	8.443
QA_B19	Bare Earth	1076867.759	1449228.736	220.033	222.654	2.621
QA_B20	Bare Earth	1114942.851	1434281.254	179.762	186.041	6.279
QA_F01	Forest	1091479.916	1797950.613	384.354	380.757	-3.597
QA_F02	Forest	1135038.397	1796133.828	472.710	471.003	-1.707
QA_F03	Forest	1132245.319	1763626.612	438.600	438.874	0.274
QA_F04	Forest	1096549.430	1718443.910	368.271	365.924	-2.347
QA_F05	Forest	1132304.734	1720758.744	430.421	437.309	6.888

Vertical Measurements/Calculations						
QA_F06	Forest	1122456.136	1664223.482	258.053	253.786	-4.267
QA_F07	Forest	1076035.147	1638623.725	210.087	209.386	-0.701
QA_F08	Forest	1127367.593	1618335.066	442.366	437.855	-4.511
QA_F09	Forest	1057116.930	1637399.770	323.378	314.204	-9.174
QA_F10	Forest	1100774.188	1602714.829	260.286	261.139	0.853
QA_F11	Forest	1059307.963	1600327.854	222.680	232.007	9.327
QA_F12	Forest	1064685.012	1571328.592	229.832	228.582	-1.250
QA_F13	Forest	1092936.820	1560690.449	183.216	190.501	7.285
QA_F14	Forest	1125121.091	1570430.387	350.879	352.281	1.402
QA_F15	Forest	1067614.850	1526198.480	220.212	215.366	-4.846
QA_F16	Forest	1123796.365	1507612.391	278.757	281.378	2.621
QA_F17	Forest	1109436.281	1492478.868	206.224	201.865	-4.359
QA_F18	Forest	1133134.907	1463109.855	197.626	196.803	-0.823
QA_F19	Forest	1069648.210	1434436.860	242.083	249.947	7.864
QA_F20	Forest	1122721.427	1443228.671	183.909	178.880	-5.029
QA_U01	Urban	1072250.847	1568202.793	223.985	222.187	-1.798
QA_U02	Urban	1073093.790	1571472.455	227.745	208.939	-18.806
QA_U03	Urban	1110378.946	1737287.375	283.162	281.851	-1.311
QA_U04	Urban	1114039.427	1728899.155	297.647	298.409	0.762
QA_U05	Urban	1118484.397	1720522.525	296.658	297.420	0.762
QA_U06	Urban	1111957.468	1726379.477	267.719	267.689	-0.030
QA_U07	Urban	1110036.405	1731200.032	277.787	279.738	1.951
QA_U08	Urban	1115897.031	1661633.661	265.191	258.455	-6.736
QA_U09	Urban	1117013.457	1660474.117	266.306	265.818	-0.488
QA_U10	Urban	1091706.110	1637726.790	242.842	250.310	7.468
QA_U11	Urban	1091560.573	1635718.994	243.049	246.676	3.627
QA_U12	Urban	1088375.620	1632876.444	240.537	242.549	2.012
QA_U13	Urban	1109801.070	1629035.937	358.220	358.220	0.000
QA_U14	Urban	1072639.453	1573589.902	216.547	217.431	0.884
QA_U15	Urban	1102037.135	1543473.715	220.460	213.602	-6.858
QA_U16	Urban	1100246.801	1499539.279	205.576	201.522	-4.054
QA_U17	Urban	1104380.717	1467465.580	176.305	186.089	9.784
QA_U18	Urban	1111632.198	1454076.805	188.527	186.973	-1.554
QA_U19	Urban	1069595.577	1434530.971	242.770	257.980	15.210
QA_U20	Urban	1132919.339	1441185.657	250.838	245.931	-4.907

Table 3 – Surveyed QA Checkpoint and Z-Difference Calculations

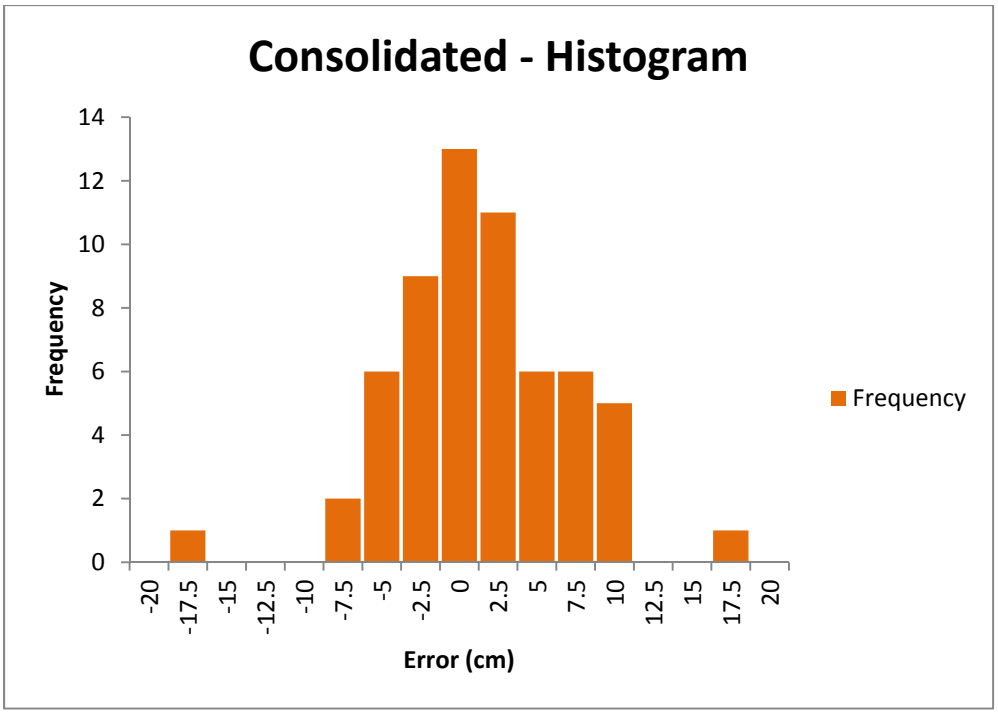


Chart 1 – Histogram of the Consolidated Checkpoints Z-Differences

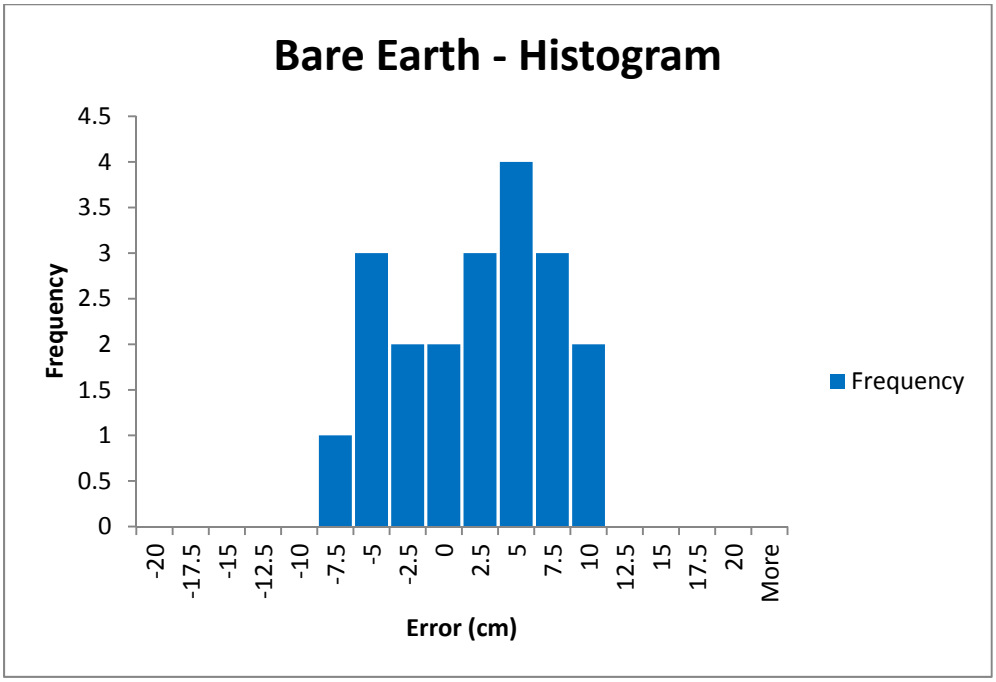


Chart 2 – Histogram of the Bare Earth Checkpoints Z-Differences

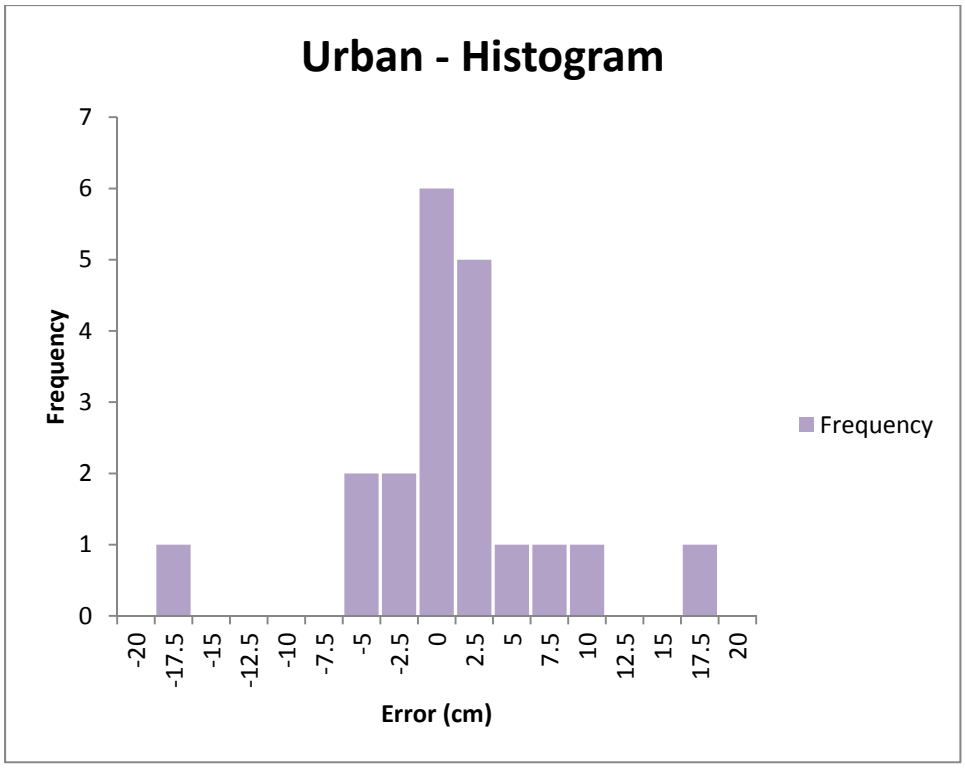


Chart 3 – Histogram of the Urban Checkpoints Z-Differences

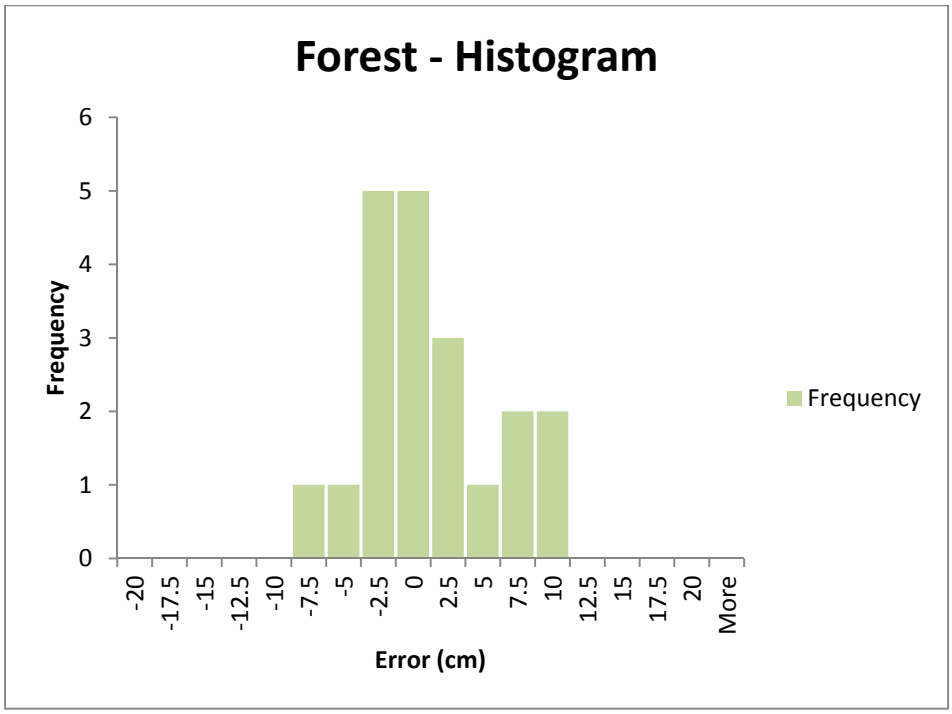


Chart 4 – Histogram of the Forest Checkpoints Z-Differences

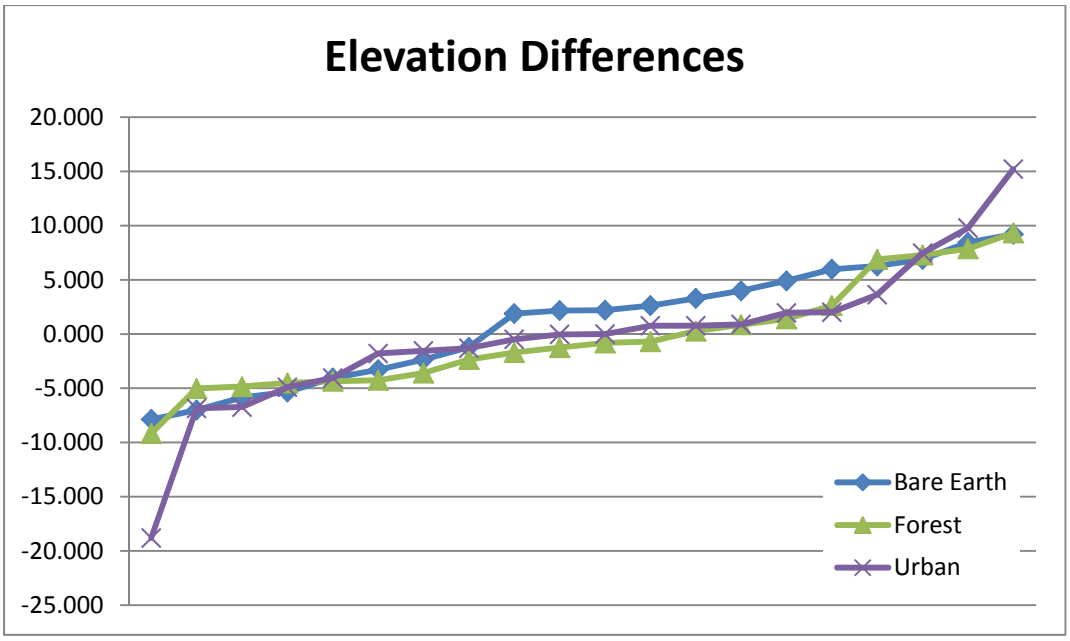


Chart 5 – QA Checkpoints Z-Differences

Vertical Accuracy Statistics - FEMA/NSSDA								
Land Cover	**# of Pts.**	**RMSEz (cm)**	**Std Dev (cm)**	**Mean (cm)**	**Median (cm)**	**Skew (cm)**	**Min (cm)**	**Max (cm)**
Consolidated	60	5.673	5.718	0.178	0.015	0.163	-18.806	15.210
Bare Earth	20	5.279	5.309	1.044	-2.179	0.222	-7.864	9.205
Urban	20	6.708	6.879	-0.204	0.015	0.357	-18.806	15.210
Forest	20	4.866	4.983	-0.305	1.036	-0.535	-9.174	9.327

Table 4 – Vertical Statistic Calculations as per FEMA/NSSDA Specifications

Vertical Accuracy Statistics - NDEP/ASPRS				
Land Cover	**# of Pts.**	**FVA - Spec = 24.5 cm**	**SVA - Spec = 36.3 cm**	**CVA - Spec = 36.3 cm**
Consolidated	60	-	-	9.350
Bare Earth	20	10.347	-	-
Urban	20	13.148	15.389	-
Forest	20	9.538	9.182	-

Table 5 – Vertical Accuracy Statistics as per NDEP/ASPRS Specifications

Accuracy Assessment Results	
PASS	FVA tested 10.347cm vertical accuracy at 95 percent confidence level
PASS	CVA tested 9.350cm vertical accuracy at 95 percentile
PASS	SVA (Urban) tested 15.389cm vertical accuracy at 95 percentile
PASS	SVA (Forest) tested 9.182cm vertical accuracy at 95 percentile

Table 6 – Vertical Accuracy Assessment Results

4 Applicable Specifications & Guidelines

The following guidelines, specifications, and standards are applicable to this project and report:

A. Mississippi Geographic Information, LLC, Work Order No. 3 – URS 03, LiDAR QA/QC Tenn-Tom, February 12, 2012

B. Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying, FEMA, April 2003
http://fema.gov/plan/prevent/fhm/dl_cgs.shtm

C. Procedure Memorandum No. 61 - Standards for Lidar and Other High Quality Digital Topography, FEMA, 2012
http://www.fema.gov/library/viewRecord.do?id=4345

D. American Society for Photogrammetry and Remote Sensing (ASPRS) Guidelines, Vertical Accuracy Reporting for LiDAR Data, May 24, 2004
http://www.asprs.org/society/committees/lidar/Downloads/Vertical_Accuracy_Reporting_for_Lidar_Data.pdf

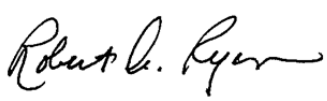
E. FGDC-STD-007.3-1998: Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA)
http://www.fgdc.gov/standards/projects/FGC-standards-projects/accuracy/part3/chapter3

F. FGDC-STD-001-1998: Content Standard for Digital Geospatial Metadata (version 2.0)
http://www.fgdc.gov/metadata/csdgm/

5 Conclusions

Although there were a handful of macro and micro data calls on this project, they were easily corrected. The LiDAR and breakline calls were limited in number and not unexpected given the size of the AOI. Overall the LiDAR had very clean editing and easily passed the accuracy assessment. The Atlantic Group addressed all edit calls and returned corrected data to URS.

Based on the 100% macro and 25% micro assessment conducted by URS on the initial data delivered as well as all redeliveries, the Tennessee-Tombigbee Waterway deliverables meet the applicable project specifications as set forth in the contractual guidelines.



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Robert A. Ryan, CP, PLS
Project Manager