Federal Emergency Management Agency

Merrimack River HUC 8 LiDAR FY2011

Belknap County, New Hampshire CID 33001C
Hillsborough County, New Hampshire CID 33011C
Merrimack County, New Hampshire CID 33013C
Rockingham County, New Hampshire CID 33015C
Strafford County, New Hampshire CID 33017C
Essex County, Massachusetts CID 25009C
Middlesex County, Massachusetts CID 25017C
Worcester County, Massachusetts CID 25027C

Technical Support Data Notebook
Terrain Project Narrative
Elevation Data Acquisition

CASE NO. 12-01-1080S
CONTRACT NO. HSFEHQ-09-D-0370
TASK ORDER NO. HSFE01-11-J-0010

Date: August 31, 2012

Prepared By:

STARR
Strategic Alliance for Risk Reduction

Table of Contents

List of Tables

List of Figures

1. Introduction

Beginning in Fiscal Year 2010, FEMA initiated a five-year program for Risk Mapping, Assessment, and Planning (Risk MAP). The vision for Risk MAP is to deliver quality data that increases public awareness and leads to action that reduces risk to life and property. In order to realize the Risk MAP vision FEMA is acquiring high resolution terrain elevation and land cover elevation data to increase production efficiencies for NFIP regulatory products and support risk assessment data development. FEMA has made a commitment through Risk MAP to work closely with NDEP (National Digital Elevation Program) partners to obtain and support the collection of terrain data throughout the United States.

Terrain data, collected under the Risk MAP program, will be required to meet minimum specifications outlined in *Procedure Memorandum No. 61—Standards for LiDAR and Other High Quality Digital Topography dated September 27, 2010*[1]. FEMA also requires all deliverables for topographic data collection be submitted in accordance with *Appendix M: Data Capture Standards March 2011*[2]. All relevant project materials have been reviewed to insure that these requirements are met.

The objectives for elevation data acquisition and processing for the Merrimack River watershed are as follows:

1. LAS point cloud files collected for 1302 square miles
2. LAS point cloud files captured using the “Highest” vertical accuracy requirements
3. LAS point cloud files collected at equivalent of a 2-foot contour accuracy
4. LAS point cloud files collected using a nominal pulse spacing of 1-meter
5. Hydro enforced break lines
6. LAS classified as Bare Earth processed for 1302 square miles
7. 1 meter Digital Elevation Models
8. Analysis and cartographic 2 foot contours

Table 1. Project Parameters

Collection Area	Processed Area	FEMA Specification Level	Contour Accuracy	NPS	$RMSE_z$	FVA	CVA
1302 mi^2	1302 mi^2	Highest	2ft	1m	18.5cm	24.5cm	36.3cm

Figure 1. Merrimack Watershed NH and MA LiDAR Collection Area

The LiDAR Acquisition area for this project covers portions of Belknap, Hillsborough, Merrimack, Richmond, and Stratford counties in New Hampshire. The project also covers portions of Essex, Middlesex and Worcester Counties in Massachusetts. The following communities are either partially or completely included within this Area of Interest:

Communities in Belknap County New Hampshire:

Town of Alton
Town of Barnstead
Town of Belmont
Town of Gilford
Town of Gilmanton

Communities in Hillsborough County New Hampshire:

Town of Amherst
Town of Bedford
Town of Bennington
Town of Brookline
Town Deering
Town of Francestown
Town of Goffstown
Town of Greenfield
Town of Hillsborough
Town of Hollis
Town of Hudson
Town of Litchfield
Town of Lyndeborough
City of Manchester
Town of Mason
Town of Merrimack
Town of Milford
Town of Mont Vernon
City of Nashua
Town of New Boston
Town of New Ipswich
Town of Pelham
Town of Peterborough
Town of Sharon
Town of Temple
Town of Weare
Town of Wilton

Communities in Merrimack County New Hampshire:

Town of Allenstown
Town of Andover
Town of Boscawen
Town of Bow
Town Canterbury
Town of Chichester
City of Concord
Town of Dunbarton
Town of Epsom
City of Franklin
Town of Henniker
Town of Hooksett
Town of Hopkinton
Town of Loudon
Town of Northfield
Town of Pembroke
Town of Pittsfield
Town of Salisbury

Communities in Rockingham County New Hampshire:

Town of Auburn
Town of Candia
Town of Deerfield
Town of Londonderry
Town of Salem
Town Windham

Communities in Strafford County New Hampshire:

Town of Farmington
Town of Strafford
Town of New Durham

Communities in Essex County Massachusetts:

Town of Methuen

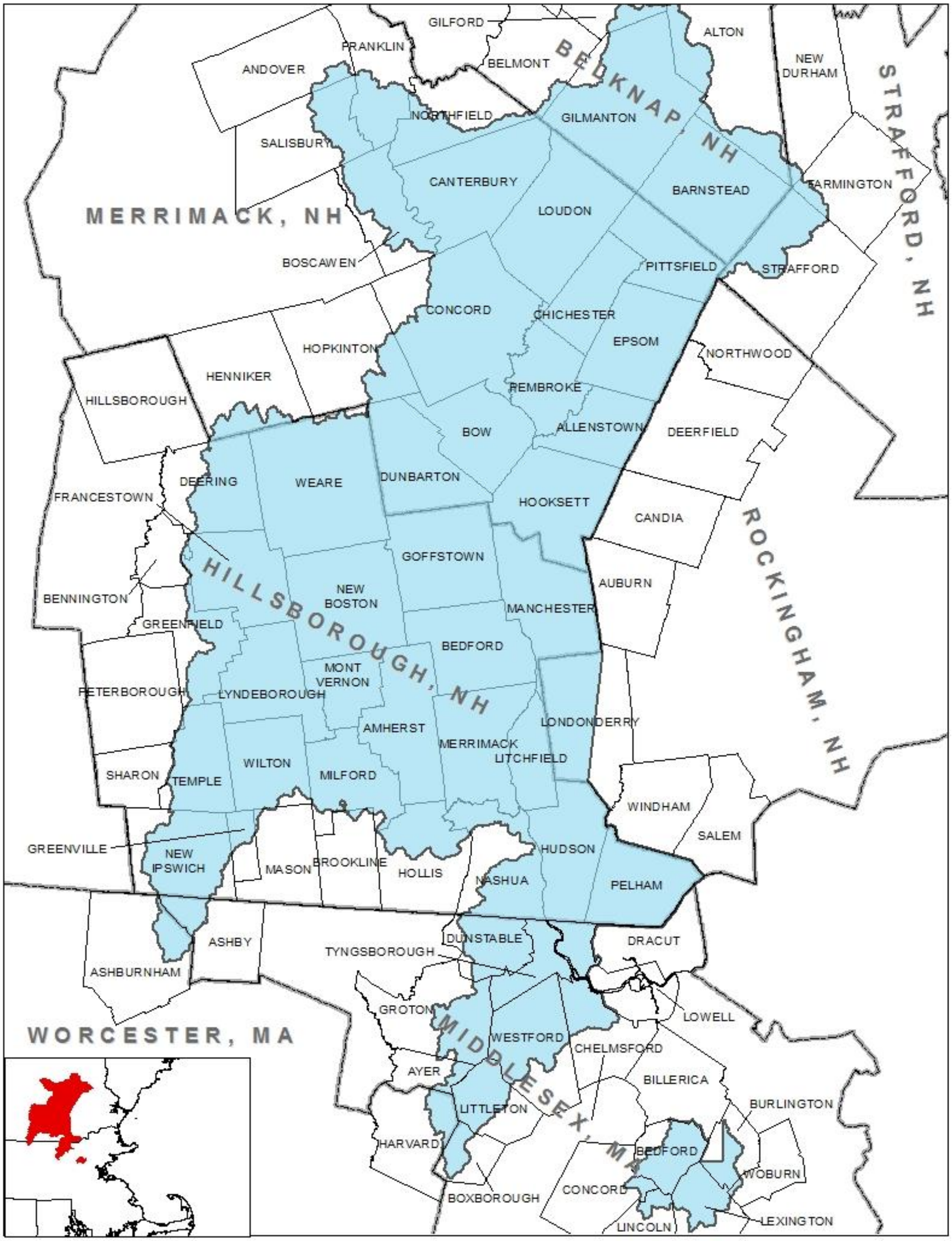
Communities in Middlesex County Massachusetts:

Town of Ashby
Town of Bedford
Town of Boxborough
Town of Chelmsford
Town of Dracut
Town of Groton
Town of Lincoln
City of Lowell
Town of Westford
Town of Ayer
Town of Billerica
Town of Burlington
Town of Concord
Town of Dunstable
Town of Lexington
Town of Littleton
Town of Tyngsborough
City of Woburn

Communities in Worcester County Massachusetts:

Town of Ashburnham
Town of Harvard

Figure 2. Merrimack Watershed Communities



2. Scope of Work

Statement of Priorities
PTS Elevation Data Acquisition
STARR – Contract # HSFEHQ-09-D-0370 Task Order # HSFE01-11-J-0010

STARR understands that the Region requires one (1) area, the Merrimack Watershed, NH-MA, to be collected and processed to bare earth under this task order. This area is to be collected to the "Highest" FEMA specification level. This means that the vertical accuracy must meet Fundamental Vertical Accuracy (FVA) and Consolidated Vertical Accuracy (CVA) requirements of 24.5cm and 36.3cm, respectively. The nominal pulse spacing requirement is less than or equal to 1-meter. These requirements are equivalent to that required for a 2-foot contour accuracy standard. Table 2 provides a summary of the collection requirements.
STARR is providing the collection of breaklines and hydro-flattening of the data, as specified in USGS NGP Base LiDAR Specifications, Version 13 (USGS v.13).
Likewise, STARR is providing the construction of derivative products (Contours and DEMs) required for engineering modeling for hydrology and hydraulic analysis.

Table 2 – Merrimack Watershed Collection Requirements

Project Name	State	Collection and Processing Area in Sq. Miles	Specification Level
Merrimack Watershed	NH-MA	1,302	Highest
Total Area		**1,302**	

Technical Discussion
Survey

STARR will obtain the ground control needed to support the LiDAR collection efforts as well as obtaining the independent QC points needed to support the FVA and CVA Assessment requirements.

STARR proposes the following methodology to meet the requirements of FEMA PM61 and the associated Appendix A. We note that Appendix A was written in 2003, and the associated NOAA TM NOS NGS -58 Guidelines for Establishing GPS-Derived Ellipsoid Heights V4.3 were written in 1997 with no revision. This approach is not entirely compliant with the procedures, technologies and methodologies detailed in PM61 and Appendix A, but provides for a very effective method of collecting high accuracy points that allows FVA testing and modified CVA testing for bare-earth evaluation at reduced costs.

Given the recent advances in GPS technology and associated updates to survey methodologies, we propose the use of PM61 and associated documents as guidelines exercised through careful GPS survey practice in conjunction with reasoned professional judgment to arrive at statistically and numerically relevant Control and Testing results for the project area as currently described. This methodology will allow FVA and CVA testing to specification, as FVA and Supplemental Vertical Accuracy (SVA) points will be collected for the project area.

STARR will collect all points with a combination of RTK and Static Post Processing with Base lines no longer than 80km to meet the specifications for the project. All points will be collected with Survey Grade GPS equipment, which typically achieves a high precision in the range of sub 3cm on a point-by-point basis. As a quality control practice STARR will also be collecting an NGS monument on a daily basis, when available, to check the collection methodology and accuracy. This allows for minimal duplication of point occupation, greatly reducing time in the field.

NMAS/NSSDA Vertical Accuracy Table 1 contained in the ASPRS Guidelines (as referenced by PM61) requires accuracy test data to be 3 times more accurate than the NSSDA accuracy requirement of the finished product. Section 2.3.3 of the ASPRS Guidelines states “QC surveys should be such that the checkpoint accuracy is at least three times more accurate than the dataset being evaluated." Based on the 95th percentile confidence level of 24.5cm, all survey points will be at ≤ 8cm precision.

Ground control points will be located only in open terrain, where there is a high probability that the sensor will have detected the ground surface without influence from surrounding vegetation or buildings. Points will be located on flat or uniformly sloping terrain and will be at least five (5) meters away from any break line where there is a change in slope. All control points will be surveyed at ≤ 8cm precision. This criterion applies for all FVA QC points as well. Control and FVA check points will be distributed to support all individual polygons. Distribution of the Control points will also be evaluated and approved by the LiDAR acquisition team. FVA points will remain confidential and only revealed to the LiDAR team at the time of the FVA assessment.

The blind vertical SVA QC points will be collected randomly across all polygons and different land use types using the ASPRS NSSDA land cover types. The points will be located in flat areas with no substantial elevation breaks within a 3-5 meter radius. All SVA points in the Urban and Brush land use categories, and the Forest land use category if practical, will be collected at ≤ 8cm precision to ensure a valid statistical test capability.
The CVA Assessment utilizes the SVA points and a representative sample of the FVA points (open terrain) such that all land classes comprising more than 10% of the total project area will be represented.

All points will be documented with an overhead image chip showing site and situation, at least 2 ground-based photos in the cardinal directions where practical. In addition, a sketch will be provided of all Control and FVA points. An Accuracy Report for the collection will be provided based on daily observation of an NGS-Point (when available) to demonstrate system collection precision against an independent known point. Shape files as well as KML files will be provided for the block.

All coordinate data will be provided in Decimal Degrees, and in UTM Meters NAD83/NAVD88 (Geoid09). Specifically, 73 control points will be surveyed to support calibration of the collected LiDAR data to ground following initial post-flight processing.
Although the area consists of one large polygon and one smaller polygon, the topography and land cover of the area are homogenous, and the smaller area will be collected on the same

mission as the nearby section of the larger polygon. Thus, it is recommended that both polygons be tested together as one unit, and there will not be a requirement to have a minimum number of points within the small polygon to provide for testing validity.
Testing at the 95th Percentile Confidence Level requires a minimum of 20 points for each category of testing. Thus STARR proposes to collect 20 FVA points, and 20 points in each of the predominant land cover categories for the SVA/CVA testing. A summary of this point requirement is found in Table 3.

Table 3 – Survey Summary

Project Name	Ground Control Points	FVA Points	SVA Points				
			Open	Urban	High Grass	Brush	Forest
Merrimack Watershed	73	20	NA	20	NA	20	20

The following will be delivered from the Survey activity:

For Ground Control Survey -
- Accuracy reports based on known monuments;
- Image chips - aerial image of the position of each point;
- Pictures - four pictures in the cardinal directions showing the point from the ground perspective;
- Shape file of the points;
- Station diagrams for each point;
- Final report - includes methodologies and general project information;
- Spreadsheet of all points; and
- Any obsolete records.

For FVA and CVA Point Survey -
- Accuracy reports based on known monuments;
- Image chips - aerial image of the position of each point;
- Pictures - four pictures in the cardinal directions showing the point from the ground perspective;
- Shape file of the points;
- Station diagrams for each point;
- Final report - includes methodologies and general project information;
- Spreadsheet of all points; and
- Any obsolete records.

For QC Testing –

- Final report;
- Excel spreadsheet with calculations;
- Metadata process steps; and
- Compliance certificate.

LiDAR Acquisition

LiDAR for the Merrimack area will be acquired to the “highest” specification level. This means that the vertical accuracy requirement must meet FVA/CVA requirements of 24.5 cm/36.3 cm. The nominal pulse spacing requirement is less than or equal to 1-meter. This vertical accuracy requirement mirrors a 2-foot equivalent contour accuracy. The LiDAR system parameters are spelled out in Table 4.

Table 4 – LiDAR System Parameters

Merrimack Watershed	
Flight altitude (AGL)	5000 feet
Rep Rate	70 KHZ
Scan frequency	33.6 Hz
Scan half angle	17 degrees
Scan full angle	34 degrees
Swath width	930.7 meters
Overlap	30% side lap (60% overlap)
Point density	1.12 ppm^2
Required point density	1 ppm
Air Speed	130 knots
No. of missions	9
Line spacing	300 meters

The following will be delivered from the LiDAR acquisition activity:

- Pre-flight Operations Plan (PreFlight Report);
- Metadata process steps

LiDAR Processing

STARR will process the data to the point cloud deliverable and to bare earth deliverables. All areas collected will be processed to bare earth. The following is a brief explanation of the LiDAR processing:

Raw airborne GPS and IMU data will be extracted from the Applanix CARD and differentially processed in PosGPS, then integrated with the IMU data in PosPAC. The GPS/IMU data will be processed in Applanix to derive a smoothed best estimate of trajectory (SBET).The SBET is used to reduce the LiDAR slant range measurements to derive the Return measurement for each LiDAR pulse within each flight line. The coverage will be imported into TerraScan and tiled into 1500m x 1500m tiles. An initial accuracy assessment using the ground point survey data will be calculated to ensure the data is accurately 'tied' to the ground. The data will then be classified using automated processes to extract a bare earth digital elevation model (DEM). Once all project data is imported and classified, the survey ground control data will be calculated against the LAS Class 2 (Ground) data for an accuracy assessment. As a QC measure, a routine will be used to generate accuracy statistical reports by comparison among LiDAR points, ground control, and triangulated irregular networks (TIN). Any systematic bias in the data is removed to meet or exceed the vertical accuracy requirements. At this point the FVA test will be conducted.

The collection of breaklines will take place just prior to the manual edit of the point cloud data. The breaklines will be collected on streams that are greater than 100 feet wide and any open water bodies greater than 2 acres in size. These breaklines will enhance the ability to classify open water points, edge of water for modeling purposes, and allow for more accurate construction of TINs required for the H&H modeling. STARR is proposing to collect the breaklines using the standard USGS specifications which will ensure this dataset will mesh seamlessly with the USGS LiDAR data that abuts within the Merrimack Watershed. Because these datasets both exist within the watershed boundary, having the datasets conform to the same specifications as nearly as possible will allow the analysis of the watershed to be more efficient.

The calibrated and filtered LiDAR point cloud will be manually checked for accuracy. Hydro-enforcement will also take place during the manual edit. Care will be taken to remove bridges, the water surfaces are flat and that all water edges are lower than adjacent ground. All points will be placed in one of the following categories: 1 Unclassified, 2 Bare-earth Ground, 7 Noise, 9 Water, 10 Ignored Ground, 11 Withheld, and 12 Overlap Points. Category 8 Model Key points will be generated from the Ground points. CVA testing will then be conducted and final reports generated.

A full suite of topographic products is included in the tasking for this watershed. The data development will be completed by the STARR staff responsible for, and immediately following, the QA of the Fully Classified (Bare Earth) LAS dataset.

The following will be delivered as a result of the processing activity:

- Post-flight Aerial Acquisition and Calibration Report (PostFlight Report);
- Point cloud LAS points (partially classified);
- Fully classified LAS points (includes 1. Unclassified, 2. Bare-earth ground, 7. Noise, 8. Model Key Points, 9. Water - if breaklines are collected, 10. Ignored ground, 11. Withheld, 12. Overlap);
- Breaklines;
- Metadata process steps; and
- Compliance certificate.

Quality Control

SURVEY. To ensure valid in-field collections, an NGS monument with suitable vertical reporting will be measured using the same equipment and procedures used for control, FVA and CVA points on a daily basis. The measurement will be compared to the NGS published values to ensure that the GPS collection schema is producing valid data and as a physical proof point of quality of collections. Those monument measurements will be summarized in the accuracy report included in the Survey data deliverables.

LiDAR Acquisition

Calibration. All of the sensors are calibrated by flying lines at multiple altitudes and at varying directions over features on land, typically at the airport where the acquisition is staged. These lines are used to remove angular errors between the IMU and scanning mirror and to determine the precise positioning of the sensor in relationship with the phase center of the GPS antenna mounted on the fuselage of the aircraft.

Cross Lines. Cross flight lines are run perpendicular to the overall flight lines for the survey area. Careful analysis takes place from the crossing flight lines to ensure that accurate modeling of the ground surface is attained from the use of the LiDAR sensor.

Sidelap Analysis. The side overlap is planned for each project based on the terrain to be acquired. Typically for flat terrain the overlap is 20%. For more rugged terrain an overlap of up to 50% (100% duplicated coverage) will be required. The proposed 30% sidelap (see Table 1.4) will ensure that no data gaps exist within the coverage.

Forward and Reverse GPS Solutions. During the initial processing of the inertial navigation system (INS) data, the raw GPS observations are processed against the ground base station data in both a forward and reverse sense. The two solutions are then compared against one another for all GPS epochs and the individual differences for the northing, easting, (x, y coordinates) and elevation components are plotted for easy comparison. Any anomalies in the data are quickly analyzed, and if required, re-flights take place for the portions of the flight missions that require remediation.

Calibration of the Elevation Surface. The raw LiDAR surface is compared against ground points that are established for the calibration of the elevation surface. System biases are identified and removed during this calibration. An early statistical analysis will take place that provides an indication of the precision of the acquired data.

Blind RMSE Testing. The LAS data will be tested at the conclusion of the automated processing step. At this point the LAS points have been calibrated and open area points should accurately reflect the bare earth surface. The x, y coordinates of the FVA points will be used to determine the elevation at each location. Calculation of the RMSE and the 95% Confidence Level will be done via a spreadsheet, comparing the LiDAR derived elevation values and the survey elevation values. If the calculated value is within the acceptable range, manual processing can continue. If the value is not within range, STARR will analyze the data further to get within the acceptable range. If the test points are compromised during that analysis, STARR will be responsible for obtaining further blind check points such that the data can be confidently checked and approved. All remedial activity must be included in the PostFlight Report. Likewise, at the conclusion of the manual bare earth processing the CVA test points will be checked against the produced bare earth surface following the same methodology.

Derived Products

A full suite of derived products will be developed immediately following final approval of the LAS datasets.

Deliverables include the following:
- 1 meter DEM;
- 3 meter DEM; and
- 2 foot contours.

Quality Assurance

STARR will perform an impartial review of the technical, scientific, and other information submitted under Develop Topographic Data to ensure that the data and modeling are consistent with FEMA standards.

These activities are guided by the STARR Quality Assurance checklist which was developed to include all of the suggested information found in PM61. In addition a statistical sampling of LAS data tiles are reviewed, checking for spikes in the data, incomplete coverage, and cleanliness of the data. This review is done using the LP360 software (commercially available software). The software allows for review of the data via a rolling cross section approach whereby a tile of data can easily be reviewed ensuring there are no artifacts remaining in the bare earth data.

All deliverable reports are read for consistency, accuracy and completeness. As deliverables are approved, they are stored in a delivery structure ready for upload to the MIP, and loading to a hard drive for delivery to the FEMA Engineering Library.

Any data issues with the LiDAR deliverables will be reevaluated and corrected accordingly. Revised data will be back checked to ensure all issues have been rectified. The final step in the quality assurance process is the construct of the Narrative documentation and the final assembly of the metadata for the terrain products.

Deliverables as a result of the QA activity are:

- A Summary Report that describes the findings of the independent QA/QC review; and
- Quality Assurance Checklist;
- Project Narrative; and
- Final compiled metadata record.

3. Issues

A. Special Problem Reports

None

B. Project Modifications

None

4. Information for the Next Mapping Partner

The Merrimack Watershed LiDAR collection AOI consists of one large functional area and one smaller area that cover 1302 square miles. This project included both LiDAR point cloud development and Bare Earth post processing. The Point Cloud LiDAR data for this project are 1,749 partially classified LAS 1.2 binary files. All 1,749 Point Cloud files were processed into Bare Earth LiDAR LAS 1.2 binary files. Bare Earth LiDAR for this project has been classified using ASPRS LiDAR classifications.

Table 5 ASPRS LiDAR Classifications

Merrimack Watershed Classified LiDAR ASPRS Classifications	
1	Unclassified
2	Ground
7	Low Point (Noise)
8	Model Key-point (Mass Point)
9	Water
10	Ignored Ground
11	Withheld
17	USGS Overlap Default
18	USGS Overlap Ground

All data for this project has been collected using the following spatial reference information:

Projection: Universal Transverse Mercator
UTM Zone: 19
Linear units: Meter
Horizontal Datum: North American Datum 1983
Vertical Datum: North American Vertical Datum of 1988
Vertical units: US Survey Foot

Vertical Accuracy Test Results

Final Test Results
The vertical accuracy requirements based on flood risk and terrain slope are met with 14.0 cm and 24.3 cm for both FVA and CVA testing. The mandatory requirements for the highest specification for vertical accuracy, 95% confidence levels are for FVA < 24.5 cm and CVA < 36.3 cm.

FVA Test
Tested 14.0 cm fundamental vertical accuracy at 95% confidence level in open terrain using RMSE(z) x 1.9600. The Root Mean Square Error for the elevation differences between GPS control points and LiDAR points is **7.1 cm** calculated with 20 FVA points.

CVA Test
Tested 24.3 cm consolidated vertical accuracy at 95th percentile in: open terrain, forest terrain, and urban terrain. The Root Mean Square Error for the elevation differences between GPS control points and LiDAR points is **11.4 cm** calculated with 76 supplemental vertical accuracy points (SVA).

LAS point files are named according to the UTM Coordinates at the southwest corner of the tile, following the zz_0xxxyyy convention, where z is the UTM zone number, x and y are the UTM coordinates. Details about the storage of this dataset can be found within Appendix G of this document.

Ground control and quality control checkpoints were collected by CompassData, Inc. Photo Science, Inc. performed LiDAR acquisition flights, automated processing and Bare

Earth manual edits. Independent QC of the point cloud and bare earth surface was performed by CompassData, Inc. Quality Assurance testing was conducted by Greenhorne & O'Mara, Inc. All firms were under contract to STARR, A Joint Venture which held the FEMA Professional Technical Services contract and task order for this work. All contact information for the project team can be found in Appendix A of this document.

A. Ground Control Survey

Ground Control is collected throughout the AOI for use in the processing of LiDAR data to ensure data accurately represents the ground surface. QA/QC checkpoints, also collected throughout the AOI, are used for independent quality checks of the processed LiDAR data.

GPS based surveys were utilized to support both processing and testing of LiDAR data within FEMA designated Areas of Interest (AOIs). Geographically distinct ground points were surveyed using GPS technology throughout the AOIs to provide support for three distinct tasks.

Task 1 was to provide Vertical Ground Control to support the aerial acquisition and subsequent bare earth model processing. To accomplish this, survey-grade Trimble R-8 GPS receivers were used to collect a series of control points located on open areas, free of excessive or significant slope, and at least 5 meters away from any significant terrain break. Most if not all control points were collected at street/road intersections on bare level pavement.

Task 2 was to collect Fundamental Vertical Accuracy (FVA) checkpoints to evaluate the initial quality of the collected point cloud and to ensure that the collected data was satisfactory for further processing to meet FEMA specifications. The FVA points were collected in identical fashion to the Vertical Ground Control Points, but segregated from the point pool to ensure independent quality testing without prior knowledge of FVA locations by the aerial vendor.

Task 3 was to collect Consolidated Vertical Accuracy CVA) checkpoints to allow vertical testing of the bare-earth processed LiDAR data in different classes of land cover, including: Open (pavement, open dirt, short grass), High Grass and Crops, Brush and Low Trees, Forest, Urban. CVA points were collected in similar fashion as Control and FVA points with emphasis on establishing point locations within the predominant land cover classes within each AOI or Functional AOI Group. In order to successfully collect the Forest land cover class, it was necessary to establish a Backsight and Initial Point with the R8 receiver, and then employ a Nikon Total Station to observe a retroreflective prism stationed under tree canopy. This was necessary due to the reduced GPS performance and degradation of signal under tree canopy.

The R-8 receivers were equipped with cellular modems to receive real-time correction signals from the Keystone Precision Virtual Reference Station (VRS) network encompassing the Region 1 AOIs. Use of the VRS network allowed rapid collection times (~3 minutes/point) at 2.54 cm (1 inch) initial accuracy.

All points collected were below the 8cm specification for testing 24cm, highest category LiDAR data. To ensure valid in-field collections, an NGS monument with suitable vertical reporting was measured using the same equipment and procedures used for Control, FVA and CVA points on a daily basis. The measurement was compared to the NGS published values to ensure that the GPS collection schema was producing valid data and as a physical proof point of quality of collection. Those monument measurements are summarized in the Accuracy report included in the data delivered to FEMA.

In order to meet FEMA budgetary requirements, 20 FVA points are necessary to allow testing to CE95 – 1 point out of 20 may fail vertical testing and still allow the entire dataset to meet 95% accuracy requirements.

In similar fashion, 76 CVA points are necessary to test to CE95 as discussed above. 72 CVA points were collected with the intention at the outset that 4 of the collected FVAs would perform double –duty as Open-class CVA points, to total 76 CVAs.

The following software packages and utilities were used to control the GPS receiver in the field during data collection, and then ingest and export the collected GPS data for all points:

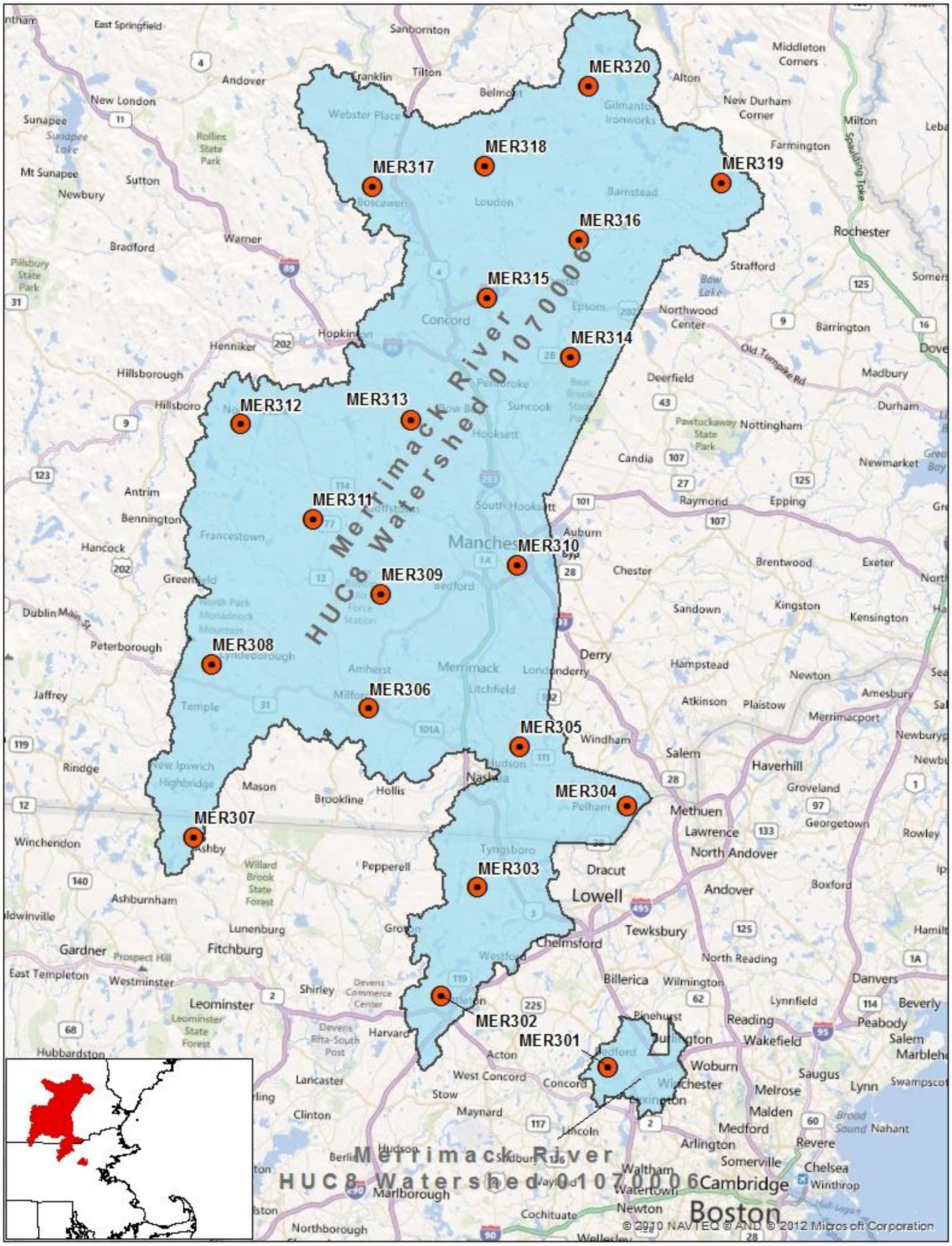
- Trimble Survey Controller
- Trimble Pathfinder Office

The following software utilities were used to translate the collected Latitude/Longitude Decimal Degree HAE GPS data for all points into Latitude/Longitude Degrees/Minutes/Seconds for checking the collected monument data against the published NGS Datasheet Lat/Long DMS values and into UTM NAD83 Northings/Eastings:

- U.S. Army Corps of Engineers CorpsCon
- National Geodetic Survey Geoid09NAVD88

MSL values were determined using the most recent NGS-approved geoid model to generate geoid separation values for each Lat/Long coordinate pair. In this fashion, Orthometric heights were determined for each Control, FVA and CVA point by subtracting the generated Geoid Separation value from the Ellipsoidal Height (HAE) for publication and use as MSL NAVD88(09).

Figure 3. Merrimack Watershed Ground Control Survey



B. Data Acquisition

LiDAR acquisition products include Pre- and Post- flight reports which contain information on the flight lines, equipment parameters, and other pertinent acquisition details. The LiDAR product is considered to be point cloud data and consists of 1500mx1500m tiles of LAS points which are partially classified such that the bare earth points can be calibrated to the ground surface and tested via the independent QC to ensure the ground surface is accurately represented.

All flights for the project were accomplished with both a customized twin-engine Piper PA-31 Navajo Fixed Wing Aircraft utilizing a Leica ALS60 LiDAR sensor and a Cessna 206 single Aircraft outfitted with an Optech Gemini LiDAR Sensor. These aircraft provide an ideal, stable aerial base for LiDAR acquisition. Both platforms have relatively fast cruise speeds that are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which can prove ideal for collection of a high-density, consistent data posting.

Using a Leica ALS60 LiDAR system, 268 flight lines of highest density (Nominal Pulse Spacing of 1.0m) were collected over the Merrimack area which encompasses 1302 square miles. Five (5) blocks (block or area is determined by the Base Station control locations, typically airports with ground control monuments available providing coverage within 18 miles of the base as possible) to cover in its entirety.

Table 6 LiDAR Acquisition Details

Area	Flight Lines	Lifts	Dates	System
CON	79	7	12/19-12/29 2011	ALS60
ASH	64	5	1/7-1/11 2012	ALS60
BED	31	1	1/11/2012	ALS60
LCI	34	2	11/12-11/13 2011	ALS60
AFN	48	4	11/12-11/13 2011	Optech Gemini
Cross Flights	12	Lifts were combined with the acquisition of each area with both sensors		

Leica proprietary software was used in the post-processing of the airborne GPS and inertial data that is critical to the positioning and orientation of the sensor during all flights. Pairing the aircraft's raw trajectory data with the stationary GPS base station data, this software yields Leica's IPAS TC ("Inertial Positioning & Attitude Sensor – Tightly Coupled") smoothed best estimate of trajectory (an "SBET", in Leica's .sol file format) that is necessary for Leica's

ALSPP post processing software to develop the resulting geo-referenced point cloud from the LiDAR missions. The point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above-ground features are removed from the data set.

The point cloud was created using Leica's Post Processor software. GeoCue was used in the creation of some of the files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. The TerraScan and TerraModeler software packages are then used for the automated data classification, manual cleanup, and bare earth generation from this data. Project specific macros were used to classify the ground and to remove the side overlap between parallel flight lines.

C. Post Processing

Point Cloud data is manually reviewed and any remaining artifacts are removed using functionality provided within the TerraScan and TerraModeler software packages. Additional project specific macros are created and run within GeoCue/TerraScan to ensure correct LAS classification prior to project delivery.

QT Modeler was used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for both the All Point Cloud Data and the Bare Earth. In-house software was then used to perform final statistical analysis of the classes in the LAS files. LAS Class 2 is used to check the independent QC points against the Triangulated LiDAR surface.

Figure 4. Merrimack Watershed Point Cloud Acquisition

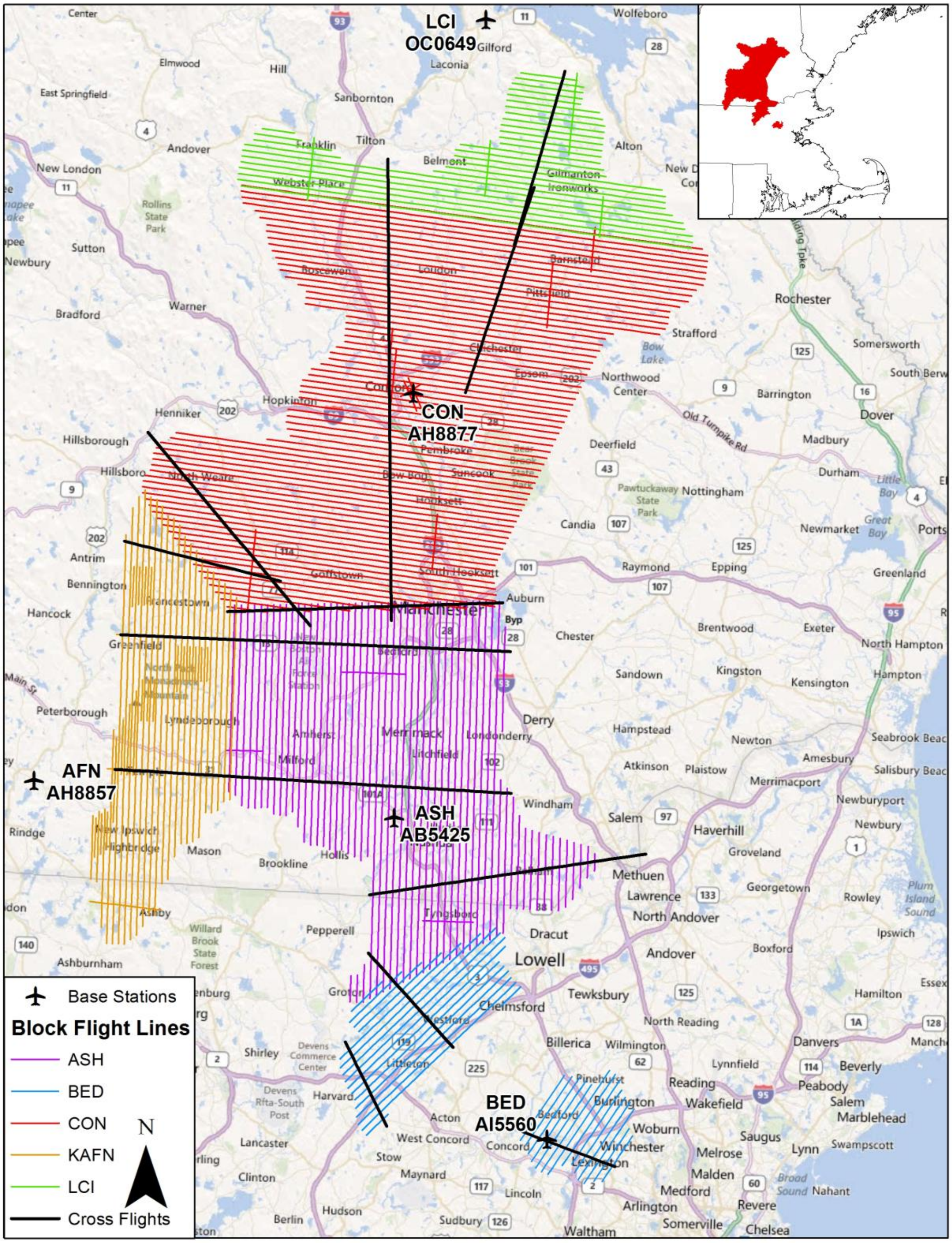
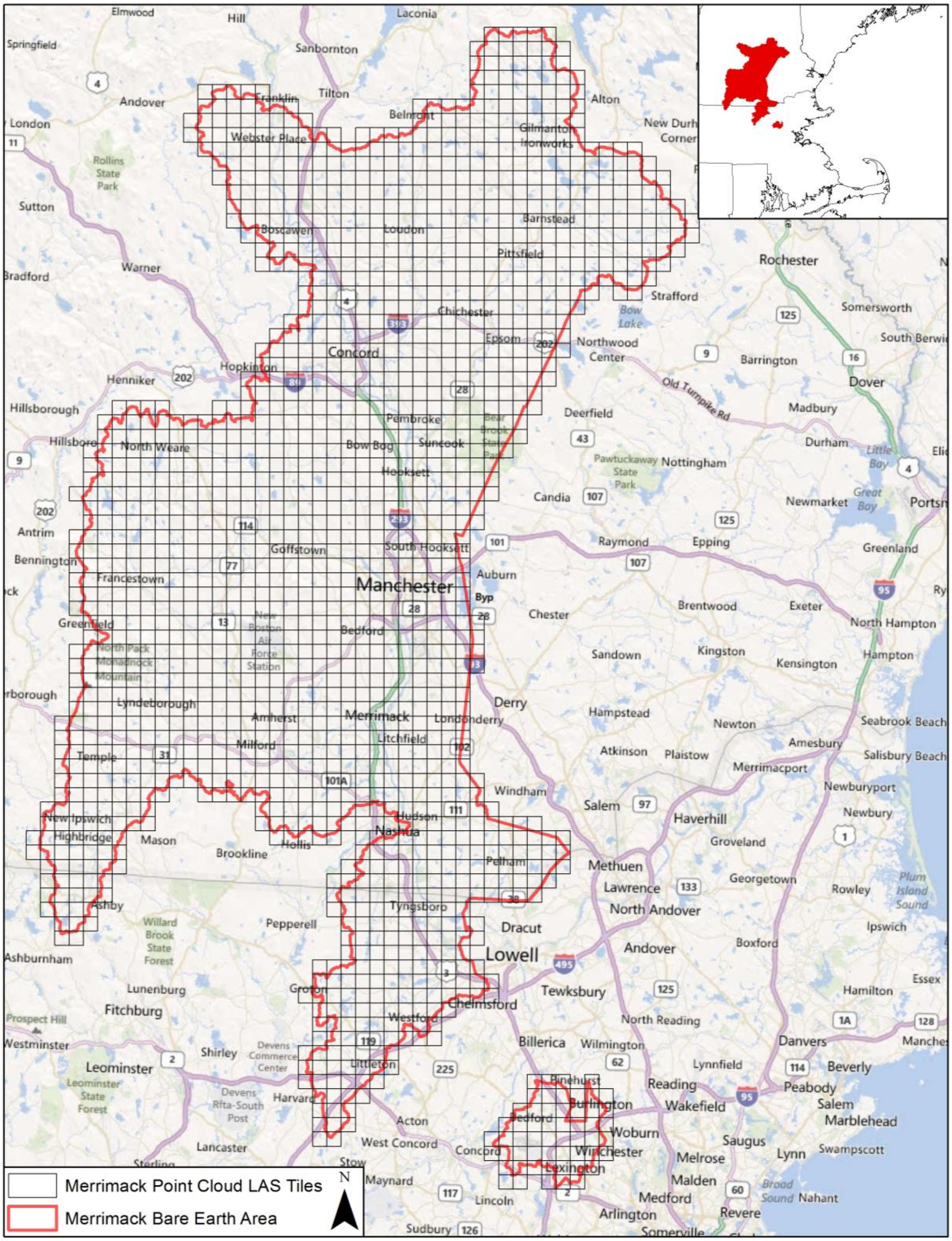


Figure 5. Merrimack Watershed Post Processing



D. Quality Control

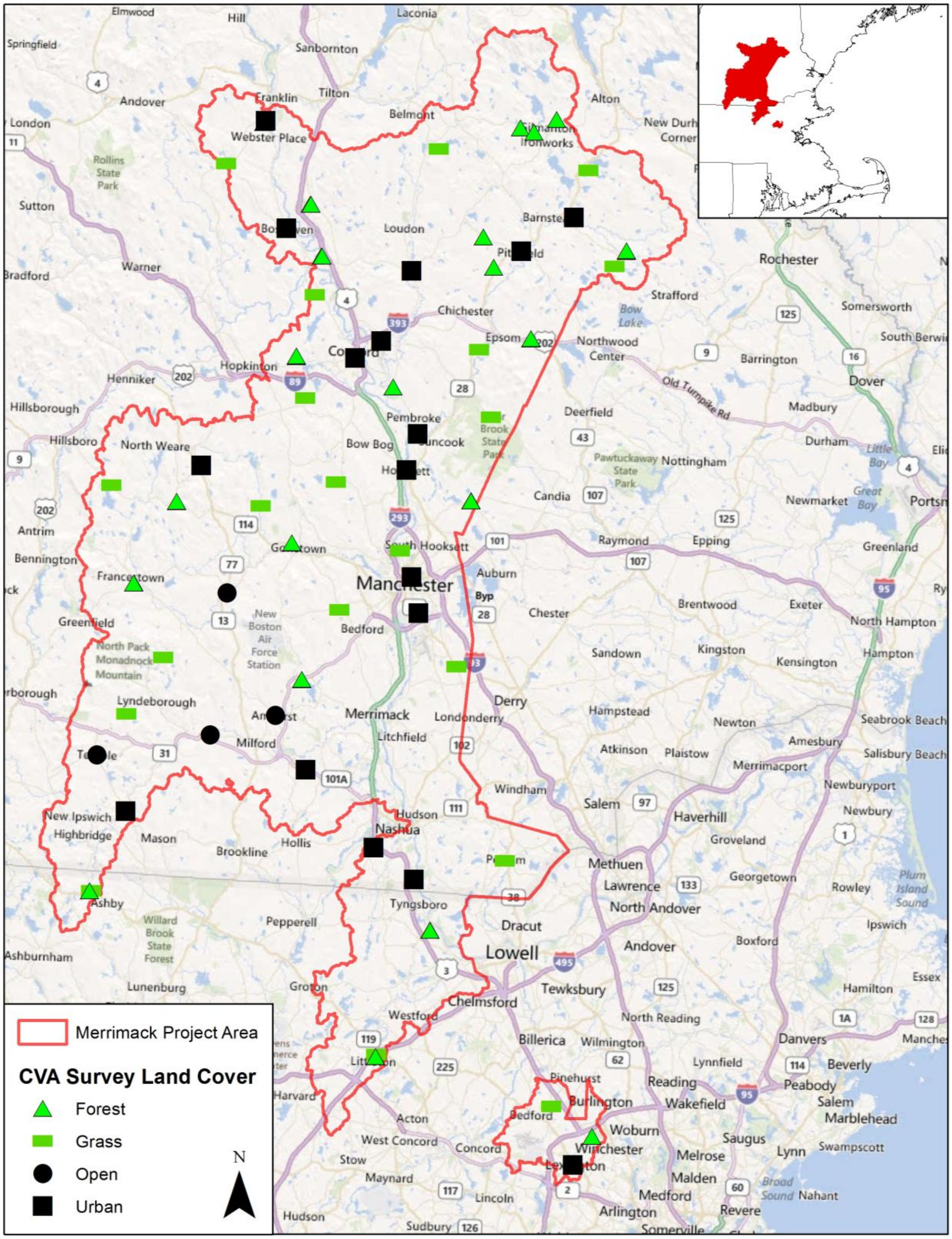
Fundamental Vertical Accuracy (FVA) checkpoints are located only in open terrain, where there is a high probability that the sensor will have detected the ground surface without influence from surrounding vegetation and/or buildings. Checkpoints are located on flat or uniformly sloping terrain and at least five (5) meters away from any break line where there is a change in slope. Checkpoints are located randomly across the acquisition area. At least 20 FVA points were collected for each test.

Consolidated Vertical Accuracy (CVA) checkpoints are collected randomly across different land use types using the ASPRS NSSDA land cover types. The points are located in flat areas with no substantial elevation breaks within a five meter radius. The CVA assessment incorporates a representative sample of the FVA assessment points into the dataset to save on the total number of points collected. CVA points were not collected for any land class comprising less that 10% of the total project area; this may have resulted in less than 4 land classes being collected in a particular area. At least 72 CVA points were collected and 4 FVA points used, for a total of at least 76 points for the CVA testing.

All checkpoints were collected by CompassData to ensure the 'independence' of the quality control check. All points were collected at three times the accuracy of the surface being checked. Thus to check a 24.5cm surface the points were collected accurate to 8cm.

Tests were conducted when processing by the LiDAR vendor was complete and points were called for. CompassData provided the point coordinates in an excel spreadsheet to the LiDAR vendor. The LiDAR vendor found the corresponding elevation from a surface created from the LiDAR points, filled in the spreadsheet and returned it to CompassData. CompassData compared the elevation of the LiDAR data with that of the accuracy check point, calculated the difference and reported their findings both in terms of $RMSE_z$ and at the 95% confidence level (computed as $RMSE_z$ x 1.9600). LiDAR datasets passing the quality control checks were delivered to STARR for quality assurance approval.

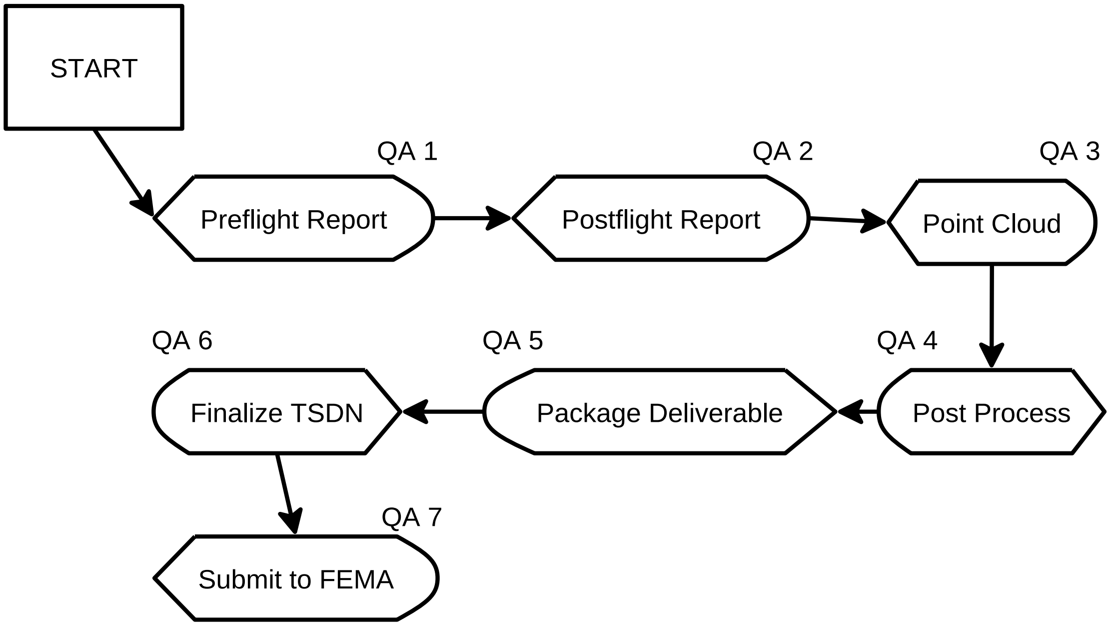
Figure 6. Merrimack Consolidated Vertical Accuracy Survey



E. Quality Assurance

Quality assurance for all elevation data collected for this project has been completed using *FEMA PM61*$_1$, *FEMA Appendix M*$_2$, *USGS LiDAR Guidelines and Base Specifications v13*$_3$, and *FEMA Appendix A*$_4$ as guidance. Products generated during this project are checked for conformance to the aforementioned guidance and specifications before submittal to FEMA.

Figure 7. Quality Assurance Workflow



QA1: Preflight Planning and Reporting

Project preflight operations planning were delivered as a report. This report was reviewed for completeness based on: *Table 4.1 and checklists provided in section 4.2.1in PM61*$_1$. The report was reviewed and is compliant with FEMA guidance and specifications. This report is included within Appendix C of this document. Appendix G contains information about the location of report data on the MIP.

QA2: Post flight Report

Post flight reporting for this project has been reviewed for both content and completeness based upon: *Table 4.2 and checklists provided in section 4.2.1in PM61*$_1$. The report is included with Appendix E of this document. The report is complete and all content meets the guidance and specifications.

QA3: Raw Point Cloud Review

Fully calibrated raw point cloud data has been reviewed at both a macro and micro level using *Table 4.3 and checklists provided in section 4.2.1in PM61*[1], and USGS *LiDAR Guidelines and Base Specifications v13*[3]. 5% of the total number of project tiles was reviewed for compliance with USGS and FEMA specifications. All tiles reviewed for this project passed both the macro and micro reviews. Quality assurance results for the point cloud are contained within Appendix F of this document.

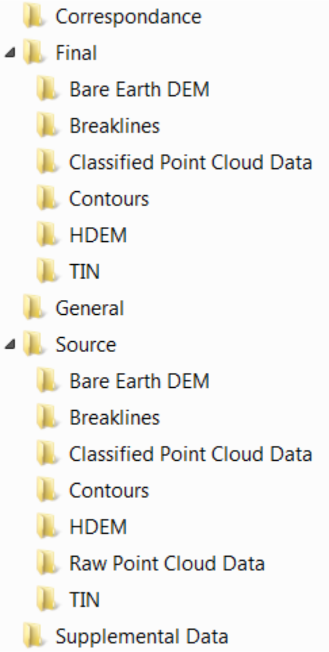
QA4: Bare Earth Review

Post-processed data has been reviewed at both a macro and micro level using *Table 4.4 and checklists provided in section 4.2.1in PM61*[1], and USGS *LiDAR Guidelines and Base Specifications v13*[3]. 10% of the total number of project tiles was reviewed for compliance with USGS and FEMA specifications. All tiles reviewed for this project passed both the macro and micro reviews. Quality assurance results for the bare earth are contained within Appendix F of this document.

QA5: Create Delivery Package

All deliverables have been organized in accordance with *Appendix M: Data Capture Standards March 2011 Section M.4.2.8*[2].

Figure 8. Terrain Deliverable Directory Structure



- Correspondance
- Final
  - Bare Earth DEM
  - Breaklines
  - Classified Point Cloud Data
  - Contours
  - HDEM
  - TIN
- General
- Source
  - Bare Earth DEM
  - Breaklines
  - Classified Point Cloud Data
  - Contours
  - HDEM
  - Raw Point Cloud Data
  - TIN
- Supplemental Data

QA6: Finalization of Deliverables and TSDN

All data to be submitted for delivery has been reviewed for completeness based on the map activity statement, scope of work, and FEMA deliverable requirements. Quality assurance checklists are included in Appendix F of this document.

QA7: FEMA submission

All data for the elevation data acquisition task was delivered to FEMA on September 14, 2012. A transmittal of this submission is included in Appendix G of this document.

F. Topographic Product Development

Following collection of the data, LiDAR was processed into several topographic products for the entire area collected in the Merrimack Watershed. The data collected under this activity will be used support Hydrologic and Hydraulic analyses for riverine and coastal flood sources identified within the watershed.

Deliverables: Upon completion of topographic data processing for the Concord watershed, STARR will make the following products available to FEMA:

- *LAS all return unclassified point cloud files
- *LAS all return classified point cloud files
- LiDAR Tile Index and Collection Area Shapefiles
- *Compressed 9.3.1 ESRI File Geodatabase containing 3D multipoint, ESRI Terrains, and LAS Information files created from Merrimack classified LAS files. LAS class code 2 (Bare Earth) and code 8 (Model-key) was used to develop products.
- *Compressed 9.3.1 ESRI File Geodatabase containing 2ft contours for HUC 8 Merrimack Watershed divided and organized by HUC 12 boundaries within watershed.
- *Floating Point Digital Elevation Model with 2 meter cell resolution in Geotif format that covers entire watershed for use in Hydrologic and Hydraulic modeling.
- Floating Point Digital Elevation Models with 1 meter cell resolution in ERDAS imagine (*.img) format that cover entire watershed for use in Hydrologic and Hydraulic modeling.
- Report summarizing methodology and results
- FEMA Terrain Metadata compliant with Federal Geographic Data Committee standards.

*: Due to file sizes datasets will be delivered to the FEMA Engineering Library for storage.

STARR will provide these deliverables to FEMA via external hard drive. To the extent possible datasets other than the LAS files will be loaded to the MIP at these locations:

J:\FEMA\R01\NEW_HAMPSHIRE_33\MERRIMACK_33013\MERRIMACK_013C\12-01-1080S\SubmissionUpload\Terrain\2152674

All details pertaining to the development of these products can be found within Appendix I of this document.

5. References

1. Federal Emergency Management Agency, Procedure Memorandum No. 61 - Standards for Lidar and Other High Quality Digital Topography, http://www.fema.gov/library/viewRecord.do?id=4345 included in Appendix H
2. Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix M: data Capture Standards http://www.fema.gov/library/file;jsessionid=1E39C93AF9CD18EE125B3DFCA5A874B8.Worker2Library?type=publishedFile&file=frm__gsam.pdf&fileid=cf85c9b0-df0f-11e0-9bf5-001cc4568fb6 included in Appendix H
3. U.S. Geological Survey National Geospatial Program, LiDAR Guidelines and Base Specification, Version 13-ILMF 2010, http://lidar.cr.usgs.gov/USGS-NGP%20Lidar%20Guidelines%20and%20Base%20Specification%20v13%28ILMF%29.pdf included in Appendix H
4. Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying [includes guidance on Light Detection and Ranging Systems (LIDAR)] http://www.fema.gov/library/file;jsessionid=1E39C93AF9CD18EE125B3DFCA5A874B8.Worker2Library?type=publishedFile&file=frm__gsaa.pdf&fileid=2daefcd0-df08-11e0-9bf5-001cc4568fb6

Appendix A: Contact Information

STARR Contacts:

Project Management and Quality Assurance

Company	Greenhorne & O'Mara, Inc.
Name	Diane Rogers
Email	drogers@g-and-o.com
Phone	301-982-2800
Mailing Address	5565 Centerview Drive, Suite 107 Raleigh, NC 27606

LiDAR Ground Control and QC survey

Company	Compass Data, Inc.
Name	Hayden Howard
Email	haydenh@compassdatainc.com
Phone	303-627-4058
Mailing Address	12353 East Easter Avenue, Suite 200 Centennial, CO 80112

LiDAR data acquisition and Post Processing

Company	Photo Science, Inc
Name	Paul Bishop
Email	bishop@photoscience.com
Phone	859-277-8700
Mailing Address	2670 Wilhite Drive Lexington, KY 40503

Appendix B: FEMA Compliance Forms and Metadata

Project Name:	**Region 1: Merrimack, New Hampshire – Elevation Data Acquisition**
Statement of Work No.:	FEMA TASK ORDER NUMBER: HSFE01-11-J-0010 WORK ORDER NUMBER: CP 01 10 001
Interagency Agreement No.:	STARR PROJECT NUMBER: 400000114 STARR PARTNER TRACKING NUMBER: CP 01 10 001
CTP Agreement No.:	N/A
Statement/Agreement Date:	10/ 15/11
Certification Date:	5/17/12

	Tasks/Activities Covered by This Certification (Check All That Apply)
☐	Base Map
☐	Topographic Data Development
X	Survey: Including Ground Control Points (GCPs), Fundamental Vertical Accuracy Testing (FVA), and Consolidated Vertical Accuracy Testing (CVA).
☐	Hydrologic Analysis
☐	Hydraulic Analysis
☐	Alluvial Fan Analysis
☐	Coastal Analysis
☐	Floodplain Mapping

This is to certify that the work summarized above was completed in accordance with the statement/agreement cited above and all amendments thereto, together with all such modifications, either written or oral, as the Regional Project Officer and/or Assistance Officer or their representative have directed, as such modifications affect the statement/agreement, and that all such work has been accomplished in accordance with the provisions contained in *Guidelines and Specifications for Flood Hazard Mapping Partners* cited in the contract document, and in accordance with sound and accepted engineering practices within the contract provisions for respective phases of the work. This is also to certify that data files submitted for the work summarized above are complete and final. Any revisions made to the already submitted data are included in the final submittal.

Name:	Philipp H. Hummel, PLS, CFedS
Title:	Professional Land Surveyor, Geodesist
Firm Represented:	Compass Data, Inc.
Registration No.:	38155

Signature: Philipp Hummel

COLORADO LICENSED PROFESSIONAL LAND SURVEYOR
PHILIPP H. HUMMEL
38155
May 17, 2012

For and on behalf of Compass Data, Inc.
Job. No.: 1619

This form must be signed by a representative of the firm or agency contracted to perform the work, who must be a registered or certified professional in the area of work performed, in compliance with Federal and State regulations.

Project Name:	Merrimack Watershed, LiDAR Acquisition
Statement of Work No.:	HSFE01-11-J-0010
Interagency Agreement No.:	N/A
CTP Agreement No.:	N/A
Statement/Agreement Date:	N/A
Certification Date:	June 21, 2012
	Tasks/Activities Covered by This Certification (Check All That Apply)
☐	Base Map
☒	Topographic Data Development
☒	Survey
☐	Hydrologic Analysis
☐	Hydraulic Analysis
☐	Alluvial Fan Analysis
☐	Coastal Analysis
☐	Floodplain Mapping
	This is to certify that the work summarized above was completed in accordance with the statement/agreement cited above and all amendments thereto, together with all such modifications, either written or oral, as the Regional Project Officer and/or Assistance Officer or their representative have directed, as such modifications affect the statement/agreement, and that all such work has been accomplished in accordance with the provisions contained in *Guidelines and Specifications for Flood Hazard Mapping Partners* cited in the contract document, and in accordance with sound and accepted engineering practices within the contract provisions for respective phases of the work. This is also to certify that data files submitted for the work summarized above are complete and final. Any revisions made to the already submitted data are included in the final submittal.
Name:	Jack L. Mitchell
Title:	Project Manager
Firm/Agency Represented:	Photo Science
Registration No.:	CP #849
Signature:	Jack L. Mitchell
	This form must be signed by a representative of the firm or agency contracted to perform the work, who must be a registered or certified professional in the area of work performed, in compliance with Federal and State regulations.

American Society for Photogrammetry and Remote Sensing
JACK L. MITCHELL
CERTIFIED
PHOTOGRAMMETRIST
(ASPRS) No. 849

```
Identification_Information:
  Citation:
    Citation_Information:
      Originator: Federal Emergency Management Agency
      Publication_Date: 20120914
      Title: TERRAIN, Merrimack HUC 8 Watershed, Massachusetts and New
Hampshire
      Geospatial_Data_Presentation_Form: FEMA-DCS-Terrain
      Publication_Information:
        Publication_Place: Washington, DC
        Publisher: Federal Emergency Management Agency
      Online_Linkage: http://hazards.fema.gov
      Larger_Work_Citation:
        Citation_Information:
           Originator: Federal Emergency Management Agency
           Publication_Date: 20120914
        Title: FEMA CASE 12-01-1080S
  Description:
    Abstract: The Merrimac AOI consists of portions of the Merrimack
Watershed amounting to 1302 square miles not previously collected under a
USGS LiDAR tasking. Ground Control is collected throughout the AOI for
use in the processing of LiDAR data to ensure data accurately represents
the ground surface.  QA/QC checkpoints, (FVA and CVA - see Ground Control
process step for further information) also collected throughout the AOI,
are used for independent quality checks of the processed LiDAR data.
LiDAR acquisition products include Pre- and Post- flight reports which
contain information on the flight lines, equipment parameters, and other
pertinent acquisition details.  The LiDAR product is considered to be
point cloud data consists of 1,749 1500 x 1500 meter tiles of LAS points
which are partially classified such that the bare earth points can be
calibrated to the ground surface and tested via the independent QC to
ensure the ground surface is accurately represented.
The Bare Earth deliverables consists of 1,749 1500m x 1500m tiles of
classified LAS points.  ASPRS classifications: 1, 2, 7, 8, 9, 10, 11, 17
and 18 have been used for this dataset.  Terrain products derived from
the Bare Earth consists of 1,749 1 meter DEM files and two foot contours.
A full TSDN accompanies this deliverable that describes the project in
more detail.
    Purpose: Provide high resolution terrain elevation and land cover
elevation data. Terrain data is used to represent the topography of a
watershed and/or floodplain environment and to extract useful information
for hydraulic and hydrologic floodplain models specifically for FEMA
Flood Insurance projects. (Source: FEMA Guidelines and Specs, Appendix
M).

  Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
    Currentness_Reference: ground condition
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: Unknown
  Spatial_Domain:
```

```
    Bounding_Coordinates:
      West_Bounding_Coordinate: -71.973079
      East_Bounding_Coordinate: -71.083734
      North_Bounding_Coordinate: 43.53304
      South_Bounding_Coordinate: 42.448337
  Keywords:
    Theme:
      Theme_Keyword_Thesaurus: ISO 19115 Topic Category
      Theme_Keyword: elevation
    Theme:
      Theme_Keyword_Thesaurus: FEMA NFIP Topic Category
      Theme_Keyword: Land Surface
      Theme_Keyword: Topography
      Theme_Keyword: Digital Terrain Model
      Theme_Keyword: Elevation Data
      Theme_Keyword: LIDAR
    Theme:
      Theme_Keyword_Thesaurus: None
      Theme_Keyword: Ground Control
      Theme_Keyword: Point Cloud
      Theme_Keyword: LAS Point Files
      Theme_Keyword: Bare Earth
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE NH
      Place_Keyword: COUNTY MERRIMACK
      Place_Keyword: COUNTY-FIPS 013
      Place_Keyword: COMMUNITY MERRIMACK COUNTY
      Place_Keyword: FEMA-CID 33013C
      Place_Keyword: HYDROLOGIC CODE 01070002
      Place_Keyword: Merrimack Watershed
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY ESSEX
      Place_Keyword: COUNTY-FIPS 009
      Place_Keyword: COMMUNITY ESSEX COUNTY
      Place_Keyword: FEMA-CID 25009C
      Place_Keyword: HYDROLOGIC CODE 01070002
      Place_Keyword: Merrimack Watershed
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY ESSEX
      Place_Keyword: COUNTY-FIPS 009
      Place_Keyword: COMMUNITY METHUEN, CITY OF
      Place_Keyword: FEMA-CID 090085
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
```

```
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY MIDDLESEX COUNTY
      Place_Keyword: FEMA-CID 25017C
      Place_Keyword: HYDROLOGIC CODE 01070002
      Place_Keyword: Merrimack Watershed
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY ASHBY, TOWN OF
      Place_Keyword: FEMA-CID 250178
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY AYER, TOWN OF
      Place_Keyword: FEMA-CID 250180
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY BOXBOROUGH, TOWN OF
      Place_Keyword: FEMA-CID 250184
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY CHELMSFORD, TOWN OF
      Place_Keyword: FEMA-CID 250188
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY DRACUT, TOWN OF
      Place_Keyword: FEMA-CID 250190
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE MA
      Place_Keyword: COUNTY MIDDLESEX
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY DUNSTABLE, TOWN OF
      Place_Keyword: FEMA-CID 250191
```

```
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
  Place_Keyword: COMMUNITY GROTON, TOWN OF
  Place_Keyword: FEMA-CID 250194
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
  Place_Keyword: COMMUNITY LITTLETON, TOWN OF
  Place_Keyword: FEMA-CID 250200
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
  Place_Keyword: COMMUNITY LOWELL, CITY OF
  Place_Keyword: FEMA-CID 250201
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
  Place_Keyword: COMMUNITY PEPPERELL, TOWN OF
  Place_Keyword: FEMA-CID 250210
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
  Place_Keyword: COMMUNITY STOW, TOWN OF
  Place_Keyword: FEMA-CID 250216
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
  Place_Keyword: COMMUNITY TYNGSBOROUGH, TOWN OF
  Place_Keyword: FEMA-CID 250220
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE MA
  Place_Keyword: COUNTY MIDDLESEX
  Place_Keyword: COUNTY-FIPS 017
```

```
    Place_Keyword: COMMUNITY WESTFORD, TOWN OF
    Place_Keyword: FEMA-CID 250225
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE MA
    Place_Keyword: COUNTY WORCESTER
    Place_Keyword: COUNTY-FIPS 027
    Place_Keyword: COMMUNITY WORCESTER COUNTY
    Place_Keyword: FEMA-CID 25027C
    Place_Keyword: HYDROLOGIC CODE 01070002
    Place_Keyword: Merrimack Watershed
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE MA
    Place_Keyword: COUNTY WORCESTER
    Place_Keyword: COUNTY-FIPS 027
    Place_Keyword: COMMUNITY ASHBURNHAM, TOWN OF
    Place_Keyword: FEMA-CID 250290
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE MA
    Place_Keyword: COUNTY WORCESTER
    Place_Keyword: COUNTY-FIPS 027
    Place_Keyword: COMMUNITY HARVARD, TOWN OF
    Place_Keyword: FEMA-CID 250308
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY BELKNAP
    Place_Keyword: COUNTY-FIPS 001
    Place_Keyword: COMMUNITY BELKNAP COUNTY
    Place_Keyword: FEMA-CID 33001C
    Place_Keyword: HYDROLOGIC CODE 01070002
    Place_Keyword: Merrimack Watershed
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY BELKNAP
    Place_Keyword: COUNTY-FIPS 001
    Place_Keyword: COMMUNITY ALTON, TOWN OF
    Place_Keyword: FEMA-CID 330001
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY BELKNAP
    Place_Keyword: COUNTY-FIPS 001
    Place_Keyword: COMMUNITY BARNSTEAD, TOWN OF
    Place_Keyword: FEMA-CID 330177
```

```
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY BELKNAP
  Place_Keyword: COUNTY-FIPS 001
  Place_Keyword: COMMUNITY BELMONT, TOWN OF
  Place_Keyword: FEMA-CID 330002
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY BELKNAP
  Place_Keyword: COUNTY-FIPS 001
  Place_Keyword: COMMUNITY GILFORD, TOWN OF
  Place_Keyword: FEMA-CID 330004
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY BELKNAP
  Place_Keyword: COUNTY-FIPS 001
  Place_Keyword: COMMUNITY GILMANTON, TOWN OF
  Place_Keyword: FEMA-CID 330208
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY CHESHIRE
  Place_Keyword: COUNTY-FIPS 005
  Place_Keyword: COMMUNITY CHESHIRE COUNTY
  Place_Keyword: FEMA-CID 33005C
  Place_Keyword: HYDROLOGIC CODE 01070002
  Place_Keyword: Merrimack Watershed
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY CHESHIRE
  Place_Keyword: COUNTY-FIPS 005
  Place_Keyword: COMMUNITY RINDGE, TOWN OF
  Place_Keyword: FEMA-CID 330189
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY HILLSBOROUGH COUNTY
  Place_Keyword: FEMA-CID 33011C
  Place_Keyword: HYDROLOGIC CODE 01070002
  Place_Keyword: Merrimack Watershed
Place:
  Place_Keyword_Thesaurus: None
```

```
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY AMHERST, TOWN OF
    Place_Keyword: FEMA-CID 330081
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY BEDFORD, TOWN OF
    Place_Keyword: FEMA-CID 330083
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY BENNINGTON, TOWN OF
    Place_Keyword: FEMA-CID 330084
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY BROOKLINE, TOWN OF
    Place_Keyword: FEMA-CID 330180
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY DEERING, TOWN OF
    Place_Keyword: FEMA-CID 330085
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY FRANCESTOWN, TOWN OF
    Place_Keyword: FEMA-CID 330086
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY HILLSBOROUGH
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY GOFFSTSOWN, TOWN OF
    Place_Keyword: FEMA-CID 330087
```

```
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY GREENFIELD, TOWN OF
  Place_Keyword: FEMA-CID 330209
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY GREENVILLE, TOWN OF
  Place_Keyword: FEMA-CID 330088
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY HILLSBOROUGH, TOWN OF
  Place_Keyword: FEMA-CID 330090
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY HOLLIS, TOWN OF
  Place_Keyword: FEMA-CID 330091
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY HUDSON, TOWN OF
  Place_Keyword: FEMA-CID 330092
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY LITCHFIELD, TOWN OF
  Place_Keyword: FEMA-CID 330093
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
```

```
  Place_Keyword: COMMUNITY LYNDEBOROUGH, TOWN OF
  Place_Keyword: FEMA-CID 330218
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY MANCHESTER, CITY OF
  Place_Keyword: FEMA-CID 330169
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 01
  Place_Keyword: COMMUNITY MASON, TOWN OF
  Place_Keyword: FEMA-CID 330221
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY MERRIMACK, TOWN OF
  Place_Keyword: FEMA-CID 330095
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY MILFORD, TOWN OF
  Place_Keyword: FEMA-CID 330096
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY MONT VERNON, TOWN OF
  Place_Keyword: FEMA-CID 330224
 Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY NASHUA, CITY OF
  Place_Keyword: FEMA-CID 330097
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
```

```
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY NEW BOSTON, TOWN OF
  Place_Keyword: FEMA-CID 330098
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY NEW IPSWICH, TOWN OF
  Place_Keyword: FEMA-CID 330099
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY PELHAM, TOWN OF
  Place_Keyword: FEMA-CID 330100
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY PETERBOROUGH, TOWN OF
  Place_Keyword: FEMA-CID 330101
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY WEARE, TOWN OF
  Place_Keyword: FEMA-CID 330235
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY HILLSBOROUGH
  Place_Keyword: COUNTY-FIPS 011
  Place_Keyword: COMMUNITY WILTON, TOWN OF
  Place_Keyword: FEMA-CID 330102
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY ALLENSTOWN, TOWN OF
  Place_Keyword: FEMA-CID 330103
Place:
  Place_Keyword_Thesaurus: None
```

```
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY ANDOVER, TOWN OF
    Place_Keyword: FEMA-CID 330104
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY BOSCAWEN, TOWN OF
    Place_Keyword: FEMA-CID 330105
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY BOW, TOWN OF
    Place_Keyword: FEMA-CID 330107
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY CANTERBURY, TOWN OF
    Place_Keyword: FEMA-CID 330108
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY CHICHESTER, TOWN OF
    Place_Keyword: FEMA-CID 330109
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY CONCORD, TOWN OF
    Place_Keyword: FEMA-CID 330110
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY DUNBARTON, TOWN OF
    Place_Keyword: FEMA-CID 330202
```

```
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY EPSOM, TOWN OF
  Place_Keyword: FEMA-CID 330112
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY FRANKLIN, CITY OF
  Place_Keyword: FEMA-CID 330113
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY HENNIKER, TOWN OF
  Place_Keyword: FEMA-CID 330114
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY HOOKSETT, TOWN OF
  Place_Keyword: FEMA-CID 330115
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY HOPKINTON, TOWN OF
  Place_Keyword: FEMA-CID 330116
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
  Place_Keyword: COMMUNITY LOUDON, TOWN OF
  Place_Keyword: FEMA-CID 330117
Place:
  Place_Keyword_Thesaurus: None
  Place_Keyword: REGION I
  Place_Keyword: STATE NH
  Place_Keyword: COUNTY MERRIMACK
  Place_Keyword: COUNTY-FIPS 013
```

```
    Place_Keyword: COMMUNITY NORTHFIELD, TOWN OF
    Place_Keyword: FEMA-CID 330118
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY PEMBROKE, TOWN OF
    Place_Keyword: FEMA-CID 330119
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY PITTSFIELD, TOWN OF
    Place_Keyword: FEMA-CID 330120
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY SALISBURY, TOWN OF
    Place_Keyword: FEMA-CID 330121
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY MERRIMACK
    Place_Keyword: COUNTY-FIPS 013
    Place_Keyword: COMMUNITY WEBSTER, TOWN OF
    Place_Keyword: FEMA-CID 330121
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY ROCKINGHAM COUNTY
    Place_Keyword: FEMA-CID 33015C
    Place_Keyword: HYDROLOGIC CODE 01070002
    Place_Keyword: Merrimack Watershed
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY AUBURN, TOWN OF
    Place_Keyword: FEMA-CID 330176
  Place:
    Place_Keyword_Thesaurus: None
```

```
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY CANDIA, TOWN OF
    Place_Keyword: FEMA-CID 330126
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY DEERFIELD, TOWN OF
    Place_Keyword: FEMA-CID 330127
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY LONDONDERRY, TOWN OF
    Place_Keyword: FEMA-CID 330134
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY NORTHWOOD, TOWN OF
    Place_Keyword: FEMA-CID 330855
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 015
    Place_Keyword: COMMUNITY SALEM, TOWN OF
    Place_Keyword: FEMA-CID 330142
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY ROCKINGHAM
    Place_Keyword: COUNTY-FIPS 011
    Place_Keyword: COMMUNITY WINDHAM, TOWN OF
    Place_Keyword: FEMA-CID 330144
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: REGION I
    Place_Keyword: STATE NH
    Place_Keyword: COUNTY STRAFFORD
    Place_Keyword: COUNTY-FIPS 017
    Place_Keyword: COMMUNITY STRAFFORD COUNTY
    Place_Keyword: FEMA-CID 33017C
```

```
      Place_Keyword: HYDROLOGIC CODE 01070002
      Place_Keyword: Merrimack Watershed
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE NH
      Place_Keyword: COUNTY STRAFFORD
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY FARMINGTON, TOWN OF
      Place_Keyword: FEMA-CID 330147
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE NH
      Place_Keyword: COUNTY STRAFFORD
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY NEW DURHAM, TOWN OF
      Place_Keyword: FEMA-CID 330227
    Place:
      Place_Keyword_Thesaurus: None
      Place_Keyword: REGION I
      Place_Keyword: STATE NH
      Place_Keyword: COUNTY STRAFFORD
      Place_Keyword: COUNTY-FIPS 017
      Place_Keyword: COMMUNITY STRAFFORD, TOWN OF
      Place_Keyword: FEMA-CID 330196

  Access_Constraints: None
  Use_Constraints: Acknowledgement of FEMA would be appreciated in
products derived from these data.  This digital data is produced for the
purposes of updating/creating a DFIRM database.
  Data_Set_Credit:   Ground control and quality control checkpoints were
collected by CompassData, Inc.  LiDAR was acquired and processed by Photo
Science, Inc. Quality Control testing was performed by CompassData, Inc.
Quality Assurance testing was conducted by Greenhorne & O'Mara, Inc.  All
firms were under contract to STARR, A Joint Venture which held the FEMA
contract and task order for this work.
Data_Quality_Information:
  Attribute_Accuracy:
      Attribute_Accuracy_Report: Elevations are recorded in floating-
point feet and the vertical datum is NAVD88. There are no other attribute
tables.
  Logical_Consistency_Report: Survey data have been confirmed to be in
proper units, coordinate systems and format. The terrain data have been
confirmed as complete LAS format data files.  Header files are in proper
LAS format with content as specified by FEMA Procedural Memo No. 61.
  Completeness_Report: Survey data have been checked for completeness,
points have been collected in correct vegetation units, and distributed
throughout the AOI. The terrain data have been checked for completeness
against AOI polygons.  No gaps as defined by FEMA Procedural Memo No. 61
are known to exist within the dataset.

  Positional_Accuracy:
    Horizontal_Positional_Accuracy:
```

```
      Horizontal_Positional_Accuracy_Report: Not applicable for pure
elevation data: every XY error has an associated Z error.
    Vertical_Positional_Accuracy:
      Vertical_Positional_Accuracy_Report: Deliverables were tested by
for vertical accuracy.  The vertical unit of the data file is in FEET
with 2-decimal point precision.
      Quantitative_Vertical_Positional_Accuracy_Assessment:
        Vertical_Positional_Accuracy_Value: 0.243
        Vertical_Positional_Accuracy_Explanation: Consolidated Vertical
Accuracy (CVA) equal to the 95th percentile confidence level (RMSE[z] x
1.9600) calculated against the bare earth surface in all ground cover
classes.  Reported in meters. The point cloud surface was also tested in
open terrain.  The Fundamental Vertical Accuracy (FVA) equal to the 95th
Percentile confidence level (RMSE[z] x 1.9600) calculated in open terrain
is 0.140 meters.  Accuracy statement is based on the area of moderate to
flat terrain.  Diminished accuracies are to be expected in areas of
rugged terrain and/or dense vegetation.  The accuracy of derived products
may be less accurate in areas of dense vegetation due to a lesser number
of points defining the bare-earth in these areas.

Lineage:
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_GroundControl
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other1
      Source_Contribution: Control points for tying LiDAR data to the
ground surface.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_FVA_CVA
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other2
      Source_Contribution: Quality Assurance points to confirm LiDAR data
meets vertical accuracy requirements.
   Source_Information:
     Source_Citation:
        Citation_Information:
```

```
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_Collection_Area
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other3
      Source_Contribution: Shapefile of Merrimack LiDAR acquisition area.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_Tile_Index
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other4
      Source_Contribution: Shapefile tile index used for naming of the
Point Cloud (All Returns) LAS data.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_PreFlightReport
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other5
      Source_Contribution: Document contains the operations plans for the
LiDAR acquisition.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_PostFlightReport
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other6
```

```
      Source_Contribution: Document contains the acquisition and
calibration report for the LiDAR acquisition
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Region 1 Merrimack Testing Results FVA CVA
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other7
      Source_Contribution: Document contains QC test results for both FVA
and CVA blind check point tests against open area and bare earth surfaces
generated from All Returns and Bare Earth (respectively) LAS points.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: All_Returns
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: VARIABLE-SPACING1
      Source_Contribution: Point Cloud (All Returns) LAS 1.2 point files
named according to Merrimack_Tile_Index.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Bare_Earth
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: VARIABLE-SPACING2
      Source_Contribution: Bare Earth LAS point files named according to
the Merrimack_Tile_Index.
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack Hydro Break Lines
```

```
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: BREAKLINES1
      Source_Contribution: Merrimack Watershed 3D polyline breaklines.
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_HUC8_ESRI_Terrain.gdb
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: publication date
      Source_Citation_Abbreviation: Other8
      Source_Contribution: File geodatabase (v9.3.1) containing Merrimack
HUC 8 ESRI Terrains. Includes bare earth multipoint (mass points), hydro
enforced breaklines (hard breakline), and project area (softclip) feature
classes.
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack HUC 8 1 meter DEM
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: publication date
      Source_Citation_Abbreviation: REGULAR-GRID1
      Source_Contribution: 1 meter geotif file for Merrimack HUC 8
watershed project area.
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack HUC 8 2 meter DEM
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: publication date
      Source_Citation_Abbreviation: REGULAR-GRID2
```

```
      Source_Contribution: 2 meter geotif file for Merrimack HUC 8
watershed project area.
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack HUC 8 tiled 1 meter DEMs
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: publication date
      Source_Citation_Abbreviation: REGULAR-GRID3
      Source_Contribution: 1749 1 meter erdas imagine files for Merrimack
HUC 8 watershed project area.
   Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack_HUC8_2ft_Contours.gdb
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: publication date
      Source_Citation_Abbreviation: CONTOURS1
      Source_Contribution: File geodatabase (v9.3) containing 2ft contour
polyline feature classes for Merrimack HUC 8 based on HUC 12 boundaries.
    Source_Information:
      Source_Citation:
        Citation_Information:
          Originator: STARR
          Publication_Date: 2012
          Title: Merrimack TSDN
      Type_of_Source_Media: DIGITAL
      Source_Time_Period_of_Content:
    Time_Period_Information:
      Single_Date/Time:
        Calendar_Date: 20120914
        Source_Currentness_Reference: MIP Submission Date
      Source_Citation_Abbreviation: Other9
      Source_Contribution: TSDN for the acquisition, processing and
product development of the LiDAR dataset.
Process_Step:
  Process_Description:
       GPS based surveys were utilized to support both processing and
testing of LiDAR data within FEMA designated Areas of Interest (AOIs).
Geographically distinct ground points were surveyed using GPS technology
throughout the AOI to provide support for three distinct tasks.
```

Task 1 was to provide Vertical Ground Control to support the aerial acquisition and subsequent bare earth model processing. To accomplish this, survey-grade Trimble R-8 GPS receivers were used to collect a series of control points located on open areas, free of excessive or significant slope, and at least 5 meters away from any significant terrain break. Most if not all control points were collected at street/road intersections on bare level pavement.

Task 2 was to collect Fundamental Vertical Accuracy (FVA) checkpoints to evaluate the initial quality of the collected point cloud and to ensure that the collected data was satisfactory for further processing to meet FEMA specifications. The FVA points were collected in identical fashion to the Vertical Ground Control Points, but segregated from the point pool to ensure independent quality testing without prior knowledge of FVA locations by the aerial vendor.

Task 3 was to collect Consolidated Vertical Accuracy CVA) checkpoints to allow vertical testing of the bare-earth processed LiDAR data in different classes of land cover, including: Open (pavement, open dirt, short grass), High Grass and Crops, Forest, Urban. CVA points were collected in similar fashion as Control and FVA points with emphasis on establishing point locations within the predominant land cover classes within each AOI or Functional AOI Group. In order to successfully collect the Forest land cover class, it was necessary to establish a Backsight and Initial Point with the R8 receiver, and then employ a Nikon Total Station to observe a retroreflective prism stationed under tree canopy. This was necessary due to the reduced GPS performance and degradation of signal under tree canopy.

The R-8 receivers were equipped with cellular modems to receive real-time correction signals from the Keystone Precision Virtual Reference Station (VRS) network encompassing the Region 1 AOIs. Use of the VRS network allowed rapid collection times (~3 minutes/point) at 2.54 cm (1 inch) initial accuracy.

All points collected were below the 8cm specification for testing 24cm, Highest category LiDAR data. To ensure valid in-field collections, an NGS monument with suitable vertical reporting was measured using the same equipment and procedures used for Control, FVA and CVA points on a daily basis. The measurement was compared to the NGS published values to ensure that the GPS collection schema was producing valid data and as a physical proof point of quality of collection. Those monument measurements are summarized in the Accuracy report included in the data deliverables.

20 FVA points are necessary to allow testing to CE95 – 1 point out of 20 may fail vertical testing and still allow the entire dataset to meet 95% accuracy requirements. In similar fashion, 76 CVA points are necessary to test to CE95 as discussed above. 72 CVA points were collected with the intention at the outset that 4 of the collected FVAs would perform double –duty as Open-class CVA points, to total 76 CVAs.

The following software packages and utilities were used to control the GPS receiver in the field during data collection, and then ingest and export the collected GPS data for all points: Trimble Survey Controller, Trimble Pathfinder Office.

The following software utilities were used to translate the collected Latitude/Longitude Decimal Degree HAE GPS data for all points into Latitude/Longitude Degrees/Minutes/Seconds for checking the collected monument data against the published NGS Datasheet Lat/Long DMS values and into UTM NAD83 Northings/Eastings: U.S. Army Corps of Engineers CorpsCon, National Geodetic Survey Geoid09NAVD88.

MSL values were determined using the most recent NGS-approved geoid model to generate geoid separation values for each Lat/Long coordinate pair. In this fashion, Orthometric heights were determined for each Control, FVA and CVA point by subtracting the generated Geoid Separation value from the Ellipsoidal Height (HAE) for publication and use as MSL NAVD88(09).

Process_Date: 2012
Process_Step:
Process_Description:

Using a Leica ALS60 LiDAR system, 268 flight lines of highest density (Nominal Pulse Spacing of 1.0m) were collected over the Merrimack area which encompasses 1302 square miles. Five (5) blocks (block or area is determined by the Base Station control locations, typically airports with ground control monuments available providing coverage within 18 miles of the base as possible) to cover in its entirety.

Area	Flight Lines	Lifts	Dates	System
CON	79	7	12/19-12/29 2011	ALS60
ASH	64	5	1/7-1/11 2012	ALS60
BED	31	1	1/11/2012	ALS60
LCI	34	2	11/12-11/13 2011	ALS60
AFN	48	4	11/12-11/13 2011	ALS60

Cross Flights 12 Flight Lines...Lifts were combined with the acquisition of each area with both sensors

Process_Date: 2012
Process_Step:
Process_Description:

Leica proprietary software was used in the post-processing of the airborne GPS and inertial data that is critical to the positioning and orientation of the sensor during all flights. Pairing the aircraft's raw trajectory data with the stationary GPS base station data, this software yields Leica's IPAS TC ("Inertial Positioning & Attitude Sensor – Tightly Coupled") smoothed best estimate of trajectory (an "SBET", in Leica's .sol file format) that is necessary for Leica's ALSPP post processing software to develop the resulting geo-referenced point cloud from the LiDAR missions. The point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above-ground features are removed from the data set.

The point cloud was created using Leica's Post Processor software. GeoCue was used in the creation of some of the files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. The TerraScan and TerraModeler software packages are then used for the automated data classification, manual cleanup, and bare earth generation from this data. Project specific macros were used to classify the ground and to remove the side overlap between parallel

```
flight lines. All data was manually reviewed and any remaining artifacts
removed using functionality provided by TerraScan and TerraModeler. QT
Modeler was used as a final check of the bare earth dataset. GeoCue was
then used to create the deliverable industry-standard LAS files for both
the All Point Cloud Data and the Bare Earth. In-house software was then
used to perform final statistical analysis of the classes in the LAS
files.
  Process_Date: 2012
Process_Step:
  Process_Description:
        Point Cloud data is manually reviewed and any remaining artifacts
are removed using functionality provided within the TerraScan and
TerraModeler software packages.
        Additional project specific macros are created and run within
GeoCue/TerraScan to ensure correct LAS classification prior to project
delivery.
        Final Classified LAS tiles are created within GeoCue to confirm
correct LAS versioning and header information.  In-house software is then
used to check LAS header information and final LAS classification prior
to delivery.  LAS Class 2 is used to check the independent QC points
against the Triangulated LiDAR surface.

        Merrimack Watershed Classified LiDAR ASPRS Classifications
        1  Unclassified
        2  Ground
        7  Low Point (Noise)
        8  Model Key-point (Mass Point)
        9  Water
        10 Ignored Ground
        11 Withheld
        17 USGS Overlap Default
        18 USGS Overlap Ground
  Process_Date: 2012
Process_Step:
  Process_Description:
        Process Steps:
             1-Convert LAS to Multipoint
             2-Create Terrain
             3-Convert Terrain to 1m Raster
             4-Split 1m Raster into 1749 imagine files
             5-Contour

             Convert LAS to multipoint:
             1.  Create file geodatabase and create a feature dataset to
store terrain information with appropriate projection and spatial domain.
             2.  Run LAS to multipoint tool in 3D analyst for the
classified LAS files and select class 2 and 8.
             3.  Store results in file geodatabase feature dataset for
terrain data.

             Create Terrain
             1.  Create Terrain using multipoint as masspoints, hydro
break lines as hard breakline and LiDAR coverage area as soft clip
```

2. Build Terrain and store in file geodatabase feature dataset for terrain data

Convert Terrain to 1m Raster
1. Run the Terrain to raster tool in 3D analyst
2. Float output data type, Linear as the method, CELLSIZE 1 as sampling distance, and Pyramid Level Resolution 0
3. Save results as a Geotiff dataset.

Split 1m Raster into tiles
1. Load 1m raster into ERDAS Imagine Mosaic pro tool
2. Split raster using LiDAR index
3. Save results as 1m imagine files

Create contours
1. Extract by mask from the 1m DEM using a HUC12 area. Save this raster as HUC12 Name 1m.
2. Focal Statistics using Extracted 1m DEM as input, Intermediate Focal Raster as Output, Neighborhood should be set to weighted kernel, and the statistic should be sum.
3. Create contours using focal stats raster as input, output polyline should be based on HUC12 name, Contour Interval of 2ft, Set base contour to DEM minimum z value
4. Check results and store in file geodatabase under the Analysis Contours feature dataset.
5. Focal Statistics using Extracted 1m DEM as input, Intermediate Focal Raster as Output, Neighborhood should be set to circle, and the statistic should be mean.
6. Create contours using focal stats raster as input, output polyline should be based on HUC12 name, Contour Interval of 2ft, Set base contour to DEM minimum z value
7. Check results and store in file geodatabase under the Cartographic Contours feature dataset.

Process_Date: 2012

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 19
Transverse_Mercator:
   Scale_Factor_at_Central_Meridian: 0.999600
   Longitude_of_Central_Meridian: -69.000000
   Latitude_of_Projection_Origin: 0.000000
   False_Easting: 500000.000000
   False_Northing: 0.000000
      Planar_Coordinate_Information:
        Planar_Coordinate_Encoding_Method: coordinate pair
        Coordinate_Representation:
          Abscissa_Resolution: 0.000010
          Ordinate_Resolution: 0.000010
        Planar_Distance_Units: meters

```
Geodetic_Model:
   Horizontal_Datum_Name: North American Datum 1983
   Ellipsoid_Name:  Geodetic Reference System 80
   Semi-major_Axis: 6378137.00
   Denominator_of_Flattening_Ratio: 298.257222
      Vertical_Coordinate_System_Definition:
        Altitude_System_Definition:
        Altitude_Datum_Name: North American Vertical Datum of 1988
        Altitude_Resolution: 0.01
        Altitude_Distance_Units:  feet
        Altitude_Encoding_Method:  Attribute Values

Entity_and_Attribute_Information:
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label:
Terrain\2152674\SupplementalData\Merrimack_Ground_Control
        Entity_Type_Definition: Digital Document
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label:
Terrain\2152674\SupplementalData\Merrimack_FVA_CVA
        Entity_Type_Definition: Digital Document
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label:
Terrain\2152674\SupplementalData\Merrimack_Collection_Area
        Entity_Type_Definition: Area Spatial File
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label:
Terrain\2152674\SupplementalData\Merrimack_Tile_Index.shp
        Entity_Type_Definition: Area Spatial File
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\SupplementalData\Merrimack
Pre-Flight Operations Plan.pdf
        Entity_Type_Definition: Digital Document
```

```
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\SupplementalData\Merrimack
Post-Flight Report
        Entity_Type_Definition: Digitial Document
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label:
Terrain\2152674\SupplementalData\Merrimack_TestingResults
        Entity_Type_Definition: Digital Document
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\Source\Raw Point Cloud Data
        Entity_Type_Definition: LAS 1.2 files
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\Source\Classified Point Cloud
Data
        Entity_Type_Definition: LAS 1.2 files
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\Source\Breaklines
        Entity_Type_Definition: 3D polyline breakline shapefile
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\Final\TIN
        Entity_Type_Definition: ESRI Terrain Data
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
```

```
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\Final\Bare Earth DEM
        Entity_Type_Definition: Digital Elevation Models
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label: Terrain\2152674\Final\Contours
        Entity_Type_Definition: ESRI File Geodatabase Feature Classes
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Detailed_Description:
      Entity_Type:
        Entity_Type_Label:
Terrain\2152674\SupplementalData\Merrimack_HUC8_TSDN
        Entity_Type_Definition: Digital Document
        Entity_Type_Definition_Source: FEMA Guidelines and Specifications
for Flood Hazard Mapping Partners, Appendix M: Data Capture Standards and
Data Capture Guidelines (available at
http://www.fema.gov/fhm/dl_cgs.shtm)
    Overview_Description:
      Entity_and_Attribute_Overview: The Terrain data package is made up
of several data themes containing primarily spatial information. These
data supplement the Elevation datasets by providing additional
information to aid flood risk evaluation and flood hazard area
delineations.
      Entity_and_Attribute_Detail_Citation: Appendix M of FEMA Guidelines
and Specifications for FEMA Flood Hazard Mapping Partners contains a
detailed description of the data themes and references to other relevant
information.
Distribution_Information:
  Distributor:
    Contact_Information:
      Contact_Organization_Primary:
        Contact_Organization: Federal Emergency Management Agency
Engineering Library
      Contact_Address:
        Address_Type: mailing address
        Address: Bill Davis
        Address: 847 South Pickett Street
        City: Alexandria
        State_or_Province: Virginia
        Postal_Code: 22304
        Country: USA
      Contact_Voice_Telephone: 1-877-336-2627
      Contact_Electronic_Mail_Address: miphelp@riskmapcds.com
```

```
Distribution_Liability:  No warranty expressed or implied is made by FEMA
regarding the utility of the data on any other system nor shall the act
of distribution constitute any such warranty.
  Standard_Order_Process:
    Digital_Form:
      Digital_Transfer_Information:
        Format_Name: FEMA-DCS-Terrain
      Digital_Transfer_Option:
        Online_Option:
          Computer_Contact_Information:
            Network_Address:
             Network_Resource_Name: http://hazards.fema.gov
    Fees: Contact Distributor

Metadata_Reference_Information:
  Metadata_Date: 20120914
  Metadata_Contact:
    Contact_Information:
      Contact_Person_Primary:
        Contact_Person: FEMA Representative
        Contact_Organization: Federal Emergency Management Agency
      Contact_Address:
        Address_Type: mailing address
        Address: 500 C Street, S.W.
        City: Washington
        State_or_Province: District of Columbia
        Postal_Code: 20472
        Country: USA
      Contact_Voice_Telephone: 1-877-336-2627
      Contact_Electronic_Mail_Address: miphelp@mapmodteam.com
  Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial
Metadata
  Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Extensions:
  Online_Linkage: http://hazards.fema.gov
  Online_Linkage: http://www.epsg.org
  Profile_Name: FEMA NFIP Metadata Content and Format Standard
```

Appendix C: Pre Flight Planning Report

STARR
Strategic Alliance
for Risk Reduction

Merrimack

Pre-Flight Operations Plan

November 2011

Planned Flight Lines

Photo Science has completed preliminary flight planning for the Merrimack project area. Merrimack is scheduled to be acquired this fall after the leaves are off in late fall and winter of 2011. The Merrimack area is approximately 1,243 square miles and initial planning details are depicted in Figure 1. This Figure details that **291 flight lines covering 4,077 flight line miles** will be collected. This area warranted a "Highest" vertical accuracy requirement and will be collected with a nominal pulse spacing of 1-meter. Key components of this flight planning include:

- ✓ Generating a plan that takes all specifications into account, and the required Laser settings to meet those specs, review of terrain and water issues, along with potential base station locations at airports with sufficient services available to support the crews.
- ✓ Orientation of flight lines parallel to major terrain features and variation in flight line spacing due to terrain variation (steeper slopes generally require tighter line spacing between adjacent parallel lines to ensure point density and side overlap are maintained)
- ✓ Check Airspace issues and access issues for Base Stations.
- ✓ Safety considerations, both for flights, and Laser collection.

Acquisition of 1,243 sq. miles @ 1-meter nominal post spacing to meet 24.5 cm FVA, with the following deliverables: LAS point cloud delivery with metadata, pre-operations flight plan, and post flight aerial acquisition report.

Planned GPS Stations

Normally existing high accuracy monuments at airports are utilized if possible. Typically a Primary Airport Control Monument (or Secondary) is available; otherwise any other high accuracy monument can be used. We typically prefer these on the airport grounds as they can be monitored for security by airport staff. If no monument is available or an existing monument is damaged, we will set a monument with re-bar and use OPUS to control the monument. These are then used for initial field processing of the data.

Planned Control

Seventy three (73) ground control points will be surveyed to control the LiDAR data and to support a vertical test. Each of these two functions shall remain independent of each other and also be collected by an independent subcontractor (CompassData). Independent check or calibration points will be three times as accurate as the surface being checked. Therefore, in order to validate a 18.5 cm LiDAR surface (consistent with 2 foot contours), STARR will collect elevation control data accurate to 6 cm. This "three times" model for collecting ground control and QA points will be used throughout the task order.

Vertical accuracy checkpoints will be located by another independent STARR contractor (CompassData) to check Photo Science's work in open terrain, where there is a high probability that the sensor will have detected the ground surface without influence from surrounding vegetation. Checkpoints will be located on flat or uniformly sloping terrain and will be at least five (5) meters away from any break line where there is a change in slope. This criterion applies for all QA .

Blind vertical QA points for the Consolidated Accuracy Check (CVA) will also be collected by CompassData to check Photo Science's work randomly across different land use types using the ASPRS NSSDA land cover types. The points will be located in flat areas with no substantial elevation breaks within a 3-5 meter radius.

The CVA assessment will incorporate a representative sample of the FVA assessment into the dataset to save on the total number of points collected. Figure 1 also includes the general location of the ground control points.

Planned Airport Locations

Photo Science will be utilizing five (5) airports for Merrimack for mobilization and demobilization and base station set-ups. As indicated in Figure 1 the airports will be: KAFN – Jaffrey; KBED – Bedford Lawrence; KASH – Nashua; KCON – Concord; KLCI – Laconia. All base stations used during flights will be at these Airports

Calibration Plans

Periodic detailed boresighting of the LiDAR sensor is performed at a boresight facility established in Lexington, Kentucky for both our LiDAR and imagery platforms. Over 95 high-accuracy control points are located within this facility. The area also has numerous pitched roofs that are necessary in boresighting LiDAR instruments. Local boresights are also carried out at individual project sites. Typically these are established at local airports and consist of opposing and cross flights conducted at multiple flight elevations. The boresight data is processed by our Lead LiDAR Specialist with the results for all boresight parameters applied to the project acquisition. Figure 2 outlines some of the basic principles that Photo Sciences conducts for LiDAR boresighting.

Figure2

Sensor Calibration Boresighting
✦ Photo Science routinely performs a Comprehensive Calibration process from our permanent boresighting location at the Capital City Airport in Frankfort, KY, as well as daily, local project specific boresighting locations.
✦ Photo Science established GPS survey points for LiDAR ground truthing and reflective survey analysis.
✦ Our calibration methodology adheres to the basic survey principle of *"working for the whole of the parts"* ensuring that residual values of the calibration are reduced, *not* multiplied.
✦ Photo Science calibration process validates roll, pitch, heading, pitch at swath edge, and torsion.

Calibration – all of our sensors are calibrated by flying lines at multiple altitudes and at varying directions over features on land, typically at the airport where the acquisition is staged. These lines are used to remove angular errors between the IMU and scanning mirror and to determine the precise positioning of the sensor in relationship with the phase center of the GPS antenna mounted on the fuselage of the aircraft.

Calibration of the Elevation Surface – the raw LiDAR surface is compared against ground points that are established for the calibration of the elevation surface. System biases are identified and removed during this calibration. An early statistical analysis takes place that provides an indication of the precision of the acquired data.

Additionally, each lift requires a cross flight over the lines collected during that flight. This also acts as a daily calibration and is used if any anomalies are discovered with processed data.

We have established a calibration site for the project near LCI Airport and BED and embedded within the area plans.

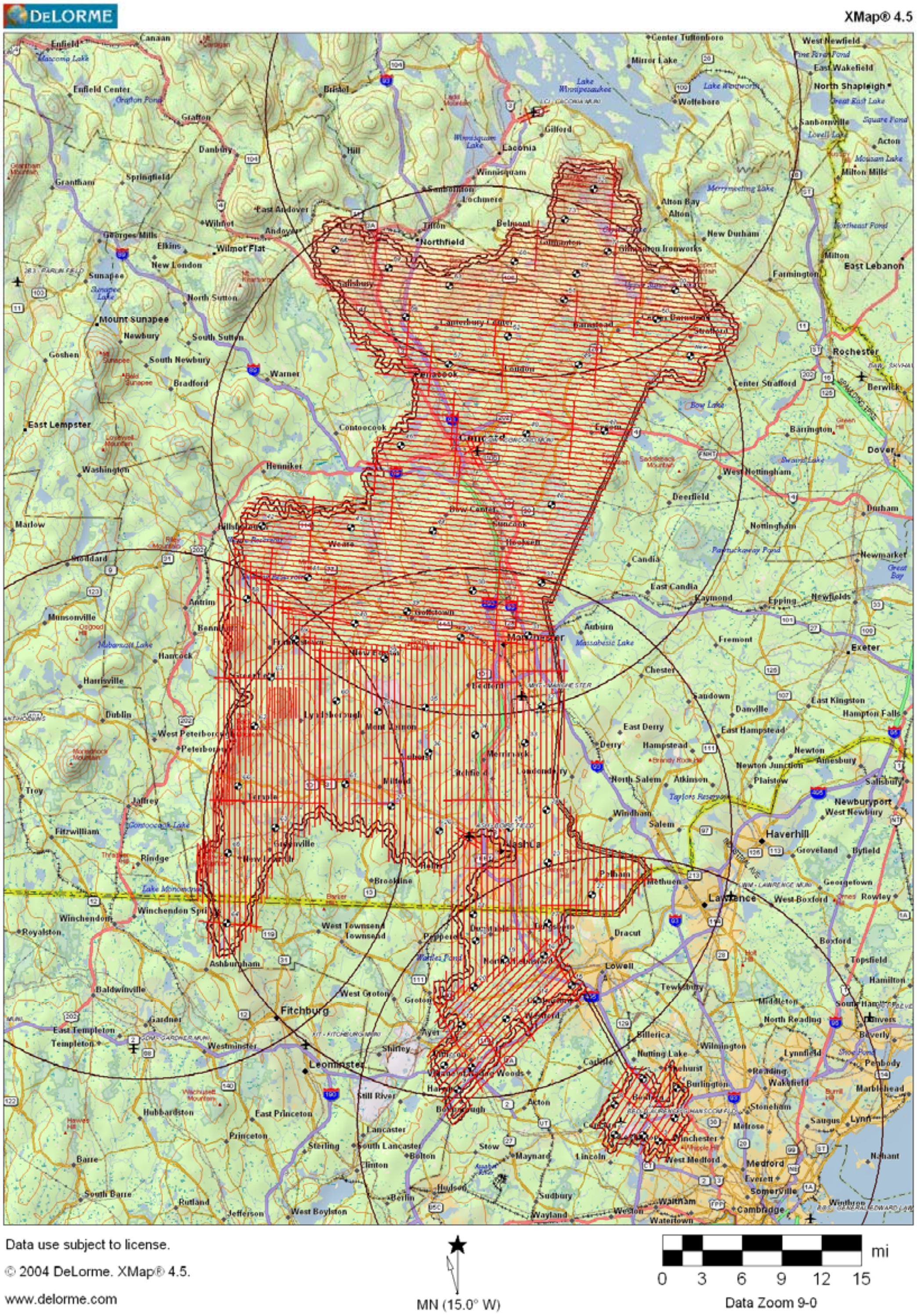


Figure 1-Merrimack Flight Lines, Ground Control, and Airport Locations

Quality Control Procedures for Flight Crew

Acquisition Crews

An experienced and knowledgeable acquisition crew is also critical to a successful LiDAR project. We will bring two capable crews to the project site with three more in reserve should any unexpected health issues or similar complications arise.

General Flight Mission Procedures

On a lift by lift basis the flight crew will check cloud conditions, atmospheric conditions (fog or probability of fog) and winds and turbulence. If any of those factors would make acquisition difficult they will wait a few hours and review again.

LiDAR crews can fly at night or during the day. Night flights can be smoother in some cases, but extra care must be used as it is easy to lose orientation with the ground if in very rural areas or over large expanses of water. Additionally, if there are fog probabilities then flights will not take place as fog will block the laser. It must be clear below the aircraft at all times.

The initial item is to set the base station properly over the monument, verify it is secure and running. Prior to setting the crew will have ascertained that it has storage space on the hard drives and full battery life. They will also verify that it is running with proper collection parameters. PDOP is also reviewed as collection will not take place during times of high PDOP.

The LiDAR system (controller hard drives and Laser) is connected to the flight management system and once the project plan is loaded the parameters for collection will load as well. The sensor operator will verify that everything loaded correctly before flight.

Once the LiDAR has been started the crew will taxi to the run up area and wait for the IMU, GPS and the rest of the system level out. They will collect data in a stationary position for about 5-10 minutes until the POS (position and orientation system) provides good level characteristics (Green Lights!).

After this they crew will take off and start collection data, avoiding hard steep turns (banks typically <20 degrees). Collection requires that speeds be maintained, sometimes quite slow depending on the accuracy requirements. Additionally altitudes must be watched closely.

During flights the sensor operator must monitor the laser to sure that temperatures are consistent and within guidelines, that pulsing is taking place correctly and returns are consistent and within guidelines while watching atmospheric conditions, speeds and monitoring the pilot.

Planned ScanSet (Laser Collection Parameters)

Parameters	**15cm RMSE, 1m**
Flying Height	5,000 – 6,000
Aircraft Ground Speed (knots)	117 - 160
Pulse Rate (KHz)	70 - 120
Scan Rate (Hz)	31 – 63.3
Full Field of View (degrees)	34 / 35
Multi-Pulse	Yes
Full Swath Width (meters)	930 - 1153
Swath Overlap (percentage)	30%
Max. Point Spacing Across Track (meters)	1.0
Max. Point Spacing Along Track (meters)	1.0
Across Track/Along Track Ratio	1.0
Average Point Density (M2)	1.25
Nadir Point Density (pts/m2)	1.25
Illuminated Foot Print Diameter (meters)	.42

Acquisition (1,243 sq. miles @ 1-meter nominal post spacing to meet 24.5 cm FVA, LAS point cloud delivery with metadata, pre-operations flight plan, and post flight aerial acquisition report)

Type of Aircraft

Five of our LiDAR sensors are currently flown in specially modified single-engine Cessna 206 platforms. This platform provides a very stable platform for LiDAR data acquisition, with the ability to easily achieve altitudes and speeds that are most common for LiDAR collection. Achieving an accurate, dense posting of LiDAR returns on the ground is most often associated with altitudes of 2,000 to 7,000 feet above the average terrain height at speeds ranging from 90 to 140 knots. These ranges are ideal for this single-engine platform. Additionally we utilize a Piper Navajo for specific projects.

Our platforms also have significant fuel capacity, which allows us considerable time over target for performing data collection. It is also a safe platform, which is important when flying over rugged terrain. The added bonus is this is a very economical platform to fly in terms of operational and maintenance costs. Moreover, that translates to competitive rates for LiDAR data acquisition.

Aircraft Name	**Engine Configuration**	**ABGPS**	**Flight Management System**	**Ceiling Feet**
Cessna U-206G (3)	Single	Yes	Yes	16,700
Cessna U-206H (2)	Single	Yes	Yes	15,700
Piper Navajo	Twin	Yes	Yes	20,000

Procedure for Tracking, Executing, and Checking Re-flights

All daily flights are tracked with specific logs for each area. These include general logs indicating the lines, date flown etc. as well as very specific mission logs concerning the lift, weather conditions, times, speeds and other criteria critical to the performance of the laser. The daily flight logs are faxed to the office on a daily basis and entered into an access database for tracking purposes. This helps determine where next to move crews and overall project status.

After flight each day, the GPS ground base station data is processed and verified and is then is run against the LiDAR POS data in both a forward and reverse sense. The two solutions are then compared against one another for all GPS epochs and the individual differences for the northing, easting, and elevation components are plotted for easy comparison. This data is then run against the LiDAR returns and a point cloud generated. Any anomalies in the data are quickly analyzed, and if required, re-flights take place for the portions of the flight missions that require remediation.

Once the data is checked it is archived, backed up and a set sent to the office via overnight delivery, while the backup copy remains with the crew.

The flight crews do not leave the area of collection until all data has been verified and shipped.

Considerations for Terrain, Cover, and Weather

Terrain is not an issue for flight planning on this project. The area is relatively flat. Cover has been considered and collection is scheduled for the Fall and Winter of 2011 during leaf-off conditions. Traditional LiDAR weather conditions will be observed for this area.

Appendix D: Ground Control Survey and Vertical Testing Quality Control

FEMA Region 1 Merrimack, NH
Ground Control Project Report for Photo Science.

May 17, 2012

Project Information

CDI Project Number:	**FSG1619**
Geographic Location:	**Merrimack, NH**
Number of FVAs/CVAs Requested:	**80**
Number of FVAs/CVAs Collected:	**96**

Project Specifications

Precision (Horizontal/Vertical):	**CDI Precision-1 ≤ 8cm H/V**
Coordinate System:	**UTM**
Datum:	**NAD83**
Zone:	**18**
Altitude Reference:	**NAVD88 (Geoid09)**
Units:	**Meters**

RTK GPS

All Ground Control Points for this project were collected with survey-grade GPS equipment and a survey-grade total station. Collected Survey-Control Points were processed in real-time with a Trimble VRS network.

All Control Points were observed for 180 epochs to determine a coordinate location ≤ 8cm in both Horizontal and Vertical to support subsequent LiDAR post-processing and bare earth deliverables generation.

Summary

The purpose of this project was to locate and survey ground control points (GCPs) in multiple areas of interest as defined by FEMA-supplied shape and kml files. The GCP coordinates are to be used to control the vertical aspect of all newly-flown LiDAR data during post-processing and subsequent deliverables creation. CompassData visited the project area, found suitable GCPs, and determined accurate coordinates for each GCP according to the customer's specifications.

Equipment

CompassData used a Trimble R6 to perform the Control survey. This device is accurate to within 1 cm on a position-by-position basis per Trimble specifications. Operating within the VRS network provided accurate coordinate values at or around 8 cm H/V. CompassData has consistently demonstrated this level of accuracy on many GCP collection jobs across North and South America and Africa. Specifications for the Trimble R6 are available upon request.

Survey Methodology

CompassData has met the required precision for this project by using a high-quality GPS receiver with differential corrections provided by a VRS network surrounding the project area. The GPS antenna sat atop a bubble-leveled, fixed-height range pole that was placed over the center of the desired GCP. At least 180 positions (captured at a rate of one per second) were geometrically averaged to calculate a single coordinate for each GCP. All required field documentation was filled out and the points were identified on web-based imagery. Digital pictures of each GCP location were collected in the field.

Quality Control Procedures

CompassData collects GCPs with an unobstructed view of the sky to ensure proper GPS operation. CompassData works to avoid potential sources of multipath error such as trees, buildings, and fences that may adversely affect the GPS accuracy. Additional quality control comes from the fact that at least 180 GPS positions are collected for each GCP. While operating within a VRS, valid solutions are reached within seconds; however, we continue to collect additional data to ensure meeting collection specifications. To ensure project integrity, a GCP will be reobserved or moved to a more suitable location if it does not meet project specifications.

In addition to the aforementioned procedures, CompassData “surveys” existing geodetic control monuments to see if our coordinates match the published coordinates to the required accuracy. These monuments are usually established by the National Geodetic Survey (NGS) in the United States. If it is found that our coordinates are outside the acceptable accuracy, the reason for the difference will be found or the GCPs will be reobserved under different GPS constellation constraints. There are certain geodetic considerations that must be taken into account that affect whether a GPS-derived coordinate will line up with a survey monument, especially when these monuments reference local coordinate systems or the systems of another country. Sometimes the published coordinates for a monument are not accurate, although this is very infrequent.

CompassData visited multiple survey monuments during the course of this project. The results of those monument measurements are summarized in the Accuracy Report.

Deliverables

Deliverables for this project include:

- ☐ Coordinates (in spreadsheet format)
- ☐ Image Chips
- ☐ Sketch Sheets
- ☐ Digital Pictures
- ☐ QA/QC Data

Project Notes

All collected points were retrieved from the Trimble Survey Controller in Decimal Degrees, NAD83, HAE Meters.

CorpsCon was used to generate files in the following format:
Degrees Minutes Decimal Seconds, NAD83 HAE (QC purposes)
UTM Meters, NAD83 HAE

Geoid09 was then used to generate the geoid separation at every Lat/Long location. NAVD88(09) orthometric heights were then generated in spreadsheet form using the formula HAE - Geoid = Orthometric Height. Those values were then included into the final delivery coordinate CSV files and have been tested against NGS monuments collected during the course of this survey and are showing millimeter-level agreement.

The Horizontal and Vertical accuracies reported in the Final Coordinates file were obtained from the Survey Report generated by Trimble Survey Controller. The report contains all points collected during each daily survey deployment, including CVAs, FVAs and Ground Control. Copies of these reports can be provided upon request once the CVA and FVA data has been redacted.

Contact Information

Hayden Howard Phone: (303) 627-4058 E-mail: haydenh@compassdatainc.com

Region 1: Test results for Merrimack, NH

Summary

In FEMA-Region 1 the Merrimack area is split up in multiple parts. This test encompasses total about 1800 square miles. A LiDAR data acquisition was ordered for a 2' equivalent contour accuracy, which equals the highest specification level. The area was flown and post-processed by Photo Science. CompassData performed the quality control of the collected and processed LiDAR data with a fundamental vertical accuracy (FVA) and a consolidated vertical accuracy (CVA) assessment, respectively. The planning, data collection, data processing, and data testing were successfully accomplished by the STARR members.

Index

Final Test Results

The vertical accuracy requirements based on flood risk and terrain slope are met with 14.0 cm and 24.3 cm for both FVA and CVA testing. The mandatory requirements for the highest specification for vertical accuracy, 95% confidence levels are for FVA < 24.5 cm and CVA < 36.3 cm.

FVA Test

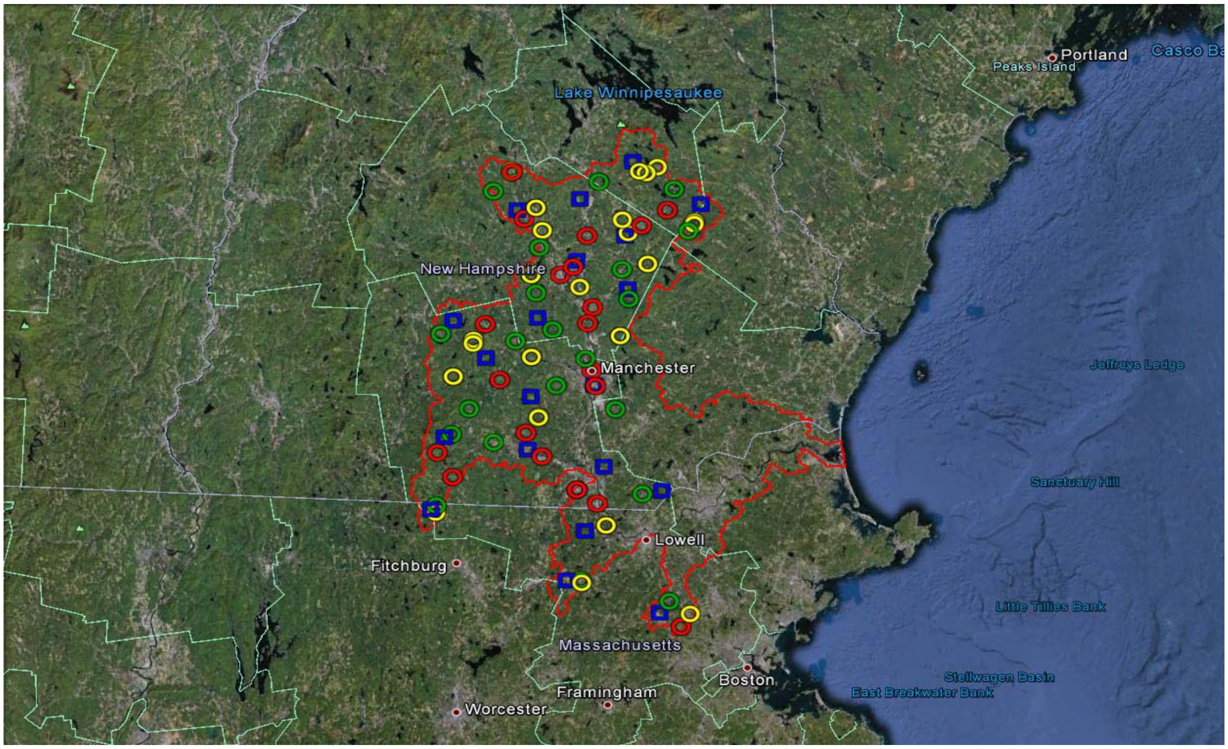
Tested 14.0 cm fundamental vertical accuracy at 95% confidence level in open terrain using $RMSE_{(z)}$ x 1.9600. The Root Mean Square Error for the elevation differences between GPS control points and LiDAR points is 7.1 cm calculated with 20 FVA points.

CVA Test

Tested 24.3 cm consolidated vertical accuracy at 95th percentile in: open terrain, forest terrain, and urban terrain. The Root Mean Square Error for the elevation differences between GPS control points and LiDAR points is 11.4 cm calculated with 76 supplemental vertical accuracy points (SVA).

Distribution of Testing Points

Region 10, Merrimack, NH



<u>Legend:</u>

🟦	FVA points in open terrain on hard surface
🟢	SVA points in grass terrain
🟡	SVA points in urban terrain
🔴	SVA points in forest terrain

According to the area to be tested the 20 FVA points are evenly distributed. Additional 76 SVA points are distributed in respect to the available major land classes.

FVA Test Details

FVA	Northing	Easting	MSL (GPS)	MSL (LiDAR)	Δ Z	Δ Z^2
MER301	4709363.03	804854.11	48.68	48.67	**0.01**	0.00
MER302	4715954.19	786017.51	67.48	67.43	**0.05**	0.00
MER303	4728027.19	789194.39	103.66	103.64	**0.02**	0.00
MER304	4738101.26	804913.66	99.78	99.68	**0.10**	0.01
MER305	4743750.09	792649.25	97.08	97.05	**0.03**	0.00
MER306	4746713.87	775836.97	76.02	75.97	**0.05**	0.00
MER307	4731315.64	757697.14	319.91	319.93	**-0.02**	0.00
MER308	4750305.98	758400.83	290.05	290.06	**-0.01**	0.00
MER309	4759303.49	776331.42	232.86	232.85	**0.01**	0.00
MER310	4763513.97	791030.81	99.14	99.11	**0.03**	0.00
MER311	4766900.62	768279.74	144.31	144.24	**0.07**	0.01
MER312	4776754.78	759600.69	270.04	270.19	**-0.15**	0.02
MER313	4778539.62	778294.85	230.53	230.61	**-0.08**	0.01
MER314	4786630.45	795214.15	152.86	152.81	**0.05**	0.00
MER315	4792471.94	785625.52	115.49	115.52	**-0.03**	0.00
MER316	4799588.65	795219.49	137.17	137.30	**-0.13**	0.02
MER317	4803685.26	772198.04	114.12	114.29	**-0.18**	0.03
MER318	4806835.00	784332.58	231.80	231.80	**-0.01**	0.00
MER319	4806890.72	810329.60	278.97	278.98	**-0.02**	0.00
MER320	4816440.44	795088.72	259.28	259.27	**0.00**	0.00

ΔZ Mean	**0.05**		
ΔZ Min	**-0.18**	**RMSE:**	**0.07**
ΔZ Max	**0.10**	*** 1.96**	**0.14**

Metadata

UTM 18 North, NAD83,
NAVD88
All units in meters where applicable.
HAE - GEOID09 = NAVD88

Note:

All 20 of the FVA points (open terrain) passed. 100% of the points are within the 24.5 cm confidence level. The FVA test is passed.

CVA Test Details

CVA	Ground Cover	Latitude(GPS)	Longitude(GPS)	Northing(GPS)	Easting(GPS)	MSL (GPS)	MSL (LiDAR)	Δ Z	Δ Z^2
MER401	Grass	42.5009187	-71.2575761	4712185.30	807515.35	40.88	40.87	**0.01**	0.00
MER402	Grass	42.5451516	-71.4823467	4716305.96	788839.72	66.54	66.57	**-0.03**	0.00
MER404	Grass	42.7314685	-71.3254064	4737546.06	800827.65	45.70	45.61	**0.09**	0.01
MER405	Grass	42.9131464	-71.3938522	4757481.59	794359.23	83.39	83.50	**-0.11**	0.01
MER406	Grass	42.8590379	-71.8151776	4750082.87	760192.46	262.32	262.47	**-0.15**	0.02
MER407	Grass	42.9135747	-71.7703816	4756279.19	763619.88	239.30	239.39	**-0.09**	0.01
MER408	Grass	42.9635076	-71.5463015	4762552.07	781684.16	123.34	123.37	**-0.03**	0.00
MER409	Grass	43.0212053	-71.4707368	4769216.47	787578.28	74.06	74.27	**-0.21**	0.05
MER410	Grass	43.0838659	-71.5560008	4775886.91	780344.13	182.00	182.27	**-0.27**	0.08
MER411	Grass	43.0591880	-71.6514587	4772831.10	772682.69	95.19	95.42	**-0.23**	0.05
MER412	Grass	43.1623687	-71.5986960	4784463.73	776514.20	109.49	109.57	**-0.08**	0.01
MER413	Grass	43.0742793	-71.8444991	4773897.28	756898.56	336.68	336.75	**-0.07**	0.00
MER414	Grass	43.1493296	-71.3589959	4783835.86	796065.67	126.09	126.15	**-0.06**	0.00
MER415	Grass	43.2129379	-71.3767813	4790837.80	794313.21	105.66	105.80	**-0.14**	0.02
MER416	Grass	43.2598996	-71.5905160	4795323.06	776737.39	111.02	111.18	**-0.16**	0.03
MER417	Grass	43.2947334	-71.2047443	4800543.07	807876.03	258.35	258.43	**-0.08**	0.01
MER418	Grass	43.3846904	-71.2416452	4810398.98	804431.86	202.65	202.75	**-0.10**	0.01
MER419	Grass	43.4007585	-71.4359930	4811491.66	788611.87	259.44	259.44	**0.00**	0.00
MER420	Grass	43.3808707	-71.7103303	4808368.68	766481.92	236.74	236.83	**-0.09**	0.01
MER421	Open	42.8419700	-71.7073511	4748526.42	769076.51	85.35	85.34	**0.01**	0.00
MER421A	Grass	42.6913114	-71.8526355	4731340.49	757827.60	319.95	319.95	**0.00**	0.00
MER701	Forest	42.4738968	-71.2044003	4709378.74	812019.84	48.03	48.07	**-0.04**	0.00
MER702	Forest	42.5436292	-71.4830508	4716134.49	788788.93	65.66	65.75	**-0.09**	0.01
MER702B	Forest	42.5434722	-71.4833558	4716116.01	788764.60	65.77	65.85	**-0.08**	0.01
MER703	Forest	42.6643038	-71.4182206	4729759.78	793545.07	72.61	72.66	**-0.05**	0.00
MER703B	Forest	42.6641537	-71.4184512	4729742.31	793526.88	72.87	72.98	**-0.11**	0.01
MER704	Forest	42.8967729	-71.5919642	4754988.25	778260.22	73.97	74.03	**-0.06**	0.00
MER704A	Forest	42.8971136	-71.5920771	4755025.71	778249.47	75.12	75.22	**-0.10**	0.01
MER705	Forest	42.6913573	-71.8549871	4731338.41	757634.76	319.76	319.80	**-0.04**	0.00
MER706	Forest	42.9828373	-71.8111437	4763844.44	760000.39	246.94	246.98	**-0.04**	0.00
MER706A	Forest	42.9827733	-71.8115768	4763835.99	759965.35	246.71	246.86	**-0.15**	0.02
MER707	Forest	43.0250367	-71.6101534	4769173.38	776199.93	96.38	96.39	**-0.01**	0.00
MER707A	Forest	43.0256583	-71.6102819	4769241.99	776186.67	98.29	98.39	**-0.10**	0.01
MER708	Forest	43.0701843	-71.3815800	4774965.89	794608.99	139.39	139.58	**-0.19**	0.03
MER708A	Forest	43.0699884	-71.3813728	4774944.86	794626.80	138.87	139.10	**-0.23**	0.05
MER709	Forest	43.0607772	-71.7596171	4772661.43	763867.52	201.96	202.25	**-0.29**	0.08
MER709A	Forest	43.0612822	-71.7597434	4772717.11	763855.07	203.23	203.50	**-0.28**	0.08
MER710	Forest	43.1751872	-71.4858631	4786266.59	785628.04	101.26	101.27	**-0.01**	0.00
MER711	Forest	43.2242581	-71.3102046	4792331.76	799666.16	132.99	133.03	**-0.04**	0.00
MER711A	Forest	43.2244650	-71.3100698	4792355.22	799676.10	134.18	134.28	**-0.10**	0.01
MER712	Forest	43.2968043	-71.5833413	4799445.71	777152.02	96.45	96.73	**-0.28**	0.08

MER712A	Forest	43.2967189	-71.5826486	4799438.52	777208.60	98.99	99.18	**-0.20**	0.04
MER713	Forest	43.3452379	-71.5998571	4804770.33	775592.92	170.16	170.30	**-0.14**	0.02
MER713A	Forest	43.3451176	-71.5990326	4804759.69	775660.30	164.16	164.29	**-0.13**	0.02
MER714	Forest	43.3093666	-71.1898322	4802223.50	809011.59	221.11	221.11	**0.00**	0.00
MER715	Forest	43.3192055	-71.3754481	4802645.34	793909.09	167.65	167.68	**-0.03**	0.00
MER714A	Forest	43.3098886	-71.1898890	4802281.27	809004.33	220.12	220.17	**-0.05**	0.00
MER716A	Forest	43.4230028	-71.3312173	4814330.80	796988.34	235.95	236.03	**-0.08**	0.01
MER717	Forest	43.4319642	-71.2845305	4815493.79	800723.50	302.08	302.18	**-0.10**	0.01
MER718	Forest	43.2910495	-71.3605751	4799570.63	795251.64	134.11	134.34	**-0.23**	0.05
MER719	Forest	43.4208677	-71.6633590	4812962.32	770109.16	125.04	125.00	**0.04**	0.00
MER719A	Forest	43.4208794	-71.6628789	4812965.17	770147.97	124.01	123.96	**0.05**	0.00
MER720	Forest	43.2010657	-71.6116810	4788718.75	775284.36	127.18	127.20	**-0.03**	0.00
MER720A	Forest	43.2017458	-71.6117768	4788793.97	775273.51	134.39	134.43	**-0.05**	0.00
MER721	Forest	43.4192990	-71.3137957	4813981.73	798416.95	233.99	234.07	**-0.08**	0.01
MER801	Urban	42.4463049	-71.2278332	4706228.36	810229.67	65.77	65.67	**0.10**	0.01
MER802	Urban	42.7404381	-71.4933904	4737956.59	787032.48	56.00	56.00	**0.00**	0.00
MER802A	Urban	42.7404381	-71.4933906	4737956.59	787032.47	56.00	56.00	**0.00**	0.00
MER803	Urban	42.7112348	-71.4409064	4734893.29	791465.86	47.48	47.45	**0.02**	0.00
MER804	Urban	42.9626519	-71.4450154	4762801.85	789949.85	74.90	74.86	**0.03**	0.00
MER805	Urban	42.9964867	-71.4548439	4766525.75	788989.43	78.48	78.42	**0.06**	0.00
MER806	Urban	43.1315607	-71.4525341	4781535.59	788542.70	90.82	90.80	**0.02**	0.00
MER807	Urban	43.0972436	-71.4656394	4777679.07	787637.54	67.22	67.29	**-0.07**	0.01
MER808	Urban	43.2013206	-71.5360638	4788998.86	781427.18	87.22	87.23	**-0.01**	0.00
MER809	Urban	43.2181192	-71.5029436	4790976.65	784040.18	106.86	106.88	**-0.02**	0.00
MER810	Urban	43.3396343	-71.2591111	4805330.94	803241.64	157.03	157.10	**-0.07**	0.00
MER811	Urban	43.3064586	-71.3256409	4801406.31	798010.56	150.93	151.00	**-0.07**	0.01
MER812	Urban	43.2849323	-71.4666445	4798521.37	786674.76	117.55	117.66	**-0.11**	0.01
MER813	Urban	43.3217844	-71.6296416	4802067.41	773283.90	101.28	101.40	**-0.12**	0.01
MER814	Urban	43.4222284	-71.6607434	4813121.94	770314.84	124.82	124.88	**-0.06**	0.00
MER815	Urban	43.0953633	-71.7299193	4776596.55	766136.12	195.33	195.46	**-0.13**	0.02
MER816	Open	42.9761127	-71.6916166	4763474.76	769776.12	126.89	126.83	**0.06**	0.00
MER817	Open	42.8195464	-71.8514537	4745585.48	757392.60	315.22	315.25	**-0.03**	0.00
MER818	Urban	42.7673358	-71.8119721	4739908.54	760839.88	250.33	250.41	**-0.08**	0.01
MER819	Open	42.8622513	-71.6244756	4751047.16	775759.36	79.72	79.67	**0.05**	0.00
MER820	Urban	42.8116651	-71.5832443	4745565.04	779356.07	69.02	68.99	**0.03**	0.00

ΔZ Mean	**0.09**	**RMSE:**	**0.114**
ΔZ Min	**-0.29**	***1.96**	**0.223**
ΔZ Max	**0.10**	**95-Percentile**	**0.243**

Note:

76 out of 76 of the SVA points (open, forest, and grass terrain) passed below the 36.3 cm criteria. The CVA test is passed.

Appendix E: Post Flight Reports

STARR
Strategic Alliance
for Risk Reduction

Merrimack
Post-Flight Aerial Acquisition Report

June 2012

Contents

Tables

Figures

1. Overview

1.1 Consultant contact information

GMR Aerial Surveys, Inc. DBA Photo Science
2670 Wilhite Drive
Lexington, KY 40503
(859) 277-8700
Contact: Clay Smith, CP
Email: csmith@photoscience.com

Project Number: 7556-008

1.2 Project information

The purpose of this project is to provide professional surveying and mapping services for the creation of a high-resolution digital elevation model developed from LIDAR data for the Merrimack MA and NH area of interest (AOI). The project area is shown in Figure 1.1.

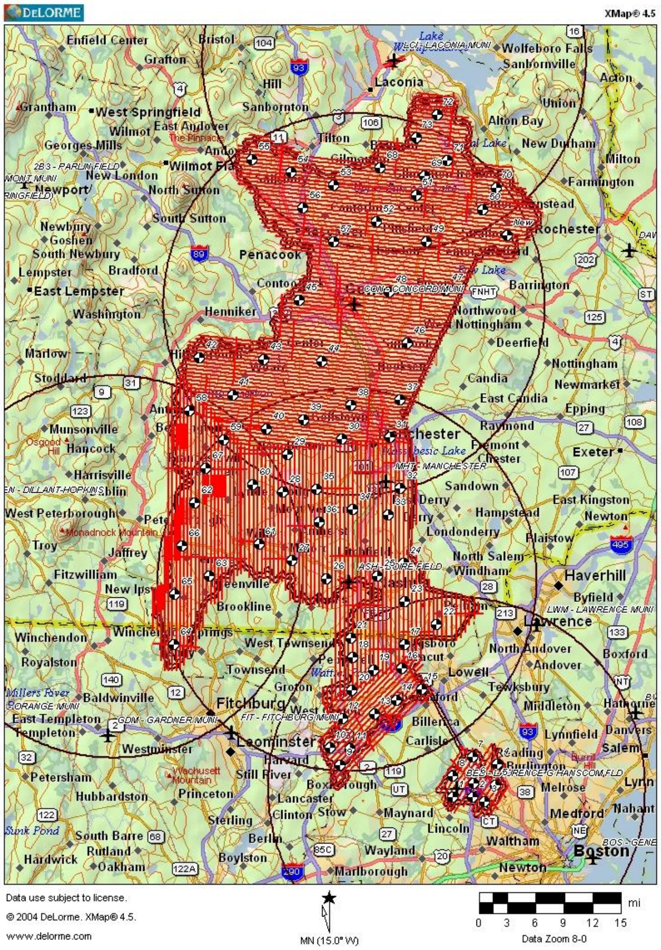


Figure 1.1: Merrimack Project Area

2. Project Planning

2.1 Flight and sensor parameters

Detailed project planning was performed for this project. This planning was based on project specific requirements and the characteristics of the project site. The basis of this planning included the required accuracies, type of development, amount and type of vegetation within the project area, the required data posting, and potential altitude restrictions for flights in the general area. A brief summary of the aerial acquisition parameters for this project are shown in the LiDAR System Specification (Table 2.1) below:

Terrain and Aircraft	
Flying Height AGL	1859 +/-m, 6,100+/- feet
Recommended Ground Speed (GS)	160 kts
Scanner	
Field of View (FOV)	35.0; degrees
Maximum Scan Rate	52.7 Hz
Scan Rate Setting used (SR)	52.7 Hz
Laser	
Maximum Laser Pulse Rate	125,000 Hz
Laser Pulse Rate used	120,000 Hz
Multi Pulse in Air Mode	Enabled
Gain Values (Up/Down)	12; 3
Range Intensity mode)	5
Nominal Maximum Slant Range	2,288.69 m
Recommended Range Gate MIN Setting	1441 m
Recommended Range Gate MAX Setting	1968 m
Equivalent Attenuator Used	0.08 OD
Recommended Laser Current	63 %
Coverage	
Full Swath Width	1153.36 m, 4,820.59 feet
Maximum Line Spacing (No DTM)	915.78 m
Point Spacing and Density	
Maximum Point Spacing Across Track	1.57 m
Maximum Point Spacing Along Track	1.57 m
Across Track/Along Track Ratio	1.00
Average Point Density	1.26 pts/m^2
Average Point Area	0.79 m^2
Average Point Spacing	0.89 m
Nadir Point Density	0.82 pts/m^2
Reflectivity and SNR	
Illuminated Footprint Diameter	0.42 m
Average SNR	18.00
Reflectivity and SNR	
Illuminated Footprint Diameter	0.42 m
Average SNR	18.00
Accuracy	
Estimated Across Track Accuracy	0.24 - 0.27 m
Estimated Along Track Accuracy	0.24 - 0.26 m
Estimated Height Accuracy	0.11 - 0.14 m

Table 2.1: LiDAR System Specifications

2.2 Base Station Information

A GPS base station was utilized at predetermined locations during all phases of flight for each block. Typically existing monuments are utilized when available, but on occasion a monument consisting of a steel pin will be set. OPUS solutions are utilized to determine the exact location of the monument if set, or verify the location if existing.

For this project five base stations were utilized. The data sheet and image of the location for each base station is included in this report on pages 7-11.

KAFN Primary Base Station

```
DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.4.2
1 National Geodetic Survey, Retrieval Date = OCTOBER 30, 2011
AH8857
***********************************************************************
AH8857 PACS - This is a Primary Airport Control Station.
AH8857 DESIGNATION - AFN A
AH8857 PID - AH8857
AH8857 STATE/COUNTY- NH/CHESHIRE
AH8857 USGS QUAD -
AH8857
AH8857 *CURRENT SURVEY CONTROL
AH8857 ___________________________________________________________________
AH8857* NAD 83(2007)- 42 48 24.05940(N) 072 00 05.05892(W) ADJUSTED
AH8857* NAVD 88 - 308.04 (meters) 1010.6 (feet) GPS OBS
AH8857 ___________________________________________________________________
AH8857 EPOCH DATE - 2002.00
AH8857 X - 1,448,185.034 (meters) COMP
AH8857 Y - -4,457,427.222 (meters) COMP
AH8857 Z - 4,311,961.336 (meters) COMP
AH8857 LAPLACE CORR- 0.29 (seconds) DEFLEC09
AH8857 ELLIP HEIGHT- 280.506 (meters) (02/10/07) ADJUSTED
AH8857 GEOID HEIGHT- -27.54 (meters) GEOID09
AH8857
AH8857 ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
AH8857 Type PID Designation North East Ellip
AH8857 -------------------------------------------------------------------
AH8857 NETWORK AH8857 AFN A 0.65 0.57 3.08
AH8857 -------------------------------------------------------------------
AH8857
AH8857.This mark is at Jaffery Mun-Silver Ranch Airport (AFN)
AH8857
AH8857.The horizontal coordinates were established by GPS observations
AH8857.and adjusted by the National Geodetic Survey in February 2007.
AH8857
AH8857.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
```

Figure 2.1: KAFN Base Station

LCI NGS Data Sheet

```
DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.88.3
1         National Geodetic Survey,   Retrieval Date = JUNE 21, 2012
 OC0649
************************************************************************
 OC0649  DESIGNATION -  ARP LCI
 OC0649  PID         -  OC0649
 OC0649  STATE/COUNTY-  NH/BELKNAP
 OC0649  COUNTRY     -  US
 OC0649  USGS QUAD   -  LACONIA (1987)
 OC0649
 OC0649                        *CURRENT SURVEY CONTROL
 OC0649  ___________________________________________________________________
 OC0649* NAD 83(2007) POSITION- 43 34 25.41196(N) 071 25 20.16228(W) ADJUSTED
 OC0649* NAD 83(2007) ELLIP HT-   136.495 (meters)      (02/10/07)   ADJUSTED
 OC0649* NAD 83(2007) EPOCH   -  2002.00
 OC0649* NAVD 88 ORTHO HEIGHT -   163.743  (meters)   537.21  (feet) ADJUSTED
 OC0649  ___________________________________________________________________
 OC0649  NAD 83(2007) X  -  1,474,550.086 (meters)                     COMP
 OC0649  NAD 83(2007) Y  - -4,387,176.359 (meters)                     COMP
 OC0649  NAD 83(2007) Z  -  4,373,993.866 (meters)                     COMP
 OC0649  LAPLACE CORR    -         1.36  (seconds)                 DEFLEC09
 OC0649  GEOID HEIGHT    -        -27.24  (meters)                  GEOID09
 OC0649  DYNAMIC HEIGHT  -       163.712 (meters)      537.11  (feet) COMP
 OC0649  MODELED GRAVITY -    980,430.5   (mgal)                    NAVD 88
 OC0649
 OC0649  VERT ORDER      -  SECOND    CLASS 0
 OC0649
 OC0649  FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
 OC0649  Type                                         Horiz  Ellip  Dist(km)
 OC0649  -------------------------------------------------------------------
 OC0649  NETWORK                                       0.88   2.74
 OC0649  -------------------------------------------------------------------
 OC0649  MEDIAN LOCAL ACCURACY AND DIST (001 points)   0.40   0.22      0.17
 OC0649  -------------------------------------------------------------------
 OC0649  NOTE: Click here for information on individual local accuracy
 OC0649  values and other accuracy information.
 OC0649
 OC0649.This mark is at Laconia Airport (LCI)
 OC0649
```

Figure 2.2: LCS Base Station

CON NGS Data Sheet

```
DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.88.3
1         National Geodetic Survey,   Retrieval Date = JUNE 21, 2012
 AH8877
***********************************************************************
 AH8877  PACS         -  This is a Primary Airport Control Station.
 AH8877  DESIGNATION -  CONCORD CBL 150
 AH8877  PID          -  AH8877
 AH8877  STATE/COUNTY-  NH/MERRIMACK
 AH8877  COUNTRY      -  US
 AH8877  USGS QUAD    -  CONCORD (1985)
 AH8877
 AH8877                          *CURRENT SURVEY CONTROL
 AH8877  ______________________________________________________________________
 AH8877* NAD 83(2007) POSITION- 43 12 07.23233(N) 071 30 20.69865(W)
ADJUSTED
 AH8877* NAD 83(2007) ELLIP HT-    74.211 (meters)    (02/10/07)   ADJUSTED
 AH8877* NAD 83(2007) EPOCH   -  2002.00
 AH8877* NAVD 88 ORTHO HEIGHT -   101.62   (meters)   333.4   (feet) GPS OBS
 AH8877  ______________________________________________________________________
 AH8877 NAVD 88 orthometric height was determined with geoid model  GEOID96
 AH8877  GEOID HEIGHT    -       -27.41  (meters)                   GEOID96
 AH8877  GEOID HEIGHT    -        -27.42  (meters)                  GEOID09
 AH8877  NAD 83(2007) X  -  1,477,140.873 (meters)                     COMP
 AH8877  NAD 83(2007) Y  - -4,416,181.422 (meters)                     COMP
 AH8877  NAD 83(2007) Z  -  4,343,938.680 (meters)                     COMP
 AH8877  LAPLACE CORR    -          2.78  (seconds)                 DEFLEC09
 AH8877
 AH8877  FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
 AH8877  Type                                         Horiz  Ellip  Dist(km)
 AH8877  ---------------------------------------------------------------------
 AH8877  NETWORK                                       0.83   2.82
 AH8877  ---------------------------------------------------------------------
 AH8877  MEDIAN LOCAL ACCURACY AND DIST (007 points)   0.65   2.82     41.69
 AH8877  ---------------------------------------------------------------------
 AH8877  NOTE: Click here for information on individual local accuracy
 AH8877  values and other accuracy information.
 AH8877
 AH8877.This mark is at Concord Airport (CON)
 AH8877
```

Figure 2.3: CON Base Station

ASH NGS Data Sheet

```
DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.88.3
1        National Geodetic Survey,   Retrieval Date = JUNE 21, 2012
 AB5425
***********************************************************************
 AB5425  DESIGNATION -  ARP ASH 1973
 AB5425  PID         -  AB5425
 AB5425  STATE/COUNTY-  NH/HILLSBOROUGH
 AB5425  COUNTRY     -  US
 AB5425  USGS QUAD   -  SOUTH MERRIMACK (1985)
 AB5425
 AB5425                         *CURRENT SURVEY CONTROL
 AB5425  ________________________________________________________________
 AB5425* NAD 83(2007) POSITION- 42 46 52.75510(N) 071 30 54.20564(W) ADJUSTED
 AB5425* NAD 83(2007) ELLIP HT-    30.226 (meters)      (02/10/07)   ADJUSTED
 AB5425* NAD 83(2007) EPOCH   -  2002.00
 AB5425* NAVD 88 ORTHO HEIGHT -   57.8    (meters)    190.    (feet) GPS OBS
 AB5425  ________________________________________________________________
 AB5425  NAVD 88 orthometric height was determined with geoid model  GEOID96
 AB5425  GEOID HEIGHT    -         -27.62  (meters)                   GEOID96
 AB5425  GEOID HEIGHT    -         -27.62  (meters)                   GEOID09
 AB5425  NAD 83(2007) X  -  1,486,517.384 (meters)                      COMP
 AB5425  NAD 83(2007) Y  - -4,446,615.243 (meters)                      COMP
 AB5425  NAD 83(2007) Z  -  4,309,723.794 (meters)                      COMP
 AB5425  LAPLACE CORR    -           1.54  (seconds)                 DEFLEC09
 AB5425
 AB5425  FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
 AB5425  Type                                         Horiz  Ellip  Dist(km)
 AB5425  -------------------------------------------------------------------
 AB5425  NETWORK                                       1.09   2.67
 AB5425  -------------------------------------------------------------------
 AB5425  MEDIAN LOCAL ACCURACY AND DIST (001 points)   0.81   0.59      0.02
 AB5425  -------------------------------------------------------------------
 AB5425  NOTE: Click here for information on individual local accuracy
 AB5425  values and other accuracy information.
 AB5425
 AB5425.This mark is at Boire Field Airport (ASH)
 AB5425
```

Figure 2.4: ASH Base Station

BED NGS Data Sheet

```
DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.88.3
1        National Geodetic Survey,   Retrieval Date = JUNE 21, 2012
 AI5560
*************************************************************************
 AI5560  SACS        -  This is a Secondary Airport Control Station.
 AI5560  DESIGNATION -  BED C
 AI5560  PID         -  AI5560
 AI5560  STATE/COUNTY-  MA/MIDDLESEX
 AI5560  COUNTRY     -  US
 AI5560  USGS QUAD   -
 AI5560
 AI5560                         *CURRENT SURVEY CONTROL
 AI5560  ___________________________________________________________________
 AI5560* NAD 83(2007) POSITION- 42 28 02.93544(N) 071 17 51.01077(W) NO CHECK
 AI5560* NAD 83(2007) ELLIP HT-    13.511 (meters)      (02/10/07)   NO CHECK
 AI5560* NAD 83(2007) EPOCH   -  2002.00
 AI5560* NAVD 88 ORTHO HEIGHT -    41.30   (meters)    135.5   (feet) GPS OBS
 AI5560  ___________________________________________________________________
 AI5560  NAVD 88 orthometric height was determined with geoid model   GEOID99
 AI5560  GEOID HEIGHT    -         -27.77  (meters)                   GEOID99
 AI5560  GEOID HEIGHT    -         -27.80  (meters)                   GEOID09
 AI5560  NAD 83(2007) X  -  1,510,956.919 (meters)                       COMP
 AI5560  NAD 83(2007) Y  - -4,463,289.407 (meters)                       COMP
 AI5560  NAD 83(2007) Z  -  4,284,059.982 (meters)                       COMP
 AI5560  LAPLACE CORR    -           3.87  (seconds)                 DEFLEC09
 AI5560
 AI5560  FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
 AI5560  Type                                         Horiz  Ellip  Dist(km)
 AI5560  -------------------------------------------------------------------
 AI5560  NETWORK                                       1.26   2.27
 AI5560  -------------------------------------------------------------------
 AI5560  MEDIAN LOCAL ACCURACY AND DIST (002 points)   0.50   0.22     0.97
 AI5560  -------------------------------------------------------------------
 AI5560  NOTE: Click here for information on individual local accuracy
 AI5560  values and other accuracy information.
 AI5560
 AI5560.This mark is at Laurence G Hanscom Fld Airport (BED)
 AI5560
```

Figure 2.5: BED Base Station

3. Acquisition

3.1 Flight information

All flights for the project were accomplished with a customized twin-engine Piper PA-31 Navajo fixed wing arcraft utilizing a Leica ALS60 LiDAR sensor, and a Cessna 206 single engine aircraft outfitted with an Optech Gemini LiDAR sensor. These aircraft provide an ideal, stable aerial base for LiDAR acquisition. Both platforms have relatively fast cruise speeds that are beneficial for project mobilization/demobilization while maintaining relatively slow stall speeds which can prove ideal for collection of a high-density, consistent data posting.

The project covered 1,244.91 square miles and required five (5) blocks (block or area is determined by the Base Station control locations, typically airports with ground control monuments available providing coverage within 18 miles of the base as possible) to cover in its entirety. This resulted in 268 flight lines totaling 2844.6 flight line miles which were captured over 19 separate lifts. Each of the five blocks are shown on Figures 3.1 - 3.5. A summary of the flight operations is provided in Table 3.1. Flight logs are found in Appendix A.

Area	Flight Lines	Number of Lifts	Dates flown	System
CON	79	7	12/29 through 12/19/2011	ALS60
ASH	64	5	1/7/2012 through 1/11/2012	ALS60
BED	31	1	1/11/2012	ALS60
LCI	34	2	11/12/2011 and 11/13/2011	ALS60
AFN	48	4	11/12/2011 and 11/13/2011	Optech
Cross flights	12	Lifts were combined with the acquisition of each area with both sensors		

Table 3.1: Flight Summary

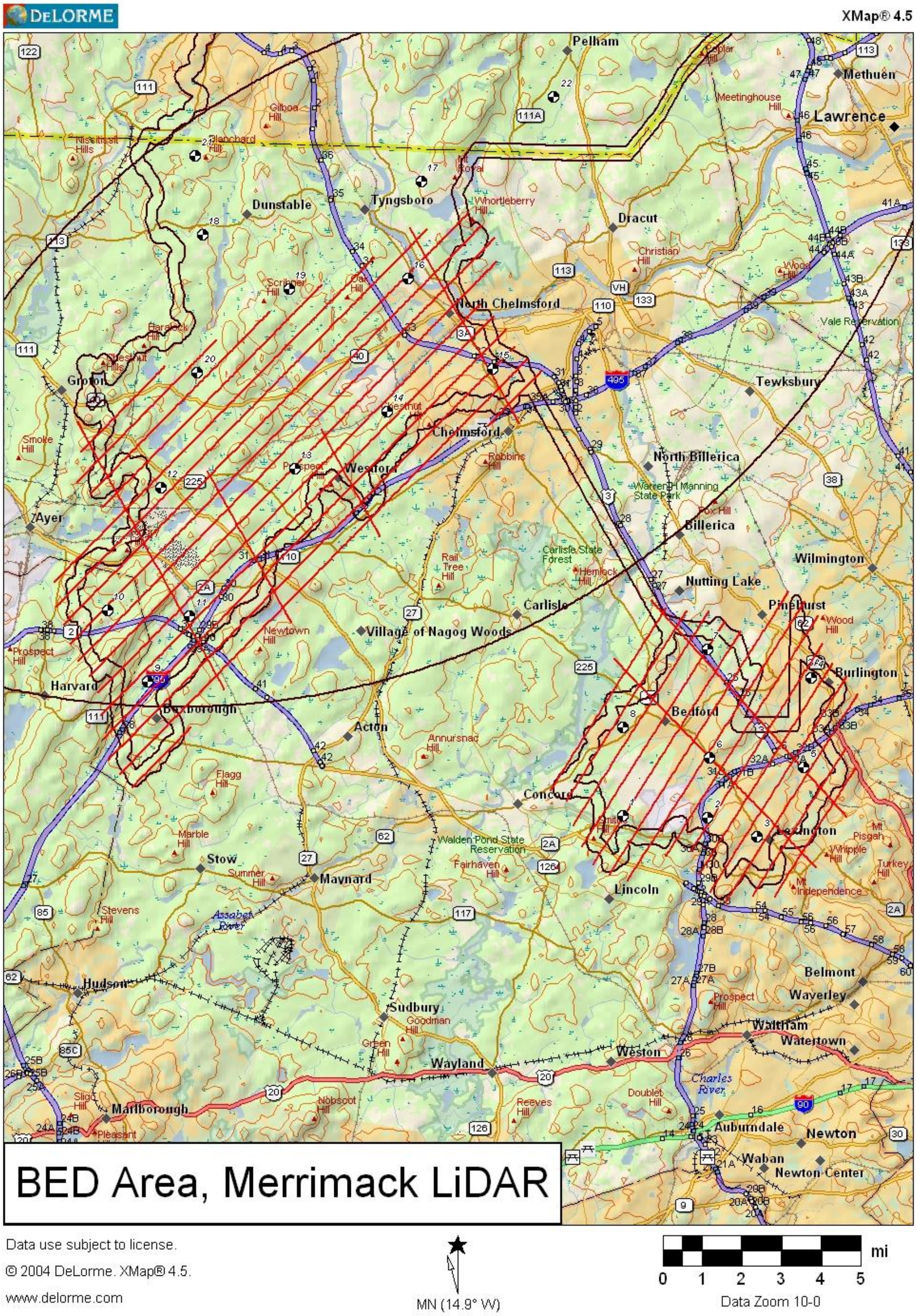


Figure 3.1: BED Block Area

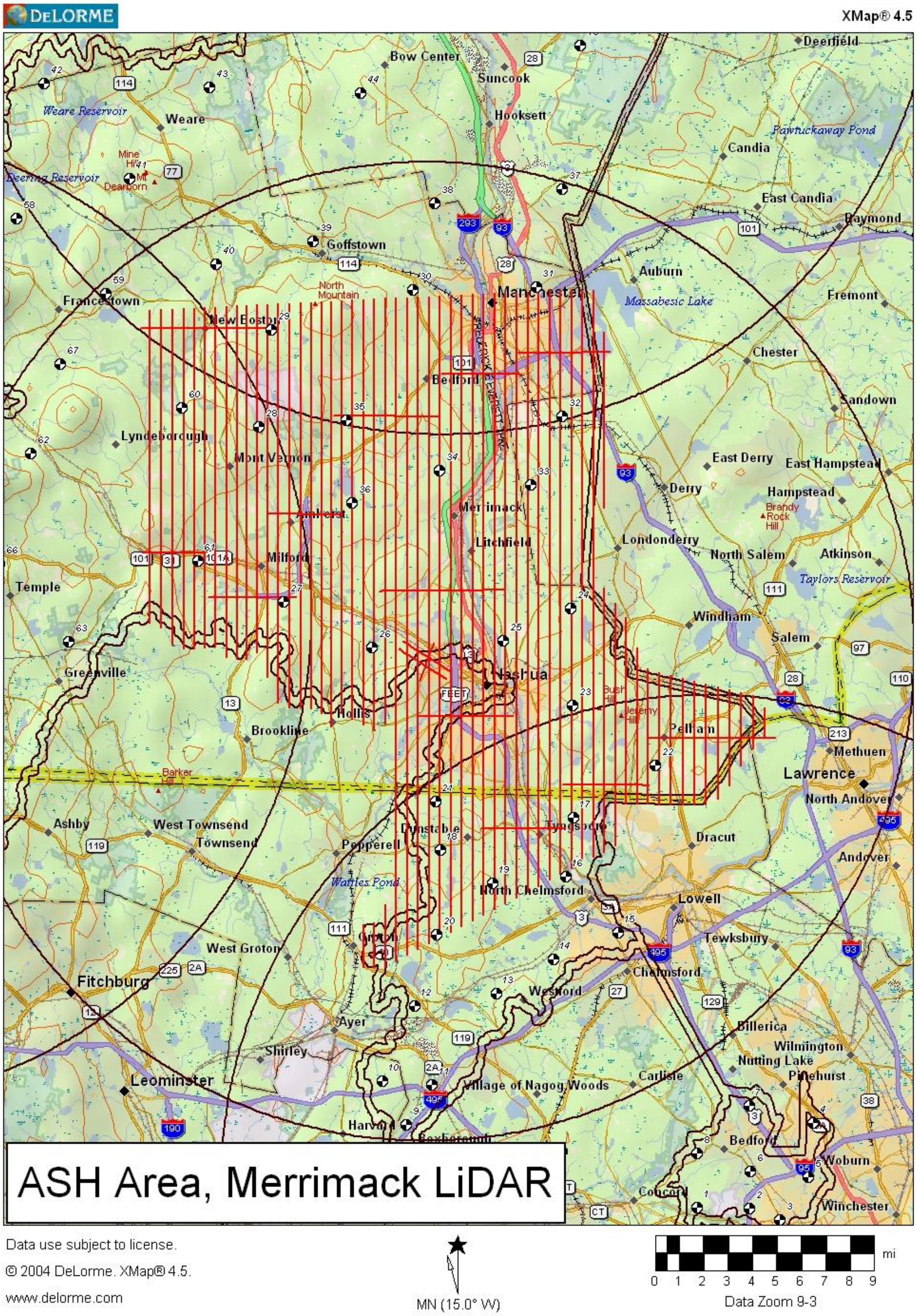


Figure 3.2 ASH Block Area

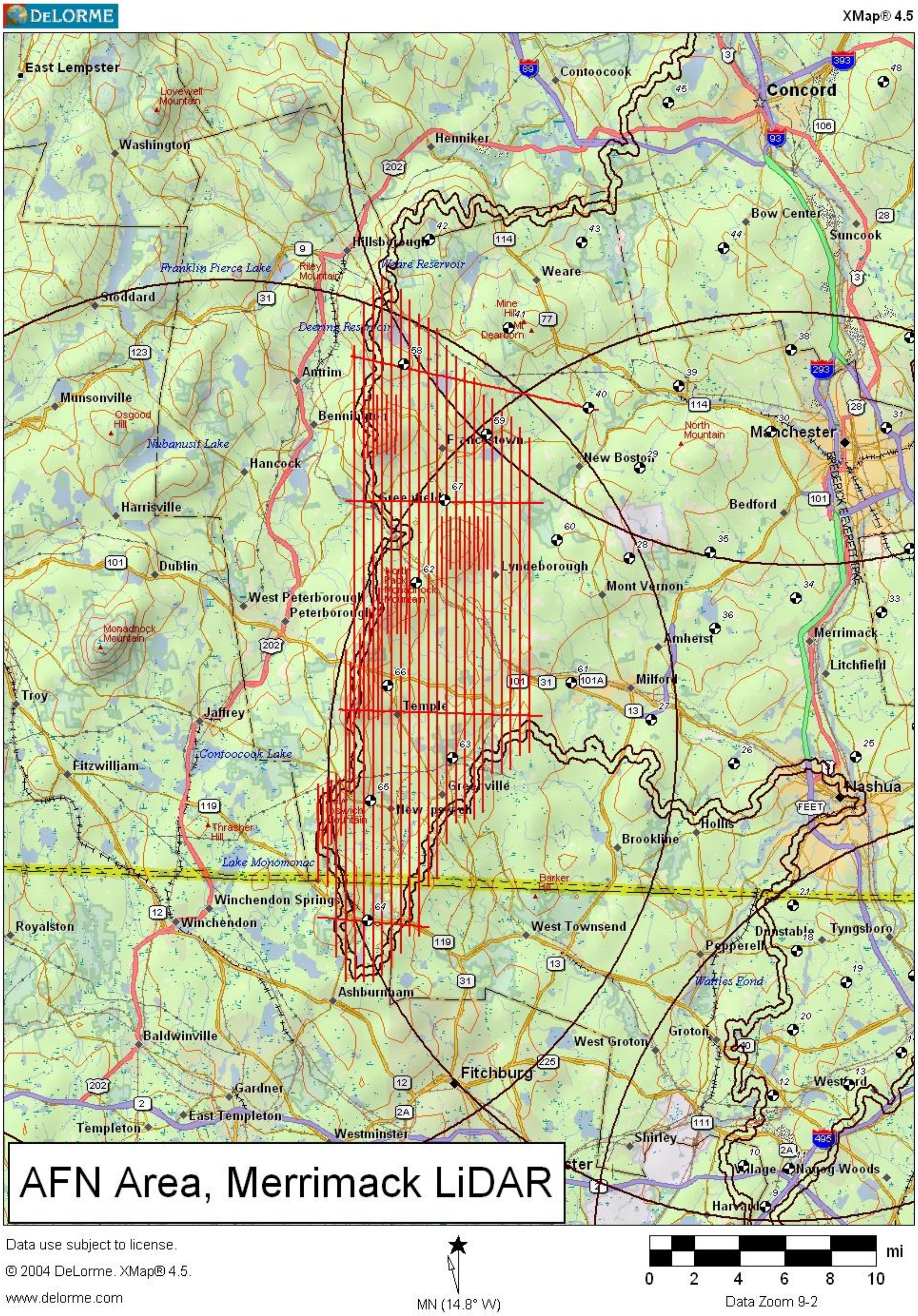


Figure 3.3 AFN Sub Area

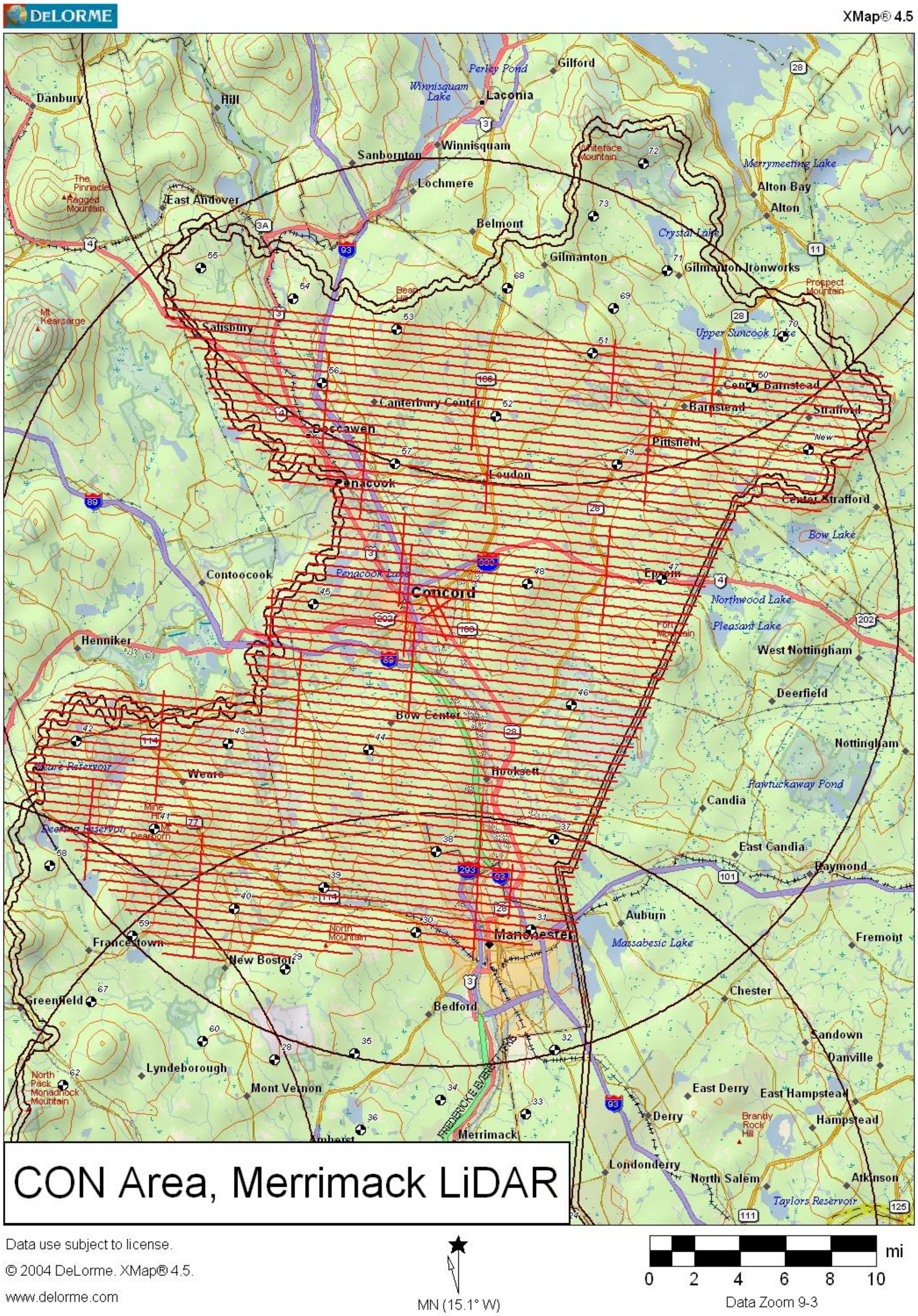
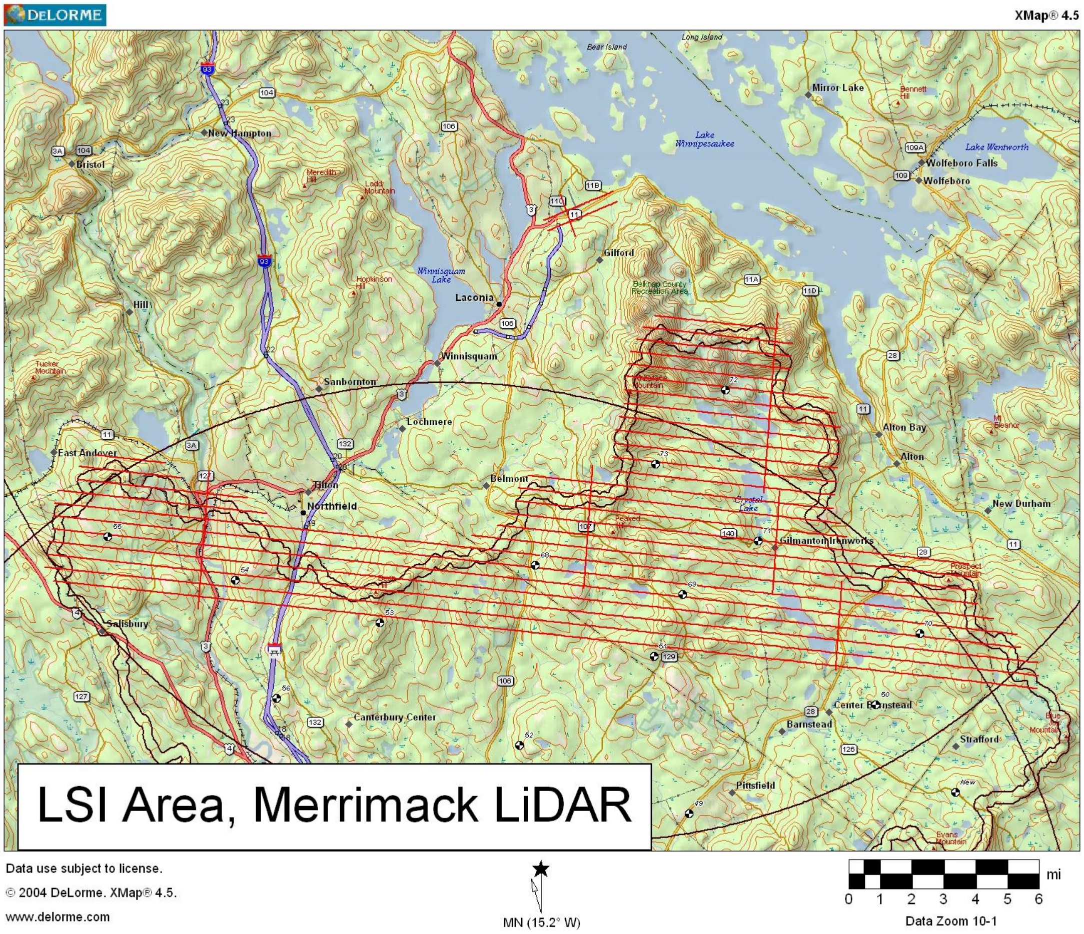


Figure 3.4: CON Block Area



Data use subject to license.

© 2004 DeLorme. XMap® 4.5.

www.delorme.com

Figure 3.5: LSI Block Area

3.2 Time Period

Missions were flown from November 11th 2011 through January 12th 2012 and totaled nineteen (19) sorties by two aircraft as outlined in Table 3.2.

Table 3.2: Flight Mission Summary

Area_ID	FL_NUM	Date_Flown	System_used	SN	AC	Lift_File_Name
ASH	1	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	2	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	3	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	4	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	5	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	6	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	7	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	8	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	9	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	10	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	11	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	12	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	13	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	14	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	15	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	16	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	17	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	18	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	19	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	20	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	21	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	22	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	23	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	24	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	25	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	26	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	27	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	28	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	29	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	30	07-Jan-12	Leica	6156	N262AS	120107A-6156
ASH	31	11-Jan-12	Leica	6156	N262AS	120111A-6156
ASH	32	11-Jan-12	Leica	6156	N262AS	120111A-6156
ASH	33	11-Jan-12	Leica	6156	N262AS	120111A-6156
ASH	34	11-Jan-12	Leica	6156	N262AS	120111A-6156
ASH	35	11-Jan-12	Leica	6156	N262AS	120111A-6156
ASH	36	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	37	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	38	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	39	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	40	09-Jan-12	Leica	6156	N262AS	120109B-6156

Table 3.2: Flight Mission Summary (Con't)

Area_ID	FL_NUM	Date_Flown	System_used	SN	AC	Lift_File_Name
ASH	41	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	42	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	43	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	44	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	45	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	46	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	47	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	48	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	49	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	50	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	51	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	52	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	53	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	54	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	55	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	56	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	57	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	58	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	59	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	60	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	61	09-Jan-12	Leica	6156	N262AS	120109A-6156
ASH	105	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	124	09-Jan-12	Leica	6156	N262AS	120109B-6156
ASH	142	07-Jan-12	Leica	6156	N262AS	120107A-6156
BED	1	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	2	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	3	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	4	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	5	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	6	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	7	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	8	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	9	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	10	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	11	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	12	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	13	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	14	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	15	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	16	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	17	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	18	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	19	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	20	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	21	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	22	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	23	11-Jan-12	Leica	6156	N262AS	120111B-6156

Table 3.2: Flight Mission Summary (Con't)

Area_ID	FL_NUM	Date_Flown	System_used	SN	AC	Lift_File_Name
BED	24	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	25	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	26	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	27	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	28	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	29	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	30	11-Jan-12	Leica	6156	N262AS	120111B-6156
BED	31	11-Jan-12	Leica	6156	N262AS	120111B-6156
CON	1	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	2	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	3	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	4	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	5	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	6	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	7	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	8	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	9	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	10	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	11	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	12	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	13	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	14	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	15	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	16	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	17	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	18	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	19	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	20	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	21	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	22	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	23	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	24	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	25	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	26	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	27	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	28	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	29	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	30	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	31	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	32	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	33	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	34	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	35	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	36	19-Dec-11	Leica	6156	N262AS	111219B-6156
CON	37	19-Dec-11	Leica	6156	N262AS	111219B-6156
CON	38	19-Dec-11	Leica	6156	N262AS	111219B-6156
CON	39	19-Dec-11	Leica	6156	N262AS	111219B-6156

Table 3.2: Flight Mission Summary (Con't)

Area_ID	FL_NUM	Date_Flown	System_used	SN	AC	Lift_File_Name
CON	40	19-Dec-11	Leica	6156	N262AS	111219B-6156
CON	41	19-Dec-11	Leica	6156	N262AS	111219B-6156
CON	42	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	43	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	44	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	45	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	46	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	47	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	48	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	49	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	50	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	51	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	52	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	53	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	54	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	55	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	56	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	57	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	58	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	59	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	60	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	61	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	62	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	63	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	64	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	65	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	66	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	67	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	68	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	69	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	70	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	116	18-Dec-11	Leica	6156	N262AS	111218B-6156
CON	118	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	119	19-Dec-11	Leica	6156	N262AS	111219A-6156
CON	125	18-Dec-11	Leica	6156	N262AS	111218A-6156
CON	133	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	134	21-Nov-11	Leica	6156	N262AS	111121A-6156
CON	201	20-Nov-11	Leica	6156	N262AS	111120A-6156
CON	202	20-Nov-11	Leica	6156	N262AS	111120A-6156
CON	203	20-Nov-11	Leica	6156	N262AS	111120A-6156
Cross Flights	1	12-Jan-12	Leica	6156	N262AS	120111A-6156
Cross Flights	2	09-Jan-12	Leica	6156	N262AS	120109B-6156
Cross Flights	3	09-Jan-12	Leica	6156	N262AS	120109A-6156
Cross Flights	6	11-Jan-12	Leica	6156	N262AS	120111B-6156
Cross Flights	7	19-Dec-11	Leica	6156	N262AS	111219B-6156
Cross Flights	8	19-Dec-11	Leica	6156	N262AS	111219B-6156
Cross Flights	9	19-Dec-11	Leica	6156	N262AS	111219B-6156

Table 3.2: Flight Mission Summary (Con't)

Area_ID	FL_NUM	Date_Flown	System_used	SN	AC	Lift_File_Name
Cross Flights	10	19-Dec-11	Leica	6156	N262AS	111219B-6156
Cross Flights	11	19-Dec-11	Leica	6156	N262AS	111219B-6156
Cross Flights	12	19-Dec-11	Leica	6156	N262AS	111219B-6156
Cross Flights	13	19-Dec-11	Leica	6156	N262AS	111219B-6156
Cross Flights	15	11-Jan-12	Leica	6156	N262AS	120111B-6156
KAFN	1	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	2	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	3	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	4	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	5	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	6	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	7	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	8	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	9	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	10	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	11	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	12	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	13	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	14	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	15	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	16	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	17	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	18	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	19	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	20	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	21	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	22	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	23	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	24	13-Nov-11	Optech	240	N9471R	111113B-240
KAFN	25	13-Nov-11	Optech	240	N9471R	111113B-240
KAFN	26	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	27	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	28	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	29	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	30	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	31	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	32	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	33	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	34	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	35	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	36	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	37	13-Nov-11	Optech	240	N9471R	111113A-240
KAFN	38	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	39	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	40	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	41	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	42	12-Nov-11	Optech	240	N9471R	111112B-240

Table 3.2: Flight Mission Summary (Con't)

Area_ID	FL_NUM	Date_Flown	System_used	SN	AC	Lift_File_Name
KAFN	43	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	44	12-Nov-11	Optech	240	N9471R	111112B-240
KAFN	45	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	46	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	47	12-Nov-11	Optech	240	N9471R	111112A-240
KAFN	48	12-Nov-11	Optech	240	N9471R	111112A-240
LCI	1	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	2	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	3	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	4	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	5	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	6	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	7	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	8	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	9	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	10	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	11	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	12	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	13	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	14	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	15	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	16	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	17	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	18	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	19	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	20	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	21	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	22	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	23	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	24	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	25	19-Nov-11	Leica	6156	N262AS	111119B-6156
LCI	26	19-Nov-11	Leica	6156	N262AS	111119B-6156
LCI	27	19-Nov-11	Leica	6156	N262AS	111119B-6156
LCI	28	19-Nov-11	Leica	6156	N262AS	111119B-6156
LCI	29	19-Nov-11	Leica	6156	N262AS	111119B-6156
LCI	30	19-Nov-11	Leica	6156	N262AS	111119B-6156
LCI	122	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	129	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	131	19-Nov-11	Leica	6156	N262AS	111119A-6156
LCI	136	19-Nov-11	Leica	6156	N262AS	111119B-6156

4. Processing Summary

4.1 Processing Summary

Leica proprietary software was used in the post-processing of the airborne GPS and inertial data that is critical to the positioning and orientation of the sensor during all flights. Pairing the aircraft's raw trajectory data with the stationary GPS base station data, this software yields Leica's IPAS TC ("Inertial Positioning & Attitude Sensor – Tightly Coupled") smoothed best estimate of trajectory (an "SBET", in Leica's .sol file format) that is necessary for Leica's ALSPP post processing software to develop the resulting geo-referenced point cloud from the LiDAR missions. The point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above-ground features are removed from the data set.

The point cloud was created using Leica's Post Processor software. GeoCue was used in the creation of some of the files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. The TerraScan and TerraModeler software packages are then used for the automated data classification, manual cleanup, and bare earth generation from this data. Project specific macros were used to classify the ground and to remove the side overlap between parallel flight lines. All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. QT Modeler was used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for both the All Point Cloud Data and the Bare Earth. In-house software was then used to perform final statistical analysis of the classes in the LAS files.

4.2 Flight Line Data Overview

The following information is an overview of the data parameters based on a per flight line analysis:

-Post Spacing (Minimum): 1.57 m
-Flying Height AGL; 1859 +/-m, 6,100+/- feet
-Recommended Ground Speed (GS); 160 kts
-Field of View (full): 35°
-Pulse Rate: 120,000 Hz
-Scan Rate: 52.7 Hz
-Side Lap (Average): 30%

During the sensor's (aircraft's) trajectory processing (combining GPS & IMU datasets) certain statistics and tables are generated within Leica's IPAS-TC software. The following information is included Appendix C of this document.

- Processing software's estimation of sensor position accuracy with satellite PDOP superimposed (Estimated_Position_Accuracy)
- Graphical Latitude/Longitude depiction of the aircraft's position (Flight_Trajectory and or Flight Map)
- Processing software's estimation of how well the trajectory compared to itself when processed forward vs. backward (Combined_Seperation)
- Chart with an indication of each individual satellite's lock from the aircraft's antenna during collection activities (L2_Satellite_Lock_Elevation)
- Observed PDOP during flight (PDOP_HDOP_VDOP)
- Number of Satellites observed (Number_of_Satellites)
- IPAS Sensor Error Estimate – Z Position (Residual Error Z)
- IPAS Sensor Error Estimate – Y Position (Residual Error Y)
- IPAS Sensor Error Estimate – X Position (Residual Error X)
- Float - Fixed Ambiguity – (Float_Fixed Ambiguity)
- Base Station Information (Base Station)
- Overall Processing Quality Factor (Quality Factor)

5. Accuracy Assessment

A number of points are provided (121 total) were surveyed as part of the project in order to provide a ground calibration and to help assure the accuracy of the data model. Initially any bias identified between the LiDAR surface and the provided control points are analyzed to average out the difference. The bias is then removed from LiDAR surface to provide a final ground surface. The two sets of data are compared again. The results provided in Table 4.1 indicate the data was well within the contract specification. Table 4.2 provides the complete comparison analysis.

Table 5.1: Accuracy Assessment Summary

Statistical Analysis	
Average Dz	0.007
Minimum Dz	-0.220
Maximum Dz	0.264
RMSE	0.099
Standard Deviation	0.099

Coordinate System
Horizontal Projection
NAD83 - UTM Zone 19N, Meters
Vertical Datum
NAVD88 - Geoid09, Meters

Table 5.2: Vertical Accuracy Statistics

Point	Easting	Northing	Known Z	LIDAR Z	Dz
MER101	311097.261	4703192.509	57.428	57.437	0.01
MER102	314456.372	4702697.961	54.242	54.163	-0.08
MER103	316250.804	4701665.972	64.319	64.252	-0.07
MER104	318692.409	4708638.069	52.023	51.902	-0.12
MER105	318735.668	4704777.247	56.563	56.476	-0.09
MER106	314695.790	4705012.174	40.318	40.215	-0.10
MER107	314904.994	4709309.470	38.966	38.869	-0.10
MER108	311434.321	4706495.409	39.163	39.163	0.00
MER109	291510.287	4708637.537	75.615	75.637	0.02
MER110	290398.500	4711406.853	96.102	96.139	0.04
MER111	293627.504	4711247.606	72.508	72.447	-0.06
MER112	292653.429	4717413.631	77.768	77.731	-0.04
MER113	298025.414	4717419.120	63.870	63.843	-0.03
MER114	301806.788	4719610.326	49.557	49.502	-0.06
MER115	306397.104	4721250.935	39.600	39.577	-0.02
MER116	303238.961	4724849.443	33.075	33.078	0.003
MER117	303642.328	4728825.047	57.263	57.193	-0.07
MER118	294915.641	4727042.760	55.072	55.071	-0.001
MER119	298197.181	4724432.232	71.692	71.697	0.005
MER120	293918.442	4721005.447	63.213	63.179	-0.034
MER121	294799.844	4730326.315	76.638	76.597	-0.041
MER122	309429.509	4732250.261	41.341	41.261	-0.08
MER123	303770.353	4736164.084	85.960	85.912	-0.05
MER124	303571.735	4742777.384	87.551	87.507	-0.04
MER125	299193.277	4740564.981	37.548	37.501	-0.05
MER126	290902.643	4740036.530	62.333	62.324	-0.01
MER127	284738.370	4743679.356	101.919	101.895	-0.02
MER128	283712.517	4754329.505	223.495	223.504	0.01
MER129	284804.106	4760899.607	169.158	169.120	-0.038
MER130	293414.739	4763422.512	125.267	125.225	-0.042
MER131	302147.643	4763650.327	102.180	102.172	-0.008
MER132	303576.657	4754745.040	89.482	89.450	-0.032
MER133	302802.269	4750478.946	78.268	78.257	-0.011
MER134	295595.857	4751836.253	61.901	61.841	-0.06
MER135	289177.065	4755494.679	84.936	84.889	-0.047
MER136	290044.182	4749754.648	80.594	80.569	-0.025
MER137	303823.197	4769990.661	170.344	170.518	0.174
MER138	296092.972	4768894.750	144.311	144.388	0.077
MER139	287439.419	4766904.887	97.105	97.202	0.097
MER140	281141.854	4765749.271	155.278	155.200	-0.078
MER141	275261.440	4771278.542	204.508	204.718	0.21
MER142	269480.463	4777160.320	262.573	262.655	0.082
MER143	281625.473	4779577.167	161.123	161.128	0.005
MER144	290645.142	4776444.960	216.846	216.842	-0.004
MER145	287761.914	4786502.014	130.571	130.598	0.027
MER146	304108.907	4780136.723	95.056	94.971	-0.085
MER147	312254.118	4788374.690	135.511	135.770	0.259
MER148	302952.143	4789201.488	245.354	245.618	0.264
MER149	309496.295	4796701.549	165.239	165.382	0.143
MER150	319181.656	4801759.161	216.952	216.982	0.03
MER151	311195.858	4802840.761	241.995	242.027	0.032
MER152	309305.715	4804459.639	260.544	260.592	0.048
MER153	303123.778	4799005.016	191.325	191.373	0.048
MER154	301294.223	4799754.947	219.463	219.543	0.08

Table 5.2: Vertical Accuracy Statistics (Con't)

Point	Easting	Northing	Known Z	LIDAR Z	Dz
MER155	296026.644	4804088.413	247.113	247.151	0.038
MER156	295872.690	4806305.262	263.284	263.370	0.086
MER157	286448.886	4809730.850	149.495	149.431	-0.064
MER158	280653.786	4811169.919	234.363	234.351	-0.012
MER159	289320.140	4802358.650	166.049	166.085	0.036
MER160	296039.055	4796071.592	159.715	159.962	0.247
MER161	269979.293	4771621.709	267.821	268.034	0.213
MER162	268251.419	4769448.193	342.882	343.007	0.125
MER163	275218.171	4764423.291	188.174	188.159	-0.015
MER164	277895.851	4756098.193	202.330	202.330	0
MER165	279232.274	4746690.389	82.683	82.639	-0.044
MER166	269995.332	4753623.757	248.099	248.327	0.228
MER167	270263.095	4739640.875	229.285	229.429	0.144
MER168	264803.561	4731806.529	325.004	325.047	0.043
MER169	264642.540	4738396.789	384.737	384.826	0.089
MER170	266958.802	4746470.299	353.113	353.192	0.079
MER171	269960.197	4758099.464	270.718	270.918	0.2
MER172	302113.647	4808988.842	232.517	232.538	0.021
MER173	308115.183	4807452.430	343.692	343.671	-0.021
MER174	308115.192	4807452.427	343.723	343.671	-0.052
MER175	320798.199	4807127.112	220.912	220.940	0.028
MER176	312607.027	4809900.079	225.450	225.465	0.015
MER177	312607.026	4809900.125	225.445	225.463	0.018
MER178	312026.044	4816409.776	221.154	221.125	-0.029
MER179	307399.099	4815267.090	328.118	328.113	-0.005
MER180	322408.514	4797531.388	221.298	221.286	-0.012
MER181	276075.414	4750799.792	221.252	221.232	-0.02
MER182	296123.664	4760474.600	77.995	77.806	-0.189
MER183	296123.640	4760474.611	77.985	77.811	-0.174
MER184	280092.975	4745878.662	87.126	87.145	0.019
MER185	280092.975	4745878.629	87.148	87.144	-0.004
MER186	315439.633	4704518.407	45.343	45.443	0.1
MER187	294596.377	4783139.878	69.198	69.158	-0.04
Concord150M	296426.663	4786296.328	101.620	101.692	0.072
NGS_MY0447	296123.664	4760474.600	77.995	77.806	-0.189
NGS_MY0447	296123.640	4760474.611	77.985	77.811	-0.174
NGS_MY5423	280092.975	4745878.662	87.126	87.145	0.019
NGS_MY5423	280092.975	4745878.629	87.148	87.144	-0.004
NGS_MY6363	315439.633	4704518.407	45.343	45.443	0.1
NGS_OC0822	294596.377	4783139.878	69.198	69.158	-0.04
500	296014.946	4791460.118	112.203	112.32	0.117
501	288566.442	4789640.405	163.757	163.85	0.093
502	293126.437	4789705.636	73.12	73.16	0.04
503	289914.296	4795624.537	79.843	79.76	-0.083
504	289457.710	4796159.791	105.206	105.27	0.064
505	289263.305	4780498.964	147.148	146.96	-0.188
506	300852.501	4790430.935	127.558	127.68	0.122
507	298406.325	4785931.098	81.255	81.17	-0.085
508	298131.518	4781924.235	89.195	89.05	-0.145
509	291716.112	4785816.109	104.857	104.74	-0.117
510	288104.505	4791979.934	111.718	111.8	0.082
511	295917.887	4787637.827	104.221	104.06	-0.161
512	292354.590	4794558.719	94.891	94.9	0.009
514	288731.957	4781400.404	106.02	105.8	-0.22

Table 5.2: Vertical Accuracy Statistics (Con't)

Point	Easting	Northing	Known Z	LIDAR Z	Dz
515	287824.793	4785301.753	131.418	131.31	-0.108
516	285783.906	4789656.955	124.558	124.64	0.082
518	288702.582	4795629.696	105.136	104.98	-0.156
519	290574.780	4793034.885	105.364	105.44	0.076
520	292043.993	4789681.866	101.561	101.63	0.069
521	293844.000	4786729.906	85.717	85.66	-0.057
522	294904.860	4784224.69	71.299	71.18	-0.119
523	297983.779	4786201.197	101.829	101.81	-0.019
524	299209.220	4789937.88	106.734	106.9	0.166
525	297728.631	4794033.272	159.58	159.61	0.03
526	295537.293	4796259.855	149.565	149.68	0.115
527	293584.822	4796384.002	117.742	117.91	0.168
528	295139.024	4792224.315	103.561	103.7	0.139

LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown: Nov 19th, 2011					
Takeoff Time (Z): 1556 z		Local: 1056 A EST		Airport LCI	
Landing Time (Z): SEE		Local: NEXT		Airport SHEET	

Project's Scanning Requirements			
Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ Multi Pulse] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information	
LiDAR Unit	Leica ALS-60 sn6156
HD #	"3"
IPAS File #	20111119_154646
from, to	000 → 037
FCMS File #	20111119_154352

	Ground	Airport	Temp Aloft
Begin Temp	+06 c °	LCI	+04 ° c
Begin Dewpoint	-07 c °		
Begin Pressure	30.23 "		
End Temp	S °	NEXT	SHEET °
End Dewpoint	E °		
End Pressure	E "		

GPS Base Location(s)	LCI D (PAGS)		
PDOP Avoidance	none 'til late		
Static or Flyover?	STATIC	--> if flyovers, times:	-

[111119A-6156
SHEET 1 OF 2]

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
111119_160950	LCI001	1609/1611 z	6913'	W	~140 kts	~99 %	~3 °	high thin bkn, good visibility, occ-turb, W winds ~45 kts.
111119_161612	LCI002	1616/1617 z	7205'	E	~180 kts	~99 %	~4 °	high thin bkn, good visibility, occ-turb, W winds ~45 kts.
111119_162335	LCI003	1623/1626 z	7093'	W	~120 kts	~99 %	~3 °	high thin bkn, good visibility, occ-turb, W winds ~45 kts.
111119_163052	LCI004	1630/1632 z	6772'	E	~175 kts	~99 %	~4 °	high thin bkn, good visibility, smooth, W winds ~45 kts.
111119_163856	LCI005	1638/1641 z	6562'	W	~120 kts	~99 %	~3 °	high thin bkn, good visibility, smooth, W winds ~45 kts.
111119_164619	LCI006	1646/1648 z	6624'	E	~175 kts	~99 %	~3 °	high thin sct, good visibility, smooth, W winds ~40 kts.
111119_165355	LCI007	1653/1657 z	6631'	W	~120 kts	~99 %	~3 °	high thin sct, good visibility, smooth, W winds ~45 kts.
111119_170147	LCI008	1701/1704 z	6594'	E	~175 kts	~99 %	~4 °	high thin sct, good visibility, smooth, W winds ~45 kts.
111119_170958	LCI009	1709/1713 z	6568'	W	~125 kts	~99 %	~3 °	high thin sct, good visibility, smooth, W winds ~45 kts.
111119_171802	LCI010	1718/1720 z	6555'	E	~175 kts	~99 %	~4 °	high thin sct, good visibility, smooth, W winds ~40 kts.
111119_172613	LCI011	1726/1729 z	6532'	W	~120 kts	~99 %	~5 °	high thin sct, good visibility, smooth, W winds ~45 kts.
111119_173406	LCI012	1734/1736 z	6532'	E	~165 kts	~99 %	~4 °	high thin sct, good visibility, smooth, W winds ~40 kts.
111119_174218	LCI013	1742/1745 z	6532'	W	~125 kts	~99 %	~5 °	high thin sct, good visibility, smooth, W winds ~40 kts.
111119_175102	LCI014	1751/1754 z	6532'	E	~170 kts	~99 %	~6 °	high thin sct, good visibility, smooth, W winds ~40 kts.
111119_175939	LCI015	1759/1804 z	6207'	W	~130 kts	~99 %	~4 °	high thin sct, good visibility, smooth, W winds ~40 kts.
111119_181432	LCI016	1814/1815 z	6211'	E	~180 kts	~99 %	~5 °	high thin few, good visibility, smooth, W winds ~40 kts.
111119_181820	LCI017	1818/1821 z	6211'	E	~180 kts	~99 %	~5 °	high thin few, good visibility, smooth, W winds ~40 kts.
111119_182615	LCI019	1826/1832 z	6184'	W	~125 kts	~99 %	~5 °	high thin few, good visibility, smooth, W winds ~40 kts.
111119_183646	LCI018	1836/1838 z	6184'	W	~120 kts	~99 %	~6 °	high thin few, good visibility, smooth, W winds ~45 kts.
111119_184242	LCI020	1842/1844 z	6171'	E	~180 kts	~99 %	~5 °	high thin few, good visibility, smooth, W winds ~45 kts.

Sheet 1 of 2

LIDAR MISSION RECORD SHEET -- Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER
Project Number	7556-008
FCMS fpd File	MERRIMACK 2011

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	Nov 19th, 2011				
Takeoff Time (Z):	SEE	Local:	PREVIOUS	Airport	SHEET
Landing Time (Z):	19 53 z	Local:	2 53 p EST	Airport	LCI

3:57 Aloft

Project's Scanning Requirements

Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ Multi Pulse] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"3"
IPAS File #	20111119_154646
from, to	000 → 037
FCMS File #	20111119_154352

	Ground	Airport	Temp Aloft
Begin Temp	S °	PREVIOUS	SHEET °
Begin Dewpoint	E °		
Begin Pressure	E "		
End Temp	+12 °c	LC1	+07 °c
End Dewpoint	-08 °c		
End Pressure	30.16 "		

GPS Base Location(s)	LCI D (PACS)		
PDOP Avoidance	none 'til late		
Static or Flyover?	STATIC	--> if flyovers, times:	-

[111119A-6156
SHEET 2 of 2]

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
111119_184636	LC1 021	$18^{46}/18^{51}$ z	6171'	E	~180 kts	~ 99 %	~5 °	high thin few, good visibility, smooth, W winds ~45 kts.
111119_185713	LC1 023	$18^{57}/19^{04}$ z	6168'	W	~130 kts	~ 99 %	~6 °	high thin few, good visibility, smooth, W winds ~40 kts.
111119_190614	LC1 022	$19^{06}/19^{09}$ z	6168'	W	~135 kts	~ 99 %	~7 °	high thin few, good visibility, smooth, W winds ~40 kts.
111119_191342	LC1 024	$19^{13}/19^{22}$ z	6168'	E	~175 kts	~ 99 %	~6 °	high thin few, good visibility, smooth, W winds ~40 kts.
111119_192927	CROSS 31	$19^{29}/19^{31}$ z	6532'	N	~165 kts	~ 99 %	~15 °	high thin few, good visibility, smooth, W winds ~40 kts. (CROSS LINE)
111119_193603	CROSS 29	$19^{36}/19^{37}$ z	6736'	S	~150 kts	~ 99 %	~14 °	high thin few, good visibility, smooth, W winds ~40 kts. (CROSS LINE)
111119_194519	CROSS 22	$19^{45}/19^{46}$ z	6168'	N	~175 kts	~ 99 %	~13 °	high thin few, good visibility, smooth, W winds ~40 kts. (CROSS LINE)
					kts	%	°	
					kts	%	°	
					kts	%	°	[LANDED FOR FUEL]
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

Sheet 2 of 2

LIDAR MISSION RECORD SHEET -- Leica

PHOTO SCIENCE *Geospatial Solutions*

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	Nov 19th, 2011	
Takeoff Time (Z): 20 37 z	Local: 3 37 p EST	Airport LCI
Landing Time (Z): 22 37 z	Local: 5 37 p EST	Airport LCI

2:00

Project's Scanning Requirements

Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"3"
IPAS File #	20111119_202857
from, to	000 → 021
FCMS File #	20111119_202623

	Ground	Airport	Temp Aloft
Begin Temp	+10 c	LCI	+07 ° c
Begin Dewpoint	-08 c		
Begin Pressure	30.17 "		
End Temp	+08 °	LCI	+06 ° c
End Dewpoint	-07 °		
End Pressure	30.17 "		

GPS Base Location(s)	LCI D (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times: -

[111119B-6156]

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
111119_204958	LCI 025	2049/2101 z	6181'	W	~135 kts	~ 99 %	~7 °	high thin few, good visibility, smooth, WSW winds ~35 kts.
111119_210547	LCI 026	2105/2115 z	6175'	E	~170 kts	~ 99 %	~7 °	high thin few, good visibility, smooth, WSW winds ~35 kts.
111119_212022	LCI 027	2120/2132 z	6158'	W	~135 kts	~ 99 %	~6 °	high thin few, good visibility, smooth, WSW winds ~35 kts.
111119_213730	LCI 028	2137/2147 z	6152'	E	~170 kts	~ 99 %	~7 °	high thin few, good visibility, smooth, WSW winds ~35 kts.
111119_215235	LCI 029	2152/2205 z	6158'	W	~130 kts	~ 99 %	~6 °	high thin few, good visibility, smooth, WSW winds ~40 kts.
111119_221028	LCI 030	2210/2220 z	6152'	E	~175 kts	~ 99 %	~7 °	high thin few, good visibility, smooth, WSW winds ~40 kts.
111119_222634	CROSS 36	2226/2227 z	6460'	N	~170 kts	~ 99 %	~13 °	high thin few, good visibility, smooth, WSW winds ~35 kts.
					kts	%	°	
					kts	%	°	[LANDED DUE TO SUB-AREA COMPLETION]
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

Sheet 1 of 1

PHOTO SCIENCE
Geospatial Solutions

Station Occupation Report
For Airborne GPS

Project: MERRIMACK RIVER LiDAR

Location: LACONIA, NH AIRPORT (KLCI)

Project Number: 7556-008

Completed by: PNH

Date: Nov. 19th, 2011

Receiver: "5"

Receiver Type: TRIMBLE R7 GNSS

Antenna Type: ZEPHYR GEODETIC 2

Station ID: LCI D (PACS)

Start -- H.I. (m): 1.484 m

End -- H.I. (m): 1.484 m

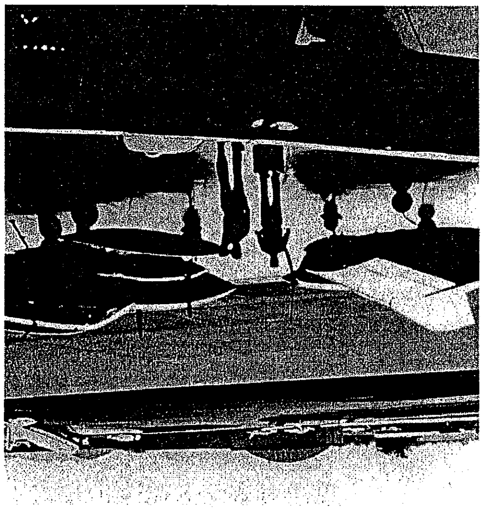
H.I. (ft): 4.87 ft.

Start Time: ~ 10³⁶ A

End Time: ~ 5⁴⁷ P

Time Zone: EST

Operator: PNH



Comments

- measured @ 3 pts. around antenna to bottom of notch
- use for 111119A-6156 & 111119B-6156

LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011

Pilot	J. Scott
Operator	P. HRABAK
Aircraft	N262AS

Date Flown: Nov. 20th, 2011		
Takeoff Time (Z): 14 39 z	Local: 9 39 A EST	Airport CON
Landing Time (Z): 15 31 z	Local: 10 31 A EST	Airport CON

0:52

Project's Scanning Requirements

Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ Multi Pulse] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"2"
IPAS File #	20111120_143229
from, to	000 → 010
FCMS File #	20111120_143005

	Ground	Airport	Temp Aloft
Begin Temp	+12 °C	CON	+07 °C
Begin Dewpoint	+03 °C		
Begin Pressure	29.98"		
End Temp	+13 °C	CON	+07 °C
End Dewpoint	+03 °C		
End Pressure	29.97"		

GPS Base Location(s)	CONCORD CBL 150 (PACS)
PDOP Avoidance	none 'til late
Static or Flyover?	STATIC --> if flyovers, times: -

[111120A-6156 CALIBRATION]

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
111120_145452	CONCAL 3	14 54/14 55 z	6122'	SW	~140 kts	~99 %	~5 °	bkn above, ovc below near, haze, occ-turb, W winds ~45 kts.
111120_150050	CONCAL 3	15 00/15 01 z	6122'	NE	~175 kts	~99 %	~9 °	scat above, ovc below near, haze, occ-turb, W winds ~45 kts.
111120_150534	CONCAL 1	15 05/15 06 z	6158'	SE	~160 kts	~99 %	~16 °	scat above, ovc below near, haze, occ-turb, W winds ~50 kts.
111120_151033	CONCAL 1	15 10/15 11 z	6158'	NW	~145 kts	~99 %	~16 °	scat above, ovc below near, haze, occ-turb, W winds ~50 kts.
111120_151539	CONCAL 2	15 15/15 16 z	6142'	SE	~170 kts	~99 %	~18 °	scat above, bkn below near, haze, occ-turb, W winds ~50 kts.
111120_152204	CONCAL 2	15 22/15 23 z	6142'	NW	~140 kts	~99 %	~17 °	scat above, bkn below near, haze, occ-turb, W winds ~50 kts.
					kts	%	°	
					kts	%	°	[LANDED DUE TO CALIBRATION COMPLETION & INABILITY TO
					kts	%	°	COLLECT FULL PROJECT LINES DUE TO CLOUDS BELOW IN
					kts	%	°	AREA OF INTEREST & CONDITIONS NOT IMPROVING]
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

Sheet 1 of 1

PHOTO SCIENCE
Geospatial Solutions

Station Occupation Report For Airborne GPS

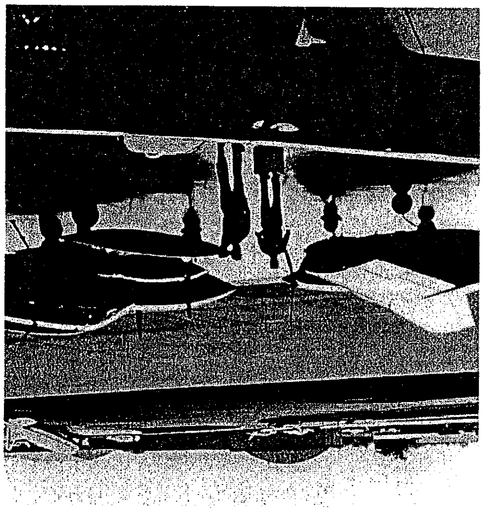
Project: MERRIMACK RIVER LiDAR

Location: CONCORD, NH AIRPORT (KCON)

Project Number: 7556-008

Completed by: PNH

Date: Nov. 20, 2011



Receiver: "5"

Receiver Type: TRIMBLE R7 GNSS

Antenna Type: ZEPHYR GEODETIC 2

Station ID: CONCORD CBL 150

Start -- H.I. (m): 1.461 m

End -- H.I. (m): 1.461 m

H.I. (ft): 4.79 ft.

Start Time: ~9$^{\underline{05}}$A

End Time: ~11$^{\underline{16}}$A

Time Zone: EST

Operator: PNH

Comments

- measured @ 3 pts around antenna to bottom of notch
- use for 111120A -6156 (CALIBRATION)

LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	Nov 21, 2011				
Takeoff Time (Z):	15 32 z	Local:	10 32 A EST	Airport	CON
Landing Time (Z):	19 40 z	Local:	2 40 P EST	Airport	CON

4:08

Project's Scanning Requirements

Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"2"
IPAS File #	20111121_152353
from, to	000 → 038
FCMS File #	20111121_152109

	Ground	Airport	Temp Aloft
Begin Temp	+05 °c	CON	-02 °c
Begin Dewpoint	-06 °c		
Begin Pressure	30.34 "		
End Temp	+07 °	CON	-03 °c
End Dewpoint	-06 °		
End Pressure	30.28 "		

[111121A-6156]

46^{30}

GPS Base Location(s)	CONCORD CBL 150 (PACS)		
PDOP Avoidance	none 'til late		
Static or Flyover?	STATIC	--> if flyovers, times:	-

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
111121_154512	CON 001	1545/1555 z	6148'	W	~165 kts	~99 %	~3 °	high thin scat, bkn below @ E, good visibility, smooth, NW winds ~15 kts.
111121_160043	CON 002	1600/1611 z	6148'	E	~165 kts	~99 %	~3 °	high thin scat, bkn below @ E, good visibility, smooth, NW winds ~15 kts.
111121_161544	CON 003	1615/1626 z	6171'	W	~160 kts	~99 %	~3 °	high thin scat, bkn below @ E, good visibility, smooth, NW winds ~15 kts.
111121_163053	CON 004	1630/1641 z	6161'	E	~165 kts	~99 %	~3 °	high thin scat, bkn below @ E, good visibility, smooth, NW winds ~10 kts.
111121_164528	CON 005	1645/1656 z	6161'	W	~155 kts	~99 %	~2 °	high thin bkn, ovc below @ SE, good visibility, smooth, NW winds ~10 kts.
111121_170050	CON 006	1700/1710 z	6155'	E	~165 kts	~99 %	~2 °	high thin bkn, ovc below @ SE, good visibility, smooth, NW winds ~10 kts.
111121_171519	CON 007	1715/1726 z	6155'	W	~155 kts	~99 %	~2 °	high thin scat, ovc below @ SE, good visibility, smooth, NW winds ~15 kts.
111121_173024	CON 008	1730/1739 z	6168'	E	~165 kts	~99 %	~2 °	high thin few, ovc below @ SE, good visibility, smooth, NW winds ~10 kts.
111121_174412	CON 009	1744/1754 z	6171'	W	~155 kts	~99 %	~3 °	high thin few, ovc below @ SE, good visibility, smooth, NW winds ~10 kts.
111121_175855	CON 010	1758/1808 z	6168'	E	~170 kts	~99 %	~2 °	high thin few, ovc below @ SE, good visibility, smooth, NW winds ~10 kts. (CLOUDS @ EXTREME E END)(OK)
111121_181411	CROSS 034	1814/1816 z	6398'	N	~160 kts	~99 %	~5 °	high thin few, ovc below @ SE, good visibility, smooth, NW winds ~10 kts. (CROSS LINE)
111121_181815	CROSS 033	1818/1819 z	6352'	S	~165 kts	~99 %	~4 °	high thin few, ovc below @ SE, good visibility, smooth, NW winds ~10 kts. (CROSS LINE)
111121_182636	CON 011	1826/1836 z	6145'	W	~155 kts	~99 %	~2 °	high thin few, ovc below @ SE, good visibility, smooth, NW winds ~15 kts.
111121_184142	CON 012	1841/1850 z	6135'	E	~165 kts	~99 %	~2 °	clear above, ovc below @ SE, going scattered in AOI, good visibility, smooth, NW winds ~10 kts.
111121_185508	CON 013	1855/1904 z	6135'	W	~155 kts	~99 %	~1 °	clear above, ovc below @ SE, going scat in AOI, good visibility, smooth, WNW winds ~15 kts.
111121_190851	CON 014	1908/1917 z	6142'	E	~170 kts	~99 %	~2 °	clear above, ovc below @ SE, going scat in AOI, good visibility, smooth, WNW winds ~15 kts. (CLOUDS @ E END?)
111121_192228	CON 015	1922/1931 z	6142'	W	~155 kts	~99 %	~1 °	clear above, bkn below @ SE, scat in AOI, good visibility, smooth, WNW winds ~15 kts. (CLOUDS @ E END?)
					kts	%	°	[LANDED FOR FUEL; CLOUDS PREVENTING FURTHER PROGRESS]
					kts	%	°	
					kts	%	°	

Sheet 1 of 1

PHOTO SCIENCE
Geospatial Solutions

Station Occupation Report
For Airborne GPS

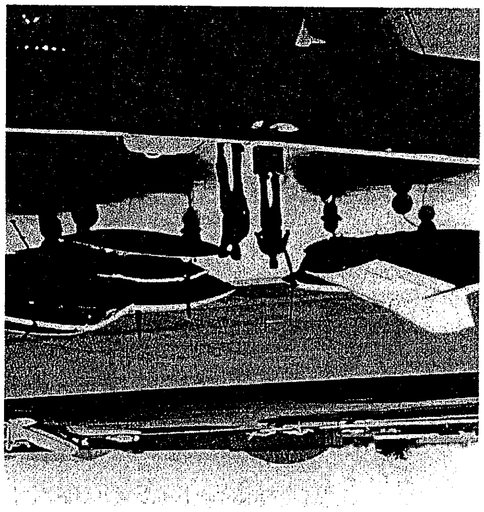
Project: MERRIMACK RIVER LIDAR

Location: CONCORD, NH AIRPORT (KCON)

Project Number: 7556-008

Completed by: PNH

Date: Nov. 21, 2011



Receiver: "5"

Receiver Type: TRIMBLE R7 GNSS

Antenna Type: ZEPHYR GEODETIC 2

Station ID: CONCORD CBL 150 (PACS)

Start -- H.I. (m): 1.464 m

End -- H.I. (m): 1.464 m

H.I. (ft): 4.805'

Start Time: ~ 9 $^{\underline{55}}$A

End Time: ~ 3 $^{\underline{06}}$p

Time Zone: EST

Operator: PNH

Comments

- measured @ 3 pts. around antenna to bottom of notch

- use for 111121A-6156

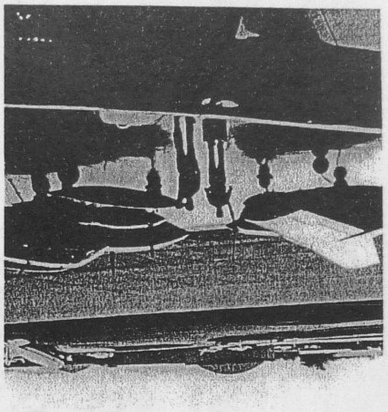
PHOTO SCIENCE
Geospatial Solutions

Station Occupation Report
For Airborne GPS

Project: MERRIMACK RIVER 2011 LiDAR

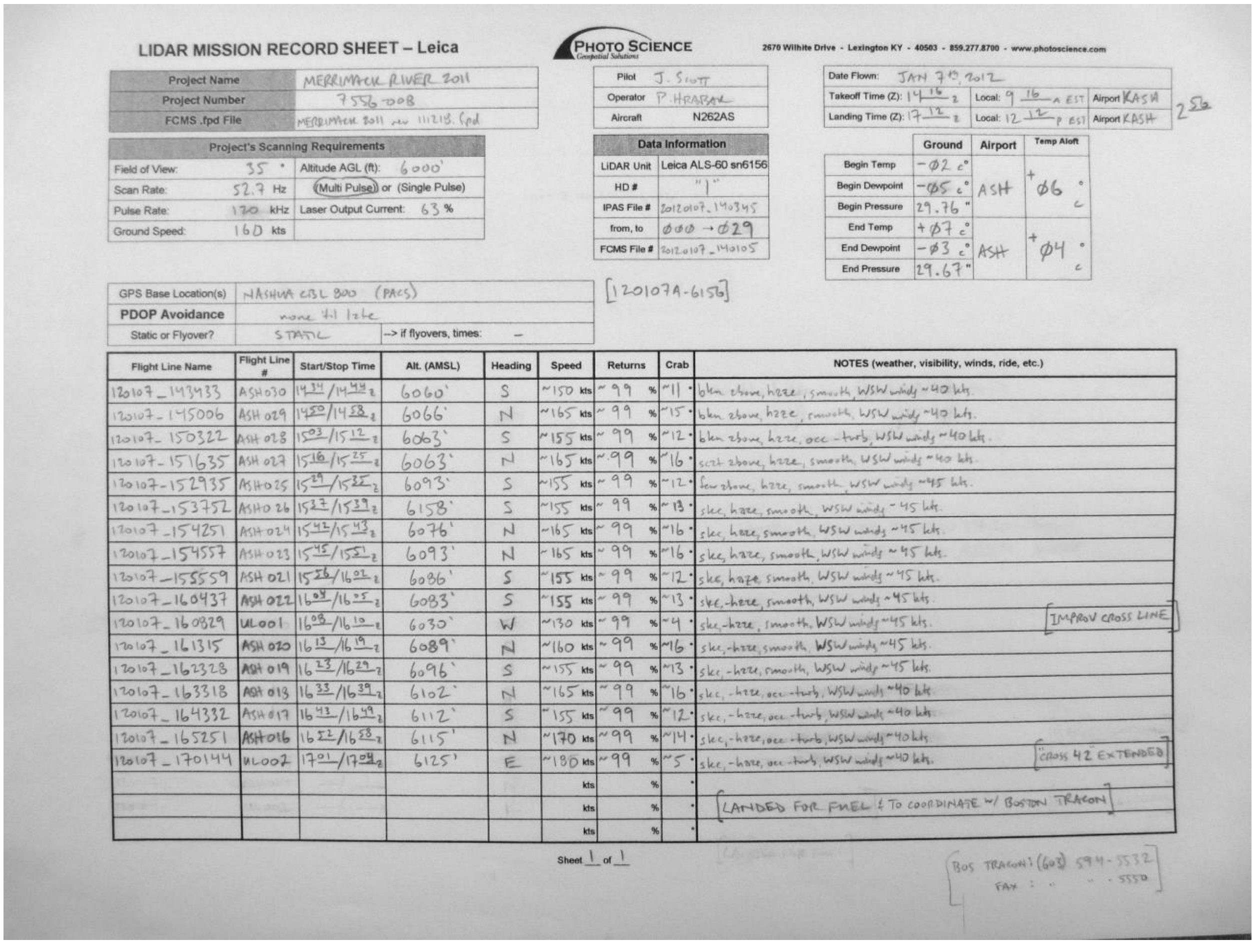
Location: NASHUA NH AIRPORT (KASH)
Project Number: 7556-008
Completed by: PNH
Date: JAN 7, 2012

Receiver: "5"
Receiver Type: TRIMBLE R7 GNSS
Antenna Type: ZEPHYR GEODETIC 2
Station ID: NASHUA CBL 800 (PACS)
Start -- H.I. (m): 1.693 m
End -- H.I. (m): 1.694 m
H.I. (ft): 5.555 ft.
Start Time: 8^{55}A
End Time: ~2^{33}p
Time Zone: EST
Operator: PNH



Comments
- measured @ 3 pts. around antenna to bottom of notch
- use for 120107A-6156 & 120107B-6156 (VOID)

PSI\FORMS\Station Occupation Report April 19, 2011



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 rev 111213. fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	JAN 7th, 2012		
Takeoff Time (Z):	14 16 z	Local: 9 16 A EST	Airport KASH
Landing Time (Z):	17 12 z	Local: 12 12 P EST	Airport KASH

2 56

Project's Scanning Requirements			
Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ Multi Pulse] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information	
LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120107_140345
from, to	000 → 029
FCMS File #	20120107_140105

	Ground	Airport	Temp Aloft
Begin Temp	−02 c°	ASH	+06 °c
Begin Dewpoint	−05 c°		
Begin Pressure	29.76 "		
End Temp	+07 c°	ASH	+04 °c
End Dewpoint	−03 c°		
End Pressure	29.67 "		

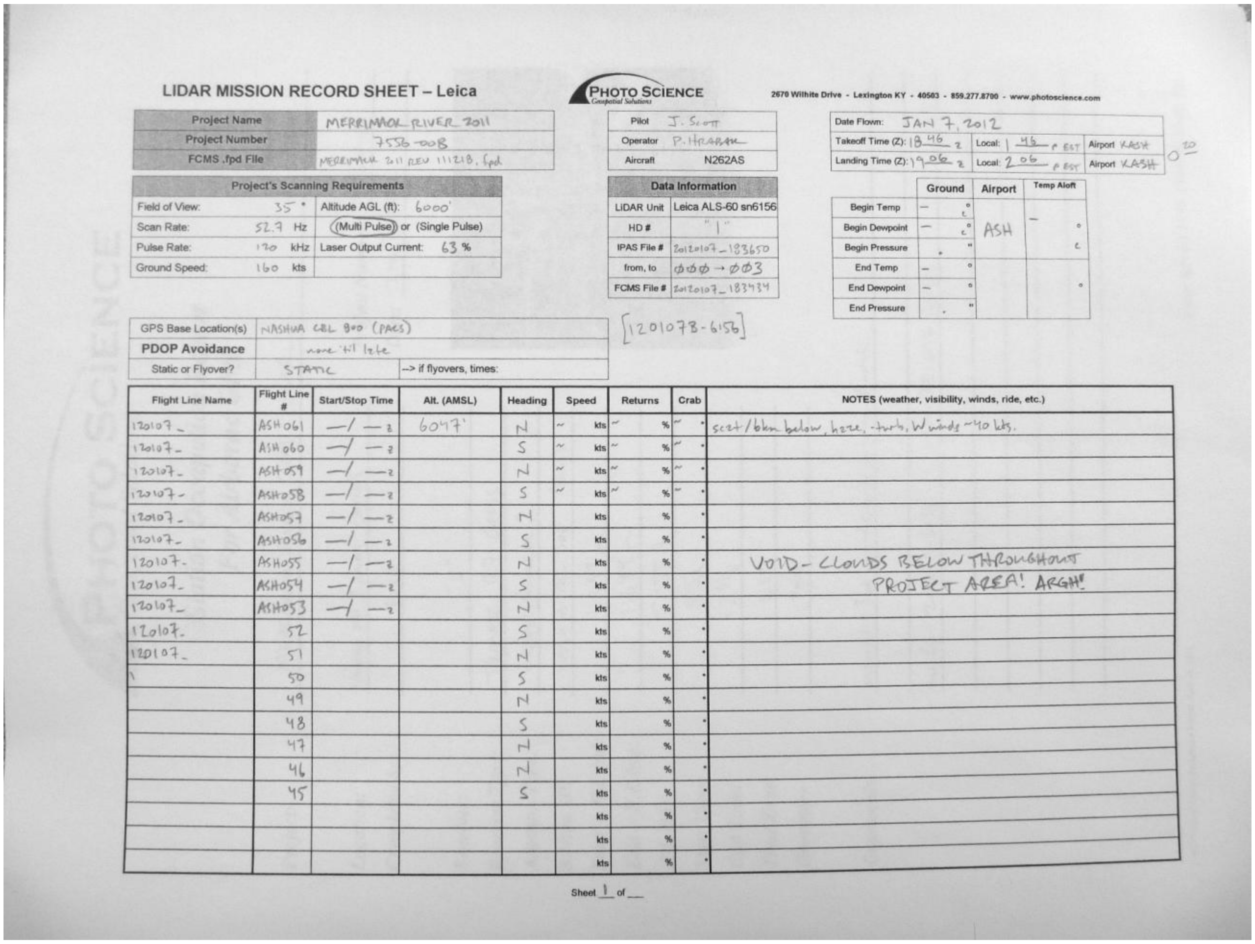
GPS Base Location(s)	NASHUA CBL 800 (PACS)	
PDOP Avoidance	none til late	
Static or Flyover?	STATIC	--> if flyovers, times: –

[120107A-6156]

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120107_143433	ASH030	1434/1444 z	6060'	S	~150 kts	~99 %	~11 °	bkn above, haze, smooth, WSW winds ~40 kts.
120107_145006	ASH 029	1450/1458 z	6066'	N	~165 kts	~99 %	~15 °	bkn above, haze, smooth, WSW winds ~40 kts.
120107_150322	ASH 028	1503/1512 z	6063'	S	~155 kts	~99 %	~12 °	bkn above, haze, occ -turb, WSW winds ~40 kts.
120107_151635	ASH 027	1516/1525 z	6063'	N	~165 kts	~99 %	~16 °	sct above, haze, smooth, WSW winds ~40 kts.
120107_152935	ASH025	1529/1535 z	6093'	S	~155 kts	~99 %	~12 °	few above, haze, smooth, WSW winds ~45 kts.
120107_153752	ASH0 26	1537/1539 z	6158'	S	~155 kts	~99 %	~13 °	skc, haze, smooth, WSW winds ~45 kts.
120107_154251	ASH 024	1542/1543 z	6076'	N	~165 kts	~99 %	~16 °	skc, haze, smooth, WSW winds ~45 kts.
120107_154557	ASH 023	1545/1551 z	6093'	N	~165 kts	~99 %	~16 °	skc, haze, smooth, WSW winds ~45 kts.
120107_155559	ASH 021	1556/1602 z	6086'	S	~155 kts	~99 %	~12 °	skc, haze smooth, WSW winds ~45 kts.
120107_160437	ASH 022	1604/1605 z	6083'	S	~155 kts	~99 %	~13 °	skc, -haze, smooth, WSW winds ~45 kts.
120107_160829	UL001	1608/1610 z	6030'	W	~130 kts	~99 %	~4 °	skc, -haze, smooth, WSW winds ~45 kts. [IMPROV CROSS LINE]
120107_161315	ASH 020	1613/1619 z	6089'	N	~160 kts	~99 %	~16 °	skc, -haze, smooth, WSW winds ~45 kts.
120107_162328	ASH 019	1623/1629 z	6096'	S	~155 kts	~99 %	~13 °	skc, -haze, smooth, WSW winds ~45 kts.
120107_163318	ASH 018	1633/1639 z	6102'	N	~165 kts	~99 %	~16 °	skc, -haze, occ -turb, WSW winds ~40 kts.
120107_164332	ASH 017	1643/1649 z	6112'	S	~155 kts	~99 %	~12 °	skc, -haze, occ -turb, WSW winds ~40 kts.
120107_165251	ASH 016	1652/1658 z	6115'	N	~170 kts	~99 %	~14 °	skc, -haze, occ -turb, WSW winds ~40 kts.
120107_170144	UL002	1701/1704 z	6125'	E	~180 kts	~99 %	~5 °	skc, -haze, occ -turb, WSW winds ~40 kts. ["CROSS 42" EXTENDED]
					kts	%	°	
					kts	%	°	[LANDED FOR FUEL & TO COORDINATE w/ BOSTON TRACON]
					kts	%	°	

Sheet 1 of 1

[BOS TRACON: (603) 594-5532
FAX : " " - 5550]



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 111218. fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	JAN 7, 2012		
Takeoff Time (Z): 18 46 z	Local: 1 46 p EST	Airport KASH	
Landing Time (Z): 19 06 z	Local: 2 06 p EST	Airport KASH	0^{20}

Project's Scanning Requirements

Field of View: 35 °	Altitude AGL (ft): 6000'
Scan Rate: 52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)
Pulse Rate: 120 kHz	Laser Output Current: 63 %
Ground Speed: 160 kts	

Data Information

LIDAR Unit	Leica ALS-60 sn6156
HD #	" 1 "
IPAS File #	20120107_183650
from, to	000 → 003
FCMS File #	20120107_183434

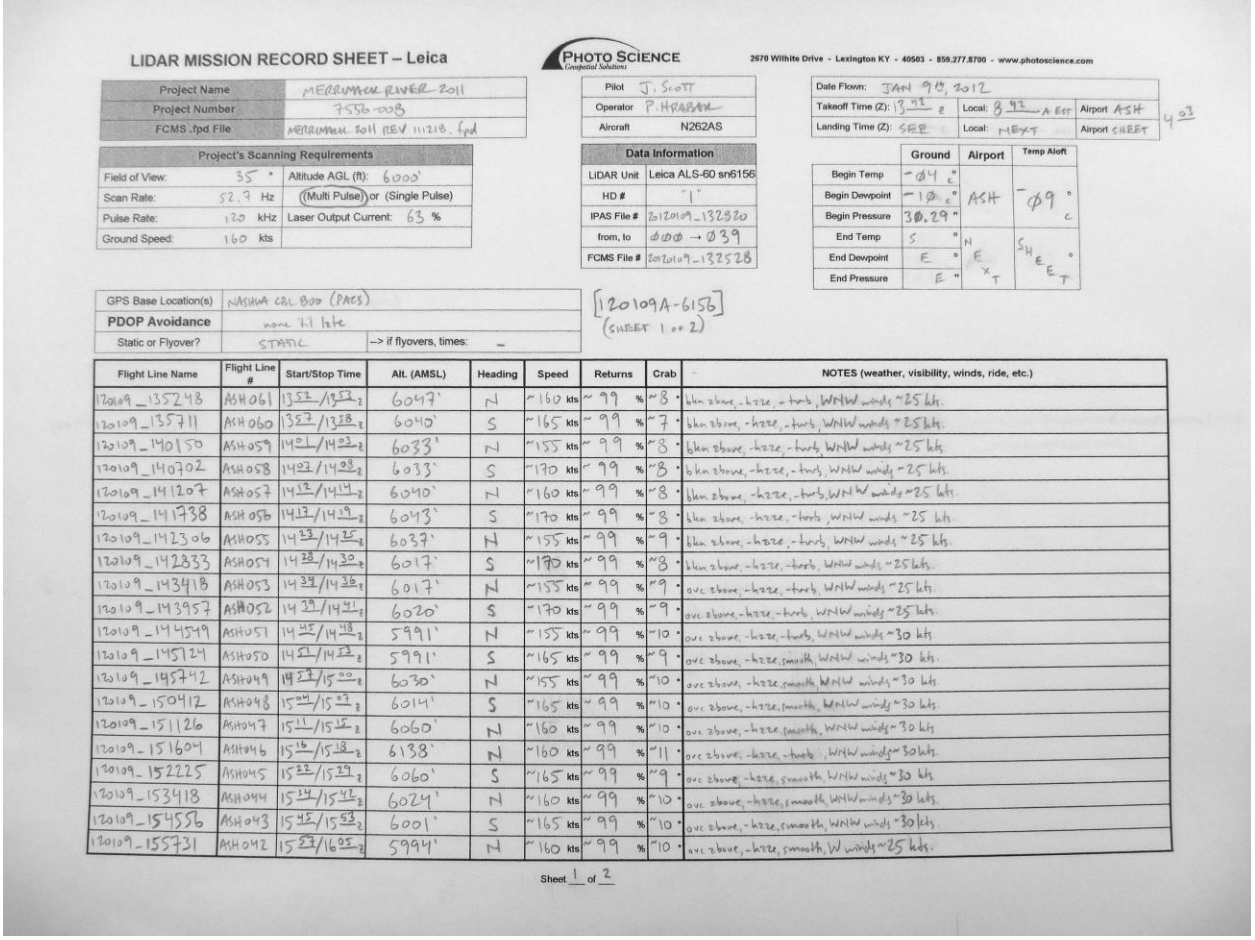
	Ground	Airport	Temp Aloft
Begin Temp	— °C	ASH	— °C
Begin Dewpoint	— °C		
Begin Pressure	. "		
End Temp	— °		°
End Dewpoint	— °		
End Pressure	. "		

[120107B-6156]

GPS Base Location(s)	NASHUA CBL 900 (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times:

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120107_	ASH061	—/ — z	6047'	N	~ kts	~ %	~ °	scat/bkn below, haze, -turb, W winds ~40 kts.
120107_	ASH060	—/ — z		S	~ kts	~ %	~ °	
120107_	ASH059	—/ — z		N	~ kts	~ %	~ °	
120107_	ASH058	—/ — z		S	~ kts	~ %	~ °	
120107_	ASH057	—/ — z		N	kts	%	°	
120107_	ASH056	—/ — z		S	kts	%	°	
120107_	ASH055	—/ — z		N	kts	%	°	VOID - CLOUDS BELOW THROUGHOUT
120107_	ASH054	—/ — z		S	kts	%	°	PROJECT AREA! ARGH!
120107_	ASH053	—/ — z		N	kts	%	°	
120107_	52			S	kts	%	°	
120107_	51			N	kts	%	°	
\	50			S	kts	%	°	
	49			N	kts	%	°	
	48			S	kts	%	°	
	47			N	kts	%	°	
	46			N	kts	%	°	
	45			S	kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

Sheet 1 of __



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions
2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 111218. fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown: JAN 9th, 2012		
Takeoff Time (Z): 13^{42} z	Local: 8^{42} A EST	Airport ASH
Landing Time (Z): SEE	Local: NEXT	Airport SHEET

4^{03}

Project's Scanning Requirements

Field of View: 35 °	Altitude AGL (ft): 6000'
Scan Rate: 52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)
Pulse Rate: 120 kHz	Laser Output Current: 63 %
Ground Speed: 160 kts	

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120109_132820
from, to	000 → 039
FCMS File #	20120109_132528

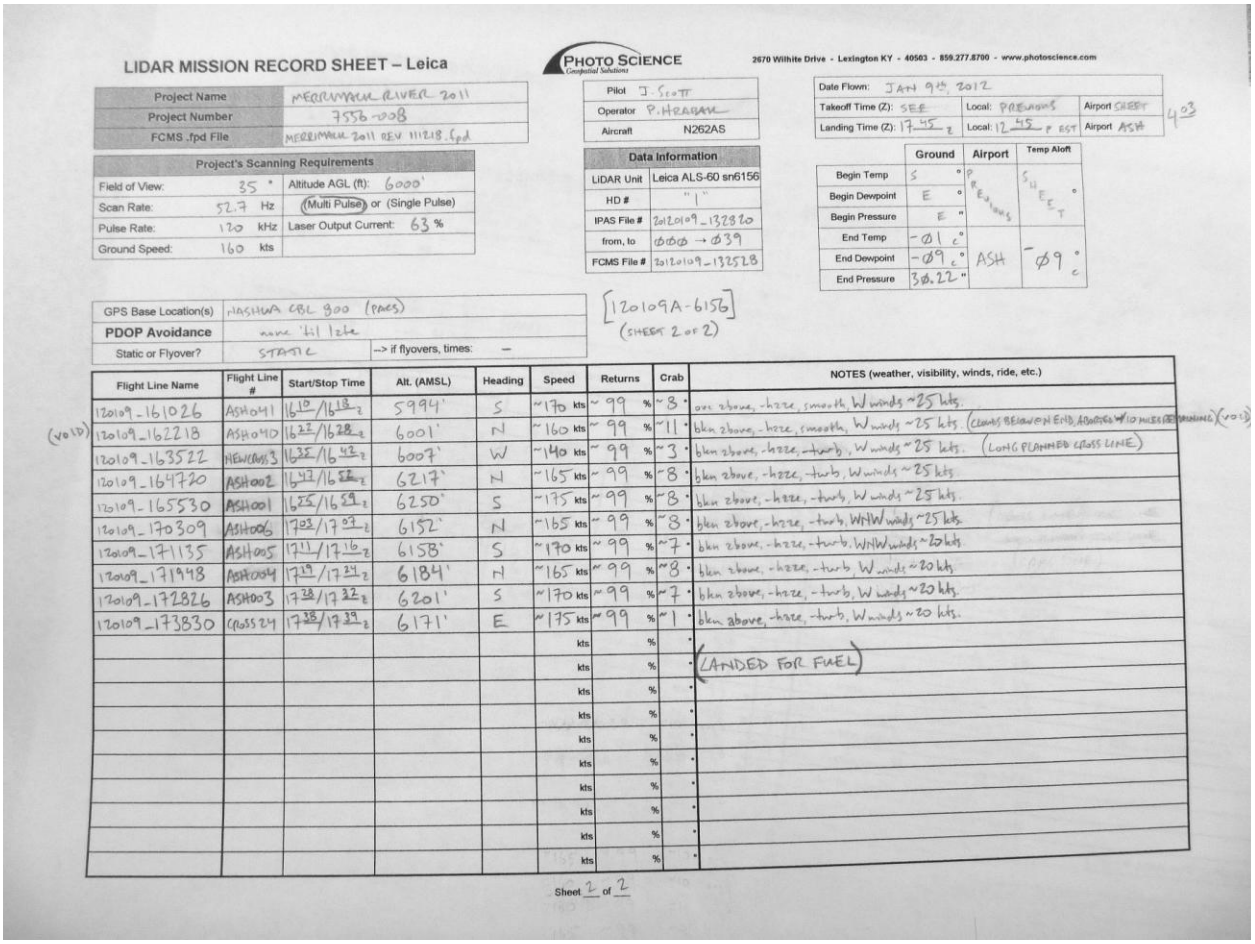
	Ground	Airport	Temp Aloft
Begin Temp	-04 °c	ASH	-09 °c
Begin Dewpoint	-10 °c		
Begin Pressure	30.29 "		
End Temp	S °	N E X T	S H E E T °
End Dewpoint	E °		
End Pressure	E "		

GPS Base Location(s)	NASHUA CRL B00 (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times: –

[120109A-6156]
(SHEET 1 of 2)

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120109_135248	ASH061	$13^{52}/13^{53}$z	6047'	N	~160 kts	~99 %	~8 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_135711	ASH060	$13^{57}/13^{58}$z	6040'	S	~165 kts	~99 %	~7 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_140150	ASH059	$14^{01}/14^{03}$z	6033'	N	~155 kts	~99 %	~8 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_140702	ASH058	$14^{07}/14^{08}$z	6033'	S	~170 kts	~99 %	~8 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_141207	ASH057	$14^{12}/14^{14}$z	6040'	N	~160 kts	~99 %	~8 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_141738	ASH056	$14^{17}/14^{19}$z	6043'	S	~170 kts	~99 %	~8 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_142306	ASH055	$14^{23}/14^{25}$z	6037'	N	~155 kts	~99 %	~9 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_142833	ASH054	$14^{28}/14^{30}$z	6017'	S	~170 kts	~99 %	~8 °	bkn above, -haze, -turb, WNW winds ~25 kts.
120109_143418	ASH053	$14^{34}/14^{36}$z	6017'	N	~155 kts	~99 %	~9 °	ovc above, -haze, -turb, WNW winds ~25 kts.
120109_143957	ASH052	$14^{39}/14^{41}$z	6020'	S	~170 kts	~99 %	~9 °	ovc above, -haze, -turb, WNW winds ~25 kts.
120109_144549	ASH051	$14^{45}/14^{48}$z	5991'	N	~155 kts	~99 %	~10 °	ovc above, -haze, -turb, WNW winds ~30 kts
120109_145124	ASH050	$14^{51}/14^{53}$z	5991'	S	~165 kts	~99 %	~9 °	ovc above, -haze, smooth, WNW winds ~30 kts.
120109_145742	ASH049	$14^{57}/15^{00}$z	6030'	N	~155 kts	~99 %	~10 °	ovc above, -haze, smooth, WNW winds ~30 kts.
120109_150412	ASH048	$15^{04}/15^{07}$z	6014'	S	~165 kts	~99 %	~10 °	ovc above, -haze, smooth, WNW winds ~30 kts.
120109_151126	ASH047	$15^{11}/15^{15}$z	6060'	N	~160 kts	~99 %	~10 °	ovc above, -haze, smooth, WNW winds ~30 kts
120109_151604	ASH046	$15^{16}/15^{18}$z	6138'	N	~160 kts	~99 %	~11 °	ovc above, -haze, -turb , WNW winds ~30 kts.
120109_152225	ASH045	$15^{22}/15^{29}$z	6060'	S	~165 kts	~99 %	~9 °	ovc above, -haze, smooth, WNW winds ~30 kts
120109_153418	ASH044	$15^{34}/15^{42}$z	6024'	N	~160 kts	~99 %	~10 °	ovc above, -haze, smooth, WNW winds ~30 kts.
120109_154556	ASH043	$15^{45}/15^{53}$z	6001'	S	~165 kts	~99 %	~10 °	ovc above, -haze, smooth, WNW winds ~30 kts
120109_155731	ASH042	$15^{57}/16^{05}$z	5994'	N	~160 kts	~99 %	~10 °	ovc above, -haze, smooth, W winds ~25 kts.

Sheet 1 of 2



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 111218.fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown: JAN 9th, 2012		
Takeoff Time (Z): SEE	Local: PREVIOUS	Airport SHEET
Landing Time (Z): 17^{45} z	Local: 12^{45} P EST	Airport ASH

4^{03}

Project's Scanning Requirements			
Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information	
LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120109_132820
from, to	000 → 039
FCMS File #	20120109_132528

	Ground	Airport	Temp Aloft
Begin Temp	S °	PREVIOUS	SHEET °
Begin Dewpoint	E °		
Begin Pressure	E "		
End Temp	-01 c°	ASH	-09 ° c
End Dewpoint	-09 c°		
End Pressure	30.22 "		

GPS Base Location(s)	NASHUA CBL 900 (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times: —

[120109A-6156]
(SHEET 2 OF 2)

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120109_161026	ASH041	$16^{10}/16^{18}$ z	5994'	S	~170 kts	~99 %	~8 °	ovc above, -haze, smooth, W winds ~25 kts.
(VOID) 120109_162218	ASH040	$16^{22}/16^{28}$ z	6001'	N	~160 kts	~99 %	~11 °	bkn above, -haze, smooth, W winds ~25 kts. (CLOUDS BELOW ON END, ABORTED W/10 MILES REMAINING) (VOID)
120109_163522	NEWCROSS3	$16^{35}/16^{42}$ z	6007'	W	~140 kts	~99 %	~3 °	bkn above, -haze, -turb, W winds ~25 kts. (LONG PLANNED CROSS LINE)
120109_164720	ASH002	$16^{47}/16^{52}$ z	6217'	N	~165 kts	~99 %	~8 °	bkn above, -haze, -turb, W winds ~25 kts
120109_165530	ASH001	$16^{55}/16^{59}$ z	6250'	S	~175 kts	~99 %	~8 °	bkn above, -haze, -turb, W winds ~25 kts.
120109_170309	ASH006	$17^{03}/17^{07}$ z	6152'	N	~165 kts	~99 %	~8 °	bkn above, -haze, -turb. WNW winds ~25 kts.
120109_171135	ASH005	$17^{11}/17^{16}$ z	6158'	S	~170 kts	~99 %	~7 °	bkn above, -haze, -turb. WNW winds ~20 kts.
120109_171948	ASH004	$17^{19}/17^{24}$ z	6184'	N	~165 kts	~99 %	~8 °	bkn above, -haze, -turb, W winds ~20 kts.
120109_172826	ASH003	$17^{28}/17^{32}$ z	6201'	S	~170 kts	~99 %	~7 °	bkn above, -haze, -turb, W winds ~20 kts.
120109_173830	CROSS24	$17^{38}/17^{39}$ z	6171'	E	~175 kts	~99 %	~1 °	bkn above, -haze, -turb, W winds ~20 kts.
					kts	%	°	
					kts	%	°	(LANDED FOR FUEL)
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

Sheet 2 of 2

PHOTO SCIENCE
Geospatial Solutions

Station Occupation Report
For Airborne GPS

Project: MERRIMACK RIVER LIDAR "2011"

Location: NASHUA, NH AIRPORT (KASH)

Project Number: 7556-008

Completed by: PNH

Date: JAN 9th, 2012

Receiver: "5"

Receiver Type: TRIMBLE R7 GNSS

Antenna Type: ZEPHYR GEODETIC 2

Station ID: NASHUA CBL 800 (PACS)

Start -- H.I. (m): 1.646 m

End -- H.I. (m): 1.646 m

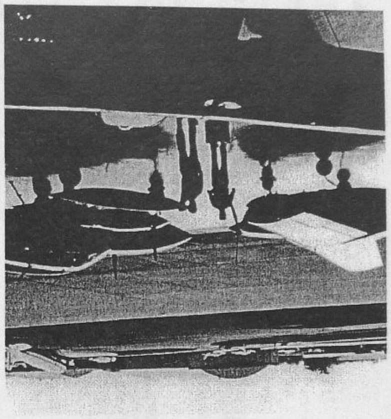
H.I. (ft): 5.40 ft.

Start Time: ~8^{15}A

End Time: ~5^{19}p

Time Zone: EST

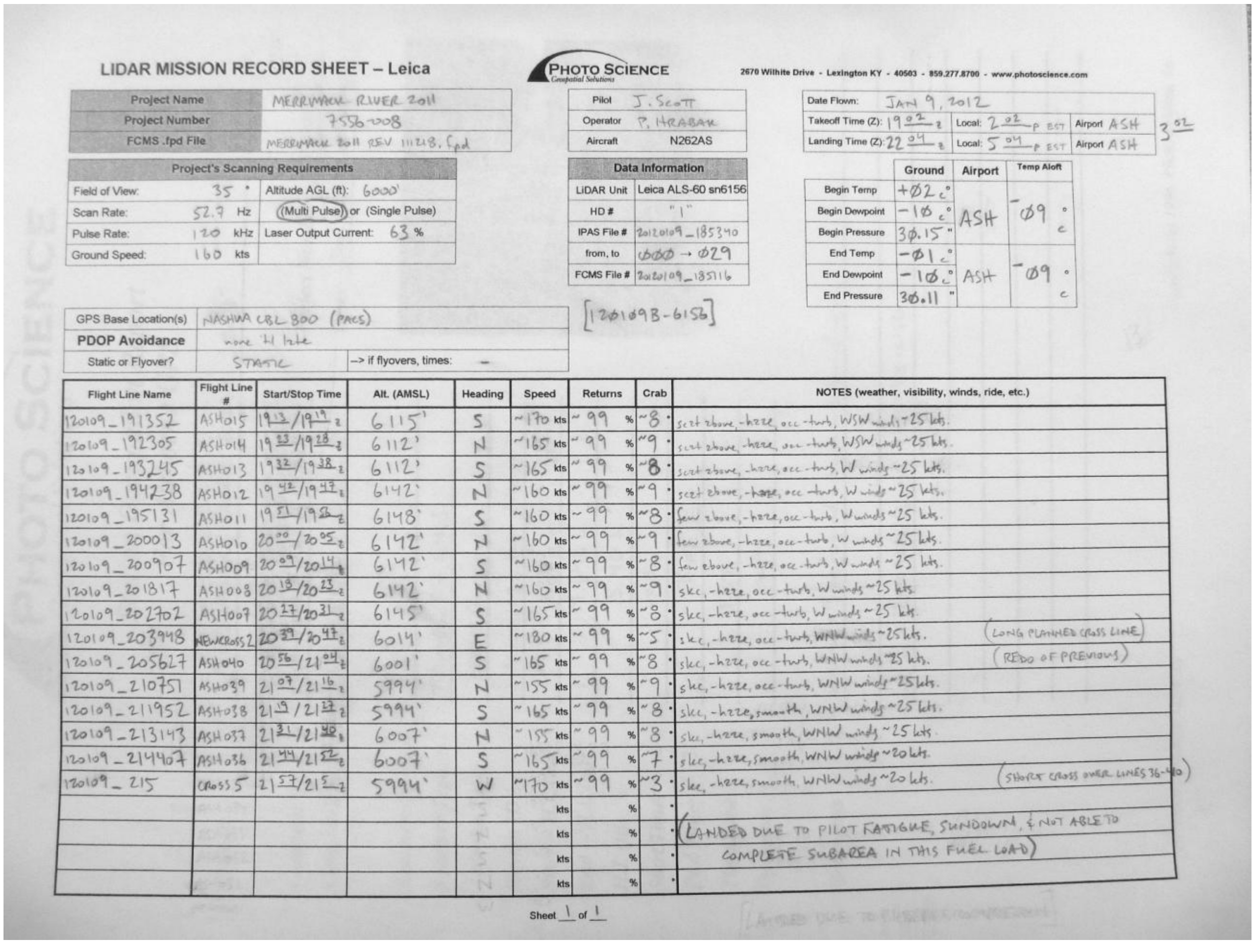
Operator: PNH



Comments

- measured @ 3 pts. around antenna to bottom of notch
- use for 120109A-6156 & 120109B-6156

PSI\FORMS\Station Occupation Report April 19, 2011



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 111218.fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	JAN 9, 2012			
Takeoff Time (Z):	19^{02} z	Local: 2^{02} P EST	Airport ASH	3^{02}
Landing Time (Z):	22^{04} z	Local: 5^{04} P EST	Airport ASH	

Project's Scanning Requirements

Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120109_185340
from, to	000 → 029
FCMS File #	20120109_185116

[120109B-6156]

	Ground	Airport	Temp Aloft
Begin Temp	+02 c°	ASH	-09 °c
Begin Dewpoint	-10 c°		
Begin Pressure	30.15 "		
End Temp	-01 c°	ASH	-09 °c
End Dewpoint	-10 c°		
End Pressure	30.11 "		

GPS Base Location(s)	NASHUA CBL 800 (PACS)	
PDOP Avoidance	none til late	
Static or Flyover?	STATIC	--> if flyovers, times: –

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120109_191352	ASH015	$19^{13}/19^{19}$ z	6115'	S	~170 kts	~99 %	~8 °	scat above, -haze, occ-turb, WSW winds ~25 kts.
120109_192305	ASH014	$19^{23}/19^{28}$ z	6112'	N	~165 kts	~99 %	~9 °	scat above, -haze, occ-turb, WSW winds ~25 kts.
120109_193245	ASH013	$19^{32}/19^{38}$ z	6112'	S	~165 kts	~99 %	~8 °	scat above, -haze, occ-turb, W winds ~25 kts.
120109_194238	ASH012	$19^{42}/19^{47}$ z	6142'	N	~160 kts	~99 %	~9 °	scat above, -haze, occ-turb, W winds ~25 kts.
120109_195131	ASH011	$19^{51}/19^{56}$ z	6148'	S	~160 kts	~99 %	~8 °	few above, -haze, occ-turb, W winds ~25 kts.
120109_200013	ASH010	$20^{00}/20^{05}$ z	6142'	N	~160 kts	~99 %	~9 °	few above, -haze, occ-turb, W winds ~25 kts.
120109_200907	ASH009	$20^{09}/20^{14}$ z	6142'	S	~160 kts	~99 %	~8 °	few above, -haze, occ-turb, W winds ~25 kts.
120109_201817	ASH008	$20^{18}/20^{23}$ z	6142'	N	~160 kts	~99 %	~9 °	skc, -haze, occ-turb, W winds ~25 kts.
120109_202702	ASH007	$20^{27}/20^{31}$ z	6145'	S	~165 kts	~99 %	~8 °	skc, -haze, occ-turb, W winds ~25 kts.
120109_203948	NEWCROSS2	$20^{39}/20^{47}$ z	6014'	E	~180 kts	~99 %	~5 °	skc, -haze, occ-turb, WNW winds ~25 kts. (LONG PLANNED CROSS LINE)
120109_205627	ASH040	$20^{56}/21^{04}$ z	6001'	S	~165 kts	~99 %	~8 °	skc, -haze, occ-turb, WNW winds ~25 kts. (REDO OF PREVIOUS)
120109_210751	ASH039	$21^{07}/21^{16}$ z	5994'	N	~155 kts	~99 %	~9 °	skc, -haze, occ-turb, WNW winds ~25 kts.
120109_211952	ASH038	$21^{19}/21^{27}$ z	5994'	S	~165 kts	~99 %	~8 °	skc, -haze, smooth, WNW winds ~25 kts.
120109_213143	ASH037	$21^{31}/21^{40}$ z	6007'	N	~155 kts	~99 %	~8 °	skc, -haze, smooth, WNW winds ~25 kts.
120109_214407	ASH036	$21^{44}/21^{52}$ z	6007'	S	~165 kts	~99 %	~7 °	skc, -haze, smooth, WNW winds ~20 kts.
120109_215	CROSS5	$21^{57}/21^{5}$ z	5994'	W	~170 kts	~99 %	~3 °	skc, -haze, smooth, WNW winds ~20 kts. (SHORT CROSS OVER LINES 36-40)
					kts	%	°	
					kts	%	°	(LANDED DUE TO PILOT FATIGUE, SUNDOWN, & NOT ABLE TO
					kts	%	°	COMPLETE SUBAREA IN THIS FUEL LOAD)
					kts	%	°	

Sheet 1 of 1

LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 111218 .fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown: JAN 11th, 2011		
Takeoff Time (Z): 13^{50} z	Local: 8^{50} A EST	Airport ASH
Landing Time (Z): 15^{23} z	Local: 10^{23} A EST	Airport ASH

1 33

Project's Scanning Requirements	
Field of View: 35 °	Altitude AGL (ft): 6000'
Scan Rate: 52.7 Hz	[✓ Multi Pulse] or (Single Pulse)
Pulse Rate: 120 kHz	Laser Output Current: 63 %
Ground Speed: 160 kts	

Data Information	
LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120111_133720
from, to	000 → 017
FCMS File #	20120111_133407

	Ground	Airport	Temp Aloft
Begin Temp	-02 °	ASH	-03 °c
Begin Dewpoint	-07 °		
Begin Pressure	30.12 "		
End Temp	-01 c°	ASH	-04 °c
End Dewpoint	-08 c°		
End Pressure	30.14 "		

[120111A-6156]

GPS Base Location(s)	NASHUA CBL 800 (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times: –

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120111_135915	ASH035	13^{59}/14^{07} z	6010'	N	~170 kts	~ 99 %	~4 °	sct high above, -haze, smooth, WNW winds ~10 kts
120111_141112	ASH034	14^{11}/14^{19} z	5997'	S	~170 kts	~ 99 %	~3 °	sct high above, -haze, smooth, WNW winds ~10 kts.
120111_142250	ASH033	14^{22}/14^{31} z	6007'	N	~165 kts	~ 99 %	~4 °	sct high above, -haze, smooth, WNW winds ~10 kts.
120111_143514	ASH032	14^{35}/14^{43} z	6010'	S	~170 kts	~ 99 %	~4 °	bkn above, -haze, smooth, NW winds ~10 kts.
120111_144717	ASH031	14^{47}/14^{56} z	6047'	N	~165 kts	~ 99 %	~5 °	bkn above, -haze, smooth, WNW winds ~15 kts.
120111_150345	NEWCROSS1	15^{03}/15^{13} z	6027'	W	~155 kts	~ 99 %	~1 °	bkn above, -haze, smooth, WNW winds ~15 kts. [LONG PLANNED CROSSLINE]
					kts	%	°	
					kts	%	°	[LANDED DUE TO SUBAREA COMPLETION]
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

Sheet 1 of 1

PHOTO SCIENCE
Geospatial Solutions

Station Occupation Report For Airborne GPS

Project: MERRIMACK RIVER LIDAR "2011"

Location: BEDFORD, MA AIRPORT (KBED)

Project Number: 7556008

Completed by: PNH

Date: JAN 11, 2012

Receiver: "5"

Receiver Type: TRIMBLE R7 GNSS

Antenna Type: ZEPHYR GEODETIC 2

Station ID: BED A (PACS)

Start -- H.I. (m): 1.429 m

End -- H.I. (m): 1.429 m

H.I. (ft): 4.69 ft.

Start Time: ~ $11^{\underline{26}}$ A

End Time: ~ $4^{\underline{23}}$ p

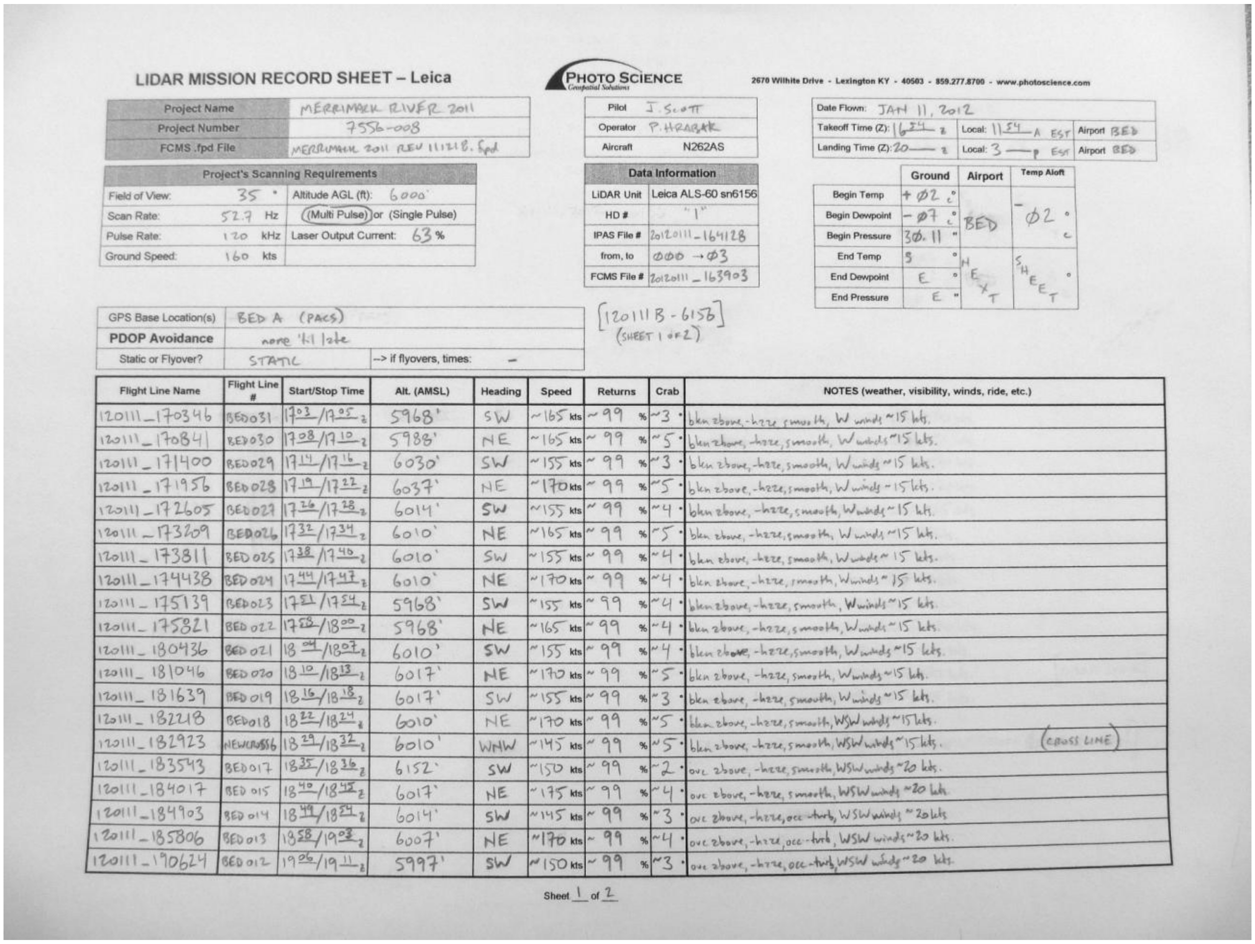
Time Zone: EST

Operator: PNH

Comments

- measured @ 3 pts. around antenna to bottom of notch
- use for 120111B-6156

PSI\FORMS\Station Occupation Report February 25, 2011



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions

2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 111218.fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown: JAN 11, 2012			
Takeoff Time (Z): 16^{54} z	Local: 11^{54} A EST	Airport BED	
Landing Time (Z): 20— z	Local: 3 — p EST	Airport BED	

Project's Scanning Requirements	
Field of View: 35 °	Altitude AGL (ft): 6000'
Scan Rate: 52.7 Hz	[✓ (Multi Pulse)] or (Single Pulse)
Pulse Rate: 120 kHz	Laser Output Current: 63 %
Ground Speed: 160 kts	

Data Information	
LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120111_164128
from, to	000 → 03
FCMS File #	20120111_163903

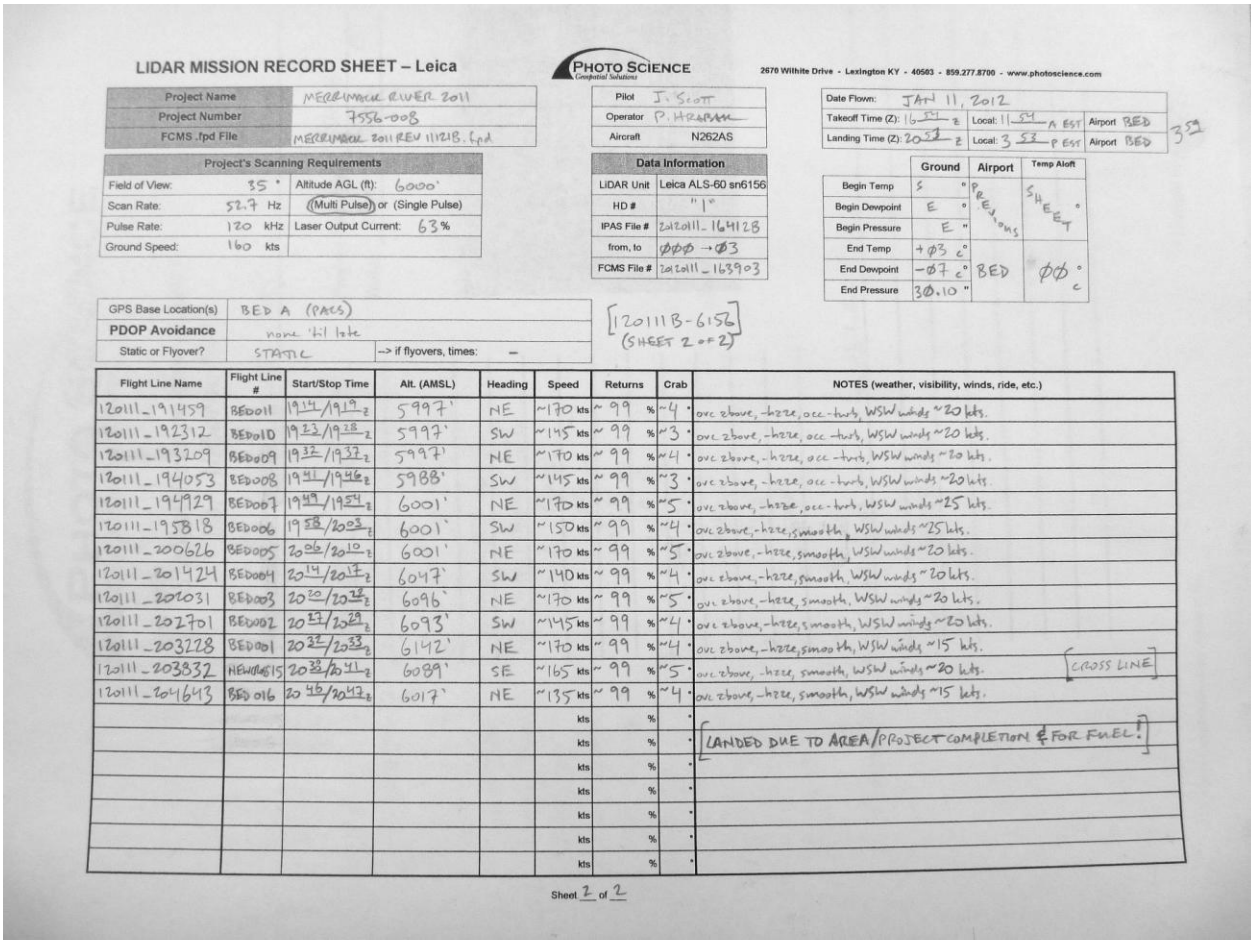
	Ground	Airport	Temp Aloft
Begin Temp	+02 °c	BED	-02 °c
Begin Dewpoint	-07 °c		
Begin Pressure	30.11 "		
End Temp	S °	NEXT	SHEET °
End Dewpoint	E °		
End Pressure	E "		

[120111B-6156]
(SHEET 1 OF 2)

GPS Base Location(s)	BED A (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times: —

Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120111_170346	BED031	$17^{03}/17^{05}$ z	5968'	SW	~165 kts	~99 %	~3 °	bkn above, -haze smooth, W winds ~15 kts.
120111_170841	BED030	$17^{08}/17^{10}$ z	5988'	NE	~165 kts	~99 %	~5 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_171400	BED029	$17^{14}/17^{16}$ z	6030'	SW	~155 kts	~99 %	~3 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_171956	BED028	$17^{19}/17^{22}$ z	6037'	NE	~170 kts	~99 %	~5 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_172605	BED027	$17^{26}/17^{28}$ z	6014'	SW	~155 kts	~99 %	~4 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_173209	BED026	$17^{32}/17^{34}$ z	6010'	NE	~165 kts	~99 %	~5 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_173811	BED025	$17^{38}/17^{40}$ z	6010'	SW	~155 kts	~99 %	~4 °	bkn above, -haze, smooth, W winds ~ 15 kts.
120111_174438	BED024	$17^{44}/17^{47}$ z	6010'	NE	~170 kts	~99 %	~4 °	bkn above, -haze, smooth, W winds ~ 15 kts.
120111_175139	BED023	$17^{51}/17^{54}$ z	5968'	SW	~155 kts	~99 %	~4 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_175821	BED022	$17^{58}/18^{00}$ z	5968'	NE	~165 kts	~99 %	~4 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_180436	BED021	$18^{04}/18^{07}$ z	6010'	SW	~155 kts	~99 %	~4 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_181046	BED020	$18^{10}/18^{13}$ z	6017'	NE	~170 kts	~99 %	~5 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_181639	BED019	$18^{16}/18^{18}$ z	6017'	SW	~155 kts	~99 %	~3 °	bkn above, -haze, smooth, W winds ~15 kts.
120111_182218	BED018	$18^{22}/18^{24}$ z	6010'	NE	~170 kts	~99 %	~5 °	bkn above, -haze, smooth, WSW winds ~15 kts.
120111_182923	NEWCROSS6	$18^{29}/18^{32}$ z	6010'	WNW	~145 kts	~99 %	~5 °	bkn above, -haze, smooth, WSW winds ~15 kts. (CROSS LINE)
120111_183543	BED017	$18^{35}/18^{36}$ z	6152'	SW	~150 kts	~99 %	~2 °	ovc above, -haze, smooth, WSW winds ~20 kts.
120111_184017	BED015	$18^{40}/18^{45}$ z	6017'	NE	~175 kts	~99 %	~4 °	ovc above, -haze, smooth, WSW winds ~20 kts.
120111_184903	BED014	$18^{49}/18^{54}$ z	6014'	SW	~145 kts	~99 %	~3 °	ovc above, -haze, occ-turb, WSW winds ~20 kts
120111_185806	BED013	$18^{58}/19^{03}$ z	6007'	NE	~170 kts	~99 %	~4 °	ovc above, -haze, occ-turb, WSW winds ~20 kts.
120111_190624	BED012	$19^{06}/19^{11}$ z	5997'	SW	~150 kts	~99 %	~3 °	ovc above, -haze, occ-turb, WSW winds ~20 kts.

Sheet 1 of 2



LIDAR MISSION RECORD SHEET – Leica

PHOTO SCIENCE
Geospatial Solutions
2670 Wilhite Drive - Lexington KY - 40503 - 859.277.8700 - www.photoscience.com

Project Name	MERRIMACK RIVER 2011
Project Number	7556-008
FCMS .fpd File	MERRIMACK 2011 REV 11121B.fpd

Pilot	J. SCOTT
Operator	P. HRABAK
Aircraft	N262AS

Date Flown:	JAN 11, 2012			
Takeoff Time (Z):	1654 z	Local: 1154 A EST	Airport	BED
Landing Time (Z):	2053 z	Local: 353 P EST	Airport	BED

353

Project's Scanning Requirements

Field of View:	35 °	Altitude AGL (ft):	6000'
Scan Rate:	52.7 Hz	[✓ Multi Pulse] or (Single Pulse)	
Pulse Rate:	120 kHz	Laser Output Current:	63 %
Ground Speed:	160 kts		

Data Information

LiDAR Unit	Leica ALS-60 sn6156
HD #	"1"
IPAS File #	20120111_164128
from, to	000 → 03
FCMS File #	20120111_163903

	Ground	Airport	Temp Aloft
Begin Temp	S °	PREVIOUS	SHEET °
Begin Dewpoint	E °		
Begin Pressure	E "		
End Temp	+03 c°		
End Dewpoint	-07 c°	BED	00 °c
End Pressure	30.10 "		

GPS Base Location(s)	BED A (PACS)	
PDOP Avoidance	none 'til late	
Static or Flyover?	STATIC	--> if flyovers, times: –

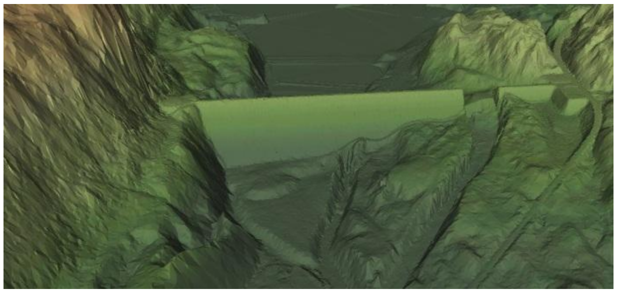
[120111B-6156
(SHEET 2 OF 2)]

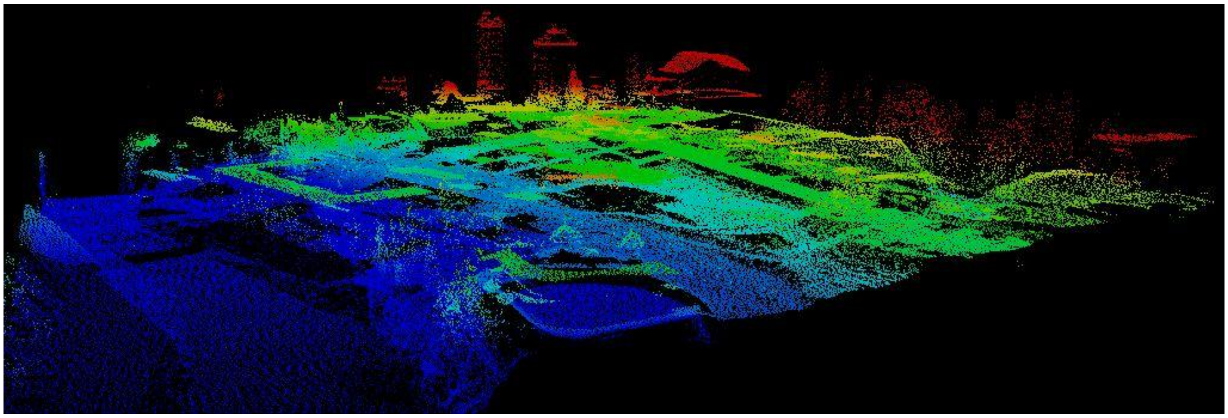
Flight Line Name	Flight Line #	Start/Stop Time	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
120111_191459	BED011	1914/1919 z	5997'	NE	~170 kts	~ 99 %	~4 °	ovc above, -haze, occ-turb, WSW winds ~20 kts.
120111_192312	BED010	1923/1928 z	5997'	SW	~145 kts	~ 99 %	~3 °	ovc above, -haze, occ-turb, WSW winds ~20 kts.
120111_193209	BED009	1932/1937 z	5997'	NE	~170 kts	~ 99 %	~4 °	ovc above, -haze, occ-turb, WSW winds ~20 kts.
120111_194053	BED008	1941/1946 z	5988'	SW	~145 kts	~ 99 %	~3 °	ovc above, -haze, occ-turb, WSW winds ~20 kts.
120111_194929	BED007	1949/1954 z	6001'	NE	~170 kts	~ 99 %	~5 °	ovc above, -haze, occ-turb, WSW winds ~25 kts.
120111_195818	BED006	1958/2003 z	6001'	SW	~150 kts	~ 99 %	~4 °	ovc above, -haze, smooth, WSW winds ~25 kts.
120111_200626	BED005	2006/2010 z	6001'	NE	~170 kts	~ 99 %	~5 °	ovc above, -haze, smooth, WSW winds ~20 kts.
120111_201424	BED004	2014/2017 z	6047'	SW	~140 kts	~ 99 %	~4 °	ovc above, -haze, smooth, WSW winds ~20 kts.
120111_202031	BED003	2020/2022 z	6096'	NE	~170 kts	~ 99 %	~5 °	ovc above, -haze, smooth, WSW winds ~20 kts.
120111_202701	BED002	2027/2029 z	6093'	SW	~145 kts	~ 99 %	~4 °	ovc above, -haze, smooth, WSW winds ~20 kts.
120111_203228	BED001	2032/2033 z	6142'	NE	~170 kts	~ 99 %	~4 °	ovc above, -haze, smooth, WSW winds ~15 kts.
120111_203832	NEWCROSS15	2038/2041 z	6089'	SE	~165 kts	~ 99 %	~5 °	ovc above, -haze, smooth, WSW winds ~20 kts. [CROSS LINE]
120111_204643	BED016	2046/2047 z	6017'	NE	~135 kts	~ 99 %	~4 °	ovc above, -haze, smooth, WSW winds ~15 kts.
					kts	%	°	
					kts	%	°	[LANDED DUE TO AREA/PROJECT COMPLETION & FOR FUEL!]
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	
					kts	%	°	

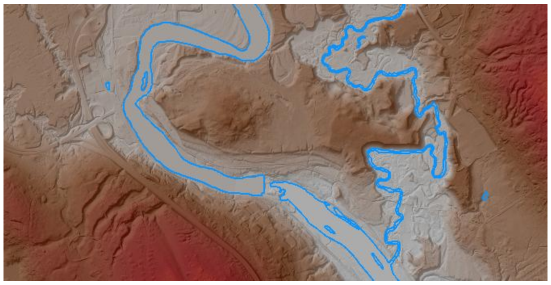
Sheet 2 of 2

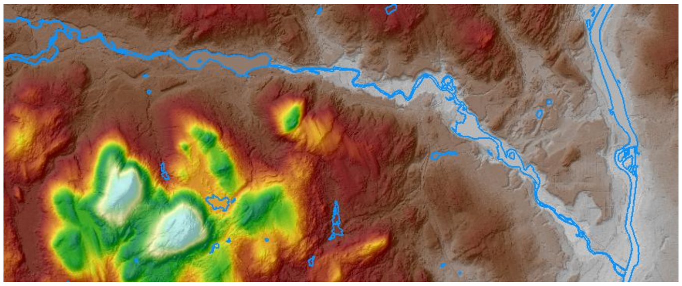
Appendix F: Quality Assurance

Elevation Data Quality Assurance Report
Merrimack HUC-8 Watershed Fully Classified Dataset
September 14, 2012









Submitted to:

Federal Emergency Management Agency, Region 1
Department of Homeland Security
99 High Street, Sixth Floor
Boston, MA 02110
Prepared by:

STARR
Strategic Alliance for Risk Reduction
Raleigh, NC

Contents

1. Executive Summary

Under FEMA task order HSFE01-11-J-0010 STARR has completed elevation data post processing for the Merrimack HUC-8 watershed. The goal of this project is to create a classified bare-earth digital terrain dataset with a vertical accuracy Root Mean Square Error of <18.5cm capable of supporting 2 foot contours.

2. Overview

STARR partner Greenhorne and O'Mara performed an independent quality assurance review on the raw Point Cloud and Classified Point Cloud data. This validates the quality of LiDAR data for use in Risk MAP projects that support the National Flood Insurance Program. This document summarizes the review process and results for the Merrimack HUC-8 watershed.

Table 1 LiDAR Project Requirements

FEMA Region 1 Merrimack HUC-8 LiDAR Post Processing Requirements	
Collection/Processing Area	1302 square miles
Breaklines Required	Yes
Specification Level	Highest
Nominal Pulse Spacing	1 m
DEM Post Spacing	1 m DEM with 2 ft. contour accuracy
Vertical Accuracy, 95% Confidence Level FVA/CVA	24.5 cm/ 36.3 cm
Coordinate System	UTM Zone 19N
Horizontal Datum and Linear Units	NAD 83 Meters
Vertical Datum and Linear Units	NAVD 88 US Survey Foot

Table 2 QA Activity and Guideline and Specifications Matrix

QA Activity	**PM 61**	**USGS LiDAR Base Spec v13**	**ASPRS LAS v1.2**	**Appendix A**	**Appendix M**
Vendor Submittal	X	X	X		X
Macro Review	X	X		X	
Micro Review	X	X	X	X	
Vertical Accuracy	X	X		X	X

3. LiDAR Data Review

Greenhorne & O'Mara, Inc. utilizes commercial software and proprietary scripts/applications to review LiDAR data. These tools, combined with guidelines and specifications, are incorporated into a standardized quality assurance workflow. Table 3 summarizes software and proprietary scripts/applications used in the review.

Table 3 Software/Tools used in Quality Assurance Review

Software/Tools	QA Process
ESRI ArcGIS 10.1 ArcInfo	LiDAR Visualization and Data Processing
ESRI 3D Analyst Extension	Visual Analysis of LiDAR Data
ESRI Spatial Analyst Extension	Grid Analysis for LiDAR Data
LP360 ArcMap Extension	Visual Analysis of LiDAR Data
SIS Topo Analyst	Vertical Accuracy Quality Assurance
Proprietary Scripts/Applications	Working with LAS files

3.1 Vendor Submittal

All project data has been delivered and is accounted for. The completed Vendor Submittal Quality Assurance checklist is included with the QA Forms delivered with this document.

3.2 Macro Data Review

The macro review is conducted on the fully classified point cloud dataset. The purpose of this review is to determine whether the dataset was produced in a manner consistent with requirements set forth in the FEMA procedural memorandum. The individual review components are discussed in the following sections.

3.2.1 LiDAR Coverage and Completeness

All LiDAR data processed for the Merrimack HUC-8 watershed Project covers the area of interest with a 100m buffer and has an area of approximately 1302 square miles (See Figure 1). All LiDAR tiles are accounted for and the project datasets have the correct projection and datum information.

3.2.2 LAS Header Review

All LAS files submitted for review have header information that is compliant with ASPRS LAS specifications version 1.2 and 1.3.

The completed LAS Header Quality Assurance checklist is included with the QA Forms delivered with this document.

3.3 Micro Data Review

The following micro reviews were completed on 5% of the fully classified point cloud datasets. Tiles selected for review were chosen throughout the project area with a focus on areas of urban development and hydrographic significance (See Figure 2).

- Scan lines removed from bare earth
- Excessive Noise in bare earth
- Elevation Steps
- Gaps/Voids
- Edge matching between tiles
- Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)
- Proper definition of roads and drainage patterns
- “Over-smoothed” areas during filtering
- Corn Row Effects
- Mounds and Divots

All tiles reviewed meet project requirements for classified LiDAR data and can be used for floodplain mapping activities. The completed Micro Data Review Quality Assurance checklist is included with the QA Forms delivered with this document.

4. Vertical Accuracy Verification

An independent review and verification of submitted CVA survey data with vendor provided LAS files was completed to insure reported vertical accuracy is correct. Survey data points containing field collected GPS elevation values were buffered by 10 meters. LiDAR points contained within the buffered areas are selected and used to create a TIN. The TIN facet z value closest to the x and y control point location is compared to the height of the survey point. The height difference is evaluated statistically and compared to the submitted CVA testing results to insure the vertical accuracy meets project expectations. All CVA survey data submitted for this project has been confirmed to meet project requirements. The report delivered with this document summarizes the results of this assessment.

5. Conclusions

Based upon the submittal verification, acquisition reports, macro/micro reviews and vertical accuracy confirmation, the Merrimack HUC-8 watershed dataset meets all applicable project specifications defined in FEMA task order HSFE01-11-J-0010 dated September 27, 2011. This data meets all project requirements for FEMA Risk MAP elevation acquisition and can be used for flood risk analysis.

Approvals

___________________________________ **Date: 9/14/2012**

James L. Huffines, QA Team Lead

6. References

Links to guidelines and specifications used in production of the LiDAR datasets:

1. Federal Emergency Management Agency, Procedure Memorandum No. 61 - Standards for Lidar and Other High Quality Digital Topography, http://www.fema.gov/library/viewRecord.do?id=4345
2. U.S. Geological Survey National Geospatial Program, LiDAR Guidelines and Base Specification, Version 13-ILMF 2010, http://lidar.cr.usgs.gov/USGS-NGP%20Lidar%20Guidelines%20and%20Base%20Specification%20v13%28ILMF%29.pdf
3. American Society for Photogrammetry and Remote Sensing, LAS v1.2, http://www.asprs.org/a/society/committees/standards/asprs_las_format_v12.pdf
4. Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying [includes guidance on Light Detection and Ranging Systems (LIDAR)] http://www.fema.gov/library/file;jsessionid=1E39C93AF9CD18EE125B3DFCA5A874B8.Worker2Library?type=publishedFile&file=frm__gsaa.pdf&fileid=2daefcd0-df08-11e0-9bf5-001cc4568fb6
5. Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix M: data Capture Standards http://www.fema.gov/library/file;jsessionid=1E39C93AF9CD18EE125B3DFCA5A874B8.Worker2Library?type=publishedFile&file=frm__gsam.pdf&fileid=cf85c9b0-df0f-11e0-9bf5-001cc4568fb6

Figure 1 Merrimack HUC-8 Watershed Project Area

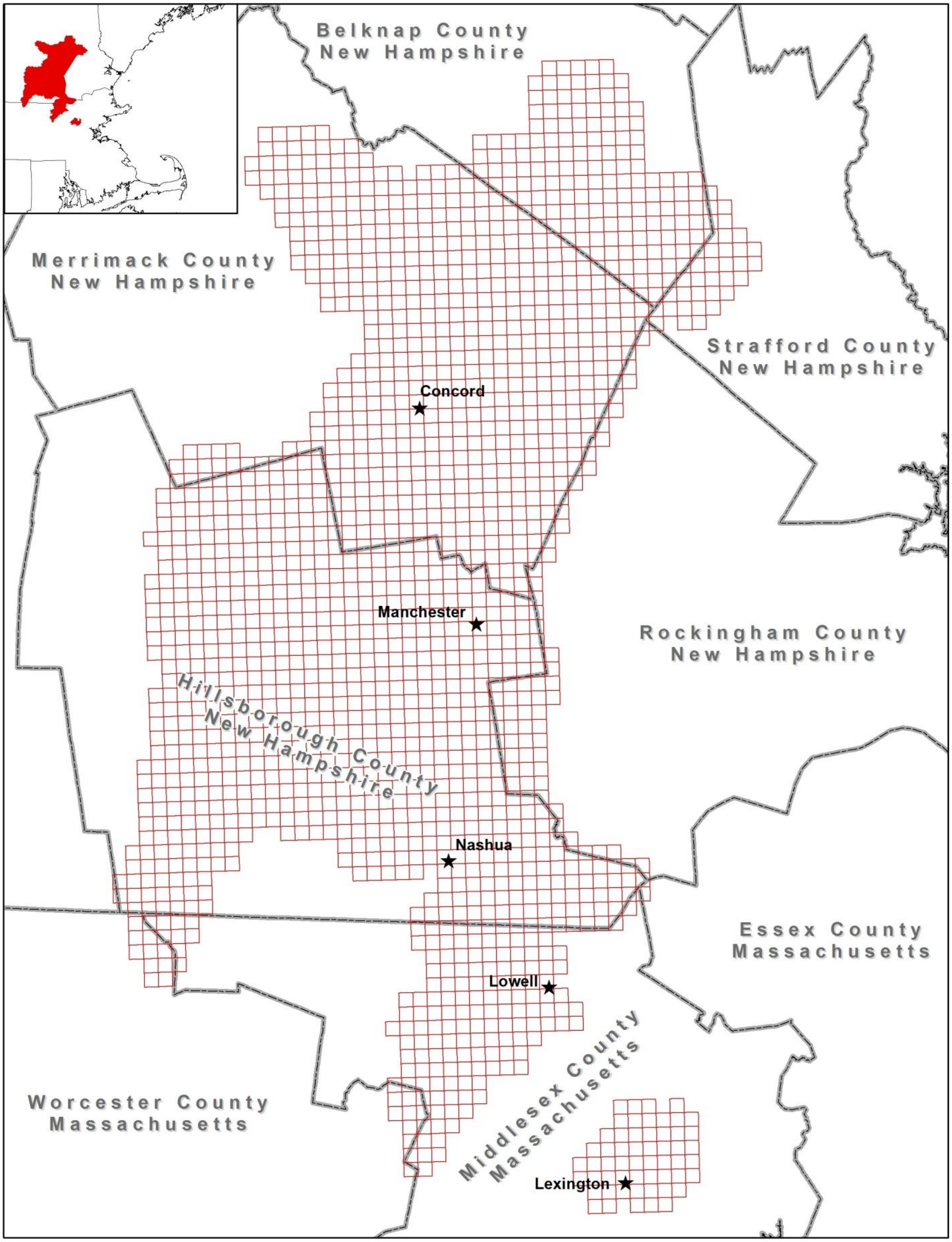
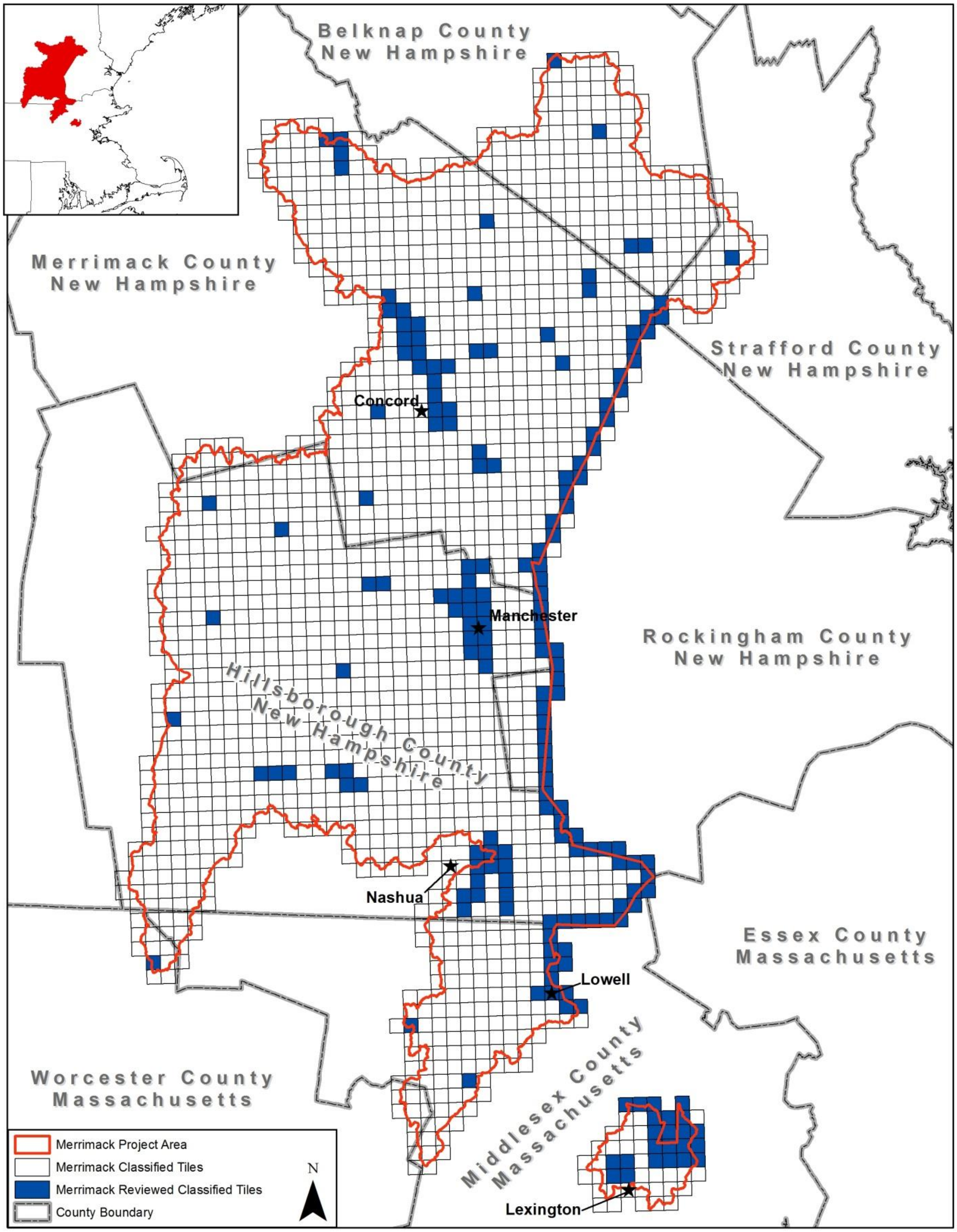


Figure 2 LiDAR Micro Review



Vendor Submittal Checklist	**Project: Merrimack Watershed**
Vendor: Photo Science, Inc	**Reviewed By: Diane Rogers/James L. Huffines**

Section: Descriptive Project Information	**Date: 16Jul12**

Item	**Included (Y/N)**	**Comments**
Metadata – Process Steps	Y	
Flight Reports – Pre-flight	Y	
Flight Reports – Post-flight	Y	
Base Station Point Shapefile	Y	NGS Base Stations
Flight Lines As Flown Trajectories Polyline Shapefile	Y	
Flight Lines Calibration Polyline Shapefile	Y	Included with flight lines
Flight Lines Planned Flight Lines Polyline Shapefile	Y	

Section: Survey Data

Item	**Included (Y/N)**	**Comments**
Ground Control – Accuracy Report	Y	From CompassData
Ground Control – Shapefile and Final Coordinates	Y	From CompassData
Ground Control – Final Report	Y	From CompassData
Vertical Accuracy – Shapefile and Final Coordinates	Y	From CompassData
Vertical Accuracy – FVA Accuracy Final Report	Y	From CompassData
Vertical Accuracy – FVA Accuracy Testing Results	Y	From CompassData

Section: Raw Point Cloud LiDAR

Item	**Included (Y/N)**	**Comments**
Project Area Coverage (100m Buffer) Polygon Shapefile	Y	
LiDAR Swath – LAS v1.2 or v1.3 < 2GB	NA	LAS data was delivered in tiled format
LiDAR Swath – Project Swath Index Polygon Shapefile	NA	LAS data was delivered in tiled format

Section: Classified Point Cloud LiDAR

Item	**Included (Y/N)**	**Comments**
Project Area Coverage (100m Buffer) Polygon Shapefile	Y	
LiDAR Tiles – LAS v1.2 or v1.3	Y	
LiDAR Tiles – Project Tile Index Polygon Shapefile	Y	

Pre-flight Aerial Calibration Report Checklist		**Project: Merrimack Watershed**
Vendor: Photo Science, Inc		**Reviewed By: Diane Rogers**
Section: Main		**Date: 16 Jul 12**

Item	**Included (Y/N)**	**Comments**
Planned flight lines (sufficient coverage, spacing, length)	Y	
Planned flight line Shapefile	Y	
Planned GPS stations	Y	In report
Planned Ground Control	Y	In report and Control Report
Calibration Plans	Y	Provided and in planned shapefiles
Vendor Quality Procedures	Y	In report
LiDAR sensor scan set – scan angle, sidelap, design pulse	Y	In report
Aircraft utilizes ABGPS	Y	In report
Sensor supports project design pulse density	Y	In report
Type of aircraft – supports project design parameters	Y	Cessna 206 and Piper Navajo 206 with Optech Gemini and Navajo with Leica ALS60
Re-flight procedure – tracking, documenting, processing	Y	On Logs
Project design supports accuracy requirements of project	Y	In report
Project design accounts for land cover and terrain types	Y	In report

Post-flight Aerial Acquisition and Calibration Report Checklist	**Project: Merrimack Watershed**
Vendor: Photo Science, Inc.	**Reviewed By: Diane Rogers**

Section: Flight Logs **Date: 16 Jul 12**

Item	**Included**	**Comments**
Flight logs – Job #/name	Y	Included with flight logs
Flight logs – Lift #	Y	Included with flight logs
Flight logs – Block or AOI	Y	Included with flight logs
Flight logs – Date	Y	Included with flight logs
Flight logs – Aircraft type	Y	Included with flight logs
Flight logs – Aircraft tail #	Y	Included with flight logs and report pg.2
Flight logs – Lines – #	Y	Included with flight logs
Flight logs – Lines – direction	Y	Included with flight logs
Flight logs – Lines – start/stop	Y	Included with flight logs
Flight logs – Lines – altitude	Y	Included with flight logs
Flight logs – Lines – scan angle	Y	Included with flight logs
Flight logs – Lines – speed	Y	Included with flight logs
Flight logs – Conditions	Y	Included with flight logs
Flight logs – Comments	Y	Included with flight logs
Flight logs – Pilot name	Y	Included with flight logs
Flight logs – Operator name	Y	Included with flight logs
Flight logs – Automatic Gain Control switch setting	NA	
Flight logs – Laser pulse rate	Y	Included with flight logs and report
Flight logs – Mirror rate	Y	Included with flight logs and report
Flight logs – Field of view	Y	Included with flight logs and report
Flight logs – Airport of operations	Y	Included with flight logs and report
Flight logs – GPS base stations names or numbers	Y	Included with flight logs and report

Section: GPS Base station		
Item	**Included**	**Comments**
GPS base station – names	Y	Included in report and shapefile
GPS base station – lat/longs	Y	Included in report and shapefile
GPS base station – heights	Y	Included in report and shapefile
GPS base station – map	Y	Included in report
GPS base station – Base height (Ellipsoidal meters)	Y	Included in report and shapefile
GPS base station – Max PDOP	Y	Included in report
GPS base station – Map of locations	Y	Included in report and shapefile
Section: GPS/IMU Quality		
GPS quality – Max Horizontal GPS Variance (cm)	Y	Appendix C
GPS quality – Max Vertical GPS Variance (cm)	Y	Appendix C
GPS quality – separation plot	Y	Appendix C
GPS quality – altitude plot	Y	Appendix C
GPS quality – PDOP plot	Y	Appendix C
Plot of GPS distance from base station/s	Y	In report
Notes on GPS quality (High, Good, etc.)	Y	Appendix C
Section: Data Verification and Quality Control		
Description of data verification and QC process	Y	Included in report
Results of verification and QC process steps	Y	Included in report
Section: Spatial Data		
Base Station Point Shapefile	Y	By Others
Ground Control Point Shapefile	Y	Provided
Project Area Coverage (100m Buffer) Polygon Shapefile	Y	Appendix C
Flight Lines As Flown Trajectories Polyline Shapefile	Y	Provided as part of the overall project shapefiles
Flight Lines Calibration Polyline Shapefile	Y	Provided
Flight Lines Planned Flight Lines Polyline Shapefile	Y	Provided
Project Swath Index Polygon Shapefile	NA	Provided
Project Tile Index Polygon Shapefile	Y	

LAS Header Checklist	**Project: Merrimack HUC-8 Watershed Post Processed LiDAR**
Vendor: Photo Science, Inc	**Reviewed By: James L. Huffines**
Files Reviewed: 1749 LAS 1.2 Tiles	

Section: Public Block	**Date: 20AUG2012**

Item	**Included**	**Comments**
File Signature (“LASF”)	Y	
File Source ID	Y	Zero means an ID has not been assigned
Global Encoding	N	Encoded as (0) GPS Week Time
Version Major\Minor	Y	Version 1.2
System Identifier	Y	NIIRS10
Generating Software	Y	
Header Size	Y	
Offset to point data	Y	
Number of Variable Length Records	Y	PCS_NAD83_UTM_zone_19N Linear Meter and NAVD88 Linear US Survey Foot
Point Data Format ID (0-99 for spec)	Y	Format 1
Point Data Record Length	Y	
Number of point records	Y	
Number of points by return	Y	4 returns
X, Y, and Z scale factor	Y	
X, Y, and Z offset	Y	
X, Y, and Z Max	Y	Z values as US Survey Foot
X, Y, and Z Min	Y	Z values as US Survey Foot
Any field in the Public Header Block that is not required and is not used must be zero filled.	Y	

Required Public Block Item Definitions:

File Signature - The file signature must contain the four characters “LASF”, and it is required by the LAS specification.
File Source ID (Flight Line Number if this file was derived from an original flight line) - This field should be set to a value between 1 and 65,535, inclusive. A value of zero (0) is interpreted to mean that an ID has not been assigned. In this case, processing software is free to assign any valid number. Note that this scheme allows a LIDAR project to contain up to 65,535 unique sources. A source can be considered an original flight line or it can be the result of merge and/or extract operations. All of the sources are the results of processing and are not based on the flight line number.
Global Encoding - This is a bit field used to indicate certain global properties about the file. The meaning of GPS Time in the Point Records 0 (not set) -> GPS time in the point record fields is GPS Week Time (the same as previous versions of LAS) 1 (set) -> GPS Time is standard GPS Time (satellite GPS Time) minus 1 x 109 . The offset moves the time back to near zero to improve floating point resolution.

Version Major\Minor - The version number consists of a major and minor field. The major and minor fields combine to form the number that indicates the format number of the current specification itself.

System Identifier - files often result from extraction, merging or modifying existing data files. Values should include: String identifying hardware (“ALS50”), “MERGE”, “MODIFICATION”, “EXTRACTION”, “TRANSFORMATION”, “OTHER” or a string up to 32 characters identifying the operation.

Generating Software – provides a mechanism for specifying which generating software package and version was used during LAS file creation (e.g. “TerraScan V-10.8”, “REALM V-4.2” and etc.).

Header Size - The size, in bytes, of the Public Header Block itself

Offset to point data - The actual number of bytes from the beginning of the file to the first field of the first point record data field. This data offset must be updated if any software adds data from the Public Header Block or adds/removes data to/from the Variable Length Records.

Number of Variable Length Records - This field contains the current number of Variable Length Records. This number must be updated if the number of Variable Length Records changes at any time.

Point Data Format ID - The point data format ID corresponds to the point data record format type. LAS 1.2 define types 0, 1, 2 and 3.

Point Data Record Length - The size, in bytes, of the Point Data Record

Number of point records – The total number of point records within the file

Number of points by return - This field contains an array of the total point records per return. The first unsigned long value will be the total number of records from the first return, and the second contains the total number for return two, and so forth up to five returns.

X, Y, and Z scale factor - The scale factor fields contain a double floating point value that is used to scale the corresponding X, Y, and Z long values within the point records. The corresponding X, Y, and Z scale factor must be multiplied by the X, Y, or Z point record value to get the actual X, Y, or Z coordinate. For example, if the X, Y, and Z coordinates are intended to have two decimal point values, then each scale factor will contain the number 0.01.

X, Y, and Z offset - The offset fields should be used to set the overall offset for the point records. In general these numbers will be zero, but for certain cases the resolution of the point data may not be large enough for a given projection system. However, it should always be assumed that these numbers are used. So to scale a given X from the point record, take the point record X multiplied by the X scale factor, and then add the X offset. (Xcoordinate = (Xrecord * Xscale) + Xoffset, Ycoordinate = (Yrecord * Yscale) + Yoffset, Zcoordinate = (Zrecord * Zscale) + Zoffset)

Max and Min X, Y, and Z - The max and min data fields are the actual unscaled extents of the LAS point file data, specified in the coordinate system of the LAS data.

LAS Header Checklist		
Section: Variable Length Records		**Date: 20AUG2012**
Item	**Included (Y/N)**	**Comments**
GeoKeyDirectoryTag	Y	VLR present in LAS header
User ID ‘LASF_Projection’	Y	VLR present in LAS header
Record ID: 34735	Y	VLR present in LAS header
Length after Header	Y	VLR present in LAS header
'GeoTiff Projection Keys'	Y	VLR present in LAS header

Required Variable Length Record Definitions:

Georeferencing Information - Georeferencing for the LAS format will use the same robust mechanism that was developed for the GeoTIFF standard. The variable length header records section will contain the same data that would be contained in the GeoTIFF key tags of a TIFF file. Since LAS is not a raster format and each point contains its own absolute location information, only 3 of the 6 GeoTIFF tags are necessary. The GeoKeyDirectoryTag (34735), GeoDoubleParamsTag (34736), and GeoASCIIParamsTag (34737) records are used. Only the GeoKeyDirectoryTag record is required. The GeoDoubleParamsTag and GeoASCIIParamsTag records may or may not be present, depending on the content of the GeoKeyDirectoryTag record.
GeoKeyDirectoryTag Record (mandatory) - User ID: LASF_Projection, Record ID: 34735. This record contains the key values that define the coordinate system.
GeoDoubleParamsTag Record (Optional) - User ID: LASF_Projection, Record ID: 34736. This record is simply an array of doubles that contain values referenced by tag sets in the GeoKeyDirectoryTag record.
GeoAsciiParamsTag Record (Optional) - User ID: LASF_Projection, Record ID: 34737. This record is simply an array of ASCII data. It contains many strings separated by null terminator characters which are referenced by position from data in the GeoKeyDirectoryTag record.

LAS Header Checklist		
Section: Point Data Record		**Date: 20AUG2012**
Item	**Included (Y/N)**	**Comments**
Point record format 1,3,4, or 5	Y	
X, Y, Z	Y	
Intensity	Y	
Edge of Flight Line	Y	
Scan Direction Flag	Y	
Return Number	Y	
Number of Returns (given pulse)	Y	
Classification	Y	1, 2, 7, 8, 9, 10, 11, 17 and 18
Scan Angle Rank (-90 to +90)	Y	
Point Source ID	Y	
GPS Time	Y	

Required Point Data Record Definitions:

X, Y, and Z – The X, Y, and Z values are stored as long integers. The X, Y, and Z values are used in conjunction with the scale values and the offset values to determine the coordinate for each point as described in the Public Header Block section.
Intensity – The integer representation of the pulse return magnitude
Edge of Flight Line – The Edge of Flight Line data bit has a value of 1 only when the point is at the end of a scan. It is the last point on a given scan line before it changes direction.
Scan Direction Flag – denotes the direction at which the scanner mirror was traveling at the time of the output pulse. A bit value of 1 is a positive scan direction, and a bit value of 0 is a negative scan direction (where positive scan direction is a scan moving from the left side of the in-track direction to the right side and negative the opposite).
Return Number – The Return Number is the pulse return number for a given output pulse. A given output laser pulse can have many returns, and they must be marked in sequence of return. The first return will have a Return Number of one, the second a Return Number of two, and so on up to five returns.
Number of Returns (for this emitted pulse) – The Number of Returns is the total number of returns for a given pulse. For example, a laser data point may be return two (Return Number) within a total number of five returns.
Scan Angle Rank – The Scan Angle Rank is a signed one-byte number with a valid range from -90 to +90. The Scan Angle Rank is the angle (rounded to the nearest integer in the absolute value sense) at which the laser point was output from the laser system including the roll of the aircraft. The scan angle is within 1 degree of accuracy from +90 to –90 degrees. The scan angle is an angle based on 0 degrees being nadir, and –90 degrees to the left side of the aircraft in the direction of flight.

Point Source ID – This value indicates the file from which this point originated. Valid values for this field are 1 to 65,535 inclusive with zero being used for a special case discussed below. The numerical value corresponds to the File Source ID from which this point originated. Zero is reserved as a convenience to system implementers. A Point Source ID of zero implies that this point originated in this file. This implies that processing software should set the Point Source ID equal to the File Source ID of the file containing this point at some time during processing.

GPS Time – The GPS Time is the double floating point time tag value at which the point was acquired. It is GPS Week Time if the Global Encoding low bit is clear and POSIX Time if the Global Encoding low bit is set (see Global Encoding in the Public Header Block description).

Classification – Standard set of ASPRS classifications

Classification Value	**Definition**
0	Created, Never Classified
1	Unclassified
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key-point (mass point)
9	Water
10	Ignored Ground (breakline proximity)
11	Withheld if Withheld bit is not implemented in processing software
12	Overlap (Should not be included)
13-31	Reserved for ASPRS Definition

```
CONSISTENCY CHECKS
FileName               1749 of 1749
CreationDate           1749 of 1749
Version                1749 of 1749
FileSourceIDHeader     0 of 1749
GeneratingSoftware     1749 of 1749
SystemID               1749 of 1749
ProjectID              1749 of 1749
MaxHeaderX             1749 of 1749
MaxHeaderY             1749 of 1749
MaxHeaderZ             1749 of 1749
MinHeaderX             1749 of 1749
MinHeaderY             1749 of 1749
MinHeaderZ             1749 of 1749
DataFormat             1749 of 1749
NumVLR                 1749 of 1749
PointDataRecordLength  1749 of 1749
FileSize               1749 of 1749
MinStatsX              1749 of 1749
MinStatsY              1749 of 1749
MinStatsZ              1749 of 1749
MaxStatsX              1749 of 1749
MaxStatsY              1749 of 1749
MaxStatsZ              1749 of 1749
OffsetX                1749 of 1749
OffsetY                1749 of 1749
OffsetZ                1749 of 1749
ScaleX                 1749 of 1749
ScaleY                 1749 of 1749
ScaleZ                 1749 of 1749
HeaderTotal            1749 of 1749
Header1stRet           1749 of 1749
Header2ndRet           1749 of 1749
Header3rdRet           1749 of 1749
Header4thRet           1749 of 1749
Header5thRet           1749 of 1749
StatsTotal             1749 of 1749
Stats1stRet            1749 of 1749
Stats2ndRet            1749 of 1749
Stats3rdRet            1749 of 1749
Stats4thRet            1749 of 1749
Stats5thRet            1749 of 1749
MinIntensityRange      1749 of 1749
MaxIntensityRange      1749 of 1749
MinEdgeOfFlightLine    1749 of 1749
MaxEdgeOfFlightLine    1749 of 1749
MinScanDirection       1749 of 1749
MaxScanDirection       1749 of 1749
MinScanAngle           1749 of 1749
MaxScanAngle           1749 of 1749
MinReturn              1749 of 1749
MaxReturn              1749 of 1749
MinPointSourceID       1749 of 1749
MaxPointSourceID       1749 of 1749
```

```
GpsStartTime           1749 of 1749
GpsEndTime             1749 of 1749
Projection             1749 of 1749
VertDatum              1749 of 1749
HorzDatum              1749 of 1749
EPSGCode               1749 of 1749
VertUnits              1749 of 1749
```

Project Information

Prepared By: James L. Huffines
Project Name: Merrimack watershed
Sensor Info: NA
Required Nominal Pulse Spacing: 1
Vendor Name: PSI
Units: US Survey Feet
Percent of Extent Tolerance: Extents Not Checked
Date of Aquisition: Start: 8/20/2012 Finish: 8/20/2012

Metadata Information

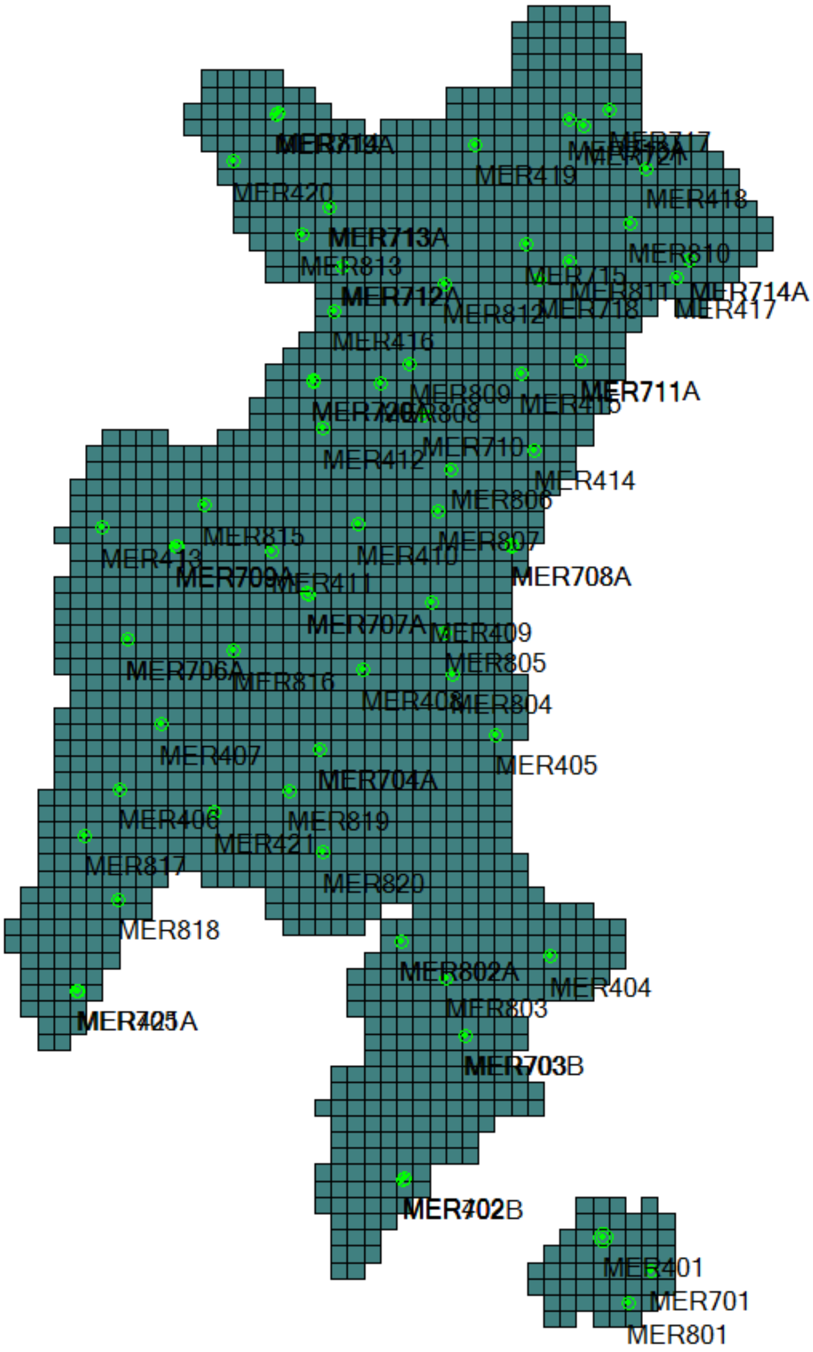
Tile Index:
- Path: C:\FEMA\Region_1\MA\Merrimack_Watershed\TopoAnalyst\Merrimack_LiDAR_Index.shp
- Number of Polys: 0

Intensity:
- Tile Index Attribute: Not Specified
- Path to Data: Not Specified
- Number of Data Files Matching Attribute: Not Specified

DEM:
- Tile Index Attribute: DEM
- Path to Data: B:\FEMA_REGION_1\Merrimack_Watershed_MA\2mDEM
- Number of Data Files Matching Attribute: 1749 out of 1749

LAS:
- Tile Index Attribute: FileName
- Path to Data: Z:\MA\Merrimack_Watershed\Merrimack_Classified_LAS
- Number of Data Files Matching Attribute: 1749 out of 1749

Tiled-Data Area



LiDAR Accuracy Assessment Summary

LC Type	# of Points	FVA	SVA	CVA
LAS				
ALL	76			0.899
Grass	20		0.893	
Open	4	0.263	0.206	
Forest	34		1.044	
Urban	18		0.433	
Total	76			
DEM				
ALL	76			
Grass	20			
Open	4			
Forest	34			
Urban	18			
Total	76			

Units: US Survey Feet

Coordinates and Offsets of Analyzed Locations

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					ΔZ DEM	ΔZ LAS	LC Type
1)	☑	MER401					
			314502.151	4707864.758	134.103	134.009	134.086
					-0.094	-0.017	Grass
2)	☑	MER402					
			296176.414	4713293.172	218.301	218.389	218.408
					0.088	0.107	Grass
3)	☑	MER404					
			309632.429	4733617.659	149.916	149.584	149.637
					-0.332	-0.279	Grass
4)	☑	MER405					
			304602.218	4753950.102	273.599	273.922	273.968
					0.323	0.369	Grass
5)	☑	MER406					
			270008.616	4749006.264	860.623	861.272	861.129
					0.649	0.506	Grass
6)	☑	MER407					
			273867.985	4754941.448	785.082	785.471	785.401
					0.389	0.319	Grass
7)	☑	MER408					
			292327.41	4759908.483	404.654	404.751	404.742
					0.097	0.088	Grass

Coordinates and Offsets of Analyzed Locations (Continued)

	ID					
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				ΔZ DEM	ΔZ LAS	LC Type
8) ☑	MER409					
		298679.174	4766132.116	242.966	243.675	243.678
				0.709	0.712	Grass
9) ☑	MER410					
		291943.439	4773299.081	597.092	598.064	597.993
				0.972	0.901	Grass
10) ☑	MER411					
		284086.191	4770799.785	312.29	313.033	313.035
				0.743	0.745	Grass
11) ☑	MER412					
		288738.405	4782124.334	359.212	359.5	359.445
				0.288	0.233	Grass
12) ☑	MER413					
		268422.51	4772990.992	1104.59	1105.028	1104.905
				0.438	0.315	Grass
13) ☑	MER414					
		308184.833	4780099.15	413.683	413.884	413.913
				0.201	0.23	Grass
14) ☑	MER415					
		306939.262	4787204.256	346.659	347.203	347.123
				0.544	0.464	Grass

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					ΔZ DEM	ΔZ LAS	LC Type
15)	☑	MER416					
			289738.978	4792935.47	364.234	364.827	364.749
					0.593	0.515	Grass
16)	☑	MER417					
			321153.55	4795905.568	847.601	847.77	847.831
					0.169	0.23	Grass
17)	☑	MER418					
			318428.501	4805975.882	664.848	665.139	665.157
					0.291	0.309	Grass
18)	☑	MER419					
			302738.109	4808202.086	851.167	851.143	851.18
					-0.024	0.013	Grass
19)	☑	MER420					
			280450.086	4806679.287	776.68	777.04	777.031
					0.36	0.351	Grass
20)	☑	MER421					
			278757.256	4746821.78	280.026	279.938	279.983
					-0.088	-0.043	Open
21)	☑	MER421A					
			266317.893	4730482.473	1049.689	1049.728	1049.724
					0.039	0.035	Grass

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	**Survey Y**	**Z1**	**Z DEM**	**Z LAS**
					ΔZ DEM	**ΔZ LAS**	**LC Type**
22)	☑	MER701					
			318793.616	4704749.082	157.57	157.714	157.716
					0.144	0.146	Forest
23)	☑	MER702					
			296113.646	4713125.813	215.401	215.802	215.731
					0.401	0.33	Forest
24)	☑	MER702B					
			296088.089	4713109.108	215.775	215.85	216.05
					0.075	0.275	Forest
25)	☑	MER703					
			301820.306	4726372.555	238.232	238.394	238.431
					0.162	0.199	Forest
26)	☑	MER703B					
			301800.93	4726356.427	239.065	239.453	239.542
					0.388	0.477	Forest
27)	☑	MER704					
			288374.536	4752611.14	242.677	242.833	242.901
					0.156	0.224	Forest
28)	☑	MER704A					
			288366.486	4752649.256	246.46	246.785	246.753
					0.325	0.293	Forest

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	**Survey Y**	**Z1**	**Z DEM**	**Z LAS**
					ΔZ DEM	**ΔZ LAS**	**LC Type**
29)	☑	**MER705**					
			266125.412	4730494.084	1049.078	1049.337	1049.4
					0.259	0.322	Forest
30)	☑	**MER706**					
			270797.933	4762743.985	810.151	810.427	810.283
					0.276	0.132	Forest
31)	☑	**MER706A**					
			270762.381	4762738.061	809.409	810.239	809.911
					0.83	0.502	Forest
32)	☑	**MER707**					
			287331.916	4766901.508	316.207	316.36	316.203
					0.153	-0.004	Forest
33)	☑	**MER707A**					
			287323.595	4766970.868	322.463	322.86	322.845
					0.397	0.382	Forest
34)	☑	**MER708**					
			306098.577	4771361.505	457.321	458.026	457.936
					0.705	0.615	Forest
35)	☑	**MER708A**					
			306114.827	4771339.266	455.605	456.425	456.397
					0.82	0.792	Forest

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	**Survey Y**	**Z1**	**Z DEM**	**Z LAS**
					ΔZ DEM	**ΔZ LAS**	**LC Type**
36)	☑	**MER709**					
			275283.972	4771260.466	662.603	663.633	663.555
					1.03	0.952	Forest
37)	☑	**MER709A**					
			275275.535	4771316.881	666.741	667.759	667.64
					1.018	0.899	Forest
38)	☑	**MER710**					
			297953.848	4783269.321	332.227	331.942	332.246
					-0.285	0.019	Forest
39)	☑	**MER711**					
			312382.055	4788309.919	436.323	436.592	436.707
					0.269	0.384	Forest
40)	☑	**MER711A**					
			312393.645	4788332.597	440.201	440.628	440.548
					0.427	0.347	Forest
41)	☑	**MER712**					
			290448.119	4797016.1	316.446	317.451	317.765
					1.005	1.319	Forest
42)	☑	**MER712A**					
			290504.016	4797004.872	324.75	325.799	325.394
					1.049	0.644	Forest

Coordinates and Offsets of Analyzed Locations (Continued)

	ID					
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				ΔZ DEM	ΔZ LAS	LC Type
43) ☑	MER713					
		289275.933	4802436.795	558.254	559.16	558.729
				0.906	0.475	Forest
44) ☑	MER713A					
		289342.347	4802421.347	538.586	538.805	539.003
				0.219	0.417	Forest
45) ☑	MER714					
		322405.86	4797498.89	725.405	725.409	725.603
				0.004	0.198	Forest
46) ☑	MER715					
		307383.115	4799003.2	550.013	550.171	550.236
				0.158	0.223	Forest
47) ☑	MER714A					
		322402.77	4797556.985	722.166	722.366	722.148
				0.2	-0.018	Forest
48) ☑	MER716A					
		311292.031	4810429.897	774.092	774.504	774.379
				0.412	0.287	Forest
49) ☑	MER717					
		315098.657	4811320.465	991.051	991.243	991.407
				0.192	0.356	Forest

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					ΔZ DEM	ΔZ LAS	LC Type
50)	☑	MER718					
			308500.742	4795841.975	439.978	440.737	440.868
					0.759	0.89	Forest
51)	☑	MER719					
			284397.138	4810998.83	410.244	410.1	410.056
					-0.144	-0.188	Forest
52)	☑	MER719A					
			284436.041	4810998.877	406.862	406.764	406.684
					-0.098	-0.178	Forest
53)	☑	MER720					
			287816.888	4786454.86	417.236	417.576	417.312
					0.34	0.076	Forest
54)	☑	MER720A					
			287811.463	4786530.638	440.89	441.042	441.26
					0.152	0.37	Forest
55)	☑	MER721					
			312690.901	4809979.227	767.684	767.74	767.925
					0.056	0.241	Forest
56)	☑	MER801					
			316786.831	4701735.469	215.778	215.41	215.379
					-0.368	-0.399	Urban

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					ΔZ DEM	ΔZ LAS	LC Type
57)	☑	MER802					
			295909.304	4735006.413	183.728	183.746	183.708
					0.018	-0.02	Urban
58)	☑	MER802A					
			295909.293	4735006.413	183.731	183.746	183.708
					0.015	-0.023	Urban
59)	☑	MER803					
			300111.679	4731637.724	155.756	155.666	155.665
					-0.09	-0.091	Urban
60)	☑	MER804					
			300585.761	4759568.06	245.716	245.572	245.512
					-0.144	-0.204	Urban
61)	☑	MER805					
			299893.94	4763348.969	257.471	257.382	257.361
					-0.089	-0.11	Urban
62)	☑	MER806					
			300520.947	4778344.319	297.969	297.997	297.936
					0.028	-0.033	Urban
63)	☑	MER807					
			299342.807	4774564.448	220.526	220.782	220.752
					0.256	0.226	Urban

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	**Survey Y**	**Z1**	**Z DEM**	**Z LAS**
					ΔZ DEM	**ΔZ LAS**	**LC Type**
64)	☑	**MER808**					
			293961.444	4786294.109	286.142	286.179	286.182
					0.037	0.04	Urban
65)	☑	**MER809**					
			296708.191	4788078.691	350.576	350.646	350.718
					0.07	0.142	Urban
66)	☑	**MER810**					
			316878.193	4801010.122	515.187	515.446	515.402
					0.259	0.215	Urban
67)	☑	**MER811**					
			311382.502	4797473.79	495.165	495.323	495.387
					0.158	0.222	Urban
68)	☑	**MER812**					
			299875.586	4795411.314	385.645	386.015	386.023
					0.37	0.378	Urban
69)	☑	**MER813**					
			286779.635	4799907.679	332.283	332.762	332.666
					0.479	0.383	Urban
70)	☑	**MER814**					
			284613.704	4811143.184	409.493	409.725	409.673
					0.232	0.18	Urban

Coordinates and Offsets of Analyzed Locations (Continued)

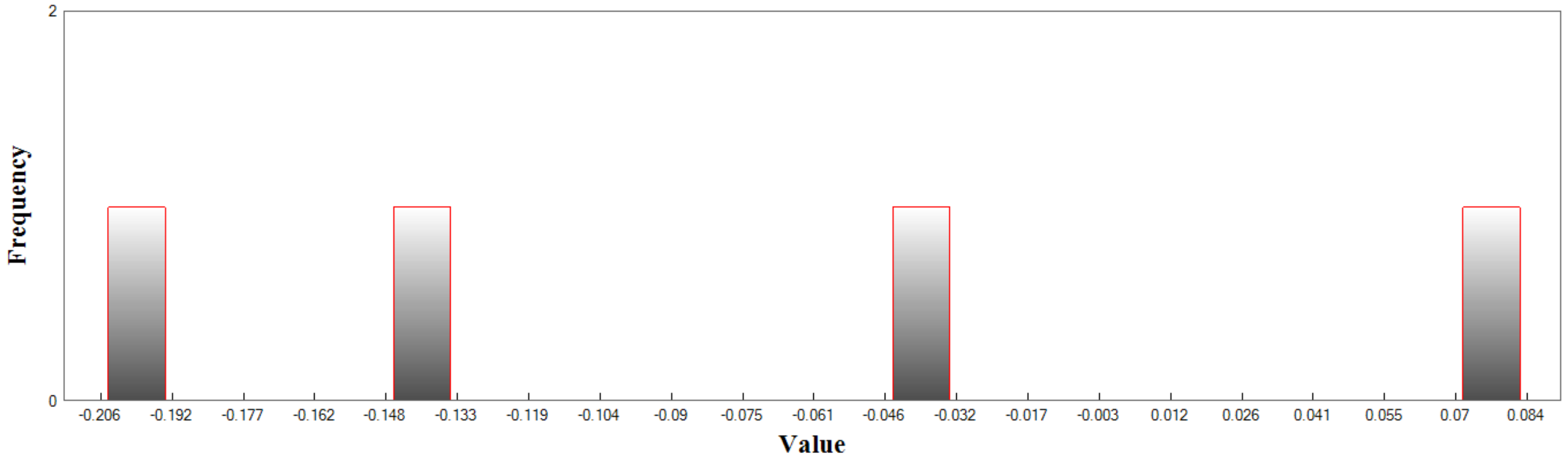
	ID					
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				ΔZ DEM	ΔZ LAS	LC Type
71) ☑	MER815					
		277827.487	4775022.376	640.845	641.218	641.278
				0.373	0.433	Urban
72) ☑	MER816					
		280519.973	4761677.85	416.307	416.14	416.101
				-0.167	-0.206	Open
73) ☑	MER817					
		266896.253	4744720.278	1034.18	1034.232	1034.265
				0.052	0.085	Open
74) ☑	MER818					
		269930.562	4738813.528	821.296	821.55	821.53
				0.254	0.234	Urban
75) ☑	MER819					
		285600.368	4748859.657	261.545	261.386	261.401
				-0.159	-0.144	Open
76) ☑	MER820					
		288796.499	4743137.663	226.438	226.346	226.351
				-0.092	-0.087	Urban

LAS

Fundamental Vertical Accuracy

LandCover Type: Open
Minimum DZ: -0.206
Maximum DZ: 0.085
Mean DZ: -0.077
Mean Magnitude DZ: 0.345
Number Observations: 4
Standard Deviation DZ: 0.127
RMSE Z: 0.134
95% Confidence Level Z: 0.263
Units: US Survey Feet

Histogram



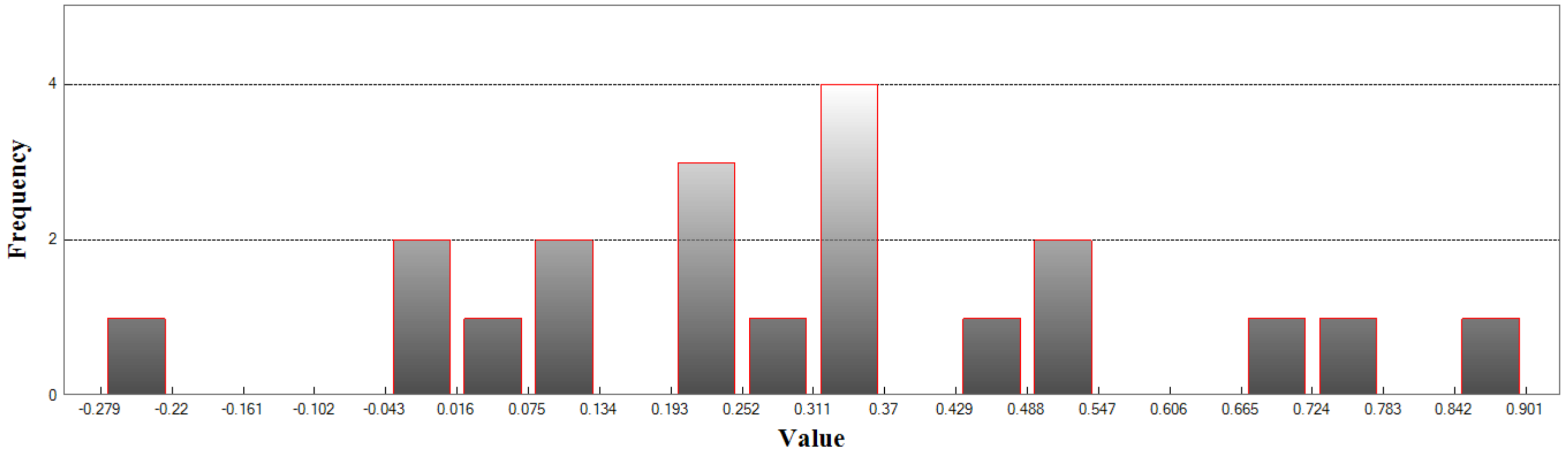
Min: -0.206
Max: 0.085
Number Of Bins: 20
Bin Interval: 0.015

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Grass
Minimum DZ: -0.279
Maximum DZ: 0.901
Mean DZ: 0.307
Mean Magnitude DZ: 0.58
Number Observations: 20
Standard Deviation DZ: 0.284
RMSE Z: 0.414
95th Percentile: 0.893
Units: US Survey Feet

Histogram



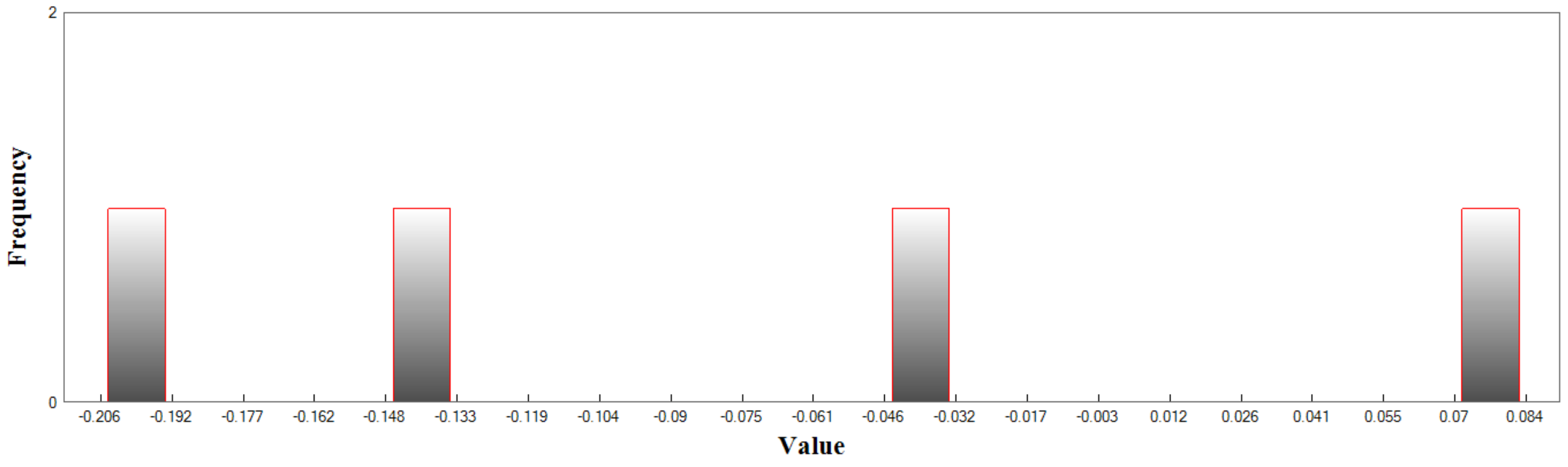
Min: -0.279
Max: 0.901
Number Of Bins: 20
Bin Interval: 0.059

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Open
Minimum DZ: -0.206
Maximum DZ: 0.085
Mean DZ: -0.077
Mean Magnitude DZ: 0.345
Number Observations: 4
Standard Deviation DZ: 0.127
RMSE Z: 0.134
95th Percentile: 0.206
Units: US Survey Feet

Histogram



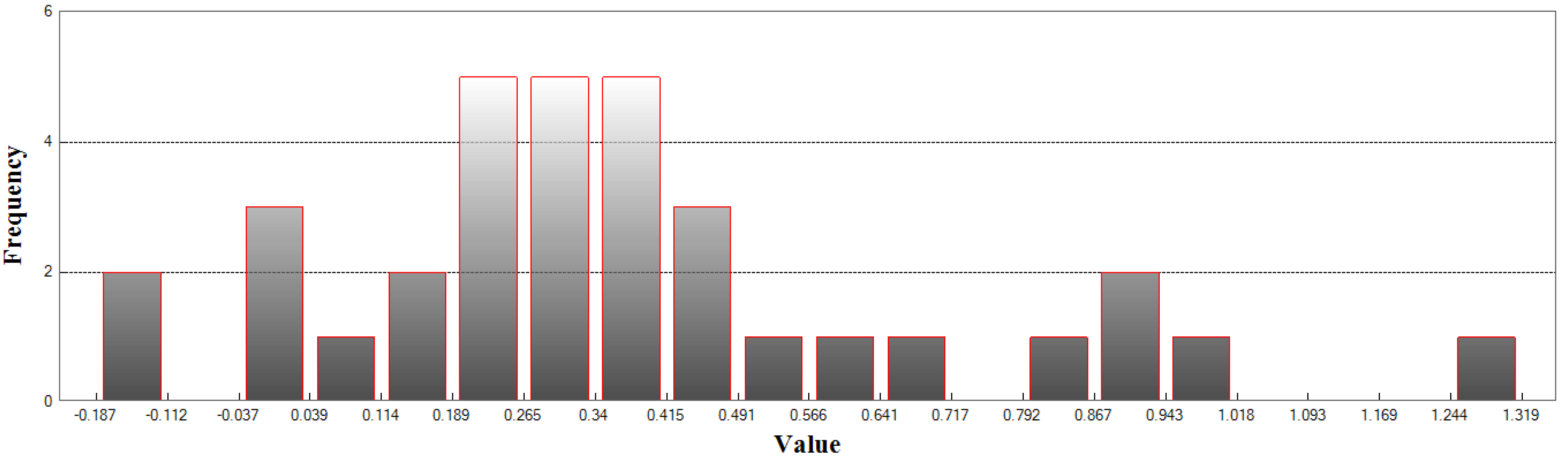
Min: -0.206
Max: 0.085
Number Of Bins: 20
Bin Interval: 0.015

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Forest
Minimum DZ: -0.188
Maximum DZ: 1.319
Mean DZ: 0.365
Mean Magnitude DZ: 0.622
Number Observations: 34
Standard Deviation DZ: 0.326
RMSE Z: 0.486
95th Percentile: 1.044
Units: US Survey Feet

Histogram



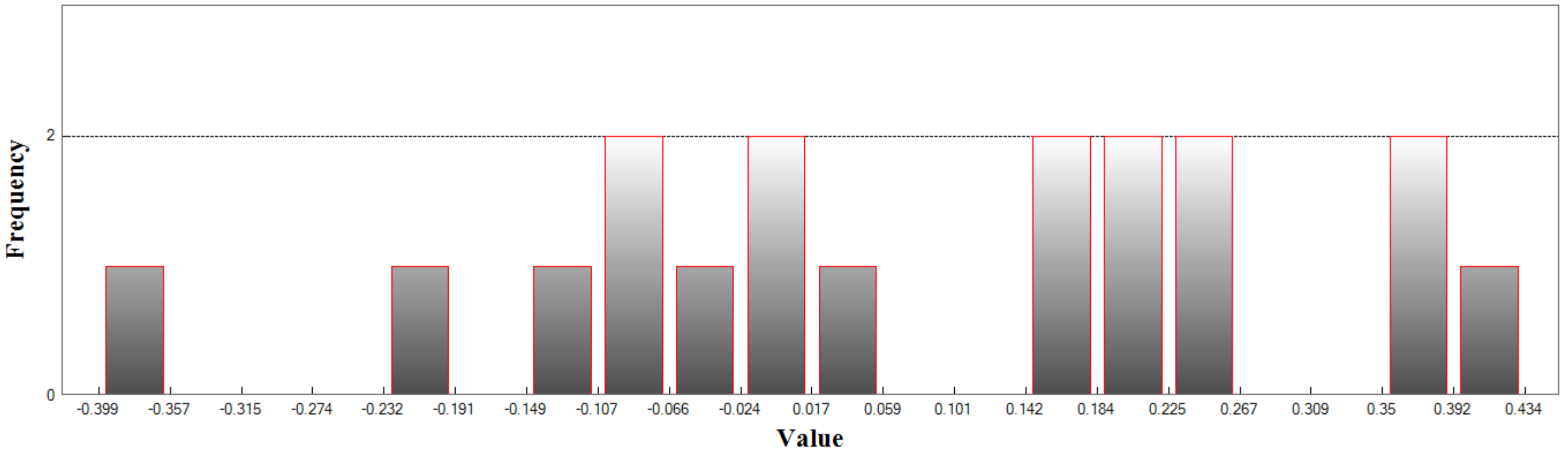
Min: -0.188
Max: 1.319
Number Of Bins: 20
Bin Interval: 0.075

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Urban
Minimum DZ: -0.399
Maximum DZ: 0.433
Mean DZ: 0.083
Mean Magnitude DZ: 0.436
Number Observations: 18
Standard Deviation DZ: 0.222
RMSE Z: 0.231
95th Percentile: 0.433
Units: US Survey Feet

Histogram



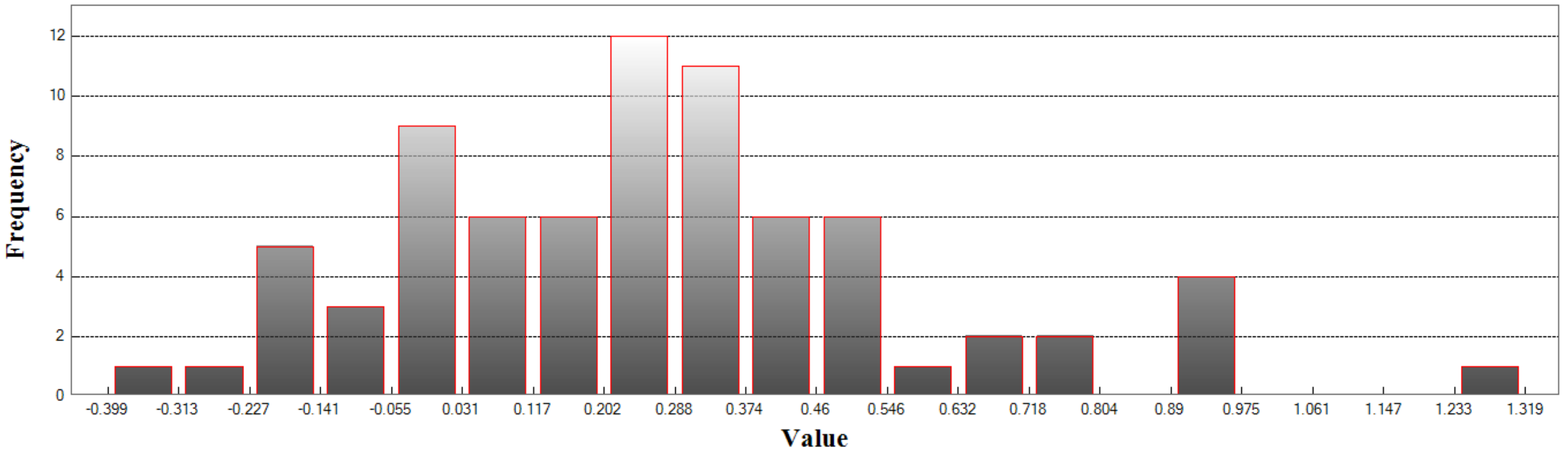
Min: -0.399
Max: 0.433
Number Of Bins: 20
Bin Interval: 0.042

LAS (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.399
Maximum DZ: 1.319
Mean DZ: 0.26
Mean Magnitude DZ: 0.56
Number Observations: 76
Standard Deviation DZ: 0.314
RMSE Z: 0.405
95th Percentile: 0.899
Units: US Survey Feet

Histogram



Min: -0.399
Max: 1.319
Number Of Bins: 20
Bin Interval: 0.086

STARR

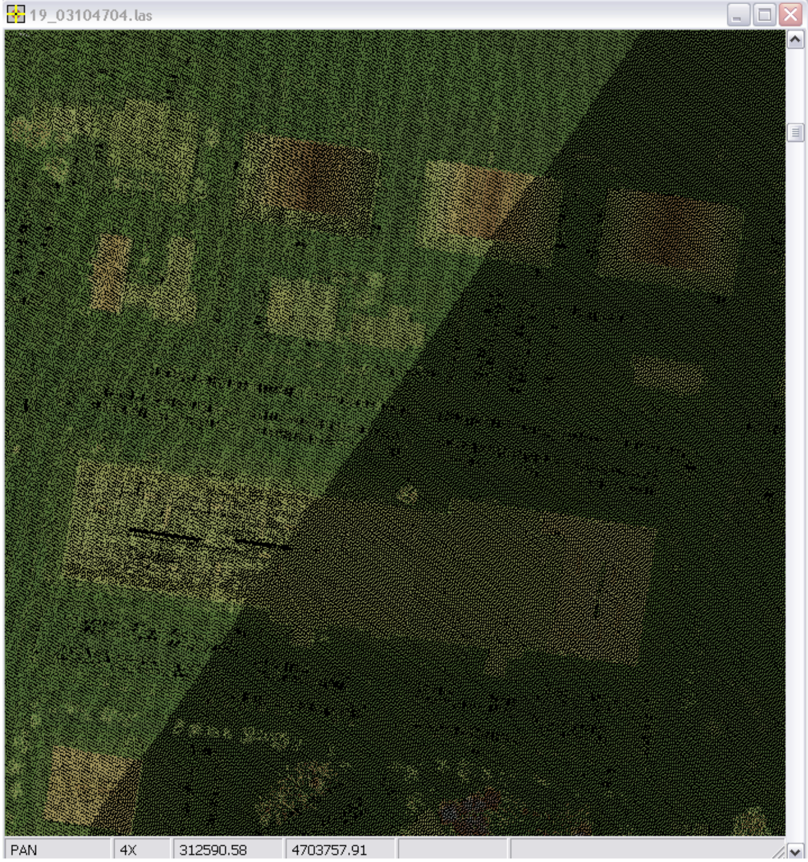
FEMA Region I Merrimack Watershed LiDAR Dataset

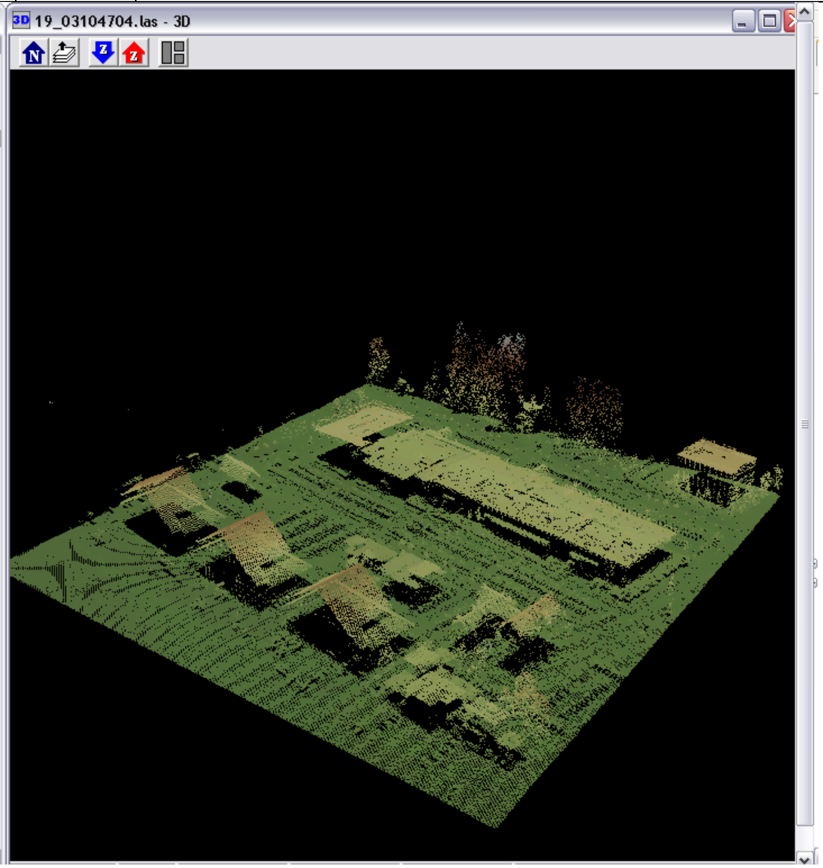
Unclassified LiDAR Micro Review

Quality Assurance Forms
7/20/2012

Unclassified Point Cloud Data Checklist	**Project: Merrimack**
Vendor:	**Reviewed By: MCC**
LAS Tiles: 19_03104702.las; 19_03104704.las; 19_03124702.las; 19_03124704.las	**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	See Fig. 2 about gap over asphalt taxiway legitimate data void
Returns	P	
Edge matching	P	





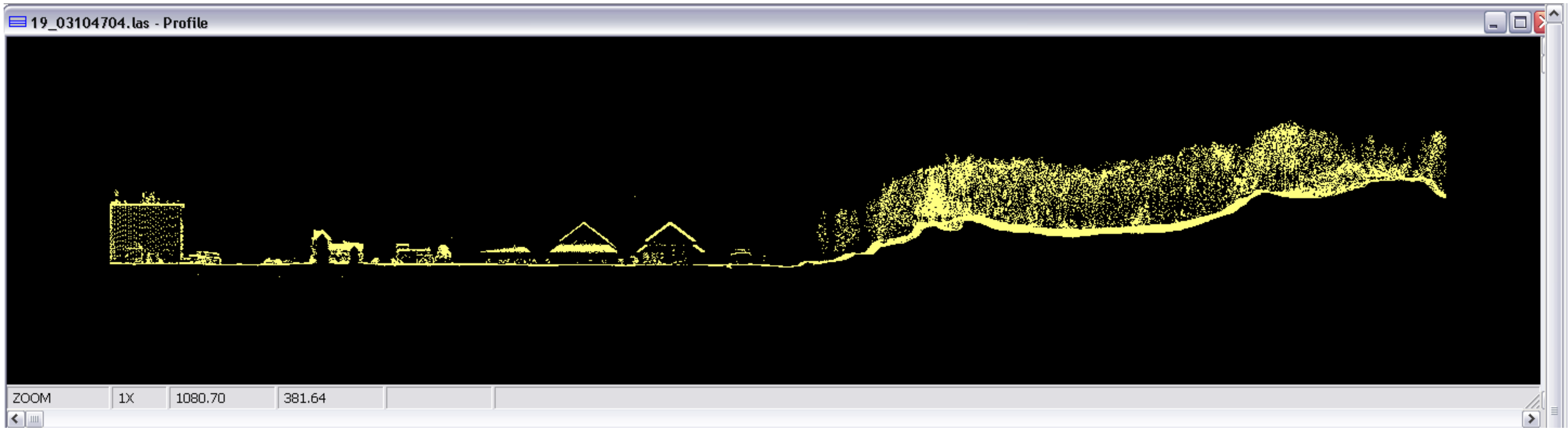


Fig. 1

Fig. 2 - Asphalt taxiway shown as gap in Point Cloud

Unclassified Point Cloud Data Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS Tiles: 19_03154707.las; 19_03154708.las; 19_03164707.las; 19_03164708.las; 19_03184707.las; 19_03184708.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS Tiles: 19_03034722.las; 19_03034724.las; 19_03034725.las; 19_03044722.las; 19_03044724.las; 19_03064722.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

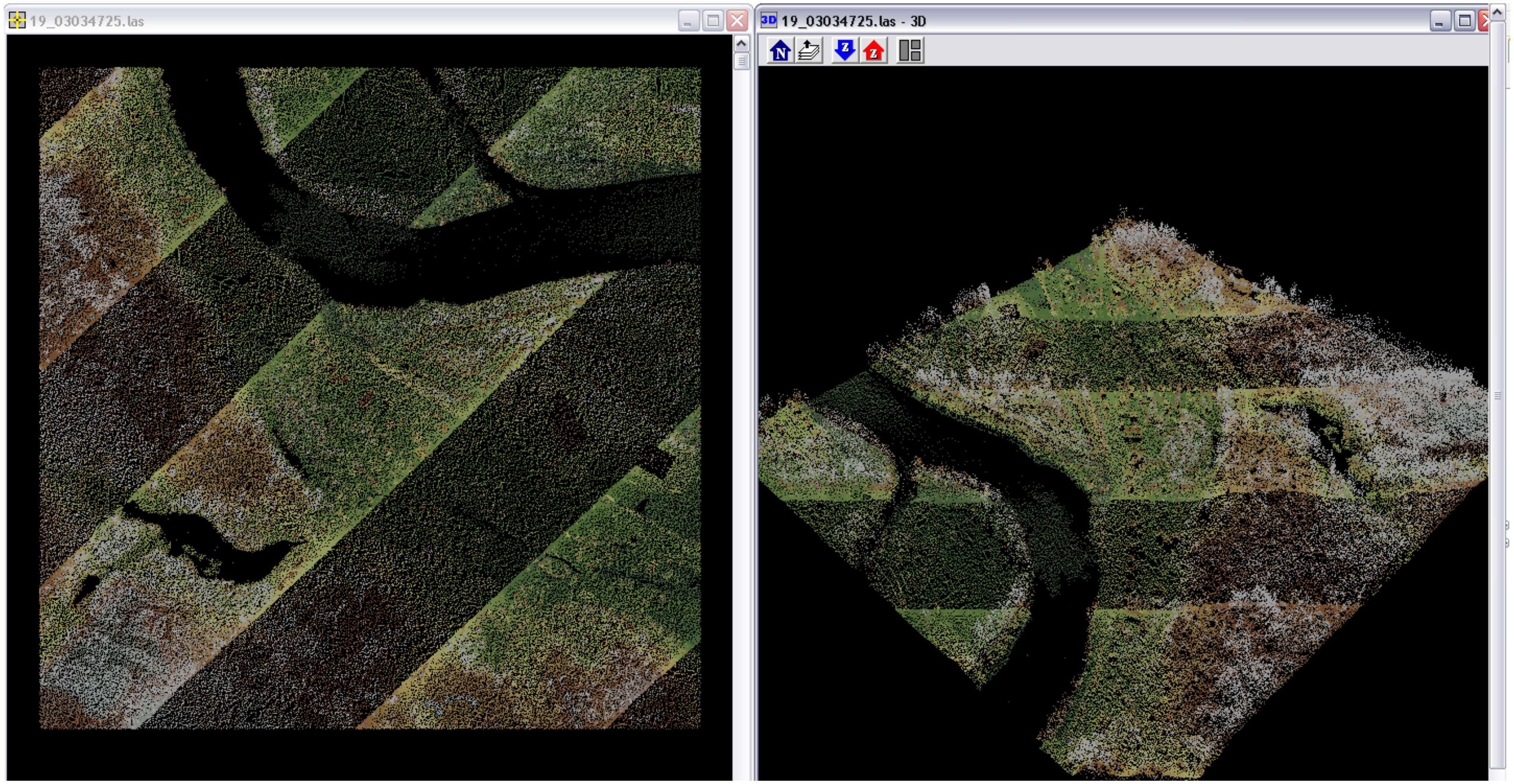


Fig. 4

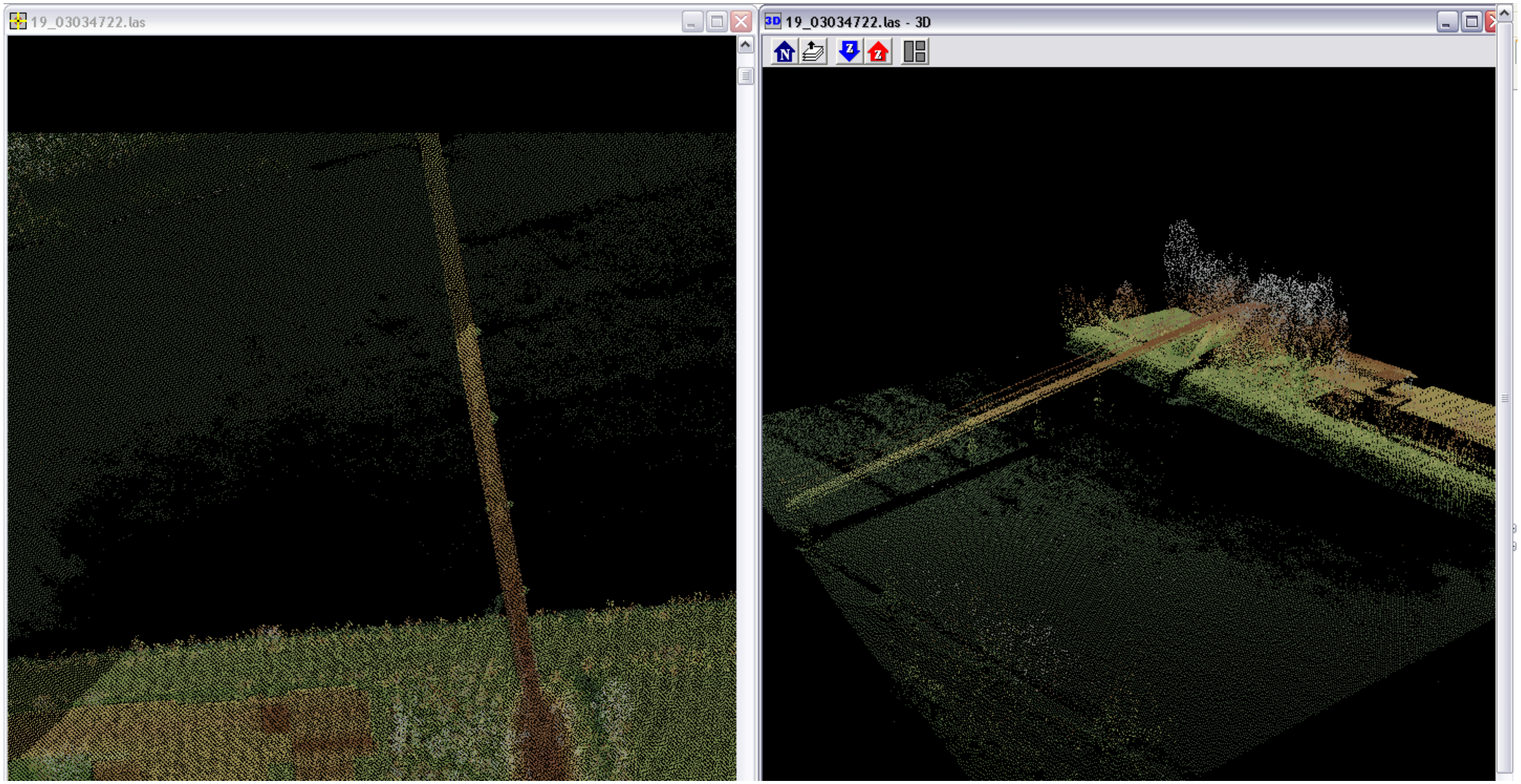


Fig. 5

Unclassified Point Cloud Data Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: MCC**	
LAS Tiles: 19_03124732.las			**Date: 7/20/12**
Item	**P/F/NA**	**Comments**	
Scan and profile	P		
Excessive Noise	P		
Elevation Steps	P		
Gaps/Voids	P		
Returns	P		
Edge matching	P		

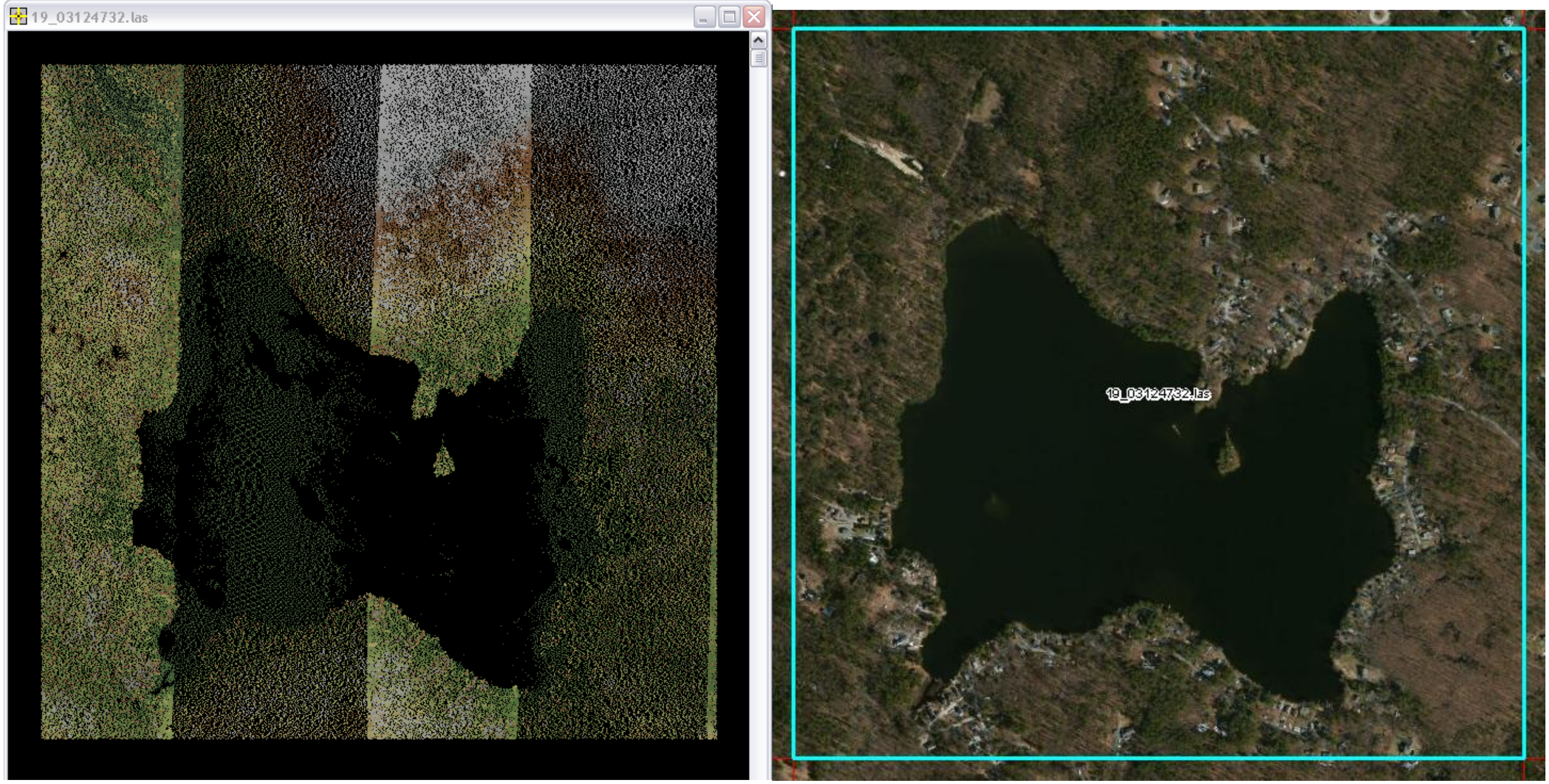


Fig. 6

Unclassified Point Cloud Data Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: MCC**

LAS Tiles: 19_02974736.las; 19_02974737.las; 19_02974738.las; 19_02984736.las; 19_02984737.las; 19_02984738.las; 19_03004736.las; 19_03004737.las; 19_03004738.las | **Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

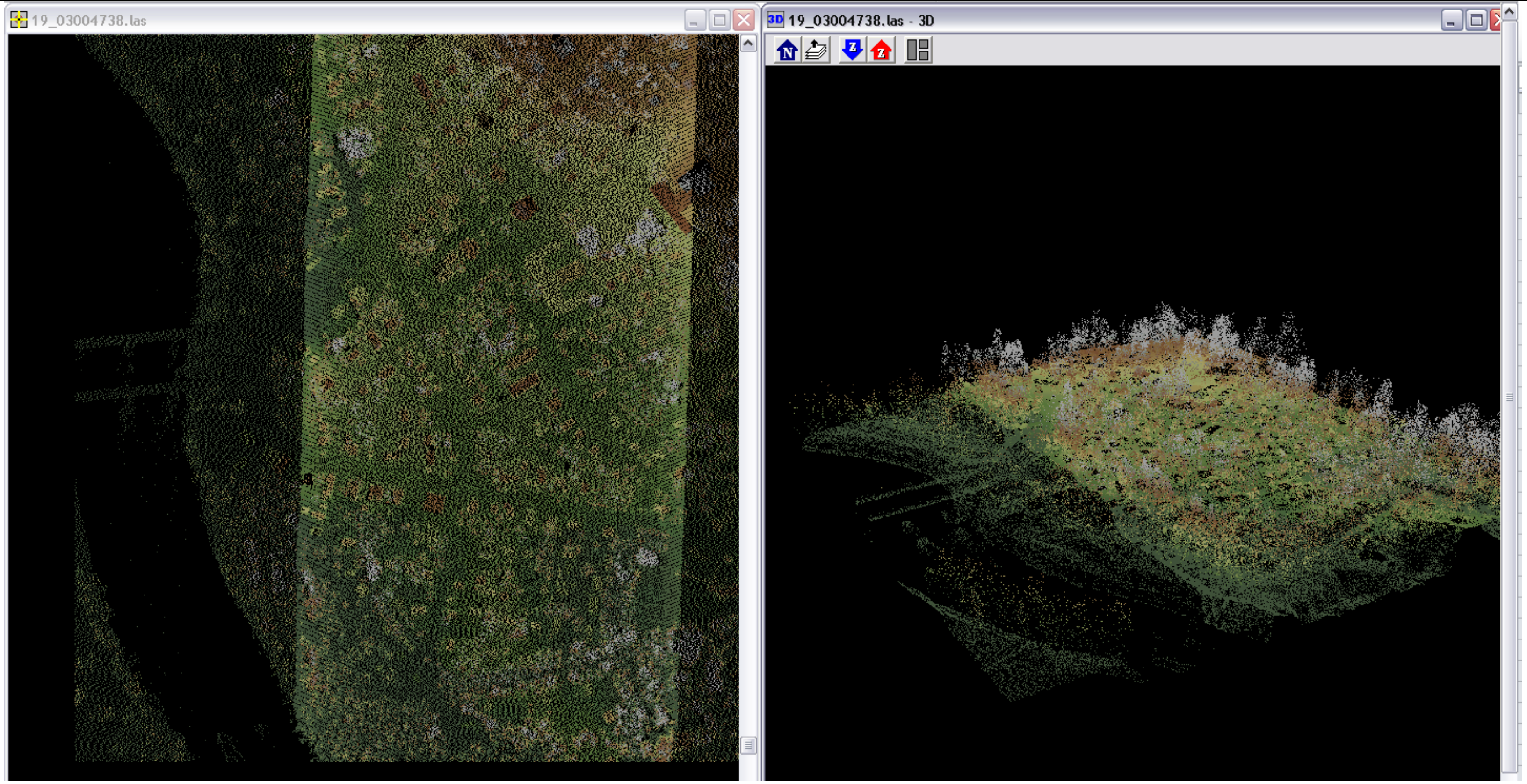


Fig. 7

Fig. 8

Unclassified Point Cloud Data Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS Tiles: 19_02964731.las; 19_02964732.las; 19_02974732.las; 19_02974734.las		**Date: 7/23/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

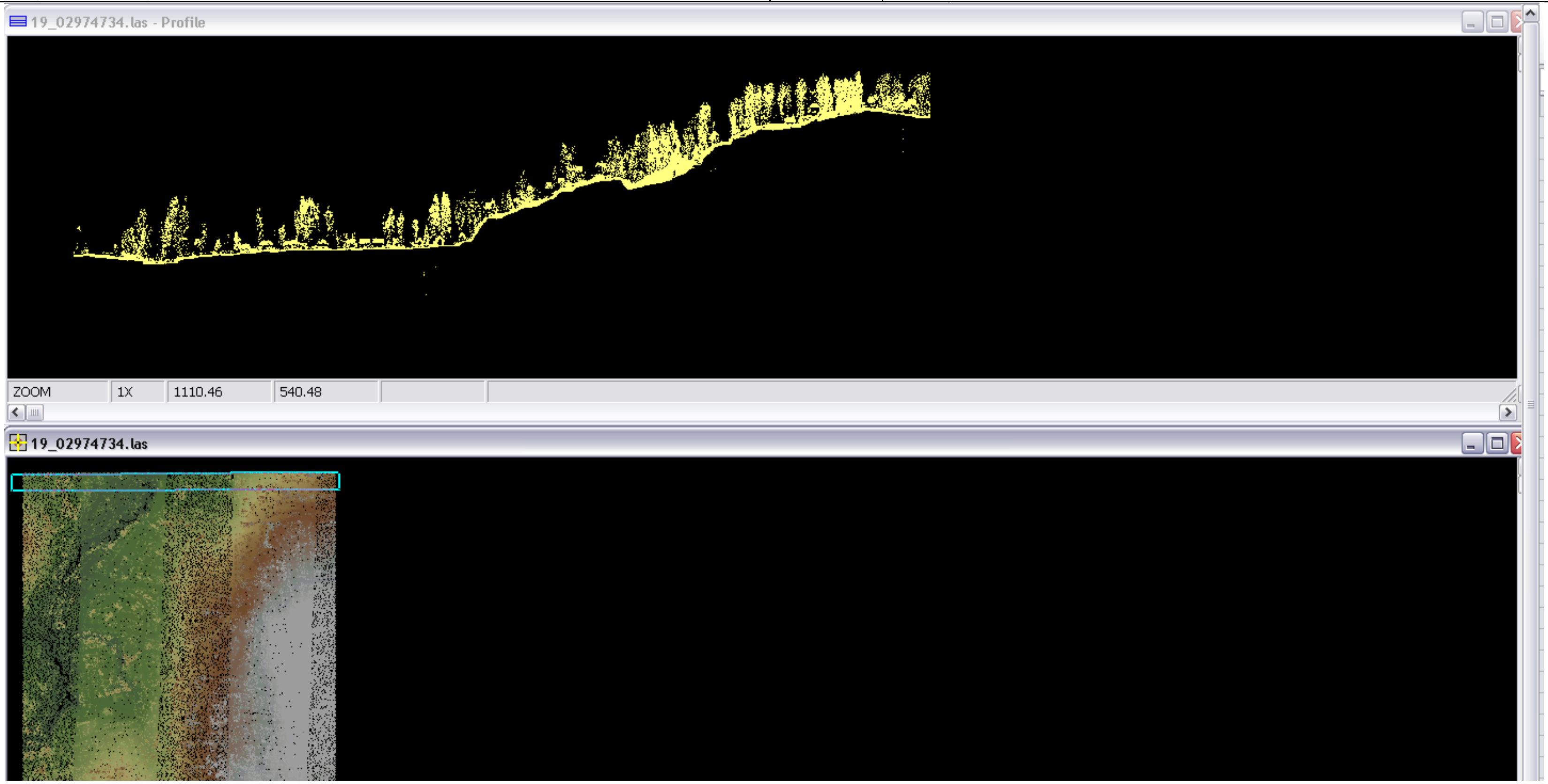


Fig. 9

Unclassified Point Cloud Data Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: MCC**

LAS Tiles: 19_03004730.las; 19_03004731.las; 19_03004732.las; 19_03004734.las | **Date: 7/23/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

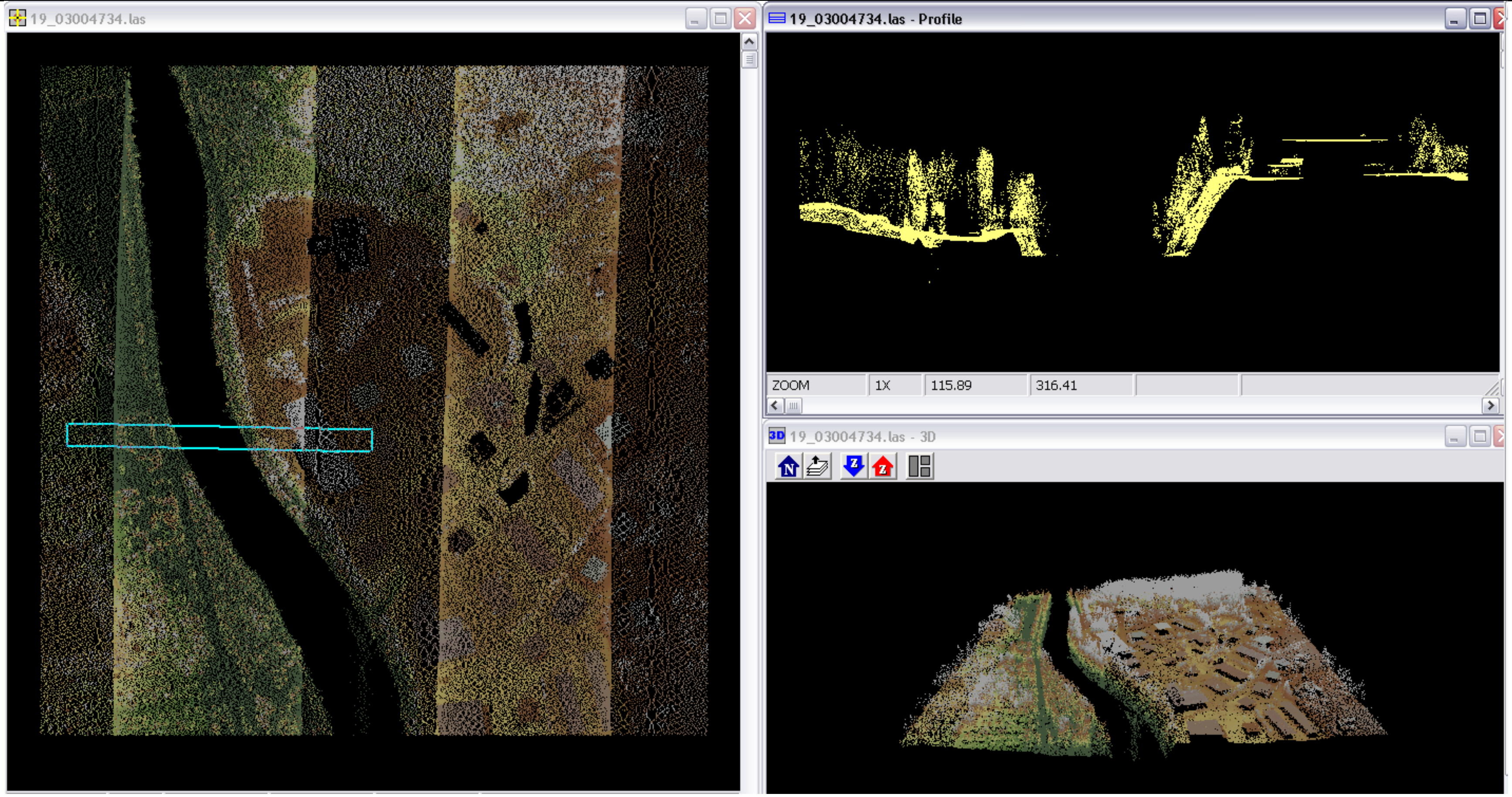


Fig. 10

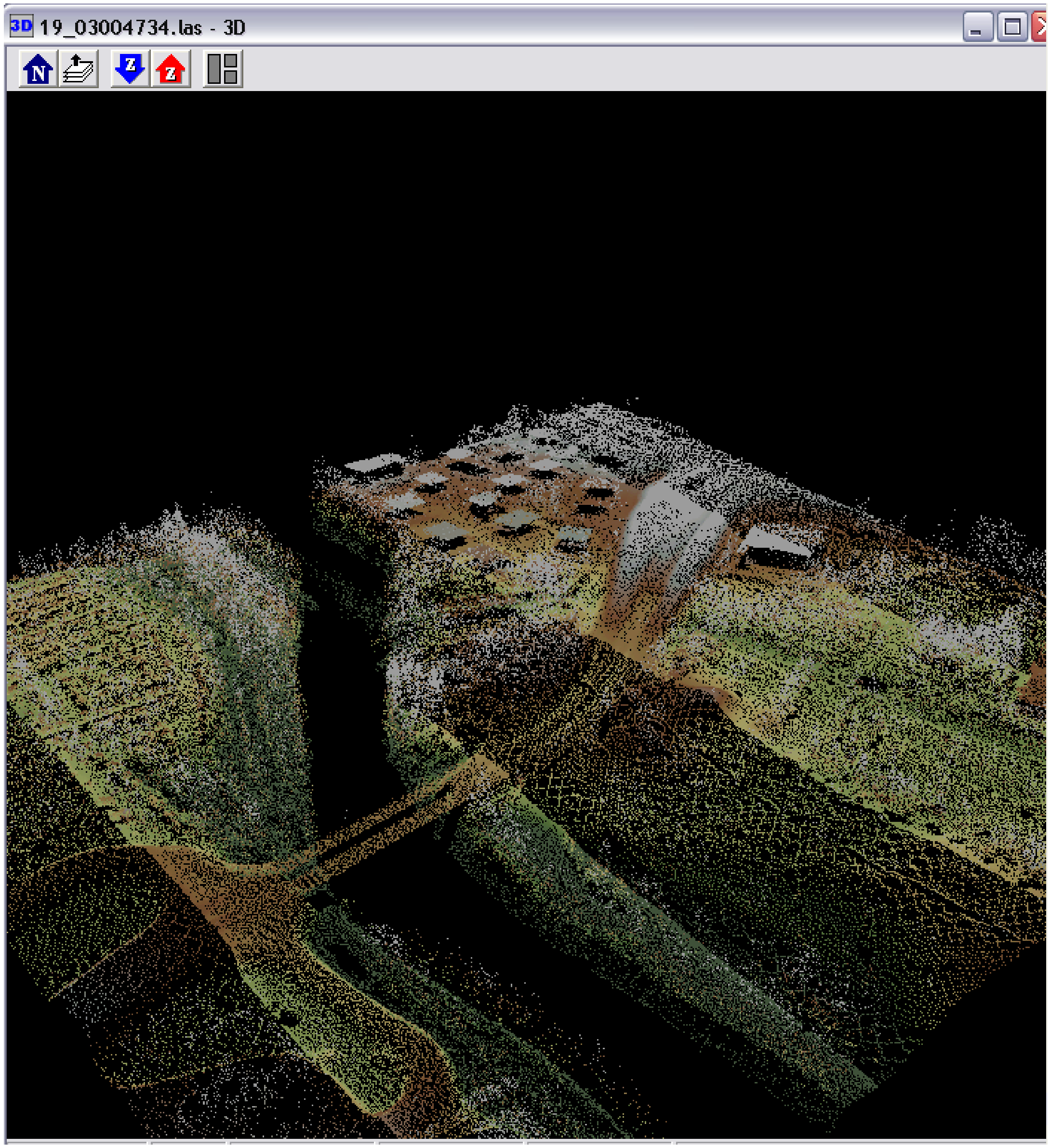


Fig. 11

Unclassified Point Cloud Data Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: MCC**

LAS Tiles: 19_02964749.las; 19_02974748.las; 19_02974749.las | **Date: 7/23/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

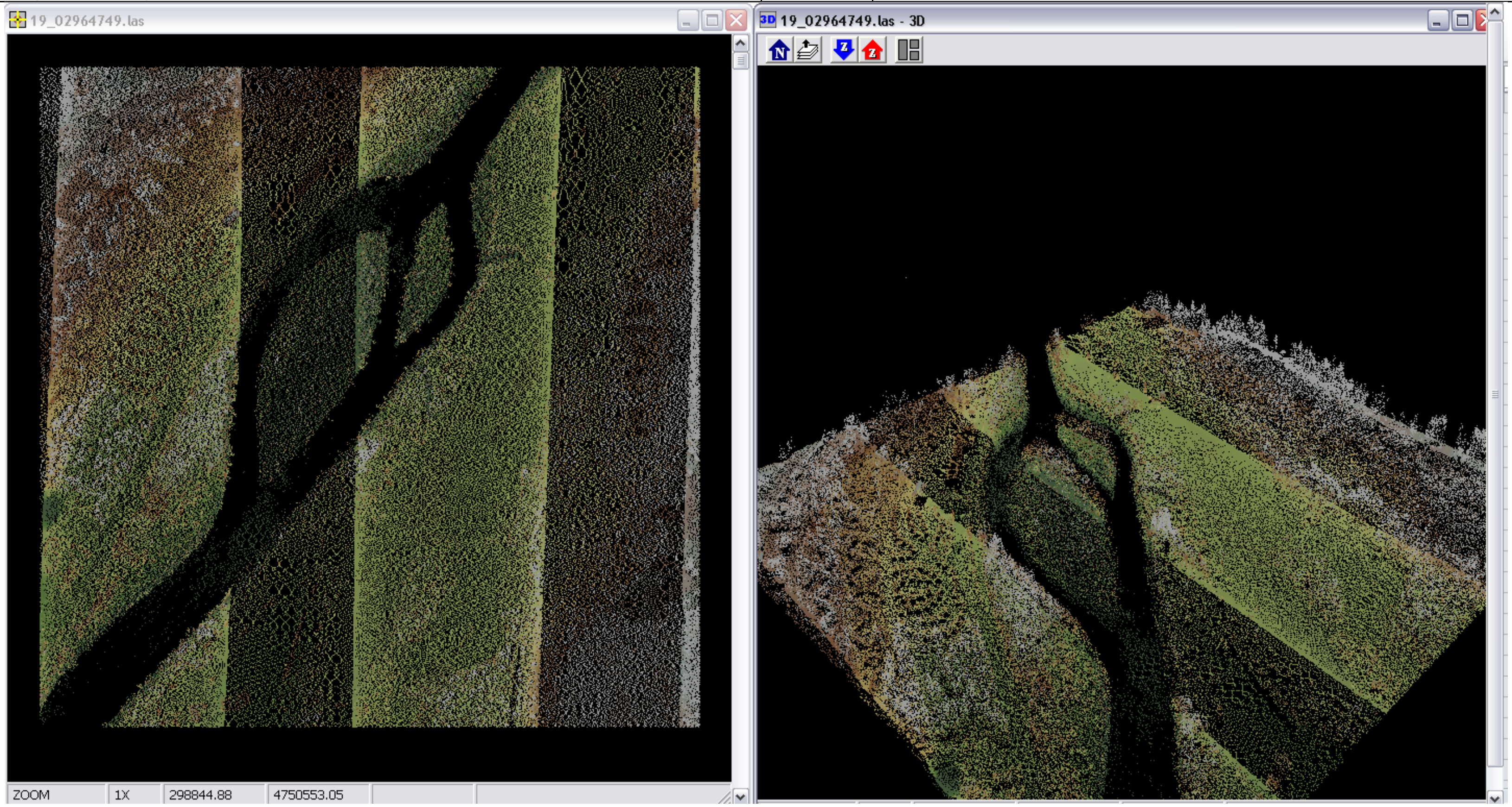


Fig. 12

Unclassified Point Cloud Data Checklist	**Project: Merrimack**	
Vendor:	**Reviewed By: MCC**	
LAS Tiles: 19_02664752.las; 19_02764746.las; 19_02794746.las; 19_02804746.las		**Date: 7/23/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

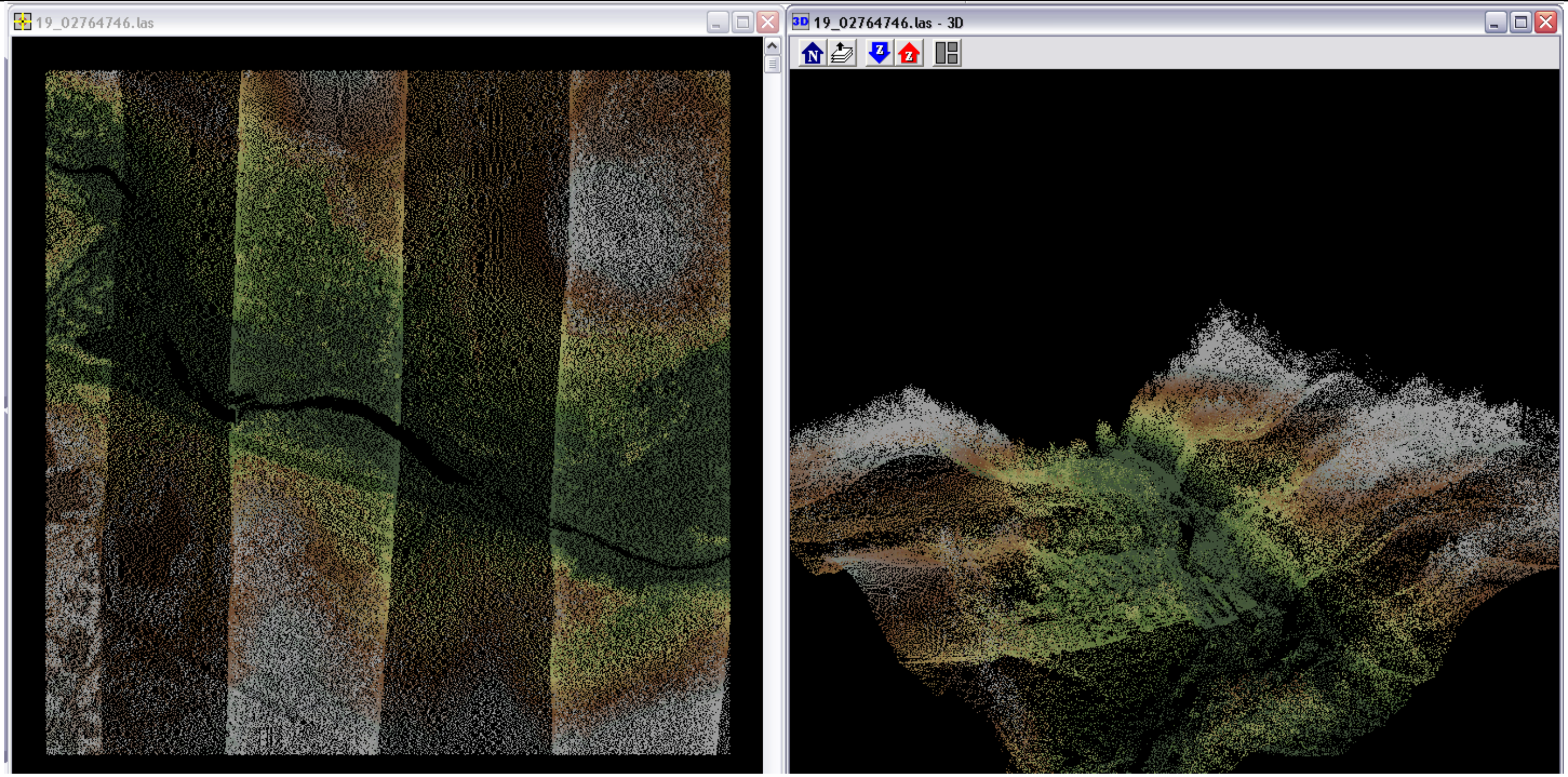


Fig. 13

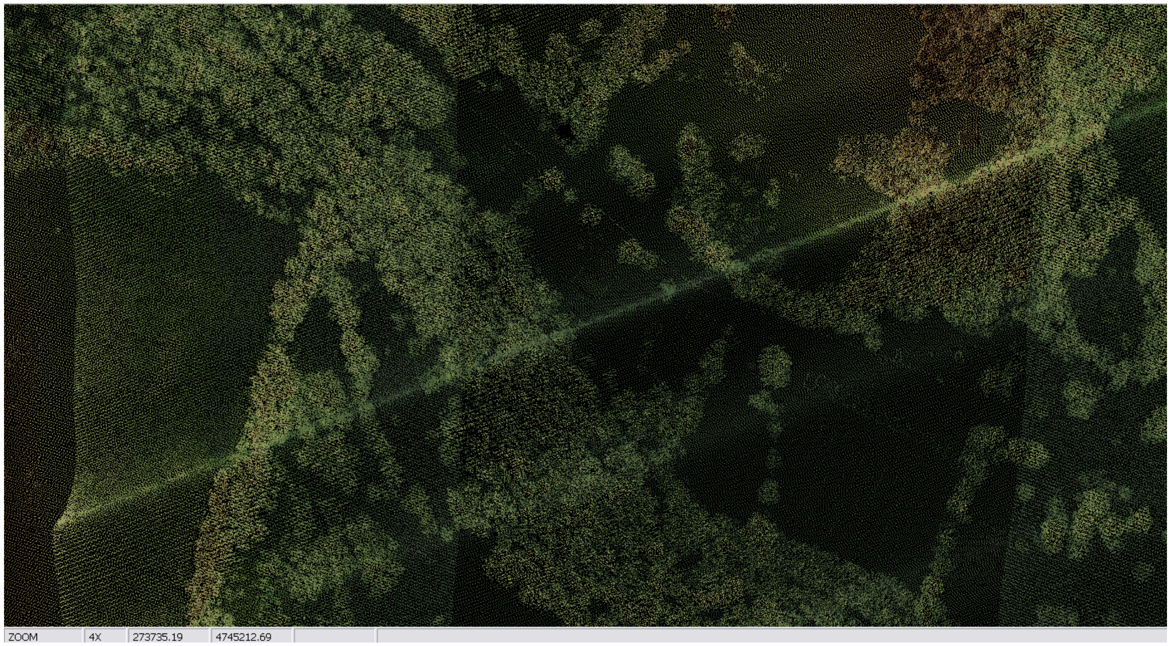
Unclassified Point Cloud Data Checklist **Project: Merrimack**

Vendor: **Reviewed By: MCC**

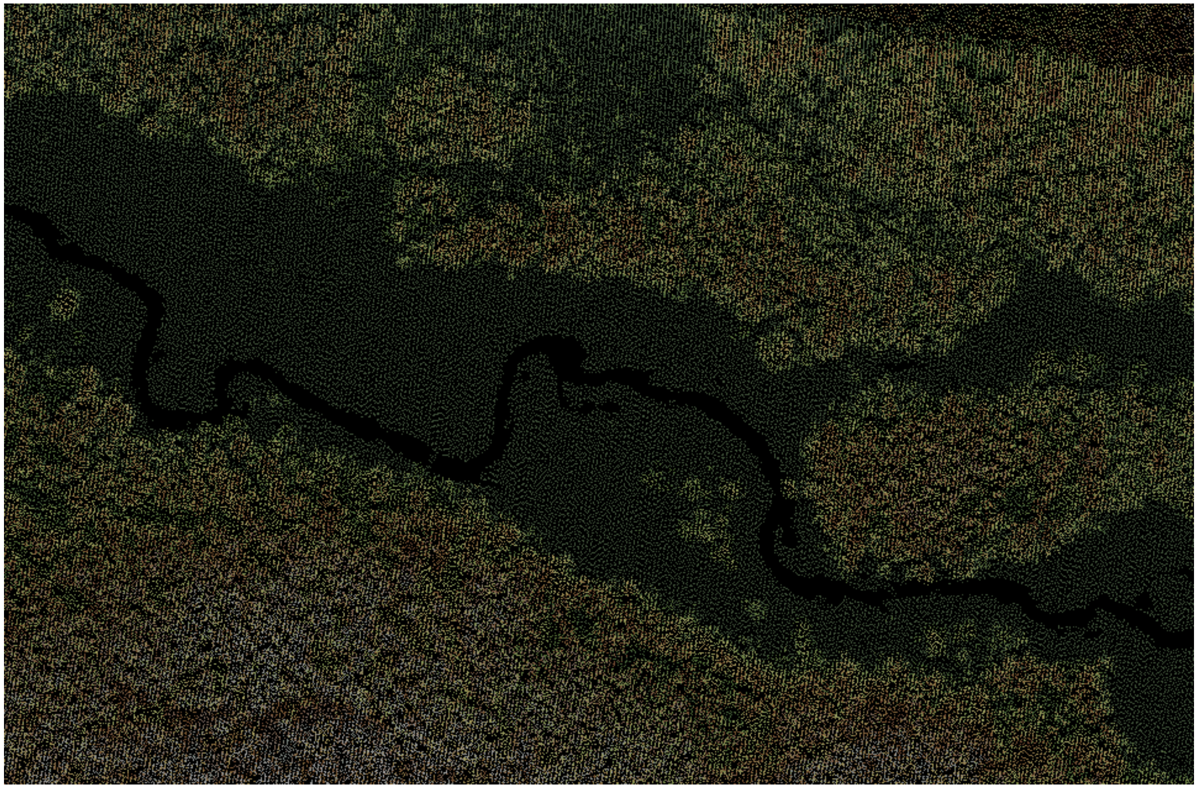
LAS Tiles: 19_02724743.las; 19_02724744.las; 19_02734743.las; 19_02734744.las **Date: 7/23/12**

Item	**P/F/NA**	**Comments**
Scan and profile		See Fig. 15 below – scanline does not affect bare earth
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Fig. 15 – Scanline - 19_02734744.las & 19_02734743.las

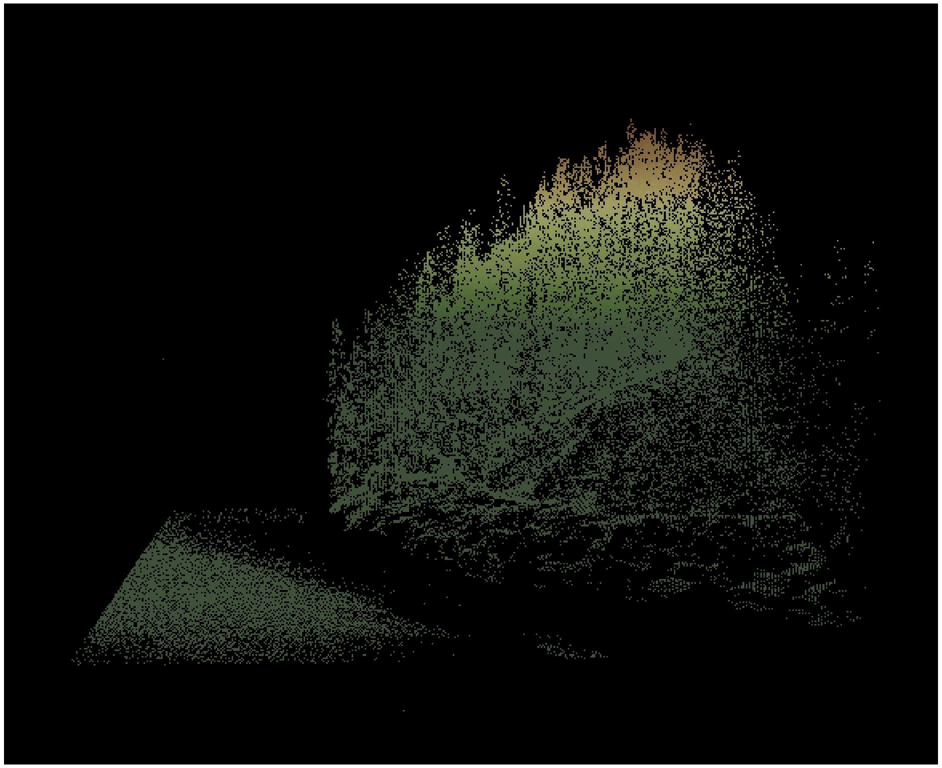


<table>
<tr><td colspan="2">Unclassified Point Cloud Data Checklist</td><td colspan="2">Project: Merrimack Watershed</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS Tiles: 19_03214798.las</td><td>Date: 7/20/12</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scan and profile</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Returns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching</td><td>NA</td><td colspan="2"></td></tr>
</table>



Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02854803.las,		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	F	Few points below ground over river
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	

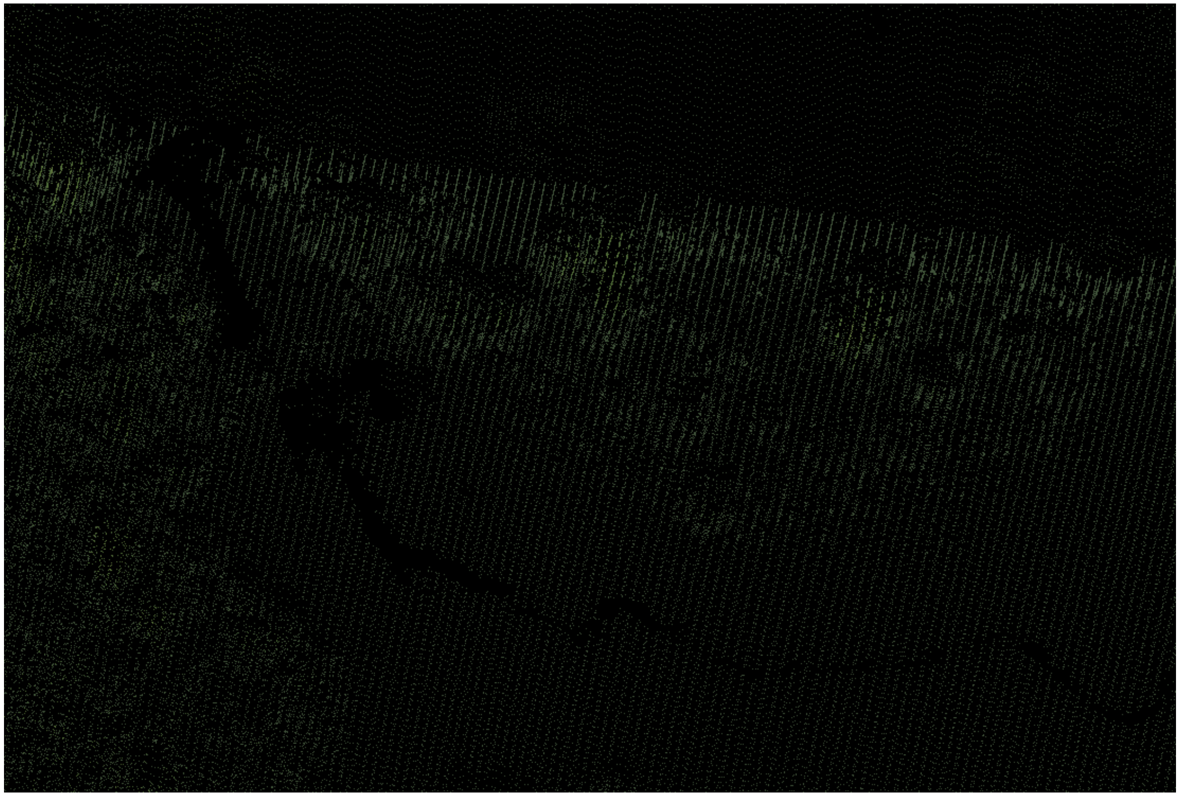
Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03154806.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	Nice slope down to lake
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_03104816.las			**Date: 7/20/12**
Item	**P/F/NA**	**Comments**	
Scan and profile	P		
Excessive Noise	P		
Elevation Steps	P		
Gaps/Voids	P		
Returns	P		
Edge matching	NA		

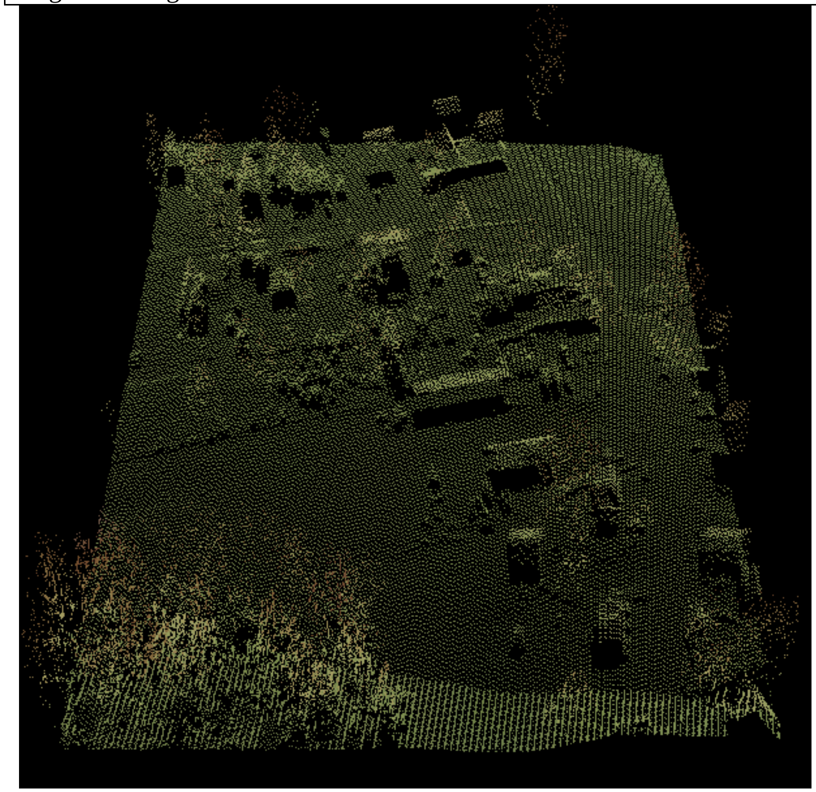
Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03024790.las	**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	See bog area below
Returns	P	
Edge matching	NA	



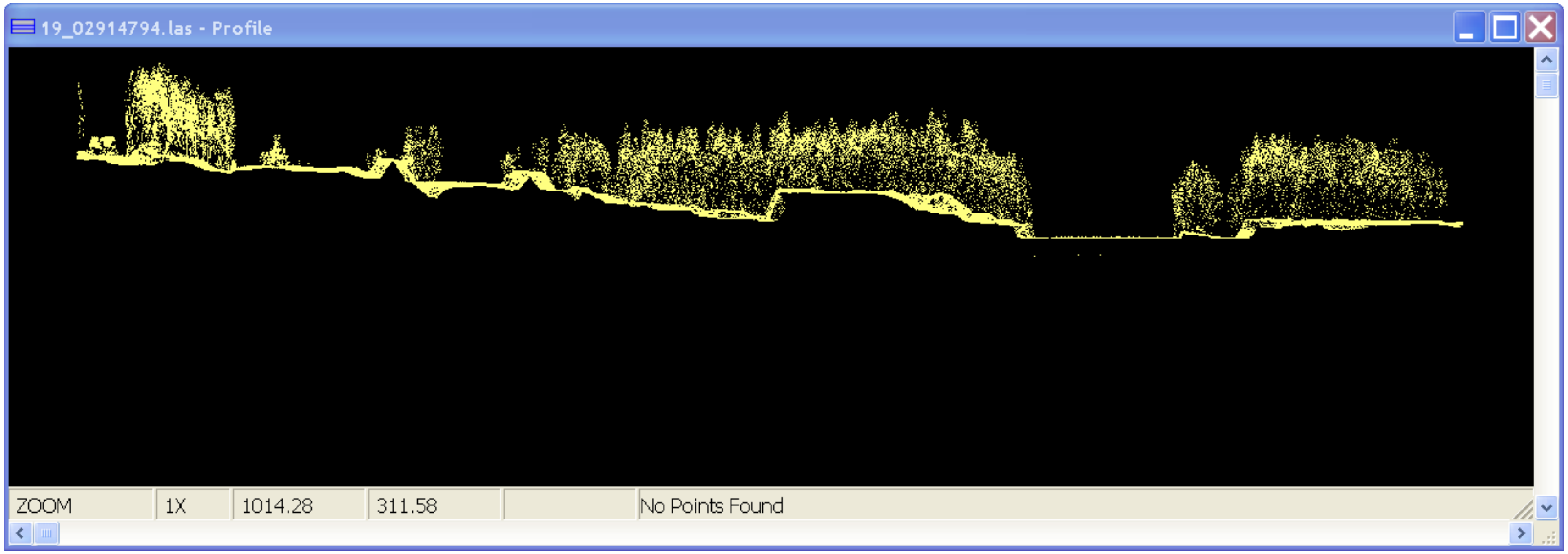
Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02904794.las		**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02914794.las		**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02904796.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02884797.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02904797.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	Good collection over swamp area. See images below.
Returns	P	
Edge matching	P	

Figure 2 Good collection on 19_02904797.las

Unclassified Point Cloud Data Checklist

Project: Merrimack Watershed

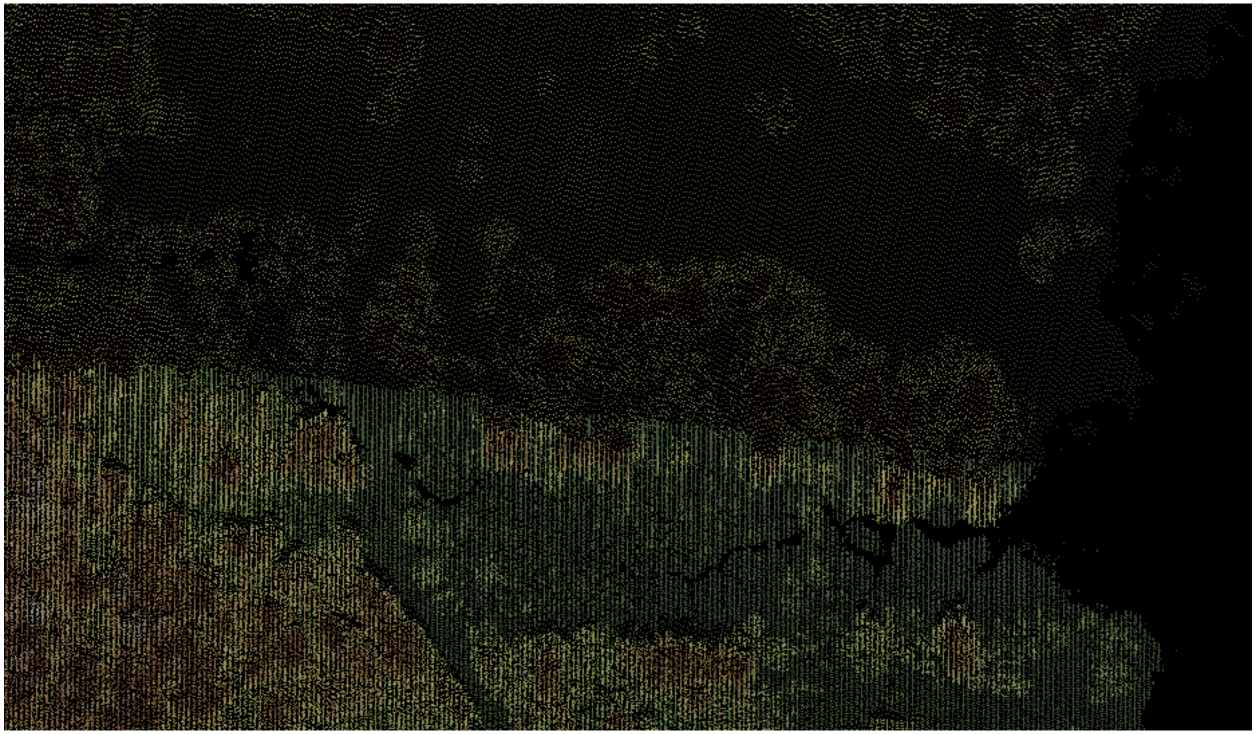
Vendor:

Reviewed By: Myra Hupfeld-Cousineau

LAS Tiles: 19_03154804.las

Date: 7/20/12

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	



Unclassified Point Cloud Data Checklist

Project: Merrimack Watershed

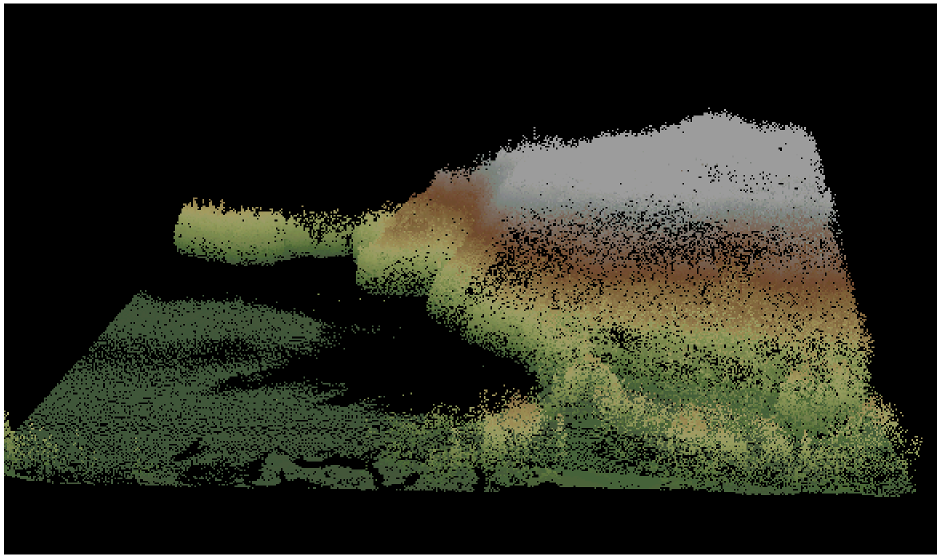
Vendor:

Reviewed By: Myra Hupfeld-Cousineau

LAS Tiles: 19_03144806.las

Date: 7/20/12

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03064785.las		**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03064786.las	**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03084788.las	**Date: 7/20/12**

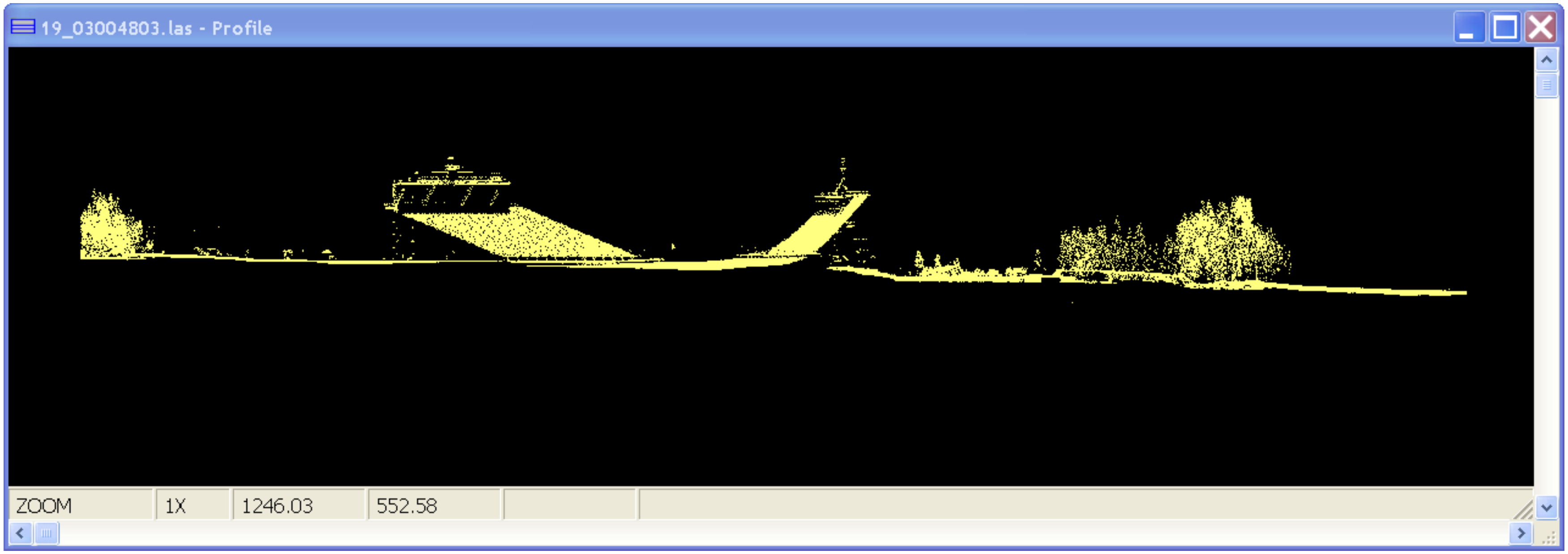
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	.
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03084786.las	**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_03004803.las		**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	



Kasey Kahne #1

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02924788.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02944788.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02974785.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist

Project: Merrimack Watershed

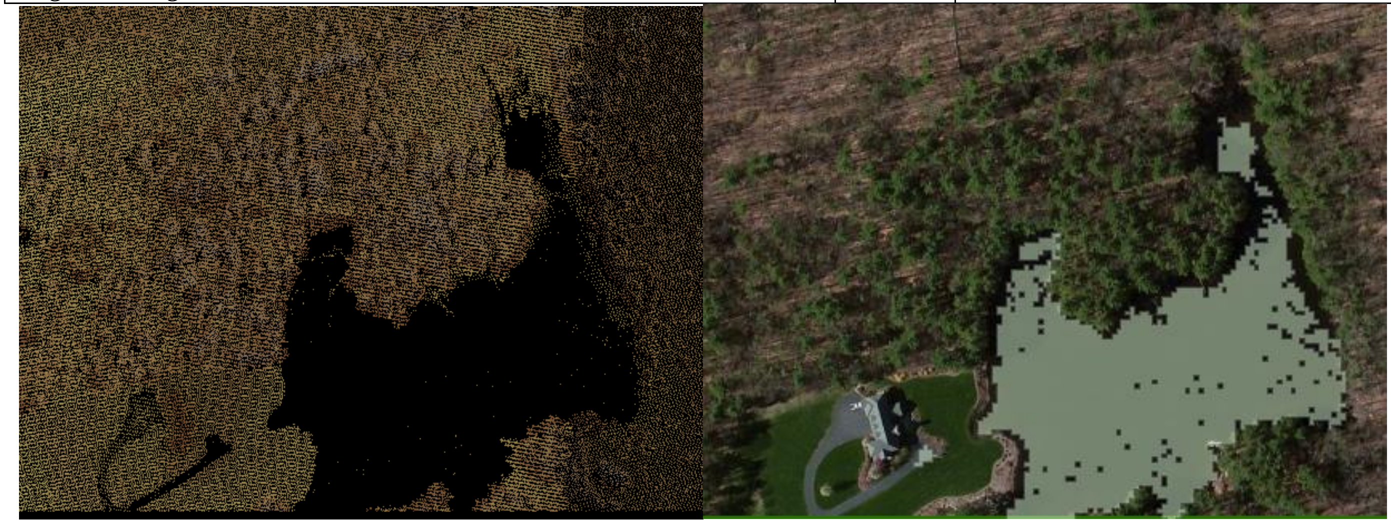
Vendor:

Reviewed By: Myra Hupfeld-Cousineau

LAS Tiles: 19_02864756.las

Date: 7/20/12

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	N/A	



Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02704764.las		**Date: 7/20/12**

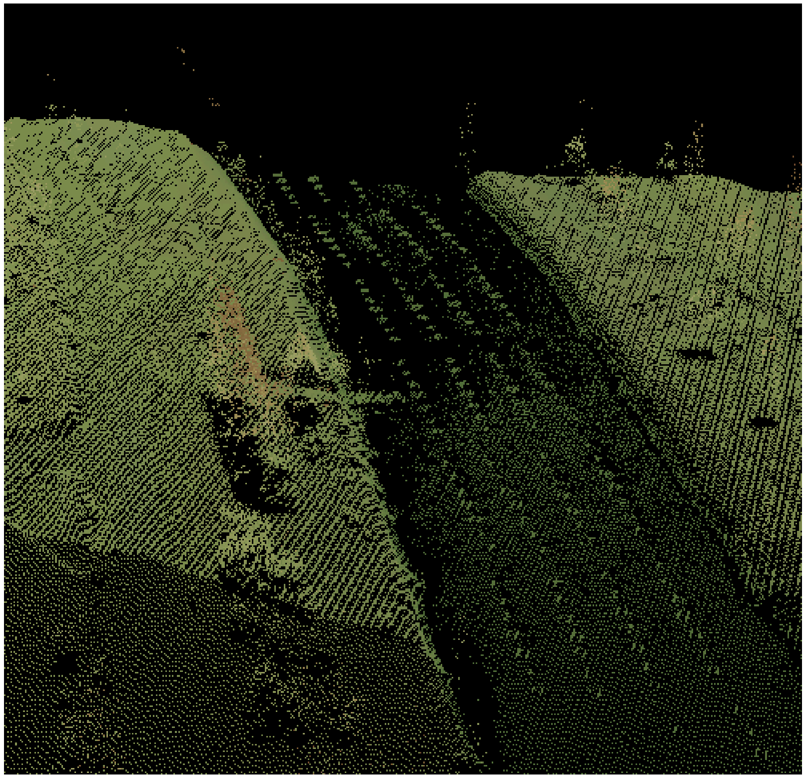
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02804774.las		**Date: 7/20/12**

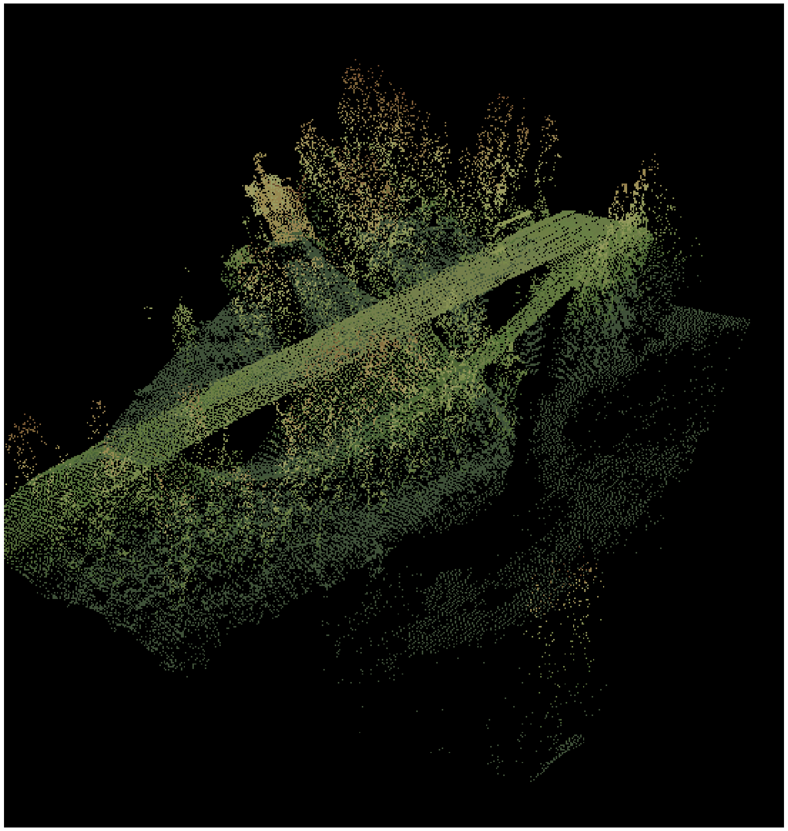
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02984778.las		**Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	NA	

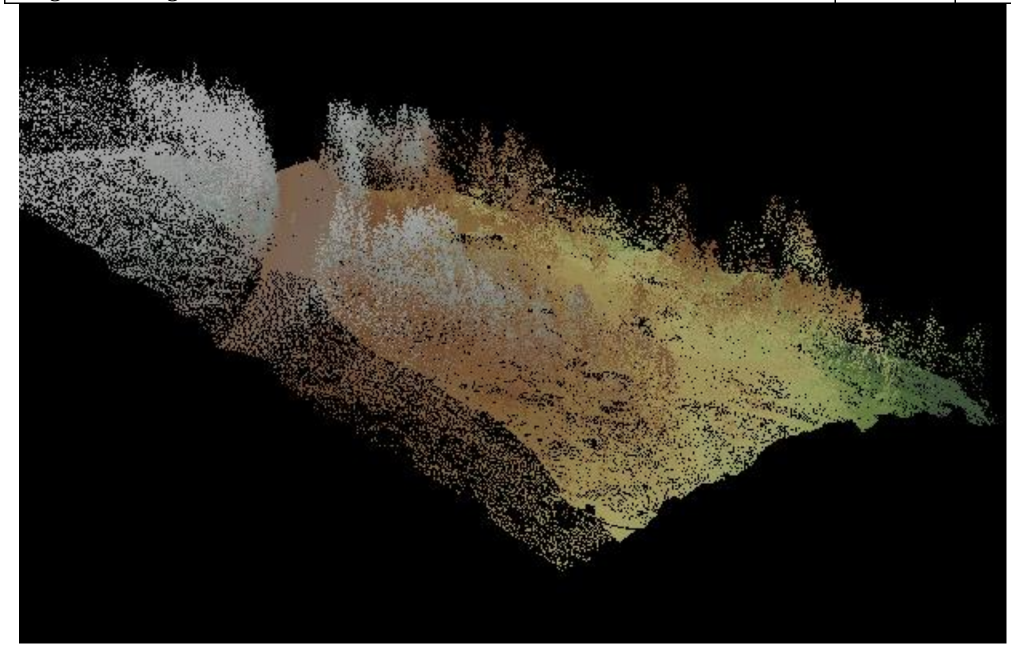


Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02974761.las and 19_02984761.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02974762.las and 19_02984762.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

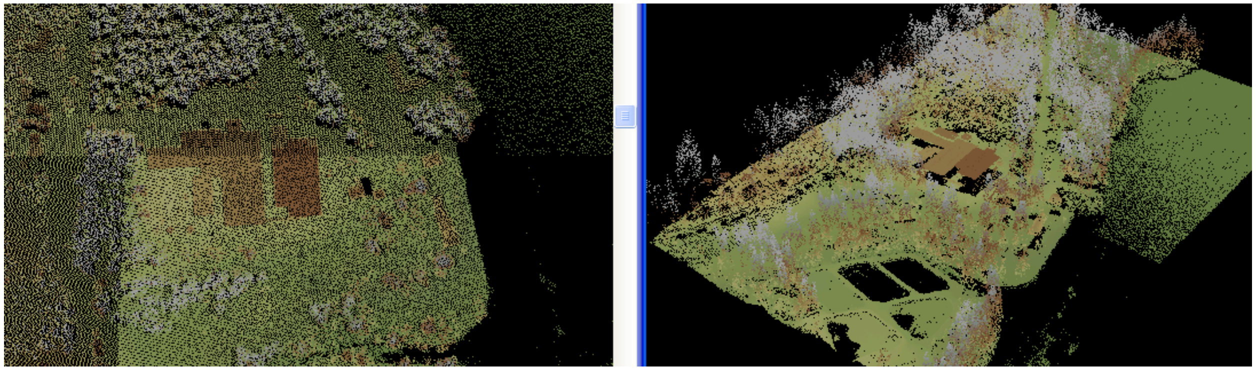
Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02964780.las			**Date: 7/20/12**
Item	**P/F/NA**	**Comments**	
Scan and profile	P		
Excessive Noise	P		
Elevation Steps	P		
Gaps/Voids	P		
Returns	P		
Edge matching	P		



Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02974780.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

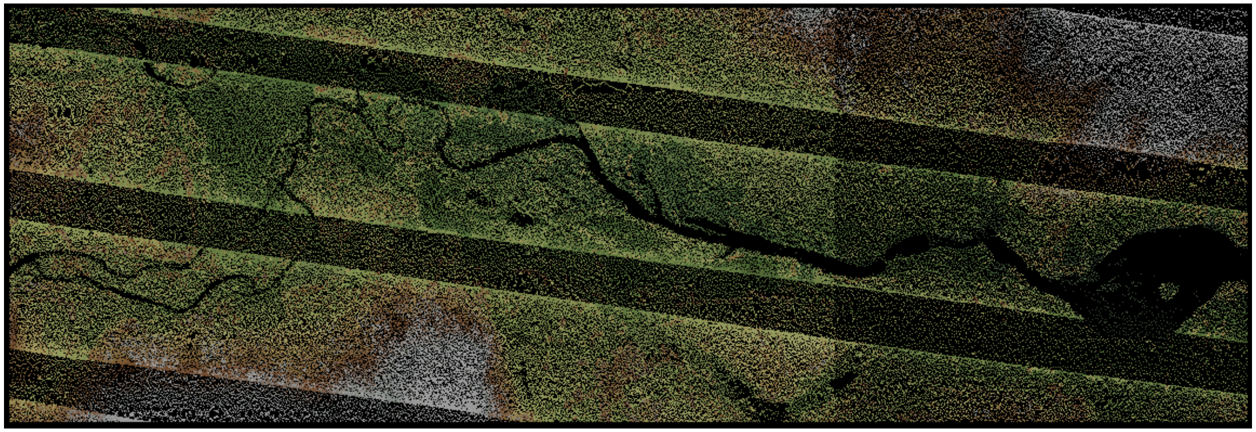
Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02974782.las and 19_02964782.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_03044760.las, 19_03044761.las and 19_03044762.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



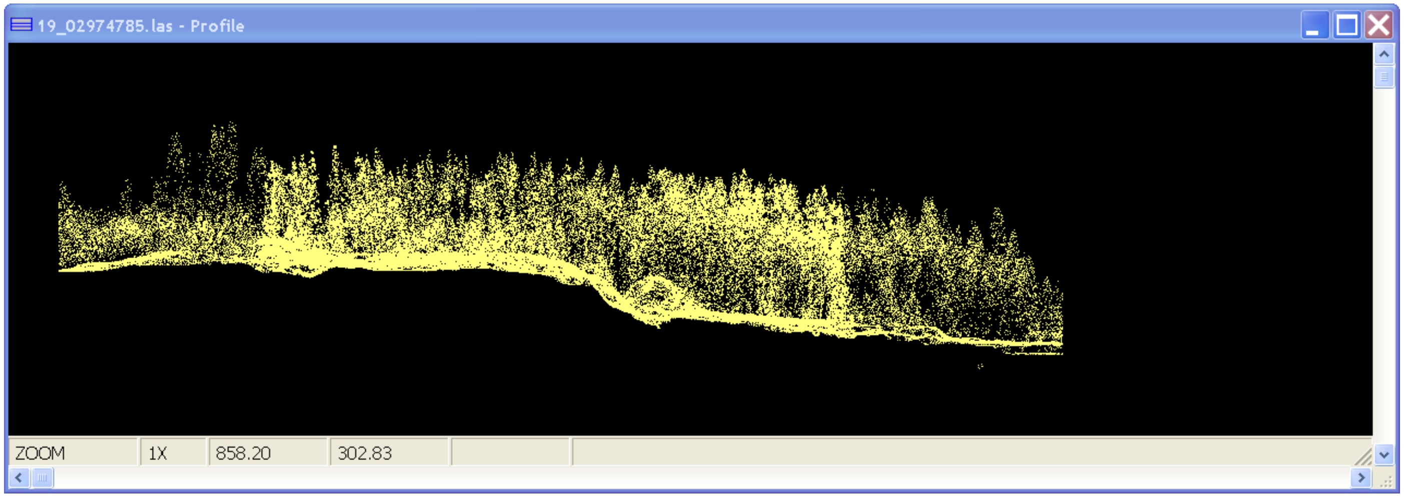
Edgematching good

Unclassified Point Cloud Data Checklist		**Project: Merrimack Watershed**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS Tiles: 19_02864766.las, 19_02884766.las and 19_02854766.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	



Unclassified Point Cloud Data Checklist
Project: Merrimack Watershed
Vendor:
Reviewed By: Myra Hupfeld-Cousineau
LAS Tiles: 19_02974784.las
Date: 7/20/12

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	See image below.



Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02964784.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile		
Excessive Noise		
Elevation Steps		
Gaps/Voids		
Returns		
Edge matching		

Unclassified Point Cloud Data Checklist	**Project: Merrimack Watershed**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS Tiles: 19_02924718.las		**Date: 7/20/12**
Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist **Project: Merrimack Watershed**

Vendor: **Reviewed By: Myra Hupfeld-Cousineau**

LAS Tiles: 19_02664734.las **Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

Unclassified Point Cloud Data Checklist **Project: Merrimack Watershed**

Vendor: **Reviewed By: Myra Hupfeld-Cousineau**

LAS Tiles: 19_02964748.las **Date: 7/20/12**

Item	**P/F/NA**	**Comments**
Scan and profile	P	
Excessive Noise	P	
Elevation Steps	P	
Gaps/Voids	P	
Returns	P	
Edge matching	P	

STARR

FEMA Region I
Merrimack Watershed LiDAR Dataset

Classified LiDAR Micro Review

Quality Assurance Forms
7/20/2012

FEMA Risk MAP Quality Assurance Comment Form

Contract: HSFEHQ-09-D-0370	Task Order: HSFE01-11-J-0010	Case Number: 12-01-1080S	FEMA Region: I

Project Name: Merrimack Watershed

Task: LAS Classified Point Cloud QA Review

Submittal Contents: 1749 Classified LAS files

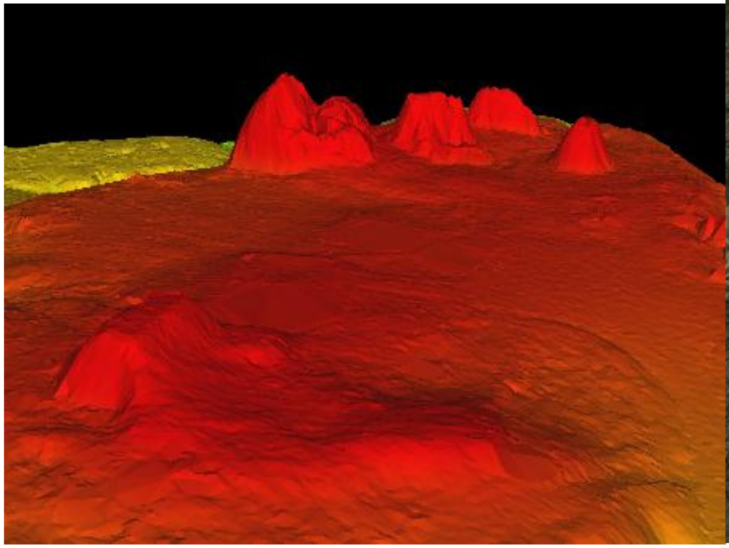
Submitted By: PSI	Submittal Date: 6/12/2012	Reviewed By: G&O	Review Date: 8/10/12	Verification Date: 9/5/2012

Applicable FEMA Guidelines and Specifications:Volume1: FEMA PM 61, USGS-NGP LiDAR Guidelines and Base Specification v13(ILMF), and ASPRS LAS format v12

#	Item	Reviewer Comment	Agree	Submitter Response	Verification
1	**19_02964713.las**	Artifacts in the bare earth		Surface Model looks correct. Project Horizontal Datum is in Meters, while the Vertical Datum is in US Feet. When cutting profiles, or looking at the surface, there is a scale in the Vertical plane. This causes the surface to look incorrect in small mounds or divots that are exaggerated. The surface has been reviewed for anomalies and been found to meet the criteria for bare earth cleanup.	JLH
2	**19_03044728.las**	Artifacts in the bare earth		See explanation above	JLH
3	**19_03124731.las**	Divots in bare earth		See explanation above	JLH
4	**19_03004736.las**	Artifacts in the bare earth		See explanation above	JLH

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03104702.las		**Date: 07/22/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies		

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03124702.las		**Date: 07/20/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Dirt piles
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

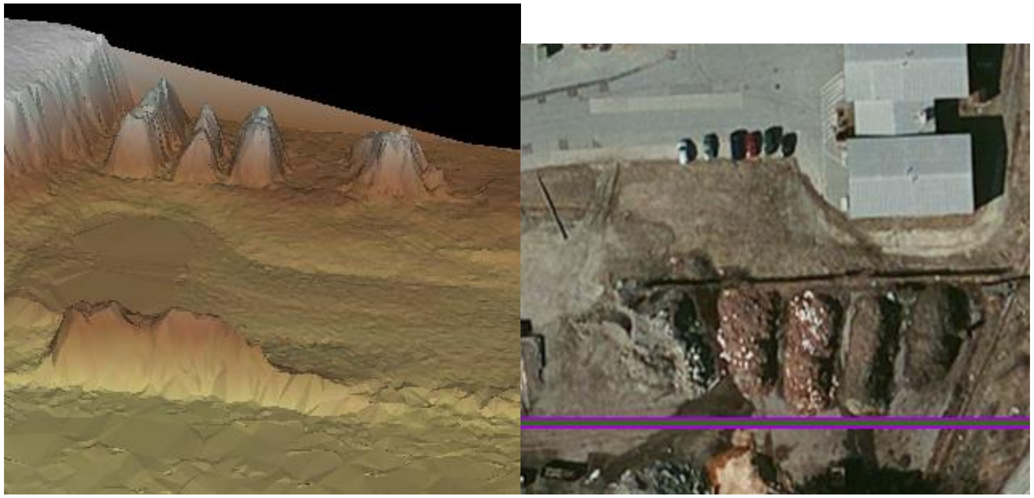


Classified Point Cloud Data Visual Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**

LAS File: 19_03124704.las | **Date: 07/20/2012**

Item	P/F/NA	Comments
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Piles of dirt
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	



Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03104704.las		**Date: 07/20/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Dirt piles
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_03154704.las, 19_03164704.las, 19_03184704.las</td><td>Date: 07/20/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>P</td><td colspan="2">Matches other Merrimack tiles</td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03204704.las			**Date: 07/27/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles	P	Matches other Merrimack tiles	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03204706.las			**Date: 07/27/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles	P		
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		

<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_03204707.las</td><td>Date: 07/27/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>P</td><td colspan="2">Matches other Merrimack tiles</td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2">End of extent</td></tr>
</table>

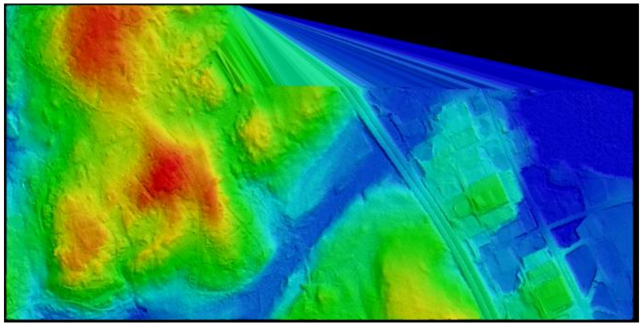
<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_03184706.las</td><td>Date: 07/27/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>P</td><td colspan="2">Matches other Merrimack tiles</td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**

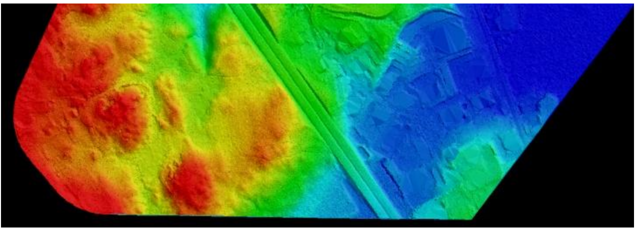
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**

LAS File: 19_03164706.las and 19_03154706.las | **Date: 07/27/2012**

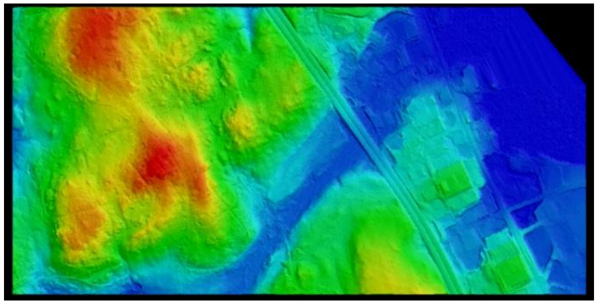
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	USGS tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Culvert No visible bridge deck on ortho
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	



Merrimack



USGS

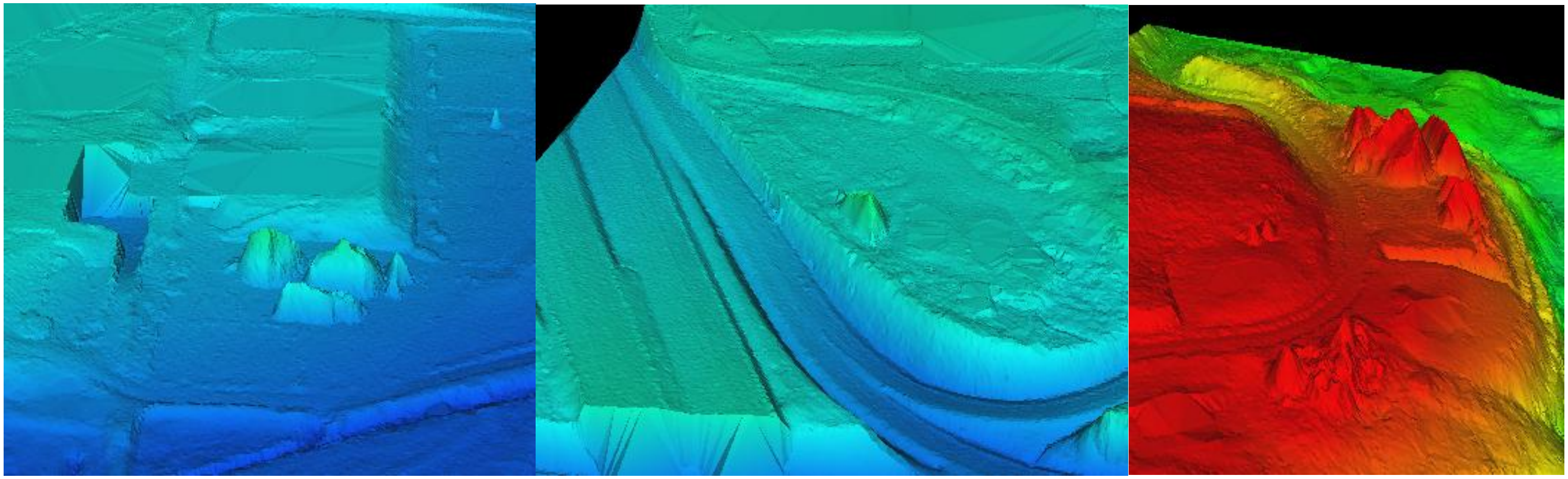


Combined

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03184707.las		**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Culvert No visible bridge deck on ortho
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03184708.las, 19_03164707.las, 19_03164708.las, and 19_03184710.las		**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03154707.las		**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Construction area, mounds of dirt
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	



Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03154708.las 19_03154710.las, 19_03144710.las, and 19_03124710.las		**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist

Project: Merrimack

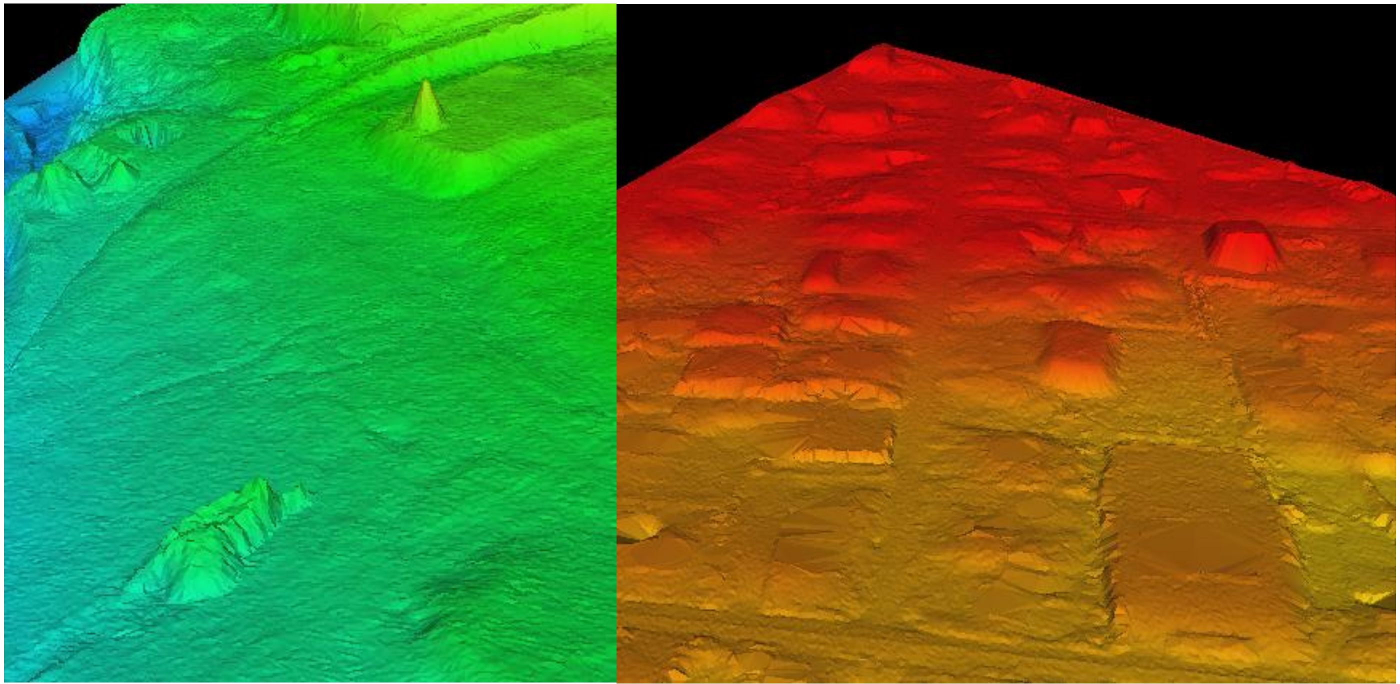
Vendor:

Reviewed By: Myra Hupfeld-Cousineau

LAS File: 19_02964713.las

Date: 07/31/2012

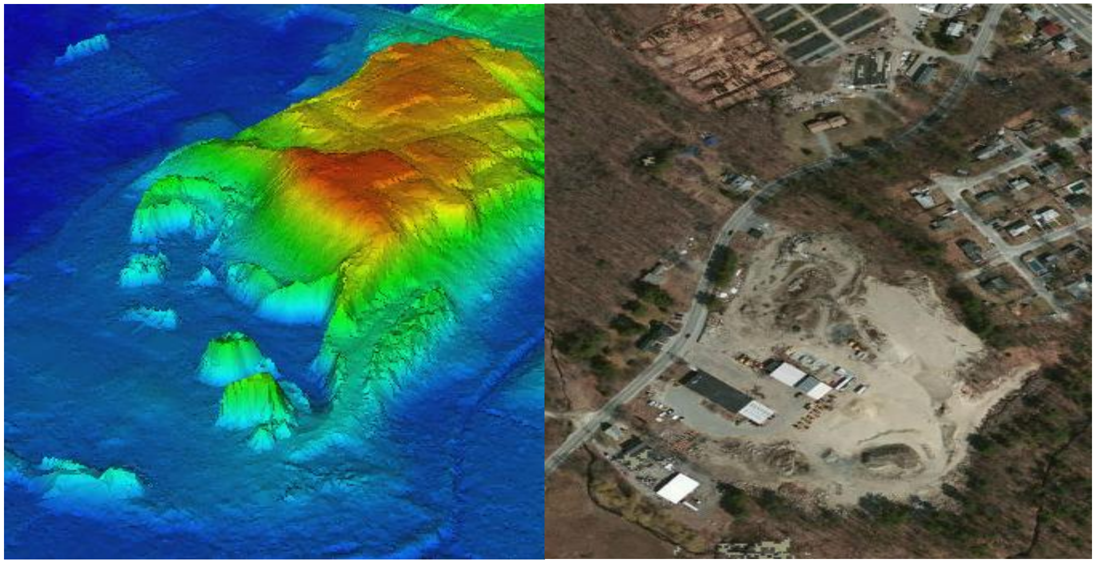
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	F	
Other anomalies	P	



Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02904719.las		**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

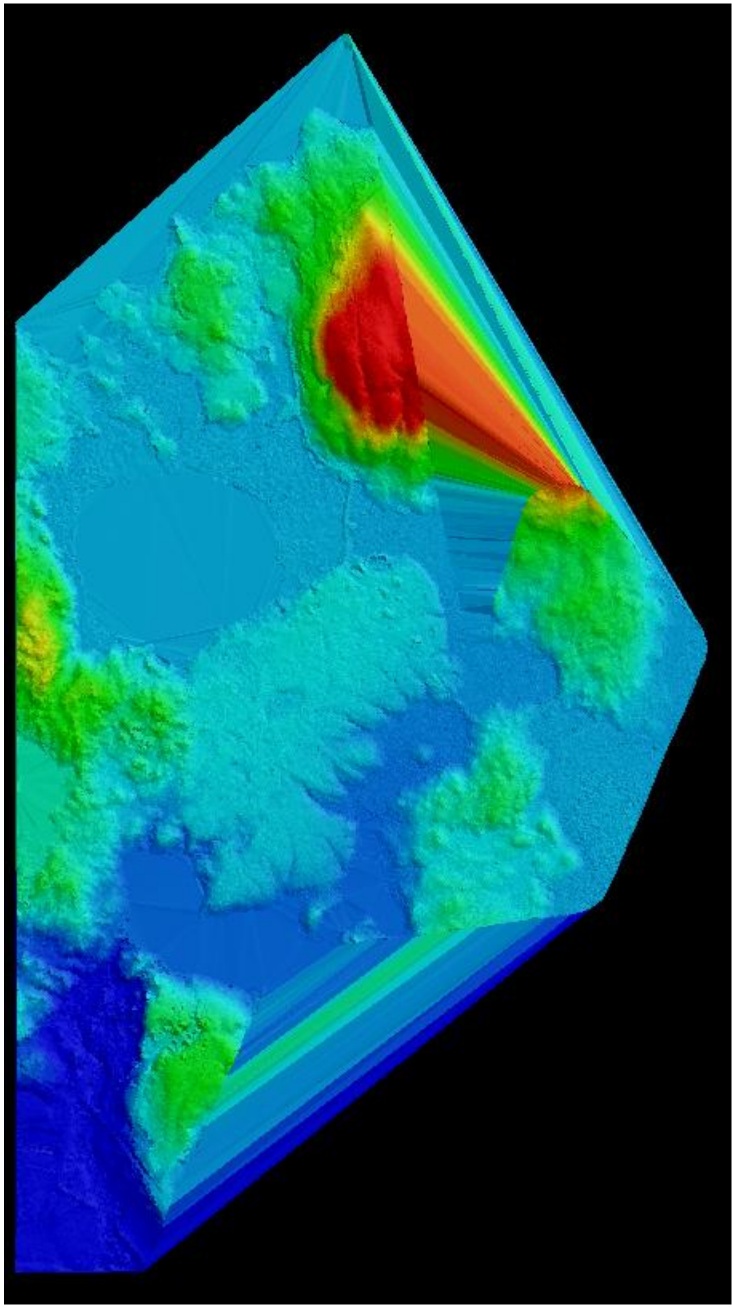
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03064720.las and 19_03084720.las			**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles	P		
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		

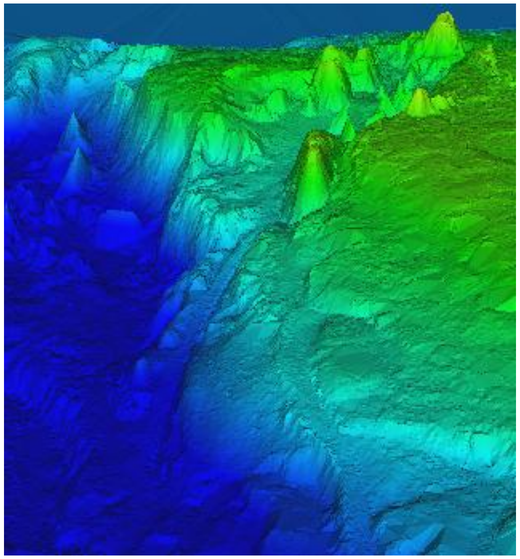
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03064722.las, 19_03044722.las, and 19_03034722.las			**Date: 07/31/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles	P		
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		

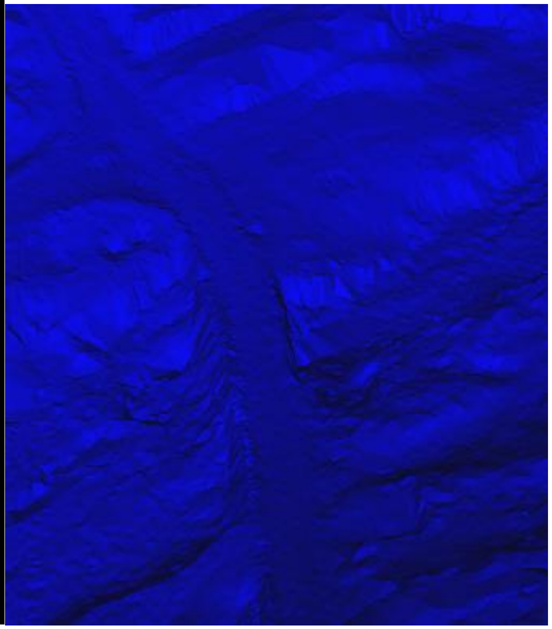


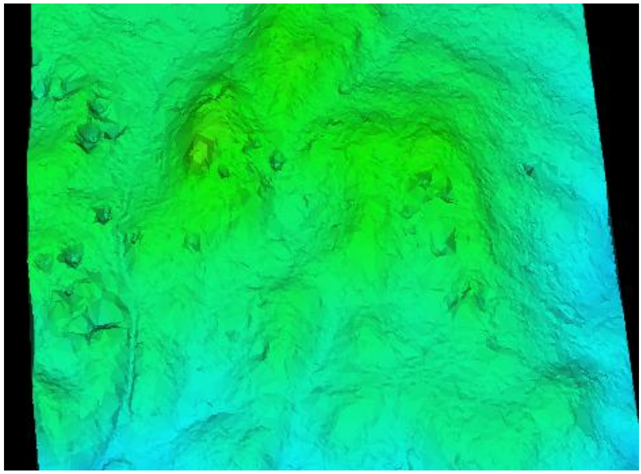
<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_03044724.las</td><td>Date: 08/01/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03064725.las, 19_03064726.las, 19_03044726.las, 19_02624726.las, and 19_03044725.las		**Date: 08/01/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	**19_03044725.las construction site**
Other anomalies	P	



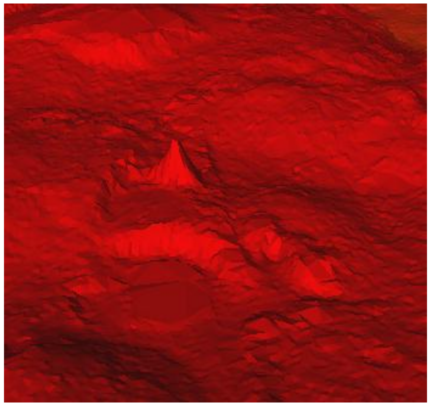






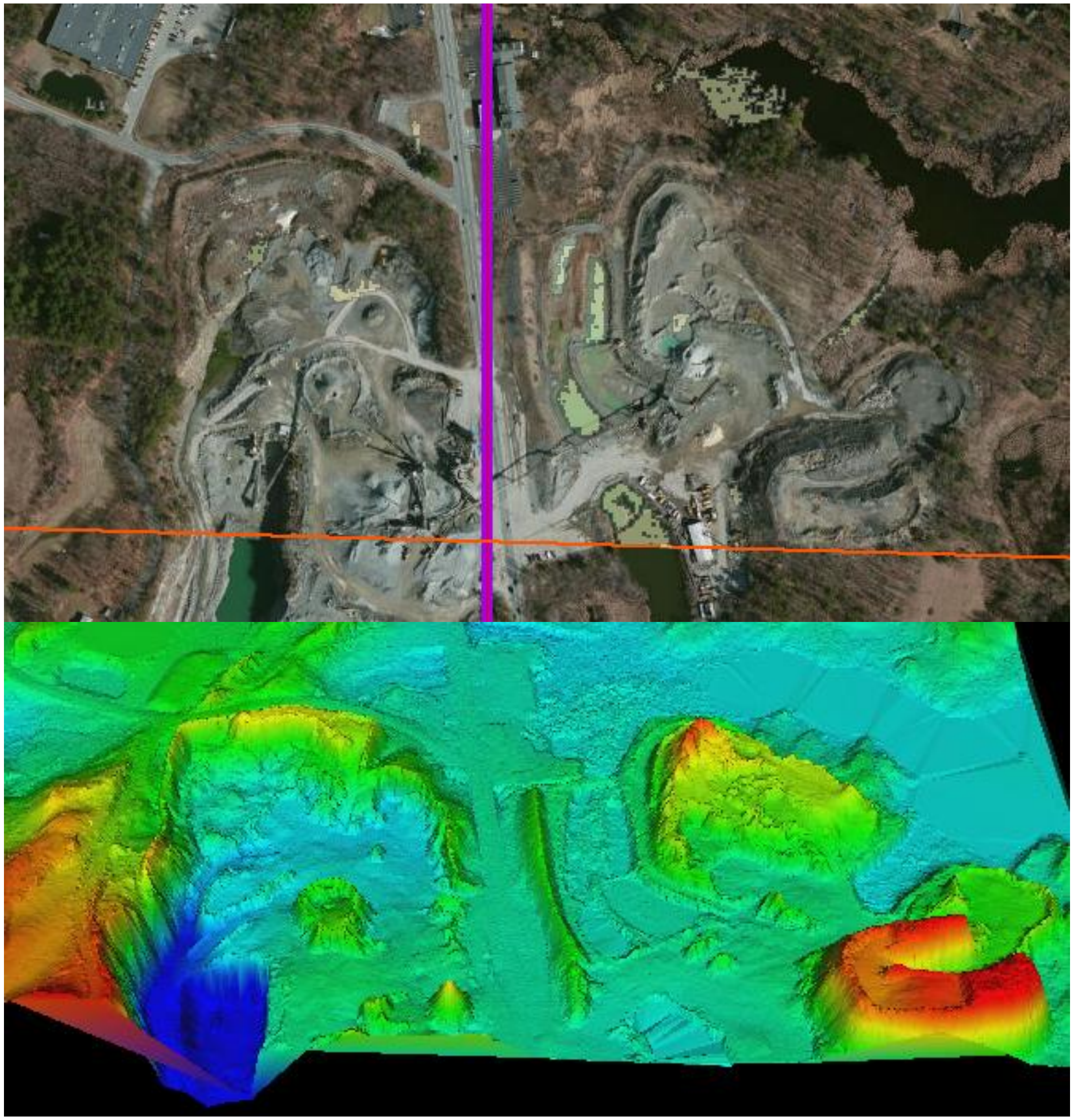
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03044728.las		**Date: 08/01/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	F	
Other anomalies	P	



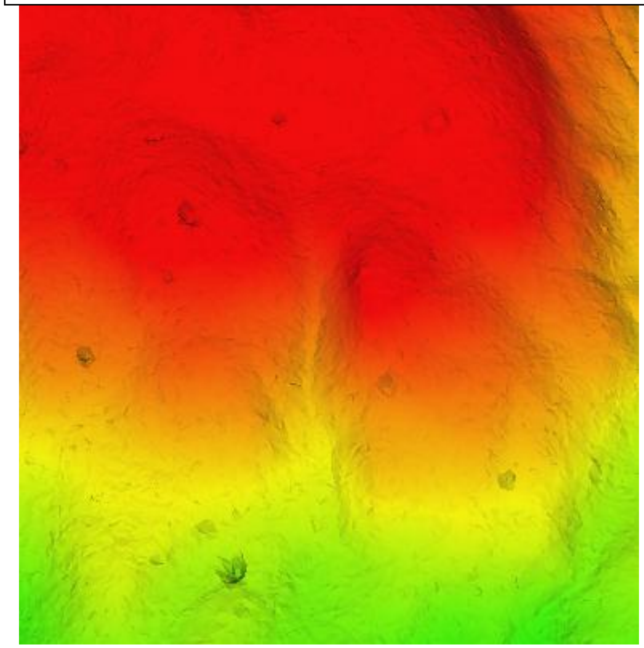
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03044730.las, 19_03064730.las, and 19_03084730.las		**Date: 08/01/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03094730.las, 19_03124730.las, and 19_03104730.las		**Date: 08/01/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	Quarry



Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03124731.las and 19_03144731.las			**Date: 08/01/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	F	Divots
Other anomalies	P	



Classified Point Cloud Data Visual Checklist

Project: Merrimack

Vendor:

Reviewed By: Myra Hupfeld-Cousineau

LAS File: 19_03144732.las, 19_03154732.las, and 19_03154734.las

Date: 08/01/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist

Project: Merrimack

Vendor:

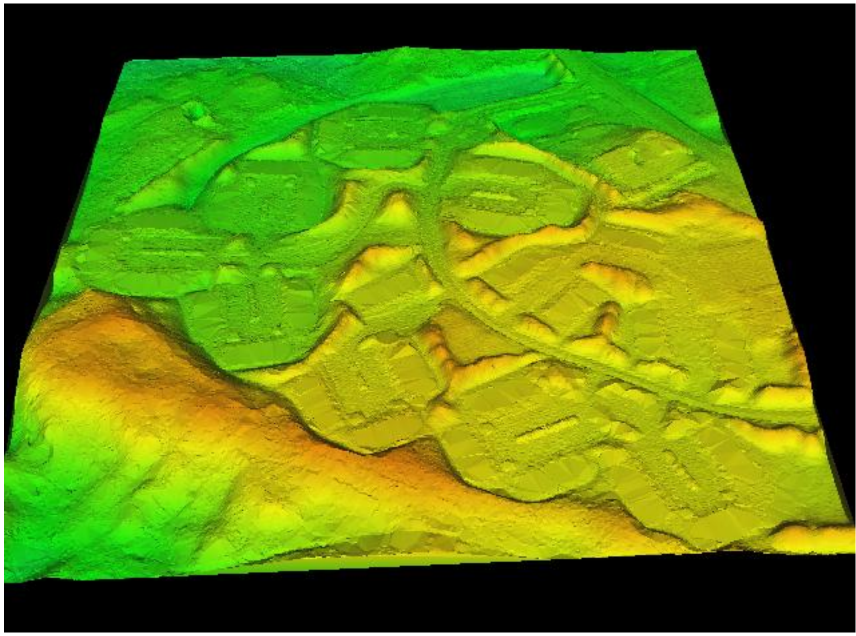
Reviewed By: Myra Hupfeld-Cousineau

LAS File: 19_03004731.las, 19_03004732.las and 19_03004734.las

Date: 08/01/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03004734.las and 19_03004736.las		**Date: 08/01/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F	Check buildings 19_03004736
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	Dirt piles
Other anomalies	P	



Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02984736.las, 19_02974736.las | **Date: 08/01/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

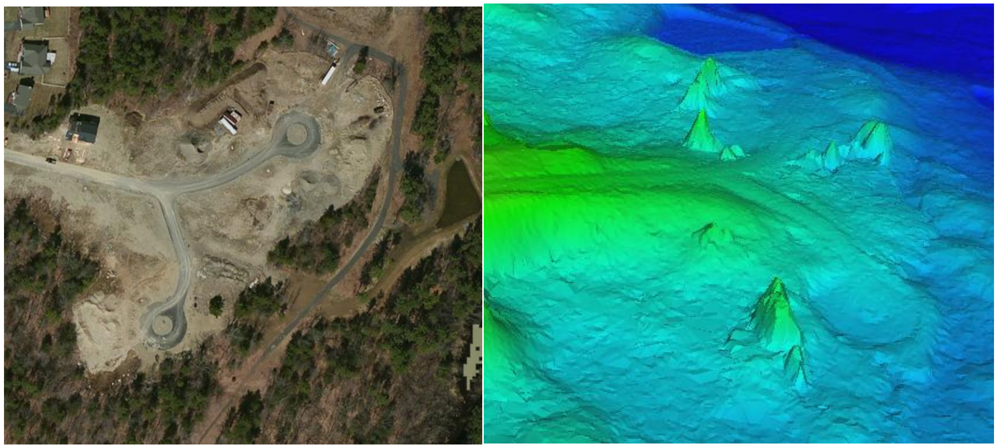
Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02974734.las | **Date: 08/01/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

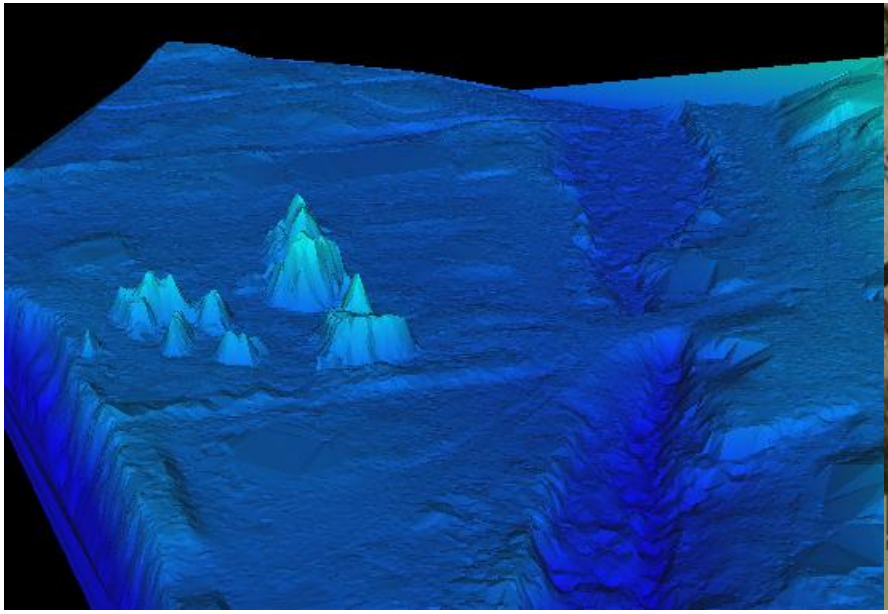
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02974732.las and 19_02964732.las			**Date: 08/01/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles	P	Matches other Merrimack tiles	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		

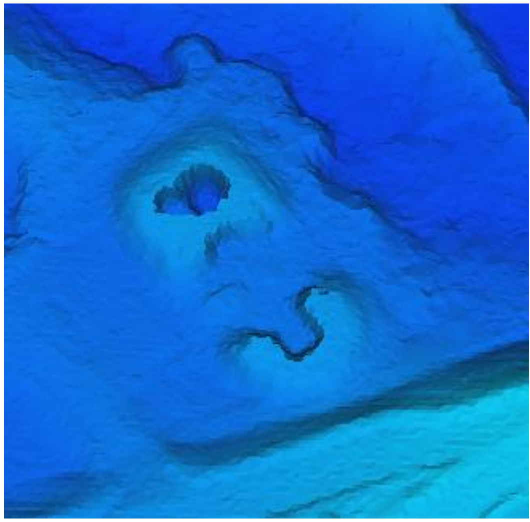
Classified Point Cloud Data Visual Checklist	**Project: Merrimack**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02964731.las		**Date: 08/01/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Construction debris and dirt piles
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	



<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_02974737.las, 19_02984737.las,and 19_03004737.las</td><td>Date: 08/02/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>P</td><td colspan="2">Matches other Merrimack tiles</td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2">Dirt piles</td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>





skateboard park

Classified Point Cloud Data Visual Checklist		Project: Merrimack
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02984738.las		**Date: 08/02/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F	bridges
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03154736.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	F	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03124736.las and 19_03144736.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist
Project: Merrimack
Vendor:
Reviewed By: Myra Hupfeld-Cousineau
LAS File: 19_03124737.las, 19_03104737.las, 19_03094737.las, 19_03084737.las and 19_03084738.las
Date: 08/02/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist
Project: Merrimack
Vendor:
Reviewed By: Myra Hupfeld-Cousineau
LAS File: 19_03064738.las
Date: 08/02/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist	**Project: Merrimack**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03064740.las, 19_03064742.las, 19_03044742.las, 19_03044743.las, 19_03044744.las, 19_03044746.las		**Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist	**Project: Merrimack**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_03044748.las		**Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	F	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**

LAS File: 19_03044749.las, 19_03044750.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**

LAS File: 19_03044752.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**

LAS File: 19_03044754.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**

Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**

LAS File: 19_03064754.las 19_03064755.las, 19_03064756.las, 19_03064758.las, 19_03044758.las, 19_03044760.las, and 19_03044761.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03034764.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03044766.las, 19_03044768.las, 19_03064770.las and 19_03064772.las | **Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03084773.las, 19_03084774.las, 19_03084776.las, 19_03094776.las, and 19_03094778.las | **Date: 08/03/2012**

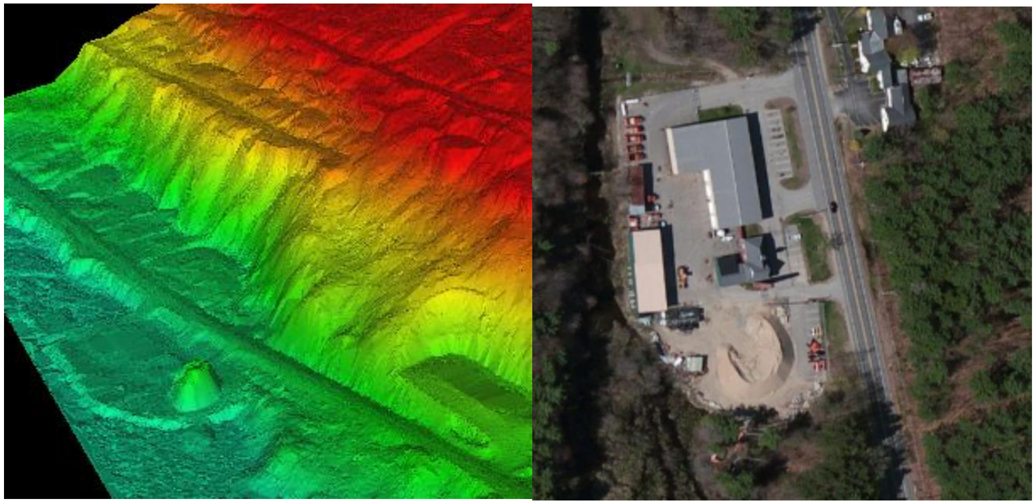
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

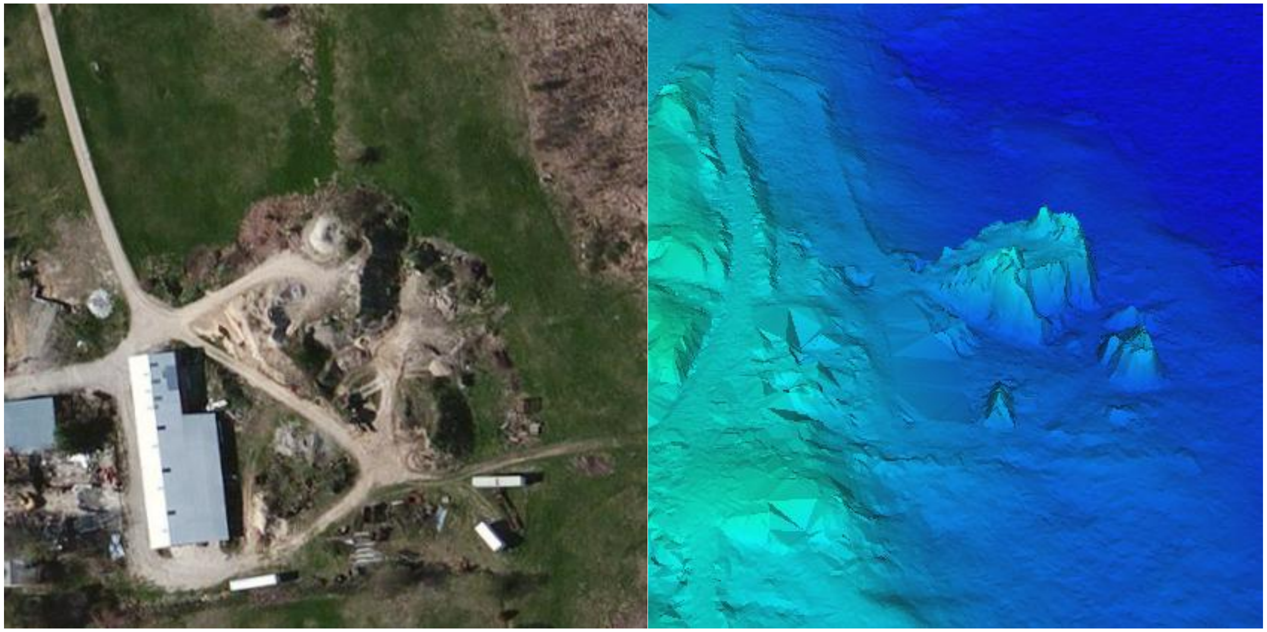
Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03104779.las, 19_03104780.las | **Date: 08/03/2012**

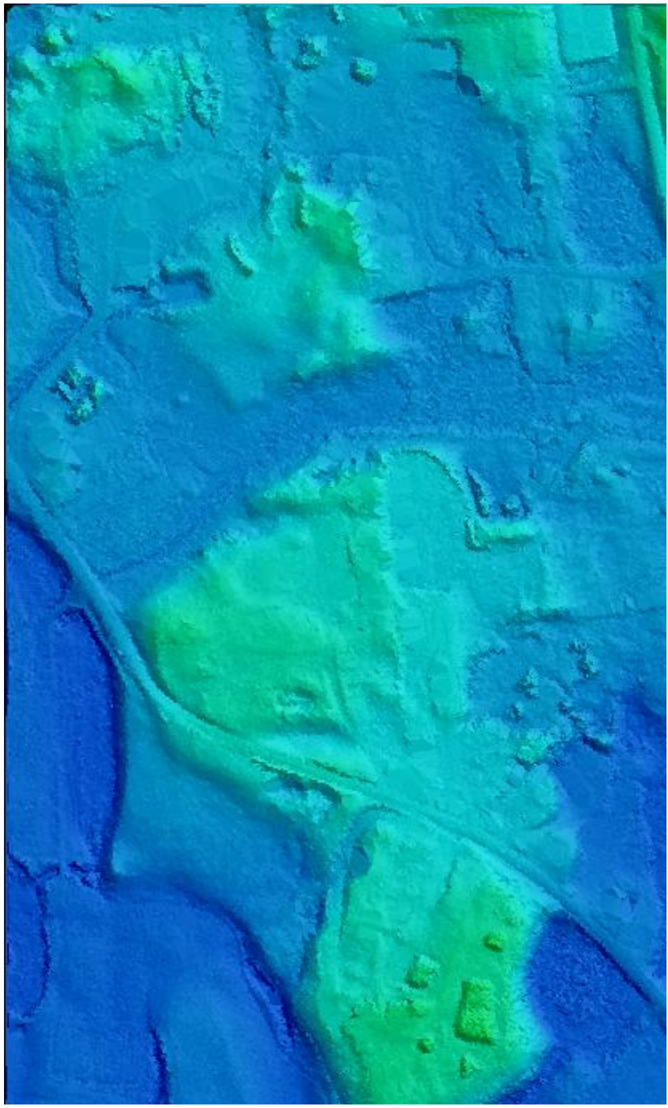
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist	**Project: Merrimack**	
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02844744.las, 19_02854744.las, 19_02844746.las, 19_02824746.las		**Date: 08/02/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	Matches other Merrimack tiles
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Dirt piles
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	







Classified Point Cloud Data Visual Checklist

Project: Merrimack

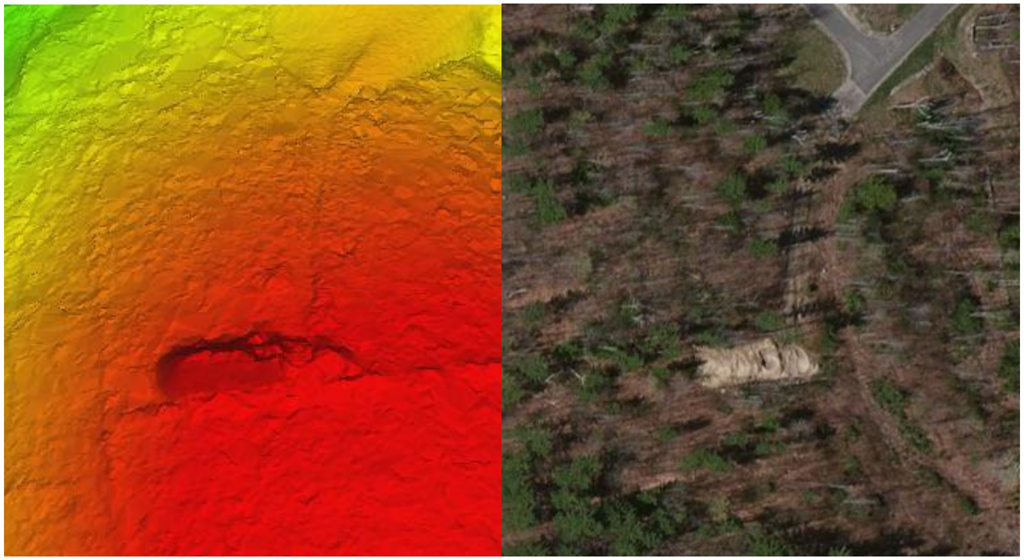
Vendor:

Reviewed By: Myra Hupfeld-Cousineau

LAS File: 19_02764746.las, 19_02744746.las, and 19_02784746.las

Date: 08/02/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

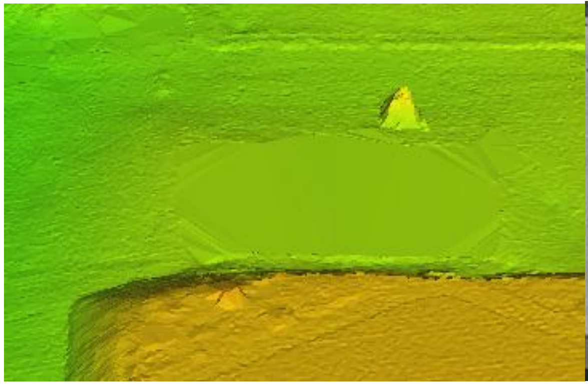


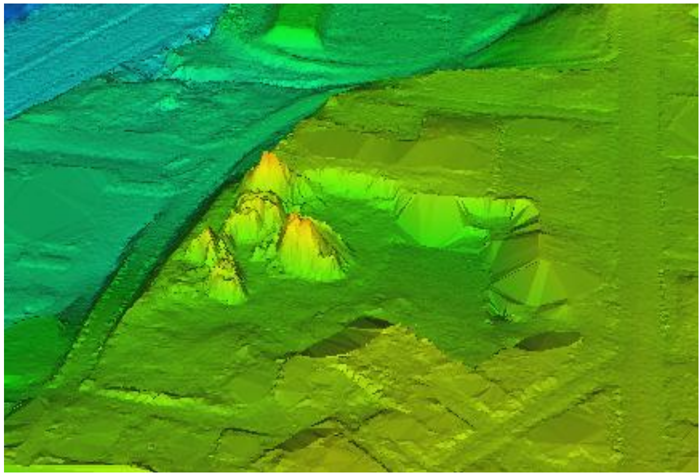
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02664752.las		**Date: 08/06/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02844756.las, 19_02984756.las, 19_02974758.las, 19_02974758.las, and 19_02984760.las		**Date: 08/06/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02974760.las			**Date: 08/06/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles	P		
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02984761.las			**Date: 08/06/2012**
Item	**P/F/NA**	**Comments**	
Scanlines removed from bare earth	P		
Excessive Noise in bare earth	P		
Elevation Steps	P		
Gaps/Voids	P		
Edge matching between tiles			
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P		
Proper definition of roads and drainage patterns	P		
"Over-smoothed" areas during filtering	P		
Corn Row Effects	P		
Mounds and Divots	P		
Other anomalies	P		



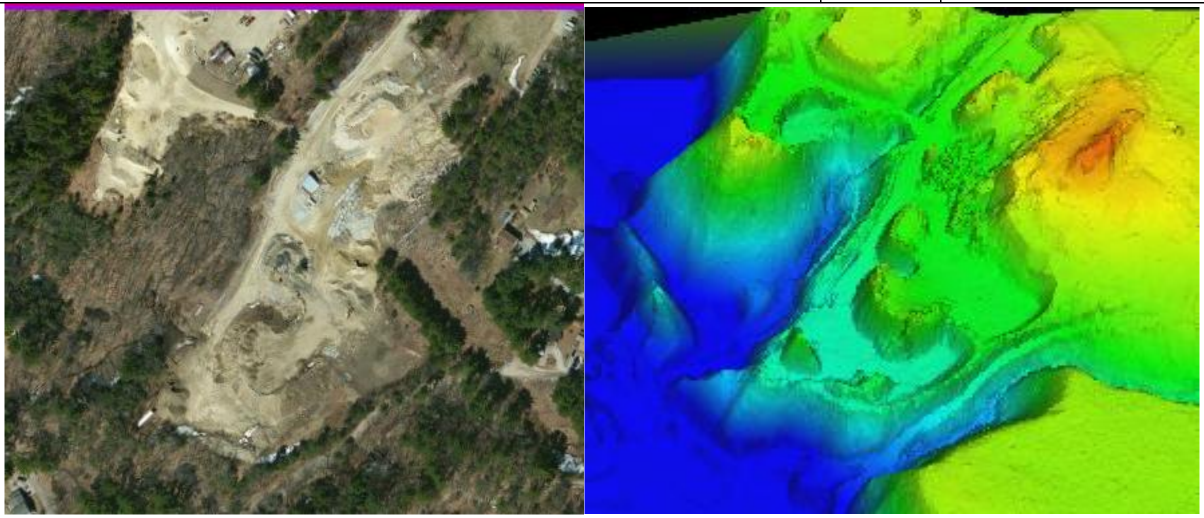


Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02984762.las, 19_02974762.las, and 19_02964762.las		**Date: 08/06/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles		
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02964762.las		**Date: 08/06/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

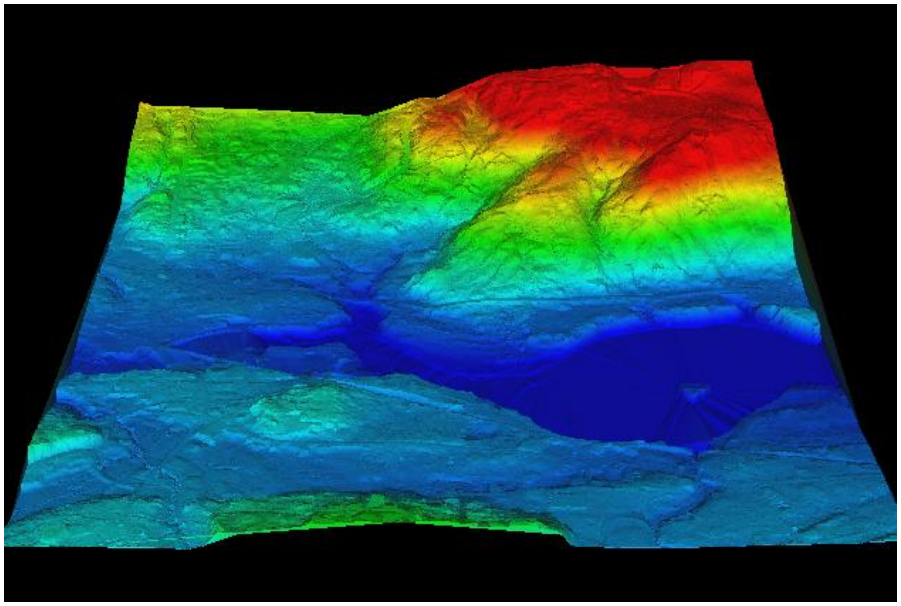
Classified Point Cloud Data Visual Checklist
Project: Merrimack
Vendor:
Reviewed By: Myra Hupfeld-Cousineau
LAS File: 19_02964764.las, 19_02944764.las
Date: 08/06/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles		
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	



<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_02704762.las</td><td>Date: 08/07/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>NA</td><td colspan="2"></td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>

<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_02864766.las and 19_02884766.las</td><td>Date: 08/07/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>



Classified Point Cloud Data Visual Checklist	**Project: Merrimack**
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02974766.las	**Date: 08/07/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	F	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02974767.las and 19_02984767.las			**Date: 08/07/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**	
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**	
LAS File: 19_02784772.las			**Date: 08/07/2012**

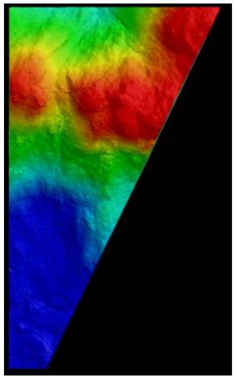
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

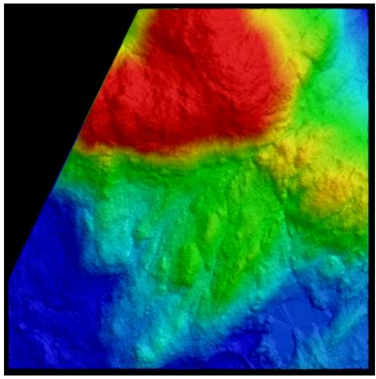
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02704774.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

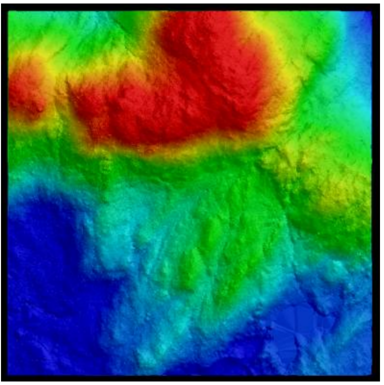
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02864774.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist	**Project: Merrimack**
Vendor:	**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03124782.las	**Date: 08/07/2012**

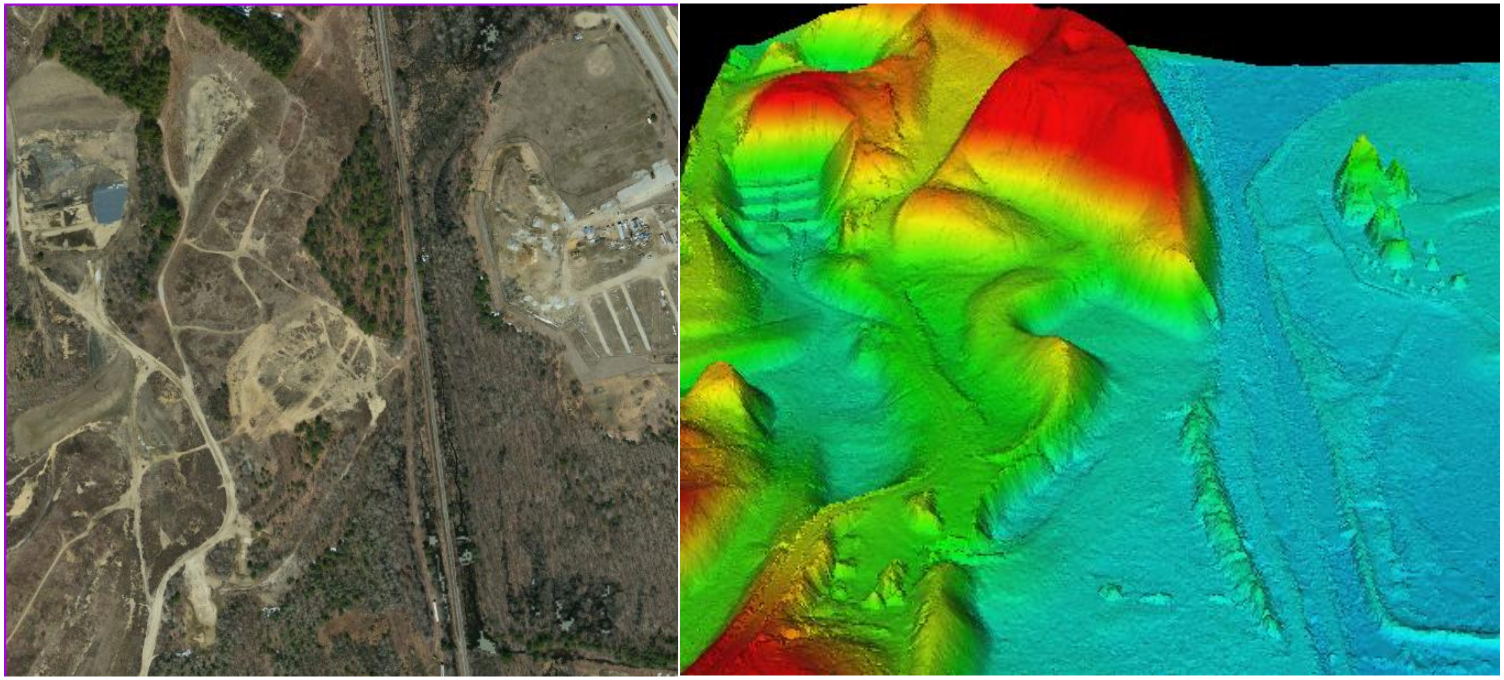
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	See images matching USGS below
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

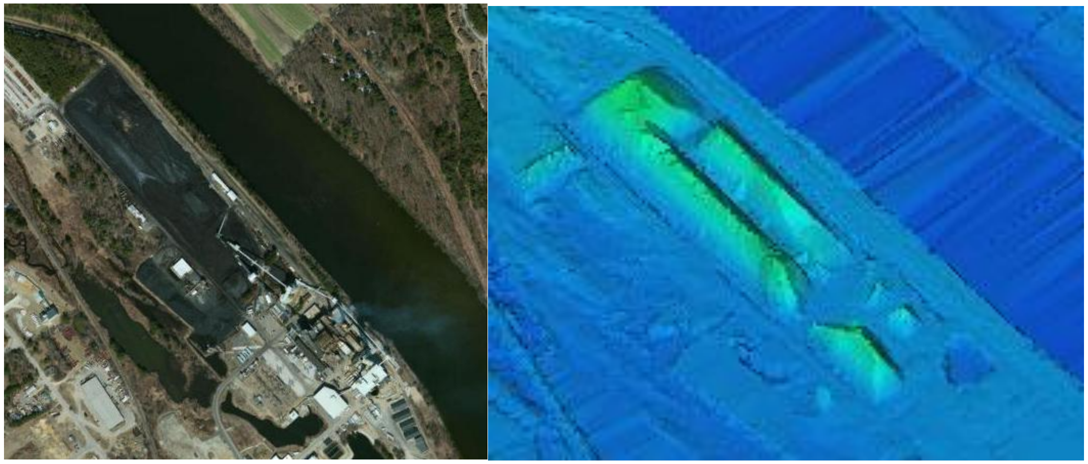

Merrimack


USGS tile


combined

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02984778.las, 19_03004778.las, and 19_02984779.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	Piles of dirt/coal
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	





piles of coal for power plant

Classified Point Cloud Data Visual Checklist
Project: Merrimack
Vendor:
Reviewed By: Myra Hupfeld-Cousineau
LAS File: 19_02884784.las
Date: 08/07/2012

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_02984790.las and 19_03004790.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03064791.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_03124784.las, 19_03144785.las, 19_03154788.las</td><td>Date: 08/07/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>NA</td><td colspan="2"></td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>

<table>
<tr><td colspan="2">Classified Point Cloud Data Visual Checklist</td><td colspan="2">Project: Merrimack</td></tr>
<tr><td colspan="2">Vendor:</td><td colspan="2">Reviewed By: Myra Hupfeld-Cousineau</td></tr>
<tr><td colspan="3">LAS File: 19_03154790.las</td><td>Date: 08/07/2012</td></tr>
<tr><td>Item</td><td>P/F/NA</td><td colspan="2">Comments</td></tr>
<tr><td>Scanlines removed from bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Excessive Noise in bare earth</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Elevation Steps</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Gaps/Voids</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Edge matching between tiles</td><td>NA</td><td colspan="2"></td></tr>
<tr><td>Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Proper definition of roads and drainage patterns</td><td>P</td><td colspan="2"></td></tr>
<tr><td>“Over-smoothed” areas during filtering</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Corn Row Effects</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Mounds and Divots</td><td>P</td><td colspan="2"></td></tr>
<tr><td>Other anomalies</td><td>P</td><td colspan="2"></td></tr>
</table>

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03154791.las and 19_03164791.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

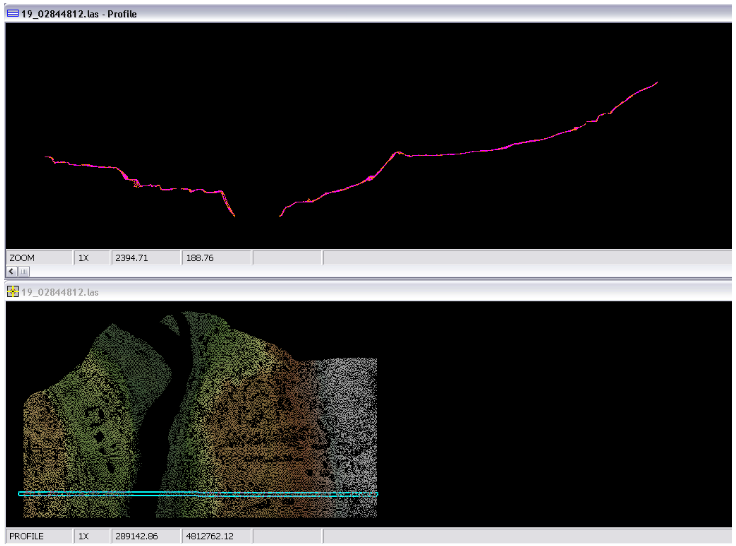
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03164792.las and 19_03184792.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
"Over-smoothed" areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: Myra Hupfeld-Cousineau**
LAS File: 19_03184794.las		**Date: 08/07/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	P	

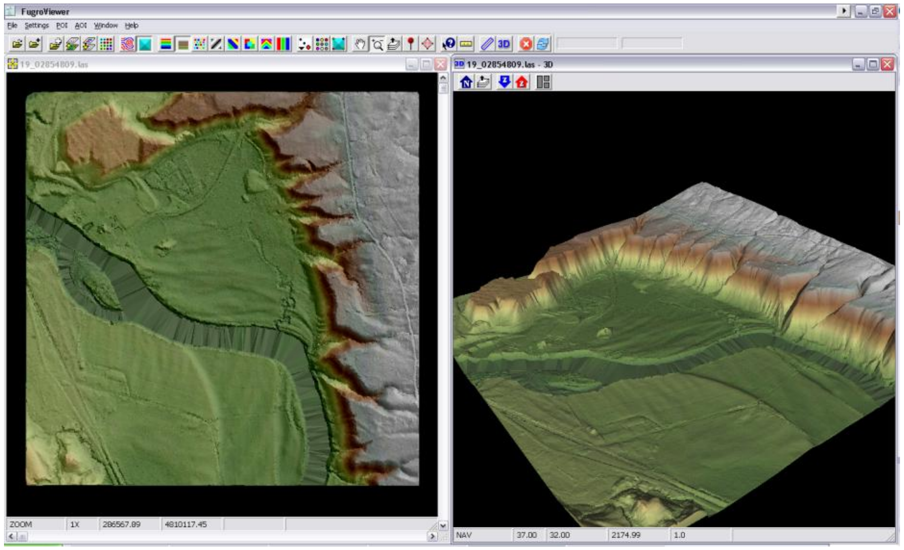
Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS File: 19_03084820.las		**Date: 07/30/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS File: 19_03124812.las		**Date: 07/30/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS File: 19_02844812.las; 19_02854809.las; 19_02854810.las; 19_02854812.las		**Date: 07/30/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	



Profile view, bare earth



bare earth TIN 3D

Classified Point Cloud Data Visual Checklist	**Project: Merrimack**	
Vendor:	**Reviewed By: MCC**	
LAS File: 19_03004803.las		**Date: 07/30/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

NH Speedway

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: MCC**
LAS File: 19_03154800.las; 19_03164800.las | **Date: 07/30/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: MCC**
LAS File: 19_03264798.las | **Date: 07/30/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

Classified Point Cloud Data Visual Checklist | **Project: Merrimack**
Vendor: | **Reviewed By: MCC**
LAS File: 19_03104796.las; 19_03104797.las | **Date: 07/30/2012**

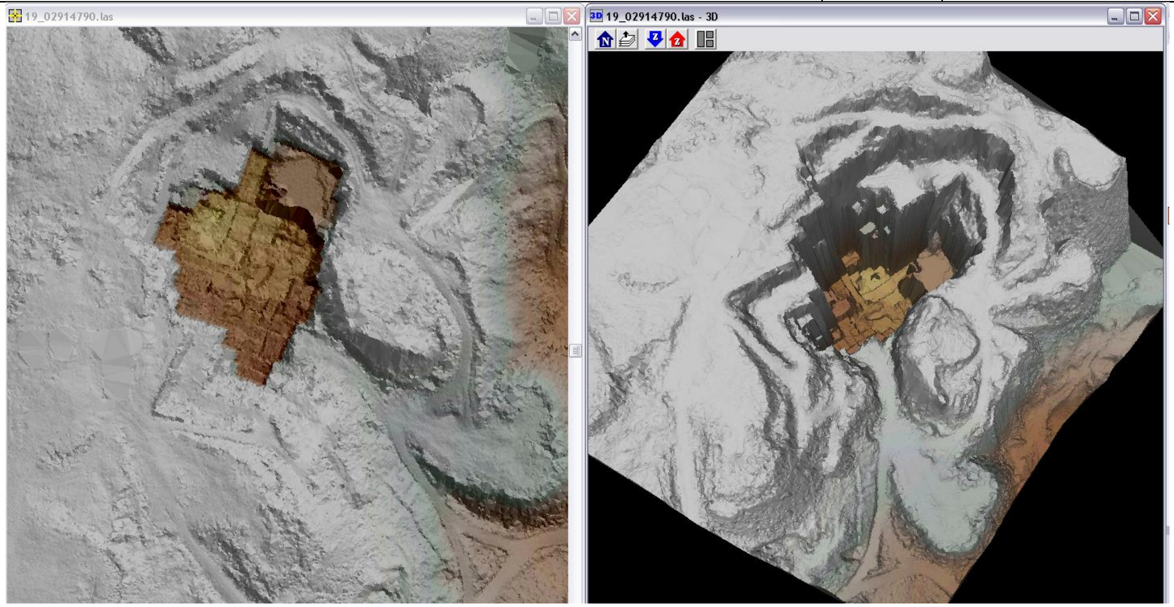
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	

Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

Classified Point Cloud Data Visual Checklist		**Project: Merrimack**
Vendor:		**Reviewed By: MCC**
LAS File: 19_02984796.las		**Date: 07/30/2012**
Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	NA	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	
Other anomalies	NA	

Classified Point Cloud Data Visual Checklist	**Project: Merrimack**
Vendor:	**Reviewed By: MCC**
LAS File: 19_02904794.las; 19_02904796.las; 19_02914790.las; 19_02914791.las; 19_02914792.las; 19_02914794.las; 19_02924788.las; 19_02924790.las; 19_02924791.las; 19_02924792.las; 19_02944782.las; 19_02944784.las; 19_02944785.las; 19_02944786.las; 19_02944788.las; 19_02964782.las; 19_02964784.las; 19_02964788.las	**Date: 07/30/2012**

Item	**P/F/NA**	**Comments**
Scanlines removed from bare earth	P	
Excessive Noise in bare earth	P	
Elevation Steps	P	
Gaps/Voids	P	
Edge matching between tiles	P	
Artifacts have been removed from bare earth (vegetation, buildings, bridges, etc.)	P	
Proper definition of roads and drainage patterns	P	
“Over-smoothed” areas during filtering	P	
Corn Row Effects	P	
Mounds and Divots	P	Dirt piles on ortho
Other anomalies	NA	



deep mine, bare earth TIN

Appendix G: Deliverables

STARR

Date:

September 14, 2012

Contract #

HSFEHQ-090D-0370

Task Order #

HSFEHQ -01-J-0010

Subject:

STARR Elevation Data (LiDAR)

Transmittal:

To: **Bill Davis**
Michael Baker Corporation
FEMA Engineering Library
847 South Pickett Street
Alexandria, VA 22304

From: James Huffines
Greenhorne & O'Mara, Inc
5565 Centerview Drive
Ste 107
Raleigh, NC 27606

Transmitted:

☐ For Your Use
☐ For Your Approval/Signature
☐ For Your Information
☐ For Your Review
☐ As Requested
☒ For Storage

The following:

COPIES	DATE	DESCRIPTION
1	9/14/2012	Portable Hard Drive Containing: Region 1 – Merrimack HUC 8 Watershed LiDAR and Terrain data See readme.txt included on hard drive for directory structure information.
		Includes: QC Checkpoint (CVA) data, Tile Index shapefile, Collection Area shapefile, QC Testing Results, QA Review, Compliance Certificates for Survey, Unclassified Point Cloud, Classified Point Cloud (Bare Earth), Metadata, Narrative, DEMs and Contours

Remarks:

If you have any questions or require additional information please feel free to contact me at 919-532-2332.
Please sign this transmittal upon receipt and mail to address shown above or fax to 919-851-8393.

Printed Name and Date: James L. Huffines 14SEP2012

Signature:

```
Folder PATH listing for volume Merrimack HUC8 LiDAR
Volume serial number is 00650076 040B:C0C3
E:\REGION1\MERRIMACK_RIVER_HUC8_TERRAIN_DATA
+---Correspondance
+---Final
|   +---Bare Earth DEM
|   |   |   Merrimack_DEM_Index.dbf
|   |   |   Merrimack_DEM_Index.prj
|   |   |   Merrimack_DEM_Index.sbn
|   |   |   Merrimack_DEM_Index.sbx
|   |   |   Merrimack_DEM_Index.shp
|   |   |   Merrimack_DEM_Index.shp.xml
|   |   |   Merrimack_DEM_Index.shx
|   |   |   
|   |   +---Merrimack_DEMs.gdb
|   |   |   
|   |   \---Raster_1m_DEM
|   |           merrimack_19_02604734.img
|   |           merrimack_19_02604734.rrd
|   |           merrimack_19_02604736.img
|   |           merrimack_19_02604736.rrd
|   |           merrimack_19_02614728.img
|   |           merrimack_19_02614728.rrd
|   |           merrimack_19_02614730.img
|   |           merrimack_19_02614730.rrd
|   |           merrimack_19_02614731.img
|   |           merrimack_19_02614731.rrd
|   |           merrimack_19_02614732.img
|   |           merrimack_19_02614732.rrd
|   |           merrimack_19_02614734.img
|   |           merrimack_19_02614734.rrd
|   |           merrimack_19_02614736.img
|   |           merrimack_19_02614736.rrd
|   |           merrimack_19_02614737.img
|   |           merrimack_19_02614737.rrd
|   |           merrimack_19_02614738.img
|   |           merrimack_19_02614738.rrd
|   |           merrimack_19_02624725.img
|   |           merrimack_19_02624725.rrd
|   |           merrimack_19_02624726.img
|   |           merrimack_19_02624726.rrd
|   |           merrimack_19_02624728.img
|   |           merrimack_19_02624728.rrd
|   |           merrimack_19_02624730.img
|   |           merrimack_19_02624730.rrd
|   |           merrimack_19_02624731.img
|   |           merrimack_19_02624731.rrd
|   |           merrimack_19_02624732.img
|   |           merrimack_19_02624732.rrd
|   |           merrimack_19_02624734.img
|   |           merrimack_19_02624734.rrd
|   |           merrimack_19_02624736.img
|   |           merrimack_19_02624736.rrd
|   |           merrimack_19_02624737.img
```

```
|    |             merrimack_19_02624737.rrd
|    |             merrimack_19_02624738.img
|    |             merrimack_19_02624738.rrd
|    |             merrimack_19_02624740.img
|    |             merrimack_19_02624740.rrd
|    |             merrimack_19_02624742.img
|    |             merrimack_19_02624742.rrd
|    |             merrimack_19_02624743.img
|    |             merrimack_19_02624743.rrd
|    |             merrimack_19_02624744.img
|    |             merrimack_19_02624744.rrd
|    |             merrimack_19_02624746.img
|    |             merrimack_19_02624746.rrd
|    |             merrimack_19_02624748.img
|    |             merrimack_19_02624748.rrd
|    |             merrimack_19_02644725.img
|    |             merrimack_19_02644725.rrd
|    |             merrimack_19_02644726.img
|    |             merrimack_19_02644726.rrd
|    |             merrimack_19_02644728.img
|    |             merrimack_19_02644728.rrd
|    |             merrimack_19_02644730.img
|    |             merrimack_19_02644730.rrd
|    |             merrimack_19_02644731.img
|    |             merrimack_19_02644731.rrd
|    |             merrimack_19_02644732.img
|    |             merrimack_19_02644732.rrd
|    |             merrimack_19_02644734.img
|    |             merrimack_19_02644734.rrd
|    |             merrimack_19_02644736.img
|    |             merrimack_19_02644736.rrd
|    |             merrimack_19_02644737.img
|    |             merrimack_19_02644737.rrd
|    |             merrimack_19_02644738.img
|    |             merrimack_19_02644738.rrd
|    |             merrimack_19_02644740.img
|    |             merrimack_19_02644740.rrd
|    |             merrimack_19_02644742.img
|    |             merrimack_19_02644742.rrd
|    |             merrimack_19_02644743.img
|    |             merrimack_19_02644743.rrd
|    |             merrimack_19_02644744.img
|    |             merrimack_19_02644744.rrd
|    |             merrimack_19_02644746.img
|    |             merrimack_19_02644746.rrd
|    |             merrimack_19_02644748.img
|    |             merrimack_19_02644748.rrd
|    |             merrimack_19_02644749.img
|    |             merrimack_19_02644749.rrd
|    |             merrimack_19_02644750.img
|    |             merrimack_19_02644750.rrd
|    |             merrimack_19_02644752.img
|    |             merrimack_19_02644752.rrd
|    |             merrimack_19_02644754.img
```

```
|    |              merrimack_19_02644754.rrd
|    |              merrimack_19_02644755.img
|    |              merrimack_19_02644755.rrd
|    |              merrimack_19_02644760.img
|    |              merrimack_19_02644760.rrd
|    |              merrimack_19_02644761.img
|    |              merrimack_19_02644761.rrd
|    |              merrimack_19_02644762.img
|    |              merrimack_19_02644762.rrd
|    |              merrimack_19_02644764.img
|    |              merrimack_19_02644764.rrd
|    |              merrimack_19_02644766.img
|    |              merrimack_19_02644766.rrd
|    |              merrimack_19_02644767.img
|    |              merrimack_19_02644767.rrd
|    |              merrimack_19_02644772.img
|    |              merrimack_19_02644772.rrd
|    |              merrimack_19_02664726.img
|    |              merrimack_19_02664726.rrd
|    |              merrimack_19_02664728.img
|    |              merrimack_19_02664728.rrd
|    |              merrimack_19_02664730.img
|    |              merrimack_19_02664730.rrd
|    |              merrimack_19_02664731.img
|    |              merrimack_19_02664731.rrd
|    |              merrimack_19_02664732.img
|    |              merrimack_19_02664732.rrd
|    |              merrimack_19_02664734.img
|    |              merrimack_19_02664734.rrd
|    |              merrimack_19_02664736.img
|    |              merrimack_19_02664736.rrd
|    |              merrimack_19_02664737.img
|    |              merrimack_19_02664737.rrd
|    |              merrimack_19_02664738.img
|    |              merrimack_19_02664738.rrd
|    |              merrimack_19_02664740.img
|    |              merrimack_19_02664740.rrd
|    |              merrimack_19_02664742.img
|    |              merrimack_19_02664742.rrd
|    |              merrimack_19_02664743.img
|    |              merrimack_19_02664743.rrd
|    |              merrimack_19_02664744.img
|    |              merrimack_19_02664744.rrd
|    |              merrimack_19_02664746.img
|    |              merrimack_19_02664746.rrd
|    |              merrimack_19_02664748.img
|    |              merrimack_19_02664748.rrd
|    |              merrimack_19_02664749.img
|    |              merrimack_19_02664749.rrd
|    |              merrimack_19_02664750.img
|    |              merrimack_19_02664750.rrd
|    |              merrimack_19_02664752.img
|    |              merrimack_19_02664752.rrd
|    |              merrimack_19_02664754.img
```

```
|    |             merrimack_19_02664754.rrd
|    |             merrimack_19_02664755.img
|    |             merrimack_19_02664755.rrd
|    |             merrimack_19_02664756.img
|    |             merrimack_19_02664756.rrd
|    |             merrimack_19_02664758.img
|    |             merrimack_19_02664758.rrd
|    |             merrimack_19_02664760.img
|    |             merrimack_19_02664760.rrd
|    |             merrimack_19_02664761.img
|    |             merrimack_19_02664761.rrd
|    |             merrimack_19_02664762.img
|    |             merrimack_19_02664762.rrd
|    |             merrimack_19_02664764.img
|    |             merrimack_19_02664764.rrd
|    |             merrimack_19_02664766.img
|    |             merrimack_19_02664766.rrd
|    |             merrimack_19_02664767.img
|    |             merrimack_19_02664767.rrd
|    |             merrimack_19_02664768.img
|    |             merrimack_19_02664768.rrd
|    |             merrimack_19_02664770.img
|    |             merrimack_19_02664770.rrd
|    |             merrimack_19_02664772.img
|    |             merrimack_19_02664772.rrd
|    |             merrimack_19_02664773.img
|    |             merrimack_19_02664773.rrd
|    |             merrimack_19_02664774.img
|    |             merrimack_19_02664774.rrd
|    |             merrimack_19_02664776.img
|    |             merrimack_19_02664776.rrd
|    |             merrimack_19_02674730.img
|    |             merrimack_19_02674730.rrd
|    |             merrimack_19_02674731.img
|    |             merrimack_19_02674731.rrd
|    |             merrimack_19_02674732.img
|    |             merrimack_19_02674732.rrd
|    |             merrimack_19_02674734.img
|    |             merrimack_19_02674734.rrd
|    |             merrimack_19_02674736.img
|    |             merrimack_19_02674736.rrd
|    |             merrimack_19_02674737.img
|    |             merrimack_19_02674737.rrd
|    |             merrimack_19_02674738.img
|    |             merrimack_19_02674738.rrd
|    |             merrimack_19_02674740.img
|    |             merrimack_19_02674740.rrd
|    |             merrimack_19_02674742.img
|    |             merrimack_19_02674742.rrd
|    |             merrimack_19_02674743.img
|    |             merrimack_19_02674743.rrd
|    |             merrimack_19_02674744.img
|    |             merrimack_19_02674744.rrd
|    |             merrimack_19_02674746.img
```

```
|    |              merrimack_19_02674746.rrd
|    |              merrimack_19_02674748.img
|    |              merrimack_19_02674748.rrd
|    |              merrimack_19_02674749.img
|    |              merrimack_19_02674749.rrd
|    |              merrimack_19_02674750.img
|    |              merrimack_19_02674750.rrd
|    |              merrimack_19_02674752.img
|    |              merrimack_19_02674752.rrd
|    |              merrimack_19_02674754.img
|    |              merrimack_19_02674754.rrd
|    |              merrimack_19_02674755.img
|    |              merrimack_19_02674755.rrd
|    |              merrimack_19_02674756.img
|    |              merrimack_19_02674756.rrd
|    |              merrimack_19_02674758.img
|    |              merrimack_19_02674758.rrd
|    |              merrimack_19_02674760.img
|    |              merrimack_19_02674760.rrd
|    |              merrimack_19_02674761.img
|    |              merrimack_19_02674761.rrd
|    |              merrimack_19_02674762.img
|    |              merrimack_19_02674762.rrd
|    |              merrimack_19_02674764.img
|    |              merrimack_19_02674764.rrd
|    |              merrimack_19_02674766.img
|    |              merrimack_19_02674766.rrd
|    |              merrimack_19_02674767.img
|    |              merrimack_19_02674767.rrd
|    |              merrimack_19_02674768.img
|    |              merrimack_19_02674768.rrd
|    |              merrimack_19_02674770.img
|    |              merrimack_19_02674770.rrd
|    |              merrimack_19_02674772.img
|    |              merrimack_19_02674772.rrd
|    |              merrimack_19_02674773.img
|    |              merrimack_19_02674773.rrd
|    |              merrimack_19_02674774.img
|    |              merrimack_19_02674774.rrd
|    |              merrimack_19_02674776.img
|    |              merrimack_19_02674776.rrd
|    |              merrimack_19_02674778.img
|    |              merrimack_19_02674778.rrd
|    |              merrimack_19_02674779.img
|    |              merrimack_19_02674779.rrd
|    |              merrimack_19_02684732.img
|    |              merrimack_19_02684732.rrd
|    |              merrimack_19_02684734.img
|    |              merrimack_19_02684734.rrd
|    |              merrimack_19_02684736.img
|    |              merrimack_19_02684736.rrd
|    |              merrimack_19_02684737.img
|    |              merrimack_19_02684737.rrd
|    |              merrimack_19_02684738.img
```

```
|    |             merrimack_19_02684738.rrd
|    |             merrimack_19_02684740.img
|    |             merrimack_19_02684740.rrd
|    |             merrimack_19_02684742.img
|    |             merrimack_19_02684742.rrd
|    |             merrimack_19_02684743.img
|    |             merrimack_19_02684743.rrd
|    |             merrimack_19_02684744.img
|    |             merrimack_19_02684744.rrd
|    |             merrimack_19_02684746.img
|    |             merrimack_19_02684746.rrd
|    |             merrimack_19_02684748.img
|    |             merrimack_19_02684748.rrd
|    |             merrimack_19_02684749.img
|    |             merrimack_19_02684749.rrd
|    |             merrimack_19_02684750.img
|    |             merrimack_19_02684750.rrd
|    |             merrimack_19_02684752.img
|    |             merrimack_19_02684752.rrd
|    |             merrimack_19_02684754.img
|    |             merrimack_19_02684754.rrd
|    |             merrimack_19_02684755.img
|    |             merrimack_19_02684755.rrd
|    |             merrimack_19_02684756.img
|    |             merrimack_19_02684756.rrd
|    |             merrimack_19_02684758.img
|    |             merrimack_19_02684758.rrd
|    |             merrimack_19_02684760.img
|    |             merrimack_19_02684760.rrd
|    |             merrimack_19_02684761.img
|    |             merrimack_19_02684761.rrd
|    |             merrimack_19_02684762.img
|    |             merrimack_19_02684762.rrd
|    |             merrimack_19_02684764.img
|    |             merrimack_19_02684764.rrd
|    |             merrimack_19_02684766.img
|    |             merrimack_19_02684766.rrd
|    |             merrimack_19_02684767.img
|    |             merrimack_19_02684767.rrd
|    |             merrimack_19_02684768.img
|    |             merrimack_19_02684768.rrd
|    |             merrimack_19_02684770.img
|    |             merrimack_19_02684770.rrd
|    |             merrimack_19_02684772.img
|    |             merrimack_19_02684772.rrd
|    |             merrimack_19_02684773.img
|    |             merrimack_19_02684773.rrd
|    |             merrimack_19_02684774.img
|    |             merrimack_19_02684774.rrd
|    |             merrimack_19_02684776.img
|    |             merrimack_19_02684776.rrd
|    |             merrimack_19_02684778.img
|    |             merrimack_19_02684778.rrd
|    |             merrimack_19_02684779.img
```

```
|    |             merrimack_19_02684779.rrd
|    |             merrimack_19_02684780.img
|    |             merrimack_19_02684780.rrd
|    |             merrimack_19_02704737.img
|    |             merrimack_19_02704737.rrd
|    |             merrimack_19_02704738.img
|    |             merrimack_19_02704738.rrd
|    |             merrimack_19_02704740.img
|    |             merrimack_19_02704740.rrd
|    |             merrimack_19_02704742.img
|    |             merrimack_19_02704742.rrd
|    |             merrimack_19_02704743.img
|    |             merrimack_19_02704743.rrd
|    |             merrimack_19_02704744.img
|    |             merrimack_19_02704744.rrd
|    |             merrimack_19_02704746.img
|    |             merrimack_19_02704746.rrd
|    |             merrimack_19_02704748.img
|    |             merrimack_19_02704748.rrd
|    |             merrimack_19_02704749.img
|    |             merrimack_19_02704749.rrd
|    |             merrimack_19_02704750.img
|    |             merrimack_19_02704750.rrd
|    |             merrimack_19_02704752.img
|    |             merrimack_19_02704752.rrd
|    |             merrimack_19_02704754.img
|    |             merrimack_19_02704754.rrd
|    |             merrimack_19_02704755.img
|    |             merrimack_19_02704755.rrd
|    |             merrimack_19_02704756.img
|    |             merrimack_19_02704756.rrd
|    |             merrimack_19_02704758.img
|    |             merrimack_19_02704758.rrd
|    |             merrimack_19_02704760.img
|    |             merrimack_19_02704760.rrd
|    |             merrimack_19_02704761.img
|    |             merrimack_19_02704761.rrd
|    |             merrimack_19_02704762.img
|    |             merrimack_19_02704762.rrd
|    |             merrimack_19_02704764.img
|    |             merrimack_19_02704764.rrd
|    |             merrimack_19_02704766.img
|    |             merrimack_19_02704766.rrd
|    |             merrimack_19_02704767.img
|    |             merrimack_19_02704767.rrd
|    |             merrimack_19_02704768.img
|    |             merrimack_19_02704768.rrd
|    |             merrimack_19_02704770.img
|    |             merrimack_19_02704770.rrd
|    |             merrimack_19_02704772.img
|    |             merrimack_19_02704772.rrd
|    |             merrimack_19_02704773.img
|    |             merrimack_19_02704773.rrd
|    |             merrimack_19_02704774.img
```

```
|    |              merrimack_19_02704774.rrd
|    |              merrimack_19_02704776.img
|    |              merrimack_19_02704776.rrd
|    |              merrimack_19_02704778.img
|    |              merrimack_19_02704778.rrd
|    |              merrimack_19_02704779.img
|    |              merrimack_19_02704779.rrd
|    |              merrimack_19_02704780.img
|    |              merrimack_19_02704780.rrd
|    |              merrimack_19_02724737.img
|    |              merrimack_19_02724737.rrd
|    |              merrimack_19_02724738.img
|    |              merrimack_19_02724738.rrd
|    |              merrimack_19_02724740.img
|    |              merrimack_19_02724740.rrd
|    |              merrimack_19_02724742.img
|    |              merrimack_19_02724742.rrd
|    |              merrimack_19_02724743.img
|    |              merrimack_19_02724743.rrd
|    |              merrimack_19_02724744.img
|    |              merrimack_19_02724744.rrd
|    |              merrimack_19_02724746.img
|    |              merrimack_19_02724746.rrd
|    |              merrimack_19_02724748.img
|    |              merrimack_19_02724748.rrd
|    |              merrimack_19_02724749.img
|    |              merrimack_19_02724749.rrd
|    |              merrimack_19_02724750.img
|    |              merrimack_19_02724750.rrd
|    |              merrimack_19_02724752.img
|    |              merrimack_19_02724752.rrd
|    |              merrimack_19_02724754.img
|    |              merrimack_19_02724754.rrd
|    |              merrimack_19_02724755.img
|    |              merrimack_19_02724755.rrd
|    |              merrimack_19_02724756.img
|    |              merrimack_19_02724756.rrd
|    |              merrimack_19_02724758.img
|    |              merrimack_19_02724758.rrd
|    |              merrimack_19_02724760.img
|    |              merrimack_19_02724760.rrd
|    |              merrimack_19_02724761.img
|    |              merrimack_19_02724761.rrd
|    |              merrimack_19_02724762.img
|    |              merrimack_19_02724762.rrd
|    |              merrimack_19_02724764.img
|    |              merrimack_19_02724764.rrd
|    |              merrimack_19_02724766.img
|    |              merrimack_19_02724766.rrd
|    |              merrimack_19_02724767.img
|    |              merrimack_19_02724767.rrd
|    |              merrimack_19_02724768.img
|    |              merrimack_19_02724768.rrd
|    |              merrimack_19_02724770.img
```

```
|    |              merrimack_19_02724770.rrd
|    |              merrimack_19_02724772.img
|    |              merrimack_19_02724772.rrd
|    |              merrimack_19_02724773.img
|    |              merrimack_19_02724773.rrd
|    |              merrimack_19_02724774.img
|    |              merrimack_19_02724774.rrd
|    |              merrimack_19_02724776.img
|    |              merrimack_19_02724776.rrd
|    |              merrimack_19_02724778.img
|    |              merrimack_19_02724778.rrd
|    |              merrimack_19_02724779.img
|    |              merrimack_19_02724779.rrd
|    |              merrimack_19_02724780.img
|    |              merrimack_19_02724780.rrd
|    |              merrimack_19_02734740.img
|    |              merrimack_19_02734740.rrd
|    |              merrimack_19_02734742.img
|    |              merrimack_19_02734742.rrd
|    |              merrimack_19_02734743.img
|    |              merrimack_19_02734743.rrd
|    |              merrimack_19_02734744.img
|    |              merrimack_19_02734744.rrd
|    |              merrimack_19_02734746.img
|    |              merrimack_19_02734746.rrd
|    |              merrimack_19_02734748.img
|    |              merrimack_19_02734748.rrd
|    |              merrimack_19_02734749.img
|    |              merrimack_19_02734749.rrd
|    |              merrimack_19_02734750.img
|    |              merrimack_19_02734750.rrd
|    |              merrimack_19_02734752.img
|    |              merrimack_19_02734752.rrd
|    |              merrimack_19_02734754.img
|    |              merrimack_19_02734754.rrd
|    |              merrimack_19_02734755.img
|    |              merrimack_19_02734755.rrd
|    |              merrimack_19_02734756.img
|    |              merrimack_19_02734756.rrd
|    |              merrimack_19_02734758.img
|    |              merrimack_19_02734758.rrd
|    |              merrimack_19_02734760.img
|    |              merrimack_19_02734760.rrd
|    |              merrimack_19_02734761.img
|    |              merrimack_19_02734761.rrd
|    |              merrimack_19_02734762.img
|    |              merrimack_19_02734762.rrd
|    |              merrimack_19_02734764.img
|    |              merrimack_19_02734764.rrd
|    |              merrimack_19_02734766.img
|    |              merrimack_19_02734766.rrd
|    |              merrimack_19_02734767.img
|    |              merrimack_19_02734767.rrd
|    |              merrimack_19_02734768.img
```

```
|   |           merrimack_19_02734768.rrd
|   |           merrimack_19_02734770.img
|   |           merrimack_19_02734770.rrd
|   |           merrimack_19_02734772.img
|   |           merrimack_19_02734772.rrd
|   |           merrimack_19_02734773.img
|   |           merrimack_19_02734773.rrd
|   |           merrimack_19_02734774.img
|   |           merrimack_19_02734774.rrd
|   |           merrimack_19_02734776.img
|   |           merrimack_19_02734776.rrd
|   |           merrimack_19_02734778.img
|   |           merrimack_19_02734778.rrd
|   |           merrimack_19_02734779.img
|   |           merrimack_19_02734779.rrd
|   |           merrimack_19_02734780.img
|   |           merrimack_19_02734780.rrd
|   |           merrimack_19_02744742.img
|   |           merrimack_19_02744742.rrd
|   |           merrimack_19_02744743.img
|   |           merrimack_19_02744743.rrd
|   |           merrimack_19_02744744.img
|   |           merrimack_19_02744744.rrd
|   |           merrimack_19_02744746.img
|   |           merrimack_19_02744746.rrd
|   |           merrimack_19_02744748.img
|   |           merrimack_19_02744748.rrd
|   |           merrimack_19_02744749.img
|   |           merrimack_19_02744749.rrd
|   |           merrimack_19_02744750.img
|   |           merrimack_19_02744750.rrd
|   |           merrimack_19_02744752.img
|   |           merrimack_19_02744752.rrd
|   |           merrimack_19_02744754.img
|   |           merrimack_19_02744754.rrd
|   |           merrimack_19_02744755.img
|   |           merrimack_19_02744755.rrd
|   |           merrimack_19_02744756.img
|   |           merrimack_19_02744756.rrd
|   |           merrimack_19_02744758.img
|   |           merrimack_19_02744758.rrd
|   |           merrimack_19_02744760.img
|   |           merrimack_19_02744760.rrd
|   |           merrimack_19_02744761.img
|   |           merrimack_19_02744761.rrd
|   |           merrimack_19_02744762.img
|   |           merrimack_19_02744762.rrd
|   |           merrimack_19_02744764.img
|   |           merrimack_19_02744764.rrd
|   |           merrimack_19_02744766.img
|   |           merrimack_19_02744766.rrd
|   |           merrimack_19_02744767.img
|   |           merrimack_19_02744767.rrd
|   |           merrimack_19_02744768.img
```

```
|    |            merrimack_19_02744768.rrd
|    |            merrimack_19_02744770.img
|    |            merrimack_19_02744770.rrd
|    |            merrimack_19_02744772.img
|    |            merrimack_19_02744772.rrd
|    |            merrimack_19_02744773.img
|    |            merrimack_19_02744773.rrd
|    |            merrimack_19_02744774.img
|    |            merrimack_19_02744774.rrd
|    |            merrimack_19_02744776.img
|    |            merrimack_19_02744776.rrd
|    |            merrimack_19_02744778.img
|    |            merrimack_19_02744778.rrd
|    |            merrimack_19_02744779.img
|    |            merrimack_19_02744779.rrd
|    |            merrimack_19_02764742.img
|    |            merrimack_19_02764742.rrd
|    |            merrimack_19_02764743.img
|    |            merrimack_19_02764743.rrd
|    |            merrimack_19_02764744.img
|    |            merrimack_19_02764744.rrd
|    |            merrimack_19_02764746.img
|    |            merrimack_19_02764746.rrd
|    |            merrimack_19_02764748.img
|    |            merrimack_19_02764748.rrd
|    |            merrimack_19_02764749.img
|    |            merrimack_19_02764749.rrd
|    |            merrimack_19_02764750.img
|    |            merrimack_19_02764750.rrd
|    |            merrimack_19_02764752.img
|    |            merrimack_19_02764752.rrd
|    |            merrimack_19_02764754.img
|    |            merrimack_19_02764754.rrd
|    |            merrimack_19_02764755.img
|    |            merrimack_19_02764755.rrd
|    |            merrimack_19_02764756.img
|    |            merrimack_19_02764756.rrd
|    |            merrimack_19_02764758.img
|    |            merrimack_19_02764758.rrd
|    |            merrimack_19_02764760.img
|    |            merrimack_19_02764760.rrd
|    |            merrimack_19_02764761.img
|    |            merrimack_19_02764761.rrd
|    |            merrimack_19_02764762.img
|    |            merrimack_19_02764762.rrd
|    |            merrimack_19_02764764.img
|    |            merrimack_19_02764764.rrd
|    |            merrimack_19_02764766.img
|    |            merrimack_19_02764766.rrd
|    |            merrimack_19_02764767.img
|    |            merrimack_19_02764767.rrd
|    |            merrimack_19_02764768.img
|    |            merrimack_19_02764768.rrd
|    |            merrimack_19_02764770.img
```

```
|    |              merrimack_19_02764770.rrd
|    |              merrimack_19_02764772.img
|    |              merrimack_19_02764772.rrd
|    |              merrimack_19_02764773.img
|    |              merrimack_19_02764773.rrd
|    |              merrimack_19_02764774.img
|    |              merrimack_19_02764774.rrd
|    |              merrimack_19_02764776.img
|    |              merrimack_19_02764776.rrd
|    |              merrimack_19_02764778.img
|    |              merrimack_19_02764778.rrd
|    |              merrimack_19_02764779.img
|    |              merrimack_19_02764779.rrd
|    |              merrimack_19_02764809.img
|    |              merrimack_19_02764809.rrd
|    |              merrimack_19_02764810.img
|    |              merrimack_19_02764810.rrd
|    |              merrimack_19_02784740.img
|    |              merrimack_19_02784740.rrd
|    |              merrimack_19_02784742.img
|    |              merrimack_19_02784742.rrd
|    |              merrimack_19_02784743.img
|    |              merrimack_19_02784743.rrd
|    |              merrimack_19_02784744.img
|    |              merrimack_19_02784744.rrd
|    |              merrimack_19_02784746.img
|    |              merrimack_19_02784746.rrd
|    |              merrimack_19_02784748.img
|    |              merrimack_19_02784748.rrd
|    |              merrimack_19_02784749.img
|    |              merrimack_19_02784749.rrd
|    |              merrimack_19_02784750.img
|    |              merrimack_19_02784750.rrd
|    |              merrimack_19_02784752.img
|    |              merrimack_19_02784752.rrd
|    |              merrimack_19_02784754.img
|    |              merrimack_19_02784754.rrd
|    |              merrimack_19_02784755.img
|    |              merrimack_19_02784755.rrd
|    |              merrimack_19_02784756.img
|    |              merrimack_19_02784756.rrd
|    |              merrimack_19_02784758.img
|    |              merrimack_19_02784758.rrd
|    |              merrimack_19_02784760.img
|    |              merrimack_19_02784760.rrd
|    |              merrimack_19_02784761.img
|    |              merrimack_19_02784761.rrd
|    |              merrimack_19_02784762.img
|    |              merrimack_19_02784762.rrd
|    |              merrimack_19_02784764.img
|    |              merrimack_19_02784764.rrd
|    |              merrimack_19_02784766.img
|    |              merrimack_19_02784766.rrd
|    |              merrimack_19_02784767.img
```

```
|    |             merrimack_19_02784767.rrd
|    |             merrimack_19_02784768.img
|    |             merrimack_19_02784768.rrd
|    |             merrimack_19_02784770.img
|    |             merrimack_19_02784770.rrd
|    |             merrimack_19_02784772.img
|    |             merrimack_19_02784772.rrd
|    |             merrimack_19_02784773.img
|    |             merrimack_19_02784773.rrd
|    |             merrimack_19_02784774.img
|    |             merrimack_19_02784774.rrd
|    |             merrimack_19_02784776.img
|    |             merrimack_19_02784776.rrd
|    |             merrimack_19_02784778.img
|    |             merrimack_19_02784778.rrd
|    |             merrimack_19_02784779.img
|    |             merrimack_19_02784779.rrd
|    |             merrimack_19_02784808.img
|    |             merrimack_19_02784808.rrd
|    |             merrimack_19_02784809.img
|    |             merrimack_19_02784809.rrd
|    |             merrimack_19_02784810.img
|    |             merrimack_19_02784810.rrd
|    |             merrimack_19_02784812.img
|    |             merrimack_19_02784812.rrd
|    |             merrimack_19_02784814.img
|    |             merrimack_19_02784814.rrd
|    |             merrimack_19_02794740.img
|    |             merrimack_19_02794740.rrd
|    |             merrimack_19_02794742.img
|    |             merrimack_19_02794742.rrd
|    |             merrimack_19_02794743.img
|    |             merrimack_19_02794743.rrd
|    |             merrimack_19_02794744.img
|    |             merrimack_19_02794744.rrd
|    |             merrimack_19_02794746.img
|    |             merrimack_19_02794746.rrd
|    |             merrimack_19_02794748.img
|    |             merrimack_19_02794748.rrd
|    |             merrimack_19_02794749.img
|    |             merrimack_19_02794749.rrd
|    |             merrimack_19_02794750.img
|    |             merrimack_19_02794750.rrd
|    |             merrimack_19_02794752.img
|    |             merrimack_19_02794752.rrd
|    |             merrimack_19_02794754.img
|    |             merrimack_19_02794754.rrd
|    |             merrimack_19_02794755.img
|    |             merrimack_19_02794755.rrd
|    |             merrimack_19_02794756.img
|    |             merrimack_19_02794756.rrd
|    |             merrimack_19_02794758.img
|    |             merrimack_19_02794758.rrd
|    |             merrimack_19_02794760.img
```

```
|    |             merrimack_19_02794760.rrd
|    |             merrimack_19_02794761.img
|    |             merrimack_19_02794761.rrd
|    |             merrimack_19_02794762.img
|    |             merrimack_19_02794762.rrd
|    |             merrimack_19_02794764.img
|    |             merrimack_19_02794764.rrd
|    |             merrimack_19_02794766.img
|    |             merrimack_19_02794766.rrd
|    |             merrimack_19_02794767.img
|    |             merrimack_19_02794767.rrd
|    |             merrimack_19_02794768.img
|    |             merrimack_19_02794768.rrd
|    |             merrimack_19_02794770.img
|    |             merrimack_19_02794770.rrd
|    |             merrimack_19_02794772.img
|    |             merrimack_19_02794772.rrd
|    |             merrimack_19_02794773.img
|    |             merrimack_19_02794773.rrd
|    |             merrimack_19_02794774.img
|    |             merrimack_19_02794774.rrd
|    |             merrimack_19_02794776.img
|    |             merrimack_19_02794776.rrd
|    |             merrimack_19_02794778.img
|    |             merrimack_19_02794778.rrd
|    |             merrimack_19_02794779.img
|    |             merrimack_19_02794779.rrd
|    |             merrimack_19_02794780.img
|    |             merrimack_19_02794780.rrd
|    |             merrimack_19_02794804.img
|    |             merrimack_19_02794804.rrd
|    |             merrimack_19_02794806.img
|    |             merrimack_19_02794806.rrd
|    |             merrimack_19_02794808.img
|    |             merrimack_19_02794808.rrd
|    |             merrimack_19_02794809.img
|    |             merrimack_19_02794809.rrd
|    |             merrimack_19_02794810.img
|    |             merrimack_19_02794810.rrd
|    |             merrimack_19_02794812.img
|    |             merrimack_19_02794812.rrd
|    |             merrimack_19_02794814.img
|    |             merrimack_19_02794814.rrd
|    |             merrimack_19_02804740.img
|    |             merrimack_19_02804740.rrd
|    |             merrimack_19_02804742.img
|    |             merrimack_19_02804742.rrd
|    |             merrimack_19_02804743.img
|    |             merrimack_19_02804743.rrd
|    |             merrimack_19_02804744.img
|    |             merrimack_19_02804744.rrd
|    |             merrimack_19_02804746.img
|    |             merrimack_19_02804746.rrd
|    |             merrimack_19_02804748.img
```

```
|    |              merrimack_19_02804748.rrd
|    |              merrimack_19_02804749.img
|    |              merrimack_19_02804749.rrd
|    |              merrimack_19_02804750.img
|    |              merrimack_19_02804750.rrd
|    |              merrimack_19_02804752.img
|    |              merrimack_19_02804752.rrd
|    |              merrimack_19_02804754.img
|    |              merrimack_19_02804754.rrd
|    |              merrimack_19_02804755.img
|    |              merrimack_19_02804755.rrd
|    |              merrimack_19_02804756.img
|    |              merrimack_19_02804756.rrd
|    |              merrimack_19_02804758.img
|    |              merrimack_19_02804758.rrd
|    |              merrimack_19_02804760.img
|    |              merrimack_19_02804760.rrd
|    |              merrimack_19_02804761.img
|    |              merrimack_19_02804761.rrd
|    |              merrimack_19_02804762.img
|    |              merrimack_19_02804762.rrd
|    |              merrimack_19_02804764.img
|    |              merrimack_19_02804764.rrd
|    |              merrimack_19_02804766.img
|    |              merrimack_19_02804766.rrd
|    |              merrimack_19_02804767.img
|    |              merrimack_19_02804767.rrd
|    |              merrimack_19_02804768.img
|    |              merrimack_19_02804768.rrd
|    |              merrimack_19_02804770.img
|    |              merrimack_19_02804770.rrd
|    |              merrimack_19_02804772.img
|    |              merrimack_19_02804772.rrd
|    |              merrimack_19_02804773.img
|    |              merrimack_19_02804773.rrd
|    |              merrimack_19_02804774.img
|    |              merrimack_19_02804774.rrd
|    |              merrimack_19_02804776.img
|    |              merrimack_19_02804776.rrd
|    |              merrimack_19_02804778.img
|    |              merrimack_19_02804778.rrd
|    |              merrimack_19_02804779.img
|    |              merrimack_19_02804779.rrd
|    |              merrimack_19_02804780.img
|    |              merrimack_19_02804780.rrd
|    |              merrimack_19_02804800.img
|    |              merrimack_19_02804800.rrd
|    |              merrimack_19_02804802.img
|    |              merrimack_19_02804802.rrd
|    |              merrimack_19_02804803.img
|    |              merrimack_19_02804803.rrd
|    |              merrimack_19_02804804.img
|    |              merrimack_19_02804804.rrd
|    |              merrimack_19_02804806.img
```

```
|   |           merrimack_19_02804806.rrd
|   |           merrimack_19_02804808.img
|   |           merrimack_19_02804808.rrd
|   |           merrimack_19_02804809.img
|   |           merrimack_19_02804809.rrd
|   |           merrimack_19_02804810.img
|   |           merrimack_19_02804810.rrd
|   |           merrimack_19_02804812.img
|   |           merrimack_19_02804812.rrd
|   |           merrimack_19_02804814.img
|   |           merrimack_19_02804814.rrd
|   |           merrimack_19_02824740.img
|   |           merrimack_19_02824740.rrd
|   |           merrimack_19_02824742.img
|   |           merrimack_19_02824742.rrd
|   |           merrimack_19_02824743.img
|   |           merrimack_19_02824743.rrd
|   |           merrimack_19_02824744.img
|   |           merrimack_19_02824744.rrd
|   |           merrimack_19_02824746.img
|   |           merrimack_19_02824746.rrd
|   |           merrimack_19_02824748.img
|   |           merrimack_19_02824748.rrd
|   |           merrimack_19_02824749.img
|   |           merrimack_19_02824749.rrd
|   |           merrimack_19_02824750.img
|   |           merrimack_19_02824750.rrd
|   |           merrimack_19_02824752.img
|   |           merrimack_19_02824752.rrd
|   |           merrimack_19_02824754.img
|   |           merrimack_19_02824754.rrd
|   |           merrimack_19_02824755.img
|   |           merrimack_19_02824755.rrd
|   |           merrimack_19_02824756.img
|   |           merrimack_19_02824756.rrd
|   |           merrimack_19_02824758.img
|   |           merrimack_19_02824758.rrd
|   |           merrimack_19_02824760.img
|   |           merrimack_19_02824760.rrd
|   |           merrimack_19_02824761.img
|   |           merrimack_19_02824761.rrd
|   |           merrimack_19_02824762.img
|   |           merrimack_19_02824762.rrd
|   |           merrimack_19_02824764.img
|   |           merrimack_19_02824764.rrd
|   |           merrimack_19_02824766.img
|   |           merrimack_19_02824766.rrd
|   |           merrimack_19_02824767.img
|   |           merrimack_19_02824767.rrd
|   |           merrimack_19_02824768.img
|   |           merrimack_19_02824768.rrd
|   |           merrimack_19_02824770.img
|   |           merrimack_19_02824770.rrd
|   |           merrimack_19_02824772.img
```

```
|    |              merrimack_19_02824772.rrd
|    |              merrimack_19_02824773.img
|    |              merrimack_19_02824773.rrd
|    |              merrimack_19_02824774.img
|    |              merrimack_19_02824774.rrd
|    |              merrimack_19_02824776.img
|    |              merrimack_19_02824776.rrd
|    |              merrimack_19_02824778.img
|    |              merrimack_19_02824778.rrd
|    |              merrimack_19_02824779.img
|    |              merrimack_19_02824779.rrd
|    |              merrimack_19_02824780.img
|    |              merrimack_19_02824780.rrd
|    |              merrimack_19_02824782.img
|    |              merrimack_19_02824782.rrd
|    |              merrimack_19_02824784.img
|    |              merrimack_19_02824784.rrd
|    |              merrimack_19_02824798.img
|    |              merrimack_19_02824798.rrd
|    |              merrimack_19_02824800.img
|    |              merrimack_19_02824800.rrd
|    |              merrimack_19_02824802.img
|    |              merrimack_19_02824802.rrd
|    |              merrimack_19_02824803.img
|    |              merrimack_19_02824803.rrd
|    |              merrimack_19_02824804.img
|    |              merrimack_19_02824804.rrd
|    |              merrimack_19_02824806.img
|    |              merrimack_19_02824806.rrd
|    |              merrimack_19_02824808.img
|    |              merrimack_19_02824808.rrd
|    |              merrimack_19_02824809.img
|    |              merrimack_19_02824809.rrd
|    |              merrimack_19_02824810.img
|    |              merrimack_19_02824810.rrd
|    |              merrimack_19_02824812.img
|    |              merrimack_19_02824812.rrd
|    |              merrimack_19_02824814.img
|    |              merrimack_19_02824814.rrd
|    |              merrimack_19_02844737.img
|    |              merrimack_19_02844737.rrd
|    |              merrimack_19_02844738.img
|    |              merrimack_19_02844738.rrd
|    |              merrimack_19_02844740.img
|    |              merrimack_19_02844740.rrd
|    |              merrimack_19_02844742.img
|    |              merrimack_19_02844742.rrd
|    |              merrimack_19_02844743.img
|    |              merrimack_19_02844743.rrd
|    |              merrimack_19_02844744.img
|    |              merrimack_19_02844744.rrd
|    |              merrimack_19_02844746.img
|    |              merrimack_19_02844746.rrd
|    |              merrimack_19_02844748.img
```

```
|    |              merrimack_19_02844748.rrd
|    |              merrimack_19_02844749.img
|    |              merrimack_19_02844749.rrd
|    |              merrimack_19_02844750.img
|    |              merrimack_19_02844750.rrd
|    |              merrimack_19_02844752.img
|    |              merrimack_19_02844752.rrd
|    |              merrimack_19_02844754.img
|    |              merrimack_19_02844754.rrd
|    |              merrimack_19_02844755.img
|    |              merrimack_19_02844755.rrd
|    |              merrimack_19_02844756.img
|    |              merrimack_19_02844756.rrd
|    |              merrimack_19_02844758.img
|    |              merrimack_19_02844758.rrd
|    |              merrimack_19_02844760.img
|    |              merrimack_19_02844760.rrd
|    |              merrimack_19_02844761.img
|    |              merrimack_19_02844761.rrd
|    |              merrimack_19_02844762.img
|    |              merrimack_19_02844762.rrd
|    |              merrimack_19_02844764.img
|    |              merrimack_19_02844764.rrd
|    |              merrimack_19_02844766.img
|    |              merrimack_19_02844766.rrd
|    |              merrimack_19_02844767.img
|    |              merrimack_19_02844767.rrd
|    |              merrimack_19_02844768.img
|    |              merrimack_19_02844768.rrd
|    |              merrimack_19_02844770.img
|    |              merrimack_19_02844770.rrd
|    |              merrimack_19_02844772.img
|    |              merrimack_19_02844772.rrd
|    |              merrimack_19_02844773.img
|    |              merrimack_19_02844773.rrd
|    |              merrimack_19_02844774.img
|    |              merrimack_19_02844774.rrd
|    |              merrimack_19_02844776.img
|    |              merrimack_19_02844776.rrd
|    |              merrimack_19_02844778.img
|    |              merrimack_19_02844778.rrd
|    |              merrimack_19_02844779.img
|    |              merrimack_19_02844779.rrd
|    |              merrimack_19_02844780.img
|    |              merrimack_19_02844780.rrd
|    |              merrimack_19_02844782.img
|    |              merrimack_19_02844782.rrd
|    |              merrimack_19_02844784.img
|    |              merrimack_19_02844784.rrd
|    |              merrimack_19_02844785.img
|    |              merrimack_19_02844785.rrd
|    |              merrimack_19_02844786.img
|    |              merrimack_19_02844786.rrd
|    |              merrimack_19_02844796.img
```

```
|    |              merrimack_19_02844796.rrd
|    |              merrimack_19_02844797.img
|    |              merrimack_19_02844797.rrd
|    |              merrimack_19_02844798.img
|    |              merrimack_19_02844798.rrd
|    |              merrimack_19_02844800.img
|    |              merrimack_19_02844800.rrd
|    |              merrimack_19_02844802.img
|    |              merrimack_19_02844802.rrd
|    |              merrimack_19_02844803.img
|    |              merrimack_19_02844803.rrd
|    |              merrimack_19_02844804.img
|    |              merrimack_19_02844804.rrd
|    |              merrimack_19_02844806.img
|    |              merrimack_19_02844806.rrd
|    |              merrimack_19_02844808.img
|    |              merrimack_19_02844808.rrd
|    |              merrimack_19_02844809.img
|    |              merrimack_19_02844809.rrd
|    |              merrimack_19_02844810.img
|    |              merrimack_19_02844810.rrd
|    |              merrimack_19_02844812.img
|    |              merrimack_19_02844812.rrd
|    |              merrimack_19_02844814.img
|    |              merrimack_19_02844814.rrd
|    |              merrimack_19_02854736.img
|    |              merrimack_19_02854736.rrd
|    |              merrimack_19_02854737.img
|    |              merrimack_19_02854737.rrd
|    |              merrimack_19_02854738.img
|    |              merrimack_19_02854738.rrd
|    |              merrimack_19_02854740.img
|    |              merrimack_19_02854740.rrd
|    |              merrimack_19_02854742.img
|    |              merrimack_19_02854742.rrd
|    |              merrimack_19_02854743.img
|    |              merrimack_19_02854743.rrd
|    |              merrimack_19_02854744.img
|    |              merrimack_19_02854744.rrd
|    |              merrimack_19_02854746.img
|    |              merrimack_19_02854746.rrd
|    |              merrimack_19_02854748.img
|    |              merrimack_19_02854748.rrd
|    |              merrimack_19_02854749.img
|    |              merrimack_19_02854749.rrd
|    |              merrimack_19_02854750.img
|    |              merrimack_19_02854750.rrd
|    |              merrimack_19_02854752.img
|    |              merrimack_19_02854752.rrd
|    |              merrimack_19_02854754.img
|    |              merrimack_19_02854754.rrd
|    |              merrimack_19_02854755.img
|    |              merrimack_19_02854755.rrd
|    |              merrimack_19_02854756.img
```

```
|    |              merrimack_19_02854756.rrd
|    |              merrimack_19_02854758.img
|    |              merrimack_19_02854758.rrd
|    |              merrimack_19_02854760.img
|    |              merrimack_19_02854760.rrd
|    |              merrimack_19_02854761.img
|    |              merrimack_19_02854761.rrd
|    |              merrimack_19_02854762.img
|    |              merrimack_19_02854762.rrd
|    |              merrimack_19_02854764.img
|    |              merrimack_19_02854764.rrd
|    |              merrimack_19_02854766.img
|    |              merrimack_19_02854766.rrd
|    |              merrimack_19_02854767.img
|    |              merrimack_19_02854767.rrd
|    |              merrimack_19_02854768.img
|    |              merrimack_19_02854768.rrd
|    |              merrimack_19_02854770.img
|    |              merrimack_19_02854770.rrd
|    |              merrimack_19_02854772.img
|    |              merrimack_19_02854772.rrd
|    |              merrimack_19_02854773.img
|    |              merrimack_19_02854773.rrd
|    |              merrimack_19_02854774.img
|    |              merrimack_19_02854774.rrd
|    |              merrimack_19_02854776.img
|    |              merrimack_19_02854776.rrd
|    |              merrimack_19_02854778.img
|    |              merrimack_19_02854778.rrd
|    |              merrimack_19_02854779.img
|    |              merrimack_19_02854779.rrd
|    |              merrimack_19_02854780.img
|    |              merrimack_19_02854780.rrd
|    |              merrimack_19_02854782.img
|    |              merrimack_19_02854782.rrd
|    |              merrimack_19_02854784.img
|    |              merrimack_19_02854784.rrd
|    |              merrimack_19_02854785.img
|    |              merrimack_19_02854785.rrd
|    |              merrimack_19_02854786.img
|    |              merrimack_19_02854786.rrd
|    |              merrimack_19_02854788.img
|    |              merrimack_19_02854788.rrd
|    |              merrimack_19_02854796.img
|    |              merrimack_19_02854796.rrd
|    |              merrimack_19_02854797.img
|    |              merrimack_19_02854797.rrd
|    |              merrimack_19_02854798.img
|    |              merrimack_19_02854798.rrd
|    |              merrimack_19_02854800.img
|    |              merrimack_19_02854800.rrd
|    |              merrimack_19_02854802.img
|    |              merrimack_19_02854802.rrd
|    |              merrimack_19_02854803.img
```

```
|    |              merrimack_19_02854803.rrd
|    |              merrimack_19_02854804.img
|    |              merrimack_19_02854804.rrd
|    |              merrimack_19_02854806.img
|    |              merrimack_19_02854806.rrd
|    |              merrimack_19_02854808.img
|    |              merrimack_19_02854808.rrd
|    |              merrimack_19_02854809.img
|    |              merrimack_19_02854809.rrd
|    |              merrimack_19_02854810.img
|    |              merrimack_19_02854810.rrd
|    |              merrimack_19_02854812.img
|    |              merrimack_19_02854812.rrd
|    |              merrimack_19_02864736.img
|    |              merrimack_19_02864736.rrd
|    |              merrimack_19_02864737.img
|    |              merrimack_19_02864737.rrd
|    |              merrimack_19_02864738.img
|    |              merrimack_19_02864738.rrd
|    |              merrimack_19_02864740.img
|    |              merrimack_19_02864740.rrd
|    |              merrimack_19_02864742.img
|    |              merrimack_19_02864742.rrd
|    |              merrimack_19_02864743.img
|    |              merrimack_19_02864743.rrd
|    |              merrimack_19_02864744.img
|    |              merrimack_19_02864744.rrd
|    |              merrimack_19_02864746.img
|    |              merrimack_19_02864746.rrd
|    |              merrimack_19_02864748.img
|    |              merrimack_19_02864748.rrd
|    |              merrimack_19_02864749.img
|    |              merrimack_19_02864749.rrd
|    |              merrimack_19_02864750.img
|    |              merrimack_19_02864750.rrd
|    |              merrimack_19_02864752.img
|    |              merrimack_19_02864752.rrd
|    |              merrimack_19_02864754.img
|    |              merrimack_19_02864754.rrd
|    |              merrimack_19_02864755.img
|    |              merrimack_19_02864755.rrd
|    |              merrimack_19_02864756.img
|    |              merrimack_19_02864756.rrd
|    |              merrimack_19_02864758.img
|    |              merrimack_19_02864758.rrd
|    |              merrimack_19_02864760.img
|    |              merrimack_19_02864760.rrd
|    |              merrimack_19_02864761.img
|    |              merrimack_19_02864761.rrd
|    |              merrimack_19_02864762.img
|    |              merrimack_19_02864762.rrd
|    |              merrimack_19_02864764.img
|    |              merrimack_19_02864764.rrd
|    |              merrimack_19_02864766.img
```

```
|    |              merrimack_19_02864766.rrd
|    |              merrimack_19_02864767.img
|    |              merrimack_19_02864767.rrd
|    |              merrimack_19_02864768.img
|    |              merrimack_19_02864768.rrd
|    |              merrimack_19_02864770.img
|    |              merrimack_19_02864770.rrd
|    |              merrimack_19_02864772.img
|    |              merrimack_19_02864772.rrd
|    |              merrimack_19_02864773.img
|    |              merrimack_19_02864773.rrd
|    |              merrimack_19_02864774.img
|    |              merrimack_19_02864774.rrd
|    |              merrimack_19_02864776.img
|    |              merrimack_19_02864776.rrd
|    |              merrimack_19_02864778.img
|    |              merrimack_19_02864778.rrd
|    |              merrimack_19_02864779.img
|    |              merrimack_19_02864779.rrd
|    |              merrimack_19_02864780.img
|    |              merrimack_19_02864780.rrd
|    |              merrimack_19_02864782.img
|    |              merrimack_19_02864782.rrd
|    |              merrimack_19_02864784.img
|    |              merrimack_19_02864784.rrd
|    |              merrimack_19_02864785.img
|    |              merrimack_19_02864785.rrd
|    |              merrimack_19_02864786.img
|    |              merrimack_19_02864786.rrd
|    |              merrimack_19_02864788.img
|    |              merrimack_19_02864788.rrd
|    |              merrimack_19_02864790.img
|    |              merrimack_19_02864790.rrd
|    |              merrimack_19_02864796.img
|    |              merrimack_19_02864796.rrd
|    |              merrimack_19_02864797.img
|    |              merrimack_19_02864797.rrd
|    |              merrimack_19_02864798.img
|    |              merrimack_19_02864798.rrd
|    |              merrimack_19_02864800.img
|    |              merrimack_19_02864800.rrd
|    |              merrimack_19_02864802.img
|    |              merrimack_19_02864802.rrd
|    |              merrimack_19_02864803.img
|    |              merrimack_19_02864803.rrd
|    |              merrimack_19_02864804.img
|    |              merrimack_19_02864804.rrd
|    |              merrimack_19_02864806.img
|    |              merrimack_19_02864806.rrd
|    |              merrimack_19_02864808.img
|    |              merrimack_19_02864808.rrd
|    |              merrimack_19_02864809.img
|    |              merrimack_19_02864809.rrd
|    |              merrimack_19_02864810.img
```

```
|    |              merrimack_19_02864810.rrd
|    |              merrimack_19_02864812.img
|    |              merrimack_19_02864812.rrd
|    |              merrimack_19_02884710.img
|    |              merrimack_19_02884710.rrd
|    |              merrimack_19_02884712.img
|    |              merrimack_19_02884712.rrd
|    |              merrimack_19_02884713.img
|    |              merrimack_19_02884713.rrd
|    |              merrimack_19_02884719.img
|    |              merrimack_19_02884719.rrd
|    |              merrimack_19_02884736.img
|    |              merrimack_19_02884736.rrd
|    |              merrimack_19_02884737.img
|    |              merrimack_19_02884737.rrd
|    |              merrimack_19_02884738.img
|    |              merrimack_19_02884738.rrd
|    |              merrimack_19_02884740.img
|    |              merrimack_19_02884740.rrd
|    |              merrimack_19_02884742.img
|    |              merrimack_19_02884742.rrd
|    |              merrimack_19_02884743.img
|    |              merrimack_19_02884743.rrd
|    |              merrimack_19_02884744.img
|    |              merrimack_19_02884744.rrd
|    |              merrimack_19_02884746.img
|    |              merrimack_19_02884746.rrd
|    |              merrimack_19_02884748.img
|    |              merrimack_19_02884748.rrd
|    |              merrimack_19_02884749.img
|    |              merrimack_19_02884749.rrd
|    |              merrimack_19_02884750.img
|    |              merrimack_19_02884750.rrd
|    |              merrimack_19_02884752.img
|    |              merrimack_19_02884752.rrd
|    |              merrimack_19_02884754.img
|    |              merrimack_19_02884754.rrd
|    |              merrimack_19_02884755.img
|    |              merrimack_19_02884755.rrd
|    |              merrimack_19_02884756.img
|    |              merrimack_19_02884756.rrd
|    |              merrimack_19_02884758.img
|    |              merrimack_19_02884758.rrd
|    |              merrimack_19_02884760.img
|    |              merrimack_19_02884760.rrd
|    |              merrimack_19_02884761.img
|    |              merrimack_19_02884761.rrd
|    |              merrimack_19_02884762.img
|    |              merrimack_19_02884762.rrd
|    |              merrimack_19_02884764.img
|    |              merrimack_19_02884764.rrd
|    |              merrimack_19_02884766.img
|    |              merrimack_19_02884766.rrd
|    |              merrimack_19_02884767.img
```

```
|    |              merrimack_19_02884767.rrd
|    |              merrimack_19_02884768.img
|    |              merrimack_19_02884768.rrd
|    |              merrimack_19_02884770.img
|    |              merrimack_19_02884770.rrd
|    |              merrimack_19_02884772.img
|    |              merrimack_19_02884772.rrd
|    |              merrimack_19_02884773.img
|    |              merrimack_19_02884773.rrd
|    |              merrimack_19_02884774.img
|    |              merrimack_19_02884774.rrd
|    |              merrimack_19_02884776.img
|    |              merrimack_19_02884776.rrd
|    |              merrimack_19_02884778.img
|    |              merrimack_19_02884778.rrd
|    |              merrimack_19_02884779.img
|    |              merrimack_19_02884779.rrd
|    |              merrimack_19_02884780.img
|    |              merrimack_19_02884780.rrd
|    |              merrimack_19_02884782.img
|    |              merrimack_19_02884782.rrd
|    |              merrimack_19_02884784.img
|    |              merrimack_19_02884784.rrd
|    |              merrimack_19_02884785.img
|    |              merrimack_19_02884785.rrd
|    |              merrimack_19_02884786.img
|    |              merrimack_19_02884786.rrd
|    |              merrimack_19_02884788.img
|    |              merrimack_19_02884788.rrd
|    |              merrimack_19_02884790.img
|    |              merrimack_19_02884790.rrd
|    |              merrimack_19_02884791.img
|    |              merrimack_19_02884791.rrd
|    |              merrimack_19_02884792.img
|    |              merrimack_19_02884792.rrd
|    |              merrimack_19_02884794.img
|    |              merrimack_19_02884794.rrd
|    |              merrimack_19_02884796.img
|    |              merrimack_19_02884796.rrd
|    |              merrimack_19_02884797.img
|    |              merrimack_19_02884797.rrd
|    |              merrimack_19_02884798.img
|    |              merrimack_19_02884798.rrd
|    |              merrimack_19_02884800.img
|    |              merrimack_19_02884800.rrd
|    |              merrimack_19_02884802.img
|    |              merrimack_19_02884802.rrd
|    |              merrimack_19_02884803.img
|    |              merrimack_19_02884803.rrd
|    |              merrimack_19_02884804.img
|    |              merrimack_19_02884804.rrd
|    |              merrimack_19_02884806.img
|    |              merrimack_19_02884806.rrd
|    |              merrimack_19_02884808.img
```

```
|    |             merrimack_19_02884808.rrd
|    |             merrimack_19_02884809.img
|    |             merrimack_19_02884809.rrd
|    |             merrimack_19_02884810.img
|    |             merrimack_19_02884810.rrd
|    |             merrimack_19_02904704.img
|    |             merrimack_19_02904704.rrd
|    |             merrimack_19_02904706.img
|    |             merrimack_19_02904706.rrd
|    |             merrimack_19_02904707.img
|    |             merrimack_19_02904707.rrd
|    |             merrimack_19_02904708.img
|    |             merrimack_19_02904708.rrd
|    |             merrimack_19_02904710.img
|    |             merrimack_19_02904710.rrd
|    |             merrimack_19_02904712.img
|    |             merrimack_19_02904712.rrd
|    |             merrimack_19_02904713.img
|    |             merrimack_19_02904713.rrd
|    |             merrimack_19_02904714.img
|    |             merrimack_19_02904714.rrd
|    |             merrimack_19_02904716.img
|    |             merrimack_19_02904716.rrd
|    |             merrimack_19_02904718.img
|    |             merrimack_19_02904718.rrd
|    |             merrimack_19_02904719.img
|    |             merrimack_19_02904719.rrd
|    |             merrimack_19_02904720.img
|    |             merrimack_19_02904720.rrd
|    |             merrimack_19_02904722.img
|    |             merrimack_19_02904722.rrd
|    |             merrimack_19_02904736.img
|    |             merrimack_19_02904736.rrd
|    |             merrimack_19_02904737.img
|    |             merrimack_19_02904737.rrd
|    |             merrimack_19_02904738.img
|    |             merrimack_19_02904738.rrd
|    |             merrimack_19_02904740.img
|    |             merrimack_19_02904740.rrd
|    |             merrimack_19_02904742.img
|    |             merrimack_19_02904742.rrd
|    |             merrimack_19_02904743.img
|    |             merrimack_19_02904743.rrd
|    |             merrimack_19_02904744.img
|    |             merrimack_19_02904744.rrd
|    |             merrimack_19_02904746.img
|    |             merrimack_19_02904746.rrd
|    |             merrimack_19_02904748.img
|    |             merrimack_19_02904748.rrd
|    |             merrimack_19_02904749.img
|    |             merrimack_19_02904749.rrd
|    |             merrimack_19_02904750.img
|    |             merrimack_19_02904750.rrd
|    |             merrimack_19_02904752.img
```

```
|    |              merrimack_19_02904752.rrd
|    |              merrimack_19_02904754.img
|    |              merrimack_19_02904754.rrd
|    |              merrimack_19_02904755.img
|    |              merrimack_19_02904755.rrd
|    |              merrimack_19_02904756.img
|    |              merrimack_19_02904756.rrd
|    |              merrimack_19_02904758.img
|    |              merrimack_19_02904758.rrd
|    |              merrimack_19_02904760.img
|    |              merrimack_19_02904760.rrd
|    |              merrimack_19_02904761.img
|    |              merrimack_19_02904761.rrd
|    |              merrimack_19_02904762.img
|    |              merrimack_19_02904762.rrd
|    |              merrimack_19_02904764.img
|    |              merrimack_19_02904764.rrd
|    |              merrimack_19_02904766.img
|    |              merrimack_19_02904766.rrd
|    |              merrimack_19_02904767.img
|    |              merrimack_19_02904767.rrd
|    |              merrimack_19_02904768.img
|    |              merrimack_19_02904768.rrd
|    |              merrimack_19_02904770.img
|    |              merrimack_19_02904770.rrd
|    |              merrimack_19_02904772.img
|    |              merrimack_19_02904772.rrd
|    |              merrimack_19_02904773.img
|    |              merrimack_19_02904773.rrd
|    |              merrimack_19_02904774.img
|    |              merrimack_19_02904774.rrd
|    |              merrimack_19_02904776.img
|    |              merrimack_19_02904776.rrd
|    |              merrimack_19_02904778.img
|    |              merrimack_19_02904778.rrd
|    |              merrimack_19_02904779.img
|    |              merrimack_19_02904779.rrd
|    |              merrimack_19_02904780.img
|    |              merrimack_19_02904780.rrd
|    |              merrimack_19_02904782.img
|    |              merrimack_19_02904782.rrd
|    |              merrimack_19_02904784.img
|    |              merrimack_19_02904784.rrd
|    |              merrimack_19_02904785.img
|    |              merrimack_19_02904785.rrd
|    |              merrimack_19_02904786.img
|    |              merrimack_19_02904786.rrd
|    |              merrimack_19_02904788.img
|    |              merrimack_19_02904788.rrd
|    |              merrimack_19_02904790.img
|    |              merrimack_19_02904790.rrd
|    |              merrimack_19_02904791.img
|    |              merrimack_19_02904791.rrd
|    |              merrimack_19_02904792.img
```

```
|   |           merrimack_19_02904792.rrd
|   |           merrimack_19_02904794.img
|   |           merrimack_19_02904794.rrd
|   |           merrimack_19_02904796.img
|   |           merrimack_19_02904796.rrd
|   |           merrimack_19_02904797.img
|   |           merrimack_19_02904797.rrd
|   |           merrimack_19_02904798.img
|   |           merrimack_19_02904798.rrd
|   |           merrimack_19_02904800.img
|   |           merrimack_19_02904800.rrd
|   |           merrimack_19_02904802.img
|   |           merrimack_19_02904802.rrd
|   |           merrimack_19_02904803.img
|   |           merrimack_19_02904803.rrd
|   |           merrimack_19_02904804.img
|   |           merrimack_19_02904804.rrd
|   |           merrimack_19_02904806.img
|   |           merrimack_19_02904806.rrd
|   |           merrimack_19_02904808.img
|   |           merrimack_19_02904808.rrd
|   |           merrimack_19_02904809.img
|   |           merrimack_19_02904809.rrd
|   |           merrimack_19_02914704.img
|   |           merrimack_19_02914704.rrd
|   |           merrimack_19_02914706.img
|   |           merrimack_19_02914706.rrd
|   |           merrimack_19_02914707.img
|   |           merrimack_19_02914707.rrd
|   |           merrimack_19_02914708.img
|   |           merrimack_19_02914708.rrd
|   |           merrimack_19_02914710.img
|   |           merrimack_19_02914710.rrd
|   |           merrimack_19_02914712.img
|   |           merrimack_19_02914712.rrd
|   |           merrimack_19_02914713.img
|   |           merrimack_19_02914713.rrd
|   |           merrimack_19_02914714.img
|   |           merrimack_19_02914714.rrd
|   |           merrimack_19_02914716.img
|   |           merrimack_19_02914716.rrd
|   |           merrimack_19_02914718.img
|   |           merrimack_19_02914718.rrd
|   |           merrimack_19_02914719.img
|   |           merrimack_19_02914719.rrd
|   |           merrimack_19_02914720.img
|   |           merrimack_19_02914720.rrd
|   |           merrimack_19_02914722.img
|   |           merrimack_19_02914722.rrd
|   |           merrimack_19_02914728.img
|   |           merrimack_19_02914728.rrd
|   |           merrimack_19_02914730.img
|   |           merrimack_19_02914730.rrd
|   |           merrimack_19_02914731.img
```

```
|    |              merrimack_19_02914731.rrd
|    |              merrimack_19_02914736.img
|    |              merrimack_19_02914736.rrd
|    |              merrimack_19_02914737.img
|    |              merrimack_19_02914737.rrd
|    |              merrimack_19_02914738.img
|    |              merrimack_19_02914738.rrd
|    |              merrimack_19_02914740.img
|    |              merrimack_19_02914740.rrd
|    |              merrimack_19_02914742.img
|    |              merrimack_19_02914742.rrd
|    |              merrimack_19_02914743.img
|    |              merrimack_19_02914743.rrd
|    |              merrimack_19_02914744.img
|    |              merrimack_19_02914744.rrd
|    |              merrimack_19_02914746.img
|    |              merrimack_19_02914746.rrd
|    |              merrimack_19_02914748.img
|    |              merrimack_19_02914748.rrd
|    |              merrimack_19_02914749.img
|    |              merrimack_19_02914749.rrd
|    |              merrimack_19_02914750.img
|    |              merrimack_19_02914750.rrd
|    |              merrimack_19_02914752.img
|    |              merrimack_19_02914752.rrd
|    |              merrimack_19_02914754.img
|    |              merrimack_19_02914754.rrd
|    |              merrimack_19_02914755.img
|    |              merrimack_19_02914755.rrd
|    |              merrimack_19_02914756.img
|    |              merrimack_19_02914756.rrd
|    |              merrimack_19_02914758.img
|    |              merrimack_19_02914758.rrd
|    |              merrimack_19_02914760.img
|    |              merrimack_19_02914760.rrd
|    |              merrimack_19_02914761.img
|    |              merrimack_19_02914761.rrd
|    |              merrimack_19_02914762.img
|    |              merrimack_19_02914762.rrd
|    |              merrimack_19_02914764.img
|    |              merrimack_19_02914764.rrd
|    |              merrimack_19_02914766.img
|    |              merrimack_19_02914766.rrd
|    |              merrimack_19_02914767.img
|    |              merrimack_19_02914767.rrd
|    |              merrimack_19_02914768.img
|    |              merrimack_19_02914768.rrd
|    |              merrimack_19_02914770.img
|    |              merrimack_19_02914770.rrd
|    |              merrimack_19_02914772.img
|    |              merrimack_19_02914772.rrd
|    |              merrimack_19_02914773.img
|    |              merrimack_19_02914773.rrd
|    |              merrimack_19_02914774.img
```

```
|    |              merrimack_19_02914774.rrd
|    |              merrimack_19_02914776.img
|    |              merrimack_19_02914776.rrd
|    |              merrimack_19_02914778.img
|    |              merrimack_19_02914778.rrd
|    |              merrimack_19_02914779.img
|    |              merrimack_19_02914779.rrd
|    |              merrimack_19_02914780.img
|    |              merrimack_19_02914780.rrd
|    |              merrimack_19_02914782.img
|    |              merrimack_19_02914782.rrd
|    |              merrimack_19_02914784.img
|    |              merrimack_19_02914784.rrd
|    |              merrimack_19_02914785.img
|    |              merrimack_19_02914785.rrd
|    |              merrimack_19_02914786.img
|    |              merrimack_19_02914786.rrd
|    |              merrimack_19_02914788.img
|    |              merrimack_19_02914788.rrd
|    |              merrimack_19_02914790.img
|    |              merrimack_19_02914790.rrd
|    |              merrimack_19_02914791.img
|    |              merrimack_19_02914791.rrd
|    |              merrimack_19_02914792.img
|    |              merrimack_19_02914792.rrd
|    |              merrimack_19_02914794.img
|    |              merrimack_19_02914794.rrd
|    |              merrimack_19_02914796.img
|    |              merrimack_19_02914796.rrd
|    |              merrimack_19_02914797.img
|    |              merrimack_19_02914797.rrd
|    |              merrimack_19_02914798.img
|    |              merrimack_19_02914798.rrd
|    |              merrimack_19_02914800.img
|    |              merrimack_19_02914800.rrd
|    |              merrimack_19_02914802.img
|    |              merrimack_19_02914802.rrd
|    |              merrimack_19_02914803.img
|    |              merrimack_19_02914803.rrd
|    |              merrimack_19_02914804.img
|    |              merrimack_19_02914804.rrd
|    |              merrimack_19_02914806.img
|    |              merrimack_19_02914806.rrd
|    |              merrimack_19_02914808.img
|    |              merrimack_19_02914808.rrd
|    |              merrimack_19_02914809.img
|    |              merrimack_19_02914809.rrd
|    |              merrimack_19_02924706.img
|    |              merrimack_19_02924706.rrd
|    |              merrimack_19_02924707.img
|    |              merrimack_19_02924707.rrd
|    |              merrimack_19_02924708.img
|    |              merrimack_19_02924708.rrd
|    |              merrimack_19_02924710.img
```

```
|    |           merrimack_19_02924710.rrd
|    |           merrimack_19_02924712.img
|    |           merrimack_19_02924712.rrd
|    |           merrimack_19_02924713.img
|    |           merrimack_19_02924713.rrd
|    |           merrimack_19_02924714.img
|    |           merrimack_19_02924714.rrd
|    |           merrimack_19_02924716.img
|    |           merrimack_19_02924716.rrd
|    |           merrimack_19_02924718.img
|    |           merrimack_19_02924718.rrd
|    |           merrimack_19_02924719.img
|    |           merrimack_19_02924719.rrd
|    |           merrimack_19_02924720.img
|    |           merrimack_19_02924720.rrd
|    |           merrimack_19_02924722.img
|    |           merrimack_19_02924722.rrd
|    |           merrimack_19_02924724.img
|    |           merrimack_19_02924724.rrd
|    |           merrimack_19_02924725.img
|    |           merrimack_19_02924725.rrd
|    |           merrimack_19_02924726.img
|    |           merrimack_19_02924726.rrd
|    |           merrimack_19_02924728.img
|    |           merrimack_19_02924728.rrd
|    |           merrimack_19_02924730.img
|    |           merrimack_19_02924730.rrd
|    |           merrimack_19_02924731.img
|    |           merrimack_19_02924731.rrd
|    |           merrimack_19_02924732.img
|    |           merrimack_19_02924732.rrd
|    |           merrimack_19_02924737.img
|    |           merrimack_19_02924737.rrd
|    |           merrimack_19_02924738.img
|    |           merrimack_19_02924738.rrd
|    |           merrimack_19_02924740.img
|    |           merrimack_19_02924740.rrd
|    |           merrimack_19_02924742.img
|    |           merrimack_19_02924742.rrd
|    |           merrimack_19_02924743.img
|    |           merrimack_19_02924743.rrd
|    |           merrimack_19_02924744.img
|    |           merrimack_19_02924744.rrd
|    |           merrimack_19_02924746.img
|    |           merrimack_19_02924746.rrd
|    |           merrimack_19_02924748.img
|    |           merrimack_19_02924748.rrd
|    |           merrimack_19_02924749.img
|    |           merrimack_19_02924749.rrd
|    |           merrimack_19_02924750.img
|    |           merrimack_19_02924750.rrd
|    |           merrimack_19_02924752.img
|    |           merrimack_19_02924752.rrd
|    |           merrimack_19_02924754.img
```

```
|    |              merrimack_19_02924754.rrd
|    |              merrimack_19_02924755.img
|    |              merrimack_19_02924755.rrd
|    |              merrimack_19_02924756.img
|    |              merrimack_19_02924756.rrd
|    |              merrimack_19_02924758.img
|    |              merrimack_19_02924758.rrd
|    |              merrimack_19_02924760.img
|    |              merrimack_19_02924760.rrd
|    |              merrimack_19_02924761.img
|    |              merrimack_19_02924761.rrd
|    |              merrimack_19_02924762.img
|    |              merrimack_19_02924762.rrd
|    |              merrimack_19_02924764.img
|    |              merrimack_19_02924764.rrd
|    |              merrimack_19_02924766.img
|    |              merrimack_19_02924766.rrd
|    |              merrimack_19_02924767.img
|    |              merrimack_19_02924767.rrd
|    |              merrimack_19_02924768.img
|    |              merrimack_19_02924768.rrd
|    |              merrimack_19_02924770.img
|    |              merrimack_19_02924770.rrd
|    |              merrimack_19_02924772.img
|    |              merrimack_19_02924772.rrd
|    |              merrimack_19_02924773.img
|    |              merrimack_19_02924773.rrd
|    |              merrimack_19_02924774.img
|    |              merrimack_19_02924774.rrd
|    |              merrimack_19_02924776.img
|    |              merrimack_19_02924776.rrd
|    |              merrimack_19_02924778.img
|    |              merrimack_19_02924778.rrd
|    |              merrimack_19_02924779.img
|    |              merrimack_19_02924779.rrd
|    |              merrimack_19_02924780.img
|    |              merrimack_19_02924780.rrd
|    |              merrimack_19_02924782.img
|    |              merrimack_19_02924782.rrd
|    |              merrimack_19_02924784.img
|    |              merrimack_19_02924784.rrd
|    |              merrimack_19_02924785.img
|    |              merrimack_19_02924785.rrd
|    |              merrimack_19_02924786.img
|    |              merrimack_19_02924786.rrd
|    |              merrimack_19_02924788.img
|    |              merrimack_19_02924788.rrd
|    |              merrimack_19_02924790.img
|    |              merrimack_19_02924790.rrd
|    |              merrimack_19_02924791.img
|    |              merrimack_19_02924791.rrd
|    |              merrimack_19_02924792.img
|    |              merrimack_19_02924792.rrd
|    |              merrimack_19_02924794.img
```

```
|    |              merrimack_19_02924794.rrd
|    |              merrimack_19_02924796.img
|    |              merrimack_19_02924796.rrd
|    |              merrimack_19_02924797.img
|    |              merrimack_19_02924797.rrd
|    |              merrimack_19_02924798.img
|    |              merrimack_19_02924798.rrd
|    |              merrimack_19_02924800.img
|    |              merrimack_19_02924800.rrd
|    |              merrimack_19_02924802.img
|    |              merrimack_19_02924802.rrd
|    |              merrimack_19_02924803.img
|    |              merrimack_19_02924803.rrd
|    |              merrimack_19_02924804.img
|    |              merrimack_19_02924804.rrd
|    |              merrimack_19_02924806.img
|    |              merrimack_19_02924806.rrd
|    |              merrimack_19_02924808.img
|    |              merrimack_19_02924808.rrd
|    |              merrimack_19_02944708.img
|    |              merrimack_19_02944708.rrd
|    |              merrimack_19_02944710.img
|    |              merrimack_19_02944710.rrd
|    |              merrimack_19_02944712.img
|    |              merrimack_19_02944712.rrd
|    |              merrimack_19_02944713.img
|    |              merrimack_19_02944713.rrd
|    |              merrimack_19_02944714.img
|    |              merrimack_19_02944714.rrd
|    |              merrimack_19_02944716.img
|    |              merrimack_19_02944716.rrd
|    |              merrimack_19_02944718.img
|    |              merrimack_19_02944718.rrd
|    |              merrimack_19_02944719.img
|    |              merrimack_19_02944719.rrd
|    |              merrimack_19_02944720.img
|    |              merrimack_19_02944720.rrd
|    |              merrimack_19_02944722.img
|    |              merrimack_19_02944722.rrd
|    |              merrimack_19_02944724.img
|    |              merrimack_19_02944724.rrd
|    |              merrimack_19_02944725.img
|    |              merrimack_19_02944725.rrd
|    |              merrimack_19_02944726.img
|    |              merrimack_19_02944726.rrd
|    |              merrimack_19_02944728.img
|    |              merrimack_19_02944728.rrd
|    |              merrimack_19_02944730.img
|    |              merrimack_19_02944730.rrd
|    |              merrimack_19_02944731.img
|    |              merrimack_19_02944731.rrd
|    |              merrimack_19_02944732.img
|    |              merrimack_19_02944732.rrd
|    |              merrimack_19_02944734.img
```

```
|   |           merrimack_19_02944734.rrd
|   |           merrimack_19_02944736.img
|   |           merrimack_19_02944736.rrd
|   |           merrimack_19_02944738.img
|   |           merrimack_19_02944738.rrd
|   |           merrimack_19_02944740.img
|   |           merrimack_19_02944740.rrd
|   |           merrimack_19_02944742.img
|   |           merrimack_19_02944742.rrd
|   |           merrimack_19_02944743.img
|   |           merrimack_19_02944743.rrd
|   |           merrimack_19_02944744.img
|   |           merrimack_19_02944744.rrd
|   |           merrimack_19_02944746.img
|   |           merrimack_19_02944746.rrd
|   |           merrimack_19_02944748.img
|   |           merrimack_19_02944748.rrd
|   |           merrimack_19_02944749.img
|   |           merrimack_19_02944749.rrd
|   |           merrimack_19_02944750.img
|   |           merrimack_19_02944750.rrd
|   |           merrimack_19_02944752.img
|   |           merrimack_19_02944752.rrd
|   |           merrimack_19_02944754.img
|   |           merrimack_19_02944754.rrd
|   |           merrimack_19_02944755.img
|   |           merrimack_19_02944755.rrd
|   |           merrimack_19_02944756.img
|   |           merrimack_19_02944756.rrd
|   |           merrimack_19_02944758.img
|   |           merrimack_19_02944758.rrd
|   |           merrimack_19_02944760.img
|   |           merrimack_19_02944760.rrd
|   |           merrimack_19_02944761.img
|   |           merrimack_19_02944761.rrd
|   |           merrimack_19_02944762.img
|   |           merrimack_19_02944762.rrd
|   |           merrimack_19_02944764.img
|   |           merrimack_19_02944764.rrd
|   |           merrimack_19_02944766.img
|   |           merrimack_19_02944766.rrd
|   |           merrimack_19_02944767.img
|   |           merrimack_19_02944767.rrd
|   |           merrimack_19_02944768.img
|   |           merrimack_19_02944768.rrd
|   |           merrimack_19_02944770.img
|   |           merrimack_19_02944770.rrd
|   |           merrimack_19_02944772.img
|   |           merrimack_19_02944772.rrd
|   |           merrimack_19_02944773.img
|   |           merrimack_19_02944773.rrd
|   |           merrimack_19_02944774.img
|   |           merrimack_19_02944774.rrd
|   |           merrimack_19_02944776.img
```

```
|    |            merrimack_19_02944776.rrd
|    |            merrimack_19_02944778.img
|    |            merrimack_19_02944778.rrd
|    |            merrimack_19_02944779.img
|    |            merrimack_19_02944779.rrd
|    |            merrimack_19_02944780.img
|    |            merrimack_19_02944780.rrd
|    |            merrimack_19_02944782.img
|    |            merrimack_19_02944782.rrd
|    |            merrimack_19_02944784.img
|    |            merrimack_19_02944784.rrd
|    |            merrimack_19_02944785.img
|    |            merrimack_19_02944785.rrd
|    |            merrimack_19_02944786.img
|    |            merrimack_19_02944786.rrd
|    |            merrimack_19_02944788.img
|    |            merrimack_19_02944788.rrd
|    |            merrimack_19_02944790.img
|    |            merrimack_19_02944790.rrd
|    |            merrimack_19_02944791.img
|    |            merrimack_19_02944791.rrd
|    |            merrimack_19_02944792.img
|    |            merrimack_19_02944792.rrd
|    |            merrimack_19_02944794.img
|    |            merrimack_19_02944794.rrd
|    |            merrimack_19_02944796.img
|    |            merrimack_19_02944796.rrd
|    |            merrimack_19_02944797.img
|    |            merrimack_19_02944797.rrd
|    |            merrimack_19_02944798.img
|    |            merrimack_19_02944798.rrd
|    |            merrimack_19_02944800.img
|    |            merrimack_19_02944800.rrd
|    |            merrimack_19_02944802.img
|    |            merrimack_19_02944802.rrd
|    |            merrimack_19_02944803.img
|    |            merrimack_19_02944803.rrd
|    |            merrimack_19_02944804.img
|    |            merrimack_19_02944804.rrd
|    |            merrimack_19_02944806.img
|    |            merrimack_19_02944806.rrd
|    |            merrimack_19_02944808.img
|    |            merrimack_19_02944808.rrd
|    |            merrimack_19_02944809.img
|    |            merrimack_19_02944809.rrd
|    |            merrimack_19_02964710.img
|    |            merrimack_19_02964710.rrd
|    |            merrimack_19_02964712.img
|    |            merrimack_19_02964712.rrd
|    |            merrimack_19_02964713.img
|    |            merrimack_19_02964713.rrd
|    |            merrimack_19_02964714.img
|    |            merrimack_19_02964714.rrd
|    |            merrimack_19_02964716.img
```

```
|    |              merrimack_19_02964716.rrd
|    |              merrimack_19_02964718.img
|    |              merrimack_19_02964718.rrd
|    |              merrimack_19_02964719.img
|    |              merrimack_19_02964719.rrd
|    |              merrimack_19_02964720.img
|    |              merrimack_19_02964720.rrd
|    |              merrimack_19_02964722.img
|    |              merrimack_19_02964722.rrd
|    |              merrimack_19_02964724.img
|    |              merrimack_19_02964724.rrd
|    |              merrimack_19_02964725.img
|    |              merrimack_19_02964725.rrd
|    |              merrimack_19_02964726.img
|    |              merrimack_19_02964726.rrd
|    |              merrimack_19_02964728.img
|    |              merrimack_19_02964728.rrd
|    |              merrimack_19_02964730.img
|    |              merrimack_19_02964730.rrd
|    |              merrimack_19_02964731.img
|    |              merrimack_19_02964731.rrd
|    |              merrimack_19_02964732.img
|    |              merrimack_19_02964732.rrd
|    |              merrimack_19_02964734.img
|    |              merrimack_19_02964734.rrd
|    |              merrimack_19_02964736.img
|    |              merrimack_19_02964736.rrd
|    |              merrimack_19_02964738.img
|    |              merrimack_19_02964738.rrd
|    |              merrimack_19_02964740.img
|    |              merrimack_19_02964740.rrd
|    |              merrimack_19_02964742.img
|    |              merrimack_19_02964742.rrd
|    |              merrimack_19_02964743.img
|    |              merrimack_19_02964743.rrd
|    |              merrimack_19_02964744.img
|    |              merrimack_19_02964744.rrd
|    |              merrimack_19_02964746.img
|    |              merrimack_19_02964746.rrd
|    |              merrimack_19_02964748.img
|    |              merrimack_19_02964748.rrd
|    |              merrimack_19_02964749.img
|    |              merrimack_19_02964749.rrd
|    |              merrimack_19_02964750.img
|    |              merrimack_19_02964750.rrd
|    |              merrimack_19_02964752.img
|    |              merrimack_19_02964752.rrd
|    |              merrimack_19_02964754.img
|    |              merrimack_19_02964754.rrd
|    |              merrimack_19_02964755.img
|    |              merrimack_19_02964755.rrd
|    |              merrimack_19_02964756.img
|    |              merrimack_19_02964756.rrd
|    |              merrimack_19_02964758.img
```

```
|    |              merrimack_19_02964758.rrd
|    |              merrimack_19_02964760.img
|    |              merrimack_19_02964760.rrd
|    |              merrimack_19_02964761.img
|    |              merrimack_19_02964761.rrd
|    |              merrimack_19_02964762.img
|    |              merrimack_19_02964762.rrd
|    |              merrimack_19_02964764.img
|    |              merrimack_19_02964764.rrd
|    |              merrimack_19_02964766.img
|    |              merrimack_19_02964766.rrd
|    |              merrimack_19_02964767.img
|    |              merrimack_19_02964767.rrd
|    |              merrimack_19_02964768.img
|    |              merrimack_19_02964768.rrd
|    |              merrimack_19_02964770.img
|    |              merrimack_19_02964770.rrd
|    |              merrimack_19_02964772.img
|    |              merrimack_19_02964772.rrd
|    |              merrimack_19_02964773.img
|    |              merrimack_19_02964773.rrd
|    |              merrimack_19_02964774.img
|    |              merrimack_19_02964774.rrd
|    |              merrimack_19_02964776.img
|    |              merrimack_19_02964776.rrd
|    |              merrimack_19_02964778.img
|    |              merrimack_19_02964778.rrd
|    |              merrimack_19_02964779.img
|    |              merrimack_19_02964779.rrd
|    |              merrimack_19_02964780.img
|    |              merrimack_19_02964780.rrd
|    |              merrimack_19_02964782.img
|    |              merrimack_19_02964782.rrd
|    |              merrimack_19_02964784.img
|    |              merrimack_19_02964784.rrd
|    |              merrimack_19_02964785.img
|    |              merrimack_19_02964785.rrd
|    |              merrimack_19_02964786.img
|    |              merrimack_19_02964786.rrd
|    |              merrimack_19_02964788.img
|    |              merrimack_19_02964788.rrd
|    |              merrimack_19_02964790.img
|    |              merrimack_19_02964790.rrd
|    |              merrimack_19_02964791.img
|    |              merrimack_19_02964791.rrd
|    |              merrimack_19_02964792.img
|    |              merrimack_19_02964792.rrd
|    |              merrimack_19_02964794.img
|    |              merrimack_19_02964794.rrd
|    |              merrimack_19_02964796.img
|    |              merrimack_19_02964796.rrd
|    |              merrimack_19_02964797.img
|    |              merrimack_19_02964797.rrd
|    |              merrimack_19_02964798.img
```

```
|    |             merrimack_19_02964798.rrd
|    |             merrimack_19_02964800.img
|    |             merrimack_19_02964800.rrd
|    |             merrimack_19_02964802.img
|    |             merrimack_19_02964802.rrd
|    |             merrimack_19_02964803.img
|    |             merrimack_19_02964803.rrd
|    |             merrimack_19_02964804.img
|    |             merrimack_19_02964804.rrd
|    |             merrimack_19_02964806.img
|    |             merrimack_19_02964806.rrd
|    |             merrimack_19_02964808.img
|    |             merrimack_19_02964808.rrd
|    |             merrimack_19_02964809.img
|    |             merrimack_19_02964809.rrd
|    |             merrimack_19_02974712.img
|    |             merrimack_19_02974712.rrd
|    |             merrimack_19_02974713.img
|    |             merrimack_19_02974713.rrd
|    |             merrimack_19_02974714.img
|    |             merrimack_19_02974714.rrd
|    |             merrimack_19_02974716.img
|    |             merrimack_19_02974716.rrd
|    |             merrimack_19_02974718.img
|    |             merrimack_19_02974718.rrd
|    |             merrimack_19_02974719.img
|    |             merrimack_19_02974719.rrd
|    |             merrimack_19_02974720.img
|    |             merrimack_19_02974720.rrd
|    |             merrimack_19_02974722.img
|    |             merrimack_19_02974722.rrd
|    |             merrimack_19_02974724.img
|    |             merrimack_19_02974724.rrd
|    |             merrimack_19_02974725.img
|    |             merrimack_19_02974725.rrd
|    |             merrimack_19_02974726.img
|    |             merrimack_19_02974726.rrd
|    |             merrimack_19_02974728.img
|    |             merrimack_19_02974728.rrd
|    |             merrimack_19_02974730.img
|    |             merrimack_19_02974730.rrd
|    |             merrimack_19_02974731.img
|    |             merrimack_19_02974731.rrd
|    |             merrimack_19_02974732.img
|    |             merrimack_19_02974732.rrd
|    |             merrimack_19_02974734.img
|    |             merrimack_19_02974734.rrd
|    |             merrimack_19_02974736.img
|    |             merrimack_19_02974736.rrd
|    |             merrimack_19_02974737.img
|    |             merrimack_19_02974737.rrd
|    |             merrimack_19_02974738.img
|    |             merrimack_19_02974738.rrd
|    |             merrimack_19_02974740.img
```

```
|    |              merrimack_19_02974740.rrd
|    |              merrimack_19_02974742.img
|    |              merrimack_19_02974742.rrd
|    |              merrimack_19_02974743.img
|    |              merrimack_19_02974743.rrd
|    |              merrimack_19_02974744.img
|    |              merrimack_19_02974744.rrd
|    |              merrimack_19_02974746.img
|    |              merrimack_19_02974746.rrd
|    |              merrimack_19_02974748.img
|    |              merrimack_19_02974748.rrd
|    |              merrimack_19_02974749.img
|    |              merrimack_19_02974749.rrd
|    |              merrimack_19_02974750.img
|    |              merrimack_19_02974750.rrd
|    |              merrimack_19_02974752.img
|    |              merrimack_19_02974752.rrd
|    |              merrimack_19_02974754.img
|    |              merrimack_19_02974754.rrd
|    |              merrimack_19_02974755.img
|    |              merrimack_19_02974755.rrd
|    |              merrimack_19_02974756.img
|    |              merrimack_19_02974756.rrd
|    |              merrimack_19_02974758.img
|    |              merrimack_19_02974758.rrd
|    |              merrimack_19_02974760.img
|    |              merrimack_19_02974760.rrd
|    |              merrimack_19_02974761.img
|    |              merrimack_19_02974761.rrd
|    |              merrimack_19_02974762.img
|    |              merrimack_19_02974762.rrd
|    |              merrimack_19_02974764.img
|    |              merrimack_19_02974764.rrd
|    |              merrimack_19_02974766.img
|    |              merrimack_19_02974766.rrd
|    |              merrimack_19_02974767.img
|    |              merrimack_19_02974767.rrd
|    |              merrimack_19_02974768.img
|    |              merrimack_19_02974768.rrd
|    |              merrimack_19_02974770.img
|    |              merrimack_19_02974770.rrd
|    |              merrimack_19_02974772.img
|    |              merrimack_19_02974772.rrd
|    |              merrimack_19_02974773.img
|    |              merrimack_19_02974773.rrd
|    |              merrimack_19_02974774.img
|    |              merrimack_19_02974774.rrd
|    |              merrimack_19_02974776.img
|    |              merrimack_19_02974776.rrd
|    |              merrimack_19_02974778.img
|    |              merrimack_19_02974778.rrd
|    |              merrimack_19_02974779.img
|    |              merrimack_19_02974779.rrd
|    |              merrimack_19_02974780.img
```

```
|    |              merrimack_19_02974780.rrd
|    |              merrimack_19_02974782.img
|    |              merrimack_19_02974782.rrd
|    |              merrimack_19_02974784.img
|    |              merrimack_19_02974784.rrd
|    |              merrimack_19_02974785.img
|    |              merrimack_19_02974785.rrd
|    |              merrimack_19_02974786.img
|    |              merrimack_19_02974786.rrd
|    |              merrimack_19_02974788.img
|    |              merrimack_19_02974788.rrd
|    |              merrimack_19_02974790.img
|    |              merrimack_19_02974790.rrd
|    |              merrimack_19_02974791.img
|    |              merrimack_19_02974791.rrd
|    |              merrimack_19_02974792.img
|    |              merrimack_19_02974792.rrd
|    |              merrimack_19_02974794.img
|    |              merrimack_19_02974794.rrd
|    |              merrimack_19_02974796.img
|    |              merrimack_19_02974796.rrd
|    |              merrimack_19_02974797.img
|    |              merrimack_19_02974797.rrd
|    |              merrimack_19_02974798.img
|    |              merrimack_19_02974798.rrd
|    |              merrimack_19_02974800.img
|    |              merrimack_19_02974800.rrd
|    |              merrimack_19_02974802.img
|    |              merrimack_19_02974802.rrd
|    |              merrimack_19_02974803.img
|    |              merrimack_19_02974803.rrd
|    |              merrimack_19_02974804.img
|    |              merrimack_19_02974804.rrd
|    |              merrimack_19_02974806.img
|    |              merrimack_19_02974806.rrd
|    |              merrimack_19_02974808.img
|    |              merrimack_19_02974808.rrd
|    |              merrimack_19_02974809.img
|    |              merrimack_19_02974809.rrd
|    |              merrimack_19_02984714.img
|    |              merrimack_19_02984714.rrd
|    |              merrimack_19_02984716.img
|    |              merrimack_19_02984716.rrd
|    |              merrimack_19_02984718.img
|    |              merrimack_19_02984718.rrd
|    |              merrimack_19_02984719.img
|    |              merrimack_19_02984719.rrd
|    |              merrimack_19_02984720.img
|    |              merrimack_19_02984720.rrd
|    |              merrimack_19_02984722.img
|    |              merrimack_19_02984722.rrd
|    |              merrimack_19_02984724.img
|    |              merrimack_19_02984724.rrd
|    |              merrimack_19_02984725.img
```

```
|    |              merrimack_19_02984725.rrd
|    |              merrimack_19_02984726.img
|    |              merrimack_19_02984726.rrd
|    |              merrimack_19_02984728.img
|    |              merrimack_19_02984728.rrd
|    |              merrimack_19_02984730.img
|    |              merrimack_19_02984730.rrd
|    |              merrimack_19_02984731.img
|    |              merrimack_19_02984731.rrd
|    |              merrimack_19_02984732.img
|    |              merrimack_19_02984732.rrd
|    |              merrimack_19_02984734.img
|    |              merrimack_19_02984734.rrd
|    |              merrimack_19_02984736.img
|    |              merrimack_19_02984736.rrd
|    |              merrimack_19_02984737.img
|    |              merrimack_19_02984737.rrd
|    |              merrimack_19_02984738.img
|    |              merrimack_19_02984738.rrd
|    |              merrimack_19_02984740.img
|    |              merrimack_19_02984740.rrd
|    |              merrimack_19_02984742.img
|    |              merrimack_19_02984742.rrd
|    |              merrimack_19_02984743.img
|    |              merrimack_19_02984743.rrd
|    |              merrimack_19_02984744.img
|    |              merrimack_19_02984744.rrd
|    |              merrimack_19_02984746.img
|    |              merrimack_19_02984746.rrd
|    |              merrimack_19_02984748.img
|    |              merrimack_19_02984748.rrd
|    |              merrimack_19_02984749.img
|    |              merrimack_19_02984749.rrd
|    |              merrimack_19_02984750.img
|    |              merrimack_19_02984750.rrd
|    |              merrimack_19_02984752.img
|    |              merrimack_19_02984752.rrd
|    |              merrimack_19_02984754.img
|    |              merrimack_19_02984754.rrd
|    |              merrimack_19_02984755.img
|    |              merrimack_19_02984755.rrd
|    |              merrimack_19_02984756.img
|    |              merrimack_19_02984756.rrd
|    |              merrimack_19_02984758.img
|    |              merrimack_19_02984758.rrd
|    |              merrimack_19_02984760.img
|    |              merrimack_19_02984760.rrd
|    |              merrimack_19_02984761.img
|    |              merrimack_19_02984761.rrd
|    |              merrimack_19_02984762.img
|    |              merrimack_19_02984762.rrd
|    |              merrimack_19_02984764.img
|    |              merrimack_19_02984764.rrd
|    |              merrimack_19_02984766.img
```

```
|   |           merrimack_19_02984766.rrd
|   |           merrimack_19_02984767.img
|   |           merrimack_19_02984767.rrd
|   |           merrimack_19_02984768.img
|   |           merrimack_19_02984768.rrd
|   |           merrimack_19_02984770.img
|   |           merrimack_19_02984770.rrd
|   |           merrimack_19_02984772.img
|   |           merrimack_19_02984772.rrd
|   |           merrimack_19_02984773.img
|   |           merrimack_19_02984773.rrd
|   |           merrimack_19_02984774.img
|   |           merrimack_19_02984774.rrd
|   |           merrimack_19_02984776.img
|   |           merrimack_19_02984776.rrd
|   |           merrimack_19_02984778.img
|   |           merrimack_19_02984778.rrd
|   |           merrimack_19_02984779.img
|   |           merrimack_19_02984779.rrd
|   |           merrimack_19_02984780.img
|   |           merrimack_19_02984780.rrd
|   |           merrimack_19_02984782.img
|   |           merrimack_19_02984782.rrd
|   |           merrimack_19_02984784.img
|   |           merrimack_19_02984784.rrd
|   |           merrimack_19_02984785.img
|   |           merrimack_19_02984785.rrd
|   |           merrimack_19_02984786.img
|   |           merrimack_19_02984786.rrd
|   |           merrimack_19_02984788.img
|   |           merrimack_19_02984788.rrd
|   |           merrimack_19_02984790.img
|   |           merrimack_19_02984790.rrd
|   |           merrimack_19_02984791.img
|   |           merrimack_19_02984791.rrd
|   |           merrimack_19_02984792.img
|   |           merrimack_19_02984792.rrd
|   |           merrimack_19_02984794.img
|   |           merrimack_19_02984794.rrd
|   |           merrimack_19_02984796.img
|   |           merrimack_19_02984796.rrd
|   |           merrimack_19_02984797.img
|   |           merrimack_19_02984797.rrd
|   |           merrimack_19_02984798.img
|   |           merrimack_19_02984798.rrd
|   |           merrimack_19_02984800.img
|   |           merrimack_19_02984800.rrd
|   |           merrimack_19_02984802.img
|   |           merrimack_19_02984802.rrd
|   |           merrimack_19_02984803.img
|   |           merrimack_19_02984803.rrd
|   |           merrimack_19_02984804.img
|   |           merrimack_19_02984804.rrd
|   |           merrimack_19_02984806.img
```

```
|    |            merrimack_19_02984806.rrd
|    |            merrimack_19_02984808.img
|    |            merrimack_19_02984808.rrd
|    |            merrimack_19_02984809.img
|    |            merrimack_19_02984809.rrd
|    |            merrimack_19_03004714.img
|    |            merrimack_19_03004714.rrd
|    |            merrimack_19_03004716.img
|    |            merrimack_19_03004716.rrd
|    |            merrimack_19_03004718.img
|    |            merrimack_19_03004718.rrd
|    |            merrimack_19_03004719.img
|    |            merrimack_19_03004719.rrd
|    |            merrimack_19_03004720.img
|    |            merrimack_19_03004720.rrd
|    |            merrimack_19_03004722.img
|    |            merrimack_19_03004722.rrd
|    |            merrimack_19_03004724.img
|    |            merrimack_19_03004724.rrd
|    |            merrimack_19_03004725.img
|    |            merrimack_19_03004725.rrd
|    |            merrimack_19_03004726.img
|    |            merrimack_19_03004726.rrd
|    |            merrimack_19_03004728.img
|    |            merrimack_19_03004728.rrd
|    |            merrimack_19_03004730.img
|    |            merrimack_19_03004730.rrd
|    |            merrimack_19_03004731.img
|    |            merrimack_19_03004731.rrd
|    |            merrimack_19_03004732.img
|    |            merrimack_19_03004732.rrd
|    |            merrimack_19_03004734.img
|    |            merrimack_19_03004734.rrd
|    |            merrimack_19_03004736.img
|    |            merrimack_19_03004736.rrd
|    |            merrimack_19_03004737.img
|    |            merrimack_19_03004737.rrd
|    |            merrimack_19_03004738.img
|    |            merrimack_19_03004738.rrd
|    |            merrimack_19_03004740.img
|    |            merrimack_19_03004740.rrd
|    |            merrimack_19_03004742.img
|    |            merrimack_19_03004742.rrd
|    |            merrimack_19_03004743.img
|    |            merrimack_19_03004743.rrd
|    |            merrimack_19_03004744.img
|    |            merrimack_19_03004744.rrd
|    |            merrimack_19_03004746.img
|    |            merrimack_19_03004746.rrd
|    |            merrimack_19_03004748.img
|    |            merrimack_19_03004748.rrd
|    |            merrimack_19_03004749.img
|    |            merrimack_19_03004749.rrd
|    |            merrimack_19_03004750.img
```

```
|    |              merrimack_19_03004750.rrd
|    |              merrimack_19_03004752.img
|    |              merrimack_19_03004752.rrd
|    |              merrimack_19_03004754.img
|    |              merrimack_19_03004754.rrd
|    |              merrimack_19_03004755.img
|    |              merrimack_19_03004755.rrd
|    |              merrimack_19_03004756.img
|    |              merrimack_19_03004756.rrd
|    |              merrimack_19_03004758.img
|    |              merrimack_19_03004758.rrd
|    |              merrimack_19_03004760.img
|    |              merrimack_19_03004760.rrd
|    |              merrimack_19_03004761.img
|    |              merrimack_19_03004761.rrd
|    |              merrimack_19_03004762.img
|    |              merrimack_19_03004762.rrd
|    |              merrimack_19_03004764.img
|    |              merrimack_19_03004764.rrd
|    |              merrimack_19_03004766.img
|    |              merrimack_19_03004766.rrd
|    |              merrimack_19_03004767.img
|    |              merrimack_19_03004767.rrd
|    |              merrimack_19_03004768.img
|    |              merrimack_19_03004768.rrd
|    |              merrimack_19_03004770.img
|    |              merrimack_19_03004770.rrd
|    |              merrimack_19_03004772.img
|    |              merrimack_19_03004772.rrd
|    |              merrimack_19_03004773.img
|    |              merrimack_19_03004773.rrd
|    |              merrimack_19_03004774.img
|    |              merrimack_19_03004774.rrd
|    |              merrimack_19_03004776.img
|    |              merrimack_19_03004776.rrd
|    |              merrimack_19_03004778.img
|    |              merrimack_19_03004778.rrd
|    |              merrimack_19_03004779.img
|    |              merrimack_19_03004779.rrd
|    |              merrimack_19_03004780.img
|    |              merrimack_19_03004780.rrd
|    |              merrimack_19_03004782.img
|    |              merrimack_19_03004782.rrd
|    |              merrimack_19_03004784.img
|    |              merrimack_19_03004784.rrd
|    |              merrimack_19_03004785.img
|    |              merrimack_19_03004785.rrd
|    |              merrimack_19_03004786.img
|    |              merrimack_19_03004786.rrd
|    |              merrimack_19_03004788.img
|    |              merrimack_19_03004788.rrd
|    |              merrimack_19_03004790.img
|    |              merrimack_19_03004790.rrd
|    |              merrimack_19_03004791.img
```

```
|    |             merrimack_19_03004791.rrd
|    |             merrimack_19_03004792.img
|    |             merrimack_19_03004792.rrd
|    |             merrimack_19_03004794.img
|    |             merrimack_19_03004794.rrd
|    |             merrimack_19_03004796.img
|    |             merrimack_19_03004796.rrd
|    |             merrimack_19_03004797.img
|    |             merrimack_19_03004797.rrd
|    |             merrimack_19_03004798.img
|    |             merrimack_19_03004798.rrd
|    |             merrimack_19_03004800.img
|    |             merrimack_19_03004800.rrd
|    |             merrimack_19_03004802.img
|    |             merrimack_19_03004802.rrd
|    |             merrimack_19_03004803.img
|    |             merrimack_19_03004803.rrd
|    |             merrimack_19_03004804.img
|    |             merrimack_19_03004804.rrd
|    |             merrimack_19_03004806.img
|    |             merrimack_19_03004806.rrd
|    |             merrimack_19_03004808.img
|    |             merrimack_19_03004808.rrd
|    |             merrimack_19_03004809.img
|    |             merrimack_19_03004809.rrd
|    |             merrimack_19_03004810.img
|    |             merrimack_19_03004810.rrd
|    |             merrimack_19_03004812.img
|    |             merrimack_19_03004812.rrd
|    |             merrimack_19_03024714.img
|    |             merrimack_19_03024714.rrd
|    |             merrimack_19_03024716.img
|    |             merrimack_19_03024716.rrd
|    |             merrimack_19_03024718.img
|    |             merrimack_19_03024718.rrd
|    |             merrimack_19_03024719.img
|    |             merrimack_19_03024719.rrd
|    |             merrimack_19_03024720.img
|    |             merrimack_19_03024720.rrd
|    |             merrimack_19_03024722.img
|    |             merrimack_19_03024722.rrd
|    |             merrimack_19_03024724.img
|    |             merrimack_19_03024724.rrd
|    |             merrimack_19_03024725.img
|    |             merrimack_19_03024725.rrd
|    |             merrimack_19_03024726.img
|    |             merrimack_19_03024726.rrd
|    |             merrimack_19_03024728.img
|    |             merrimack_19_03024728.rrd
|    |             merrimack_19_03024730.img
|    |             merrimack_19_03024730.rrd
|    |             merrimack_19_03024731.img
|    |             merrimack_19_03024731.rrd
|    |             merrimack_19_03024732.img
```

```
|    |              merrimack_19_03024732.rrd
|    |              merrimack_19_03024734.img
|    |              merrimack_19_03024734.rrd
|    |              merrimack_19_03024736.img
|    |              merrimack_19_03024736.rrd
|    |              merrimack_19_03024737.img
|    |              merrimack_19_03024737.rrd
|    |              merrimack_19_03024738.img
|    |              merrimack_19_03024738.rrd
|    |              merrimack_19_03024740.img
|    |              merrimack_19_03024740.rrd
|    |              merrimack_19_03024742.img
|    |              merrimack_19_03024742.rrd
|    |              merrimack_19_03024743.img
|    |              merrimack_19_03024743.rrd
|    |              merrimack_19_03024744.img
|    |              merrimack_19_03024744.rrd
|    |              merrimack_19_03024746.img
|    |              merrimack_19_03024746.rrd
|    |              merrimack_19_03024748.img
|    |              merrimack_19_03024748.rrd
|    |              merrimack_19_03024749.img
|    |              merrimack_19_03024749.rrd
|    |              merrimack_19_03024750.img
|    |              merrimack_19_03024750.rrd
|    |              merrimack_19_03024752.img
|    |              merrimack_19_03024752.rrd
|    |              merrimack_19_03024754.img
|    |              merrimack_19_03024754.rrd
|    |              merrimack_19_03024755.img
|    |              merrimack_19_03024755.rrd
|    |              merrimack_19_03024756.img
|    |              merrimack_19_03024756.rrd
|    |              merrimack_19_03024758.img
|    |              merrimack_19_03024758.rrd
|    |              merrimack_19_03024760.img
|    |              merrimack_19_03024760.rrd
|    |              merrimack_19_03024761.img
|    |              merrimack_19_03024761.rrd
|    |              merrimack_19_03024762.img
|    |              merrimack_19_03024762.rrd
|    |              merrimack_19_03024764.img
|    |              merrimack_19_03024764.rrd
|    |              merrimack_19_03024766.img
|    |              merrimack_19_03024766.rrd
|    |              merrimack_19_03024767.img
|    |              merrimack_19_03024767.rrd
|    |              merrimack_19_03024768.img
|    |              merrimack_19_03024768.rrd
|    |              merrimack_19_03024770.img
|    |              merrimack_19_03024770.rrd
|    |              merrimack_19_03024772.img
|    |              merrimack_19_03024772.rrd
|    |              merrimack_19_03024773.img
```

```
|    |             merrimack_19_03024773.rrd
|    |             merrimack_19_03024774.img
|    |             merrimack_19_03024774.rrd
|    |             merrimack_19_03024776.img
|    |             merrimack_19_03024776.rrd
|    |             merrimack_19_03024778.img
|    |             merrimack_19_03024778.rrd
|    |             merrimack_19_03024779.img
|    |             merrimack_19_03024779.rrd
|    |             merrimack_19_03024780.img
|    |             merrimack_19_03024780.rrd
|    |             merrimack_19_03024782.img
|    |             merrimack_19_03024782.rrd
|    |             merrimack_19_03024784.img
|    |             merrimack_19_03024784.rrd
|    |             merrimack_19_03024785.img
|    |             merrimack_19_03024785.rrd
|    |             merrimack_19_03024786.img
|    |             merrimack_19_03024786.rrd
|    |             merrimack_19_03024788.img
|    |             merrimack_19_03024788.rrd
|    |             merrimack_19_03024790.img
|    |             merrimack_19_03024790.rrd
|    |             merrimack_19_03024791.img
|    |             merrimack_19_03024791.rrd
|    |             merrimack_19_03024792.img
|    |             merrimack_19_03024792.rrd
|    |             merrimack_19_03024794.img
|    |             merrimack_19_03024794.rrd
|    |             merrimack_19_03024796.img
|    |             merrimack_19_03024796.rrd
|    |             merrimack_19_03024797.img
|    |             merrimack_19_03024797.rrd
|    |             merrimack_19_03024798.img
|    |             merrimack_19_03024798.rrd
|    |             merrimack_19_03024800.img
|    |             merrimack_19_03024800.rrd
|    |             merrimack_19_03024802.img
|    |             merrimack_19_03024802.rrd
|    |             merrimack_19_03024803.img
|    |             merrimack_19_03024803.rrd
|    |             merrimack_19_03024804.img
|    |             merrimack_19_03024804.rrd
|    |             merrimack_19_03024806.img
|    |             merrimack_19_03024806.rrd
|    |             merrimack_19_03024808.img
|    |             merrimack_19_03024808.rrd
|    |             merrimack_19_03024809.img
|    |             merrimack_19_03024809.rrd
|    |             merrimack_19_03024810.img
|    |             merrimack_19_03024810.rrd
|    |             merrimack_19_03024812.img
|    |             merrimack_19_03024812.rrd
|    |             merrimack_19_03034718.img
```

```
|    |             merrimack_19_03034718.rrd
|    |             merrimack_19_03034719.img
|    |             merrimack_19_03034719.rrd
|    |             merrimack_19_03034720.img
|    |             merrimack_19_03034720.rrd
|    |             merrimack_19_03034722.img
|    |             merrimack_19_03034722.rrd
|    |             merrimack_19_03034724.img
|    |             merrimack_19_03034724.rrd
|    |             merrimack_19_03034725.img
|    |             merrimack_19_03034725.rrd
|    |             merrimack_19_03034726.img
|    |             merrimack_19_03034726.rrd
|    |             merrimack_19_03034728.img
|    |             merrimack_19_03034728.rrd
|    |             merrimack_19_03034730.img
|    |             merrimack_19_03034730.rrd
|    |             merrimack_19_03034731.img
|    |             merrimack_19_03034731.rrd
|    |             merrimack_19_03034732.img
|    |             merrimack_19_03034732.rrd
|    |             merrimack_19_03034734.img
|    |             merrimack_19_03034734.rrd
|    |             merrimack_19_03034736.img
|    |             merrimack_19_03034736.rrd
|    |             merrimack_19_03034737.img
|    |             merrimack_19_03034737.rrd
|    |             merrimack_19_03034738.img
|    |             merrimack_19_03034738.rrd
|    |             merrimack_19_03034740.img
|    |             merrimack_19_03034740.rrd
|    |             merrimack_19_03034742.img
|    |             merrimack_19_03034742.rrd
|    |             merrimack_19_03034743.img
|    |             merrimack_19_03034743.rrd
|    |             merrimack_19_03034744.img
|    |             merrimack_19_03034744.rrd
|    |             merrimack_19_03034746.img
|    |             merrimack_19_03034746.rrd
|    |             merrimack_19_03034748.img
|    |             merrimack_19_03034748.rrd
|    |             merrimack_19_03034749.img
|    |             merrimack_19_03034749.rrd
|    |             merrimack_19_03034750.img
|    |             merrimack_19_03034750.rrd
|    |             merrimack_19_03034752.img
|    |             merrimack_19_03034752.rrd
|    |             merrimack_19_03034754.img
|    |             merrimack_19_03034754.rrd
|    |             merrimack_19_03034755.img
|    |             merrimack_19_03034755.rrd
|    |             merrimack_19_03034756.img
|    |             merrimack_19_03034756.rrd
|    |             merrimack_19_03034758.img
```

```
|    |             merrimack_19_03034758.rrd
|    |             merrimack_19_03034760.img
|    |             merrimack_19_03034760.rrd
|    |             merrimack_19_03034761.img
|    |             merrimack_19_03034761.rrd
|    |             merrimack_19_03034762.img
|    |             merrimack_19_03034762.rrd
|    |             merrimack_19_03034764.img
|    |             merrimack_19_03034764.rrd
|    |             merrimack_19_03034766.img
|    |             merrimack_19_03034766.rrd
|    |             merrimack_19_03034767.img
|    |             merrimack_19_03034767.rrd
|    |             merrimack_19_03034768.img
|    |             merrimack_19_03034768.rrd
|    |             merrimack_19_03034770.img
|    |             merrimack_19_03034770.rrd
|    |             merrimack_19_03034772.img
|    |             merrimack_19_03034772.rrd
|    |             merrimack_19_03034773.img
|    |             merrimack_19_03034773.rrd
|    |             merrimack_19_03034774.img
|    |             merrimack_19_03034774.rrd
|    |             merrimack_19_03034776.img
|    |             merrimack_19_03034776.rrd
|    |             merrimack_19_03034778.img
|    |             merrimack_19_03034778.rrd
|    |             merrimack_19_03034779.img
|    |             merrimack_19_03034779.rrd
|    |             merrimack_19_03034780.img
|    |             merrimack_19_03034780.rrd
|    |             merrimack_19_03034782.img
|    |             merrimack_19_03034782.rrd
|    |             merrimack_19_03034784.img
|    |             merrimack_19_03034784.rrd
|    |             merrimack_19_03034785.img
|    |             merrimack_19_03034785.rrd
|    |             merrimack_19_03034786.img
|    |             merrimack_19_03034786.rrd
|    |             merrimack_19_03034788.img
|    |             merrimack_19_03034788.rrd
|    |             merrimack_19_03034790.img
|    |             merrimack_19_03034790.rrd
|    |             merrimack_19_03034791.img
|    |             merrimack_19_03034791.rrd
|    |             merrimack_19_03034792.img
|    |             merrimack_19_03034792.rrd
|    |             merrimack_19_03034794.img
|    |             merrimack_19_03034794.rrd
|    |             merrimack_19_03034796.img
|    |             merrimack_19_03034796.rrd
|    |             merrimack_19_03034797.img
|    |             merrimack_19_03034797.rrd
|    |             merrimack_19_03034798.img
```

```
|    |              merrimack_19_03034798.rrd
|    |              merrimack_19_03034800.img
|    |              merrimack_19_03034800.rrd
|    |              merrimack_19_03034802.img
|    |              merrimack_19_03034802.rrd
|    |              merrimack_19_03034803.img
|    |              merrimack_19_03034803.rrd
|    |              merrimack_19_03034804.img
|    |              merrimack_19_03034804.rrd
|    |              merrimack_19_03034806.img
|    |              merrimack_19_03034806.rrd
|    |              merrimack_19_03034808.img
|    |              merrimack_19_03034808.rrd
|    |              merrimack_19_03034809.img
|    |              merrimack_19_03034809.rrd
|    |              merrimack_19_03034810.img
|    |              merrimack_19_03034810.rrd
|    |              merrimack_19_03034812.img
|    |              merrimack_19_03034812.rrd
|    |              merrimack_19_03044719.img
|    |              merrimack_19_03044719.rrd
|    |              merrimack_19_03044720.img
|    |              merrimack_19_03044720.rrd
|    |              merrimack_19_03044722.img
|    |              merrimack_19_03044722.rrd
|    |              merrimack_19_03044724.img
|    |              merrimack_19_03044724.rrd
|    |              merrimack_19_03044725.img
|    |              merrimack_19_03044725.rrd
|    |              merrimack_19_03044726.img
|    |              merrimack_19_03044726.rrd
|    |              merrimack_19_03044728.img
|    |              merrimack_19_03044728.rrd
|    |              merrimack_19_03044730.img
|    |              merrimack_19_03044730.rrd
|    |              merrimack_19_03044731.img
|    |              merrimack_19_03044731.rrd
|    |              merrimack_19_03044732.img
|    |              merrimack_19_03044732.rrd
|    |              merrimack_19_03044734.img
|    |              merrimack_19_03044734.rrd
|    |              merrimack_19_03044736.img
|    |              merrimack_19_03044736.rrd
|    |              merrimack_19_03044737.img
|    |              merrimack_19_03044737.rrd
|    |              merrimack_19_03044738.img
|    |              merrimack_19_03044738.rrd
|    |              merrimack_19_03044740.img
|    |              merrimack_19_03044740.rrd
|    |              merrimack_19_03044742.img
|    |              merrimack_19_03044742.rrd
|    |              merrimack_19_03044743.img
|    |              merrimack_19_03044743.rrd
|    |              merrimack_19_03044744.img
```

```
|    |              merrimack_19_03044744.rrd
|    |              merrimack_19_03044746.img
|    |              merrimack_19_03044746.rrd
|    |              merrimack_19_03044748.img
|    |              merrimack_19_03044748.rrd
|    |              merrimack_19_03044749.img
|    |              merrimack_19_03044749.rrd
|    |              merrimack_19_03044750.img
|    |              merrimack_19_03044750.rrd
|    |              merrimack_19_03044752.img
|    |              merrimack_19_03044752.rrd
|    |              merrimack_19_03044754.img
|    |              merrimack_19_03044754.rrd
|    |              merrimack_19_03044755.img
|    |              merrimack_19_03044755.rrd
|    |              merrimack_19_03044756.img
|    |              merrimack_19_03044756.rrd
|    |              merrimack_19_03044758.img
|    |              merrimack_19_03044758.rrd
|    |              merrimack_19_03044760.img
|    |              merrimack_19_03044760.rrd
|    |              merrimack_19_03044761.img
|    |              merrimack_19_03044761.rrd
|    |              merrimack_19_03044762.img
|    |              merrimack_19_03044762.rrd
|    |              merrimack_19_03044764.img
|    |              merrimack_19_03044764.rrd
|    |              merrimack_19_03044766.img
|    |              merrimack_19_03044766.rrd
|    |              merrimack_19_03044767.img
|    |              merrimack_19_03044767.rrd
|    |              merrimack_19_03044768.img
|    |              merrimack_19_03044768.rrd
|    |              merrimack_19_03044770.img
|    |              merrimack_19_03044770.rrd
|    |              merrimack_19_03044772.img
|    |              merrimack_19_03044772.rrd
|    |              merrimack_19_03044773.img
|    |              merrimack_19_03044773.rrd
|    |              merrimack_19_03044774.img
|    |              merrimack_19_03044774.rrd
|    |              merrimack_19_03044776.img
|    |              merrimack_19_03044776.rrd
|    |              merrimack_19_03044778.img
|    |              merrimack_19_03044778.rrd
|    |              merrimack_19_03044779.img
|    |              merrimack_19_03044779.rrd
|    |              merrimack_19_03044780.img
|    |              merrimack_19_03044780.rrd
|    |              merrimack_19_03044782.img
|    |              merrimack_19_03044782.rrd
|    |              merrimack_19_03044784.img
|    |              merrimack_19_03044784.rrd
|    |              merrimack_19_03044785.img
```

```
|    |            merrimack_19_03044785.rrd
|    |            merrimack_19_03044786.img
|    |            merrimack_19_03044786.rrd
|    |            merrimack_19_03044788.img
|    |            merrimack_19_03044788.rrd
|    |            merrimack_19_03044790.img
|    |            merrimack_19_03044790.rrd
|    |            merrimack_19_03044791.img
|    |            merrimack_19_03044791.rrd
|    |            merrimack_19_03044792.img
|    |            merrimack_19_03044792.rrd
|    |            merrimack_19_03044794.img
|    |            merrimack_19_03044794.rrd
|    |            merrimack_19_03044796.img
|    |            merrimack_19_03044796.rrd
|    |            merrimack_19_03044797.img
|    |            merrimack_19_03044797.rrd
|    |            merrimack_19_03044798.img
|    |            merrimack_19_03044798.rrd
|    |            merrimack_19_03044800.img
|    |            merrimack_19_03044800.rrd
|    |            merrimack_19_03044802.img
|    |            merrimack_19_03044802.rrd
|    |            merrimack_19_03044803.img
|    |            merrimack_19_03044803.rrd
|    |            merrimack_19_03044804.img
|    |            merrimack_19_03044804.rrd
|    |            merrimack_19_03044806.img
|    |            merrimack_19_03044806.rrd
|    |            merrimack_19_03044808.img
|    |            merrimack_19_03044808.rrd
|    |            merrimack_19_03044809.img
|    |            merrimack_19_03044809.rrd
|    |            merrimack_19_03044810.img
|    |            merrimack_19_03044810.rrd
|    |            merrimack_19_03044812.img
|    |            merrimack_19_03044812.rrd
|    |            merrimack_19_03064719.img
|    |            merrimack_19_03064719.rrd
|    |            merrimack_19_03064720.img
|    |            merrimack_19_03064720.rrd
|    |            merrimack_19_03064722.img
|    |            merrimack_19_03064722.rrd
|    |            merrimack_19_03064725.img
|    |            merrimack_19_03064725.rrd
|    |            merrimack_19_03064726.img
|    |            merrimack_19_03064726.rrd
|    |            merrimack_19_03064730.img
|    |            merrimack_19_03064730.rrd
|    |            merrimack_19_03064731.img
|    |            merrimack_19_03064731.rrd
|    |            merrimack_19_03064732.img
|    |            merrimack_19_03064732.rrd
|    |            merrimack_19_03064734.img
```

```
|   |           merrimack_19_03064734.rrd
|   |           merrimack_19_03064736.img
|   |           merrimack_19_03064736.rrd
|   |           merrimack_19_03064737.img
|   |           merrimack_19_03064737.rrd
|   |           merrimack_19_03064738.img
|   |           merrimack_19_03064738.rrd
|   |           merrimack_19_03064740.img
|   |           merrimack_19_03064740.rrd
|   |           merrimack_19_03064742.img
|   |           merrimack_19_03064742.rrd
|   |           merrimack_19_03064754.img
|   |           merrimack_19_03064754.rrd
|   |           merrimack_19_03064755.img
|   |           merrimack_19_03064755.rrd
|   |           merrimack_19_03064756.img
|   |           merrimack_19_03064756.rrd
|   |           merrimack_19_03064758.img
|   |           merrimack_19_03064758.rrd
|   |           merrimack_19_03064768.img
|   |           merrimack_19_03064768.rrd
|   |           merrimack_19_03064770.img
|   |           merrimack_19_03064770.rrd
|   |           merrimack_19_03064772.img
|   |           merrimack_19_03064772.rrd
|   |           merrimack_19_03064773.img
|   |           merrimack_19_03064773.rrd
|   |           merrimack_19_03064774.img
|   |           merrimack_19_03064774.rrd
|   |           merrimack_19_03064776.img
|   |           merrimack_19_03064776.rrd
|   |           merrimack_19_03064778.img
|   |           merrimack_19_03064778.rrd
|   |           merrimack_19_03064779.img
|   |           merrimack_19_03064779.rrd
|   |           merrimack_19_03064780.img
|   |           merrimack_19_03064780.rrd
|   |           merrimack_19_03064782.img
|   |           merrimack_19_03064782.rrd
|   |           merrimack_19_03064784.img
|   |           merrimack_19_03064784.rrd
|   |           merrimack_19_03064785.img
|   |           merrimack_19_03064785.rrd
|   |           merrimack_19_03064786.img
|   |           merrimack_19_03064786.rrd
|   |           merrimack_19_03064788.img
|   |           merrimack_19_03064788.rrd
|   |           merrimack_19_03064790.img
|   |           merrimack_19_03064790.rrd
|   |           merrimack_19_03064791.img
|   |           merrimack_19_03064791.rrd
|   |           merrimack_19_03064792.img
|   |           merrimack_19_03064792.rrd
|   |           merrimack_19_03064794.img
```

```
|    |             merrimack_19_03064794.rrd
|    |             merrimack_19_03064796.img
|    |             merrimack_19_03064796.rrd
|    |             merrimack_19_03064797.img
|    |             merrimack_19_03064797.rrd
|    |             merrimack_19_03064798.img
|    |             merrimack_19_03064798.rrd
|    |             merrimack_19_03064800.img
|    |             merrimack_19_03064800.rrd
|    |             merrimack_19_03064802.img
|    |             merrimack_19_03064802.rrd
|    |             merrimack_19_03064803.img
|    |             merrimack_19_03064803.rrd
|    |             merrimack_19_03064804.img
|    |             merrimack_19_03064804.rrd
|    |             merrimack_19_03064806.img
|    |             merrimack_19_03064806.rrd
|    |             merrimack_19_03064808.img
|    |             merrimack_19_03064808.rrd
|    |             merrimack_19_03064809.img
|    |             merrimack_19_03064809.rrd
|    |             merrimack_19_03064810.img
|    |             merrimack_19_03064810.rrd
|    |             merrimack_19_03064812.img
|    |             merrimack_19_03064812.rrd
|    |             merrimack_19_03064814.img
|    |             merrimack_19_03064814.rrd
|    |             merrimack_19_03064815.img
|    |             merrimack_19_03064815.rrd
|    |             merrimack_19_03064816.img
|    |             merrimack_19_03064816.rrd
|    |             merrimack_19_03064818.img
|    |             merrimack_19_03064818.rrd
|    |             merrimack_19_03084702.img
|    |             merrimack_19_03084702.rrd
|    |             merrimack_19_03084704.img
|    |             merrimack_19_03084704.rrd
|    |             merrimack_19_03084719.img
|    |             merrimack_19_03084719.rrd
|    |             merrimack_19_03084720.img
|    |             merrimack_19_03084720.rrd
|    |             merrimack_19_03084730.img
|    |             merrimack_19_03084730.rrd
|    |             merrimack_19_03084731.img
|    |             merrimack_19_03084731.rrd
|    |             merrimack_19_03084732.img
|    |             merrimack_19_03084732.rrd
|    |             merrimack_19_03084734.img
|    |             merrimack_19_03084734.rrd
|    |             merrimack_19_03084736.img
|    |             merrimack_19_03084736.rrd
|    |             merrimack_19_03084737.img
|    |             merrimack_19_03084737.rrd
|    |             merrimack_19_03084738.img
```

```
|    |              merrimack_19_03084738.rrd
|    |              merrimack_19_03084772.img
|    |              merrimack_19_03084772.rrd
|    |              merrimack_19_03084773.img
|    |              merrimack_19_03084773.rrd
|    |              merrimack_19_03084774.img
|    |              merrimack_19_03084774.rrd
|    |              merrimack_19_03084776.img
|    |              merrimack_19_03084776.rrd
|    |              merrimack_19_03084778.img
|    |              merrimack_19_03084778.rrd
|    |              merrimack_19_03084779.img
|    |              merrimack_19_03084779.rrd
|    |              merrimack_19_03084780.img
|    |              merrimack_19_03084780.rrd
|    |              merrimack_19_03084782.img
|    |              merrimack_19_03084782.rrd
|    |              merrimack_19_03084784.img
|    |              merrimack_19_03084784.rrd
|    |              merrimack_19_03084785.img
|    |              merrimack_19_03084785.rrd
|    |              merrimack_19_03084786.img
|    |              merrimack_19_03084786.rrd
|    |              merrimack_19_03084788.img
|    |              merrimack_19_03084788.rrd
|    |              merrimack_19_03084790.img
|    |              merrimack_19_03084790.rrd
|    |              merrimack_19_03084791.img
|    |              merrimack_19_03084791.rrd
|    |              merrimack_19_03084792.img
|    |              merrimack_19_03084792.rrd
|    |              merrimack_19_03084794.img
|    |              merrimack_19_03084794.rrd
|    |              merrimack_19_03084796.img
|    |              merrimack_19_03084796.rrd
|    |              merrimack_19_03084797.img
|    |              merrimack_19_03084797.rrd
|    |              merrimack_19_03084798.img
|    |              merrimack_19_03084798.rrd
|    |              merrimack_19_03084800.img
|    |              merrimack_19_03084800.rrd
|    |              merrimack_19_03084802.img
|    |              merrimack_19_03084802.rrd
|    |              merrimack_19_03084803.img
|    |              merrimack_19_03084803.rrd
|    |              merrimack_19_03084804.img
|    |              merrimack_19_03084804.rrd
|    |              merrimack_19_03084806.img
|    |              merrimack_19_03084806.rrd
|    |              merrimack_19_03084808.img
|    |              merrimack_19_03084808.rrd
|    |              merrimack_19_03084809.img
|    |              merrimack_19_03084809.rrd
|    |              merrimack_19_03084810.img
```

```
|    |              merrimack_19_03084810.rrd
|    |              merrimack_19_03084812.img
|    |              merrimack_19_03084812.rrd
|    |              merrimack_19_03084814.img
|    |              merrimack_19_03084814.rrd
|    |              merrimack_19_03084815.img
|    |              merrimack_19_03084815.rrd
|    |              merrimack_19_03084816.img
|    |              merrimack_19_03084816.rrd
|    |              merrimack_19_03084818.img
|    |              merrimack_19_03084818.rrd
|    |              merrimack_19_03084820.img
|    |              merrimack_19_03084820.rrd
|    |              merrimack_19_03094700.img
|    |              merrimack_19_03094700.rrd
|    |              merrimack_19_03094701.img
|    |              merrimack_19_03094701.rrd
|    |              merrimack_19_03094702.img
|    |              merrimack_19_03094702.rrd
|    |              merrimack_19_03094704.img
|    |              merrimack_19_03094704.rrd
|    |              merrimack_19_03094706.img
|    |              merrimack_19_03094706.rrd
|    |              merrimack_19_03094730.img
|    |              merrimack_19_03094730.rrd
|    |              merrimack_19_03094731.img
|    |              merrimack_19_03094731.rrd
|    |              merrimack_19_03094732.img
|    |              merrimack_19_03094732.rrd
|    |              merrimack_19_03094734.img
|    |              merrimack_19_03094734.rrd
|    |              merrimack_19_03094736.img
|    |              merrimack_19_03094736.rrd
|    |              merrimack_19_03094737.img
|    |              merrimack_19_03094737.rrd
|    |              merrimack_19_03094776.img
|    |              merrimack_19_03094776.rrd
|    |              merrimack_19_03094778.img
|    |              merrimack_19_03094778.rrd
|    |              merrimack_19_03094779.img
|    |              merrimack_19_03094779.rrd
|    |              merrimack_19_03094780.img
|    |              merrimack_19_03094780.rrd
|    |              merrimack_19_03094782.img
|    |              merrimack_19_03094782.rrd
|    |              merrimack_19_03094784.img
|    |              merrimack_19_03094784.rrd
|    |              merrimack_19_03094785.img
|    |              merrimack_19_03094785.rrd
|    |              merrimack_19_03094786.img
|    |              merrimack_19_03094786.rrd
|    |              merrimack_19_03094788.img
|    |              merrimack_19_03094788.rrd
|    |              merrimack_19_03094790.img
```

```
|    |              merrimack_19_03094790.rrd
|    |              merrimack_19_03094791.img
|    |              merrimack_19_03094791.rrd
|    |              merrimack_19_03094792.img
|    |              merrimack_19_03094792.rrd
|    |              merrimack_19_03094794.img
|    |              merrimack_19_03094794.rrd
|    |              merrimack_19_03094796.img
|    |              merrimack_19_03094796.rrd
|    |              merrimack_19_03094797.img
|    |              merrimack_19_03094797.rrd
|    |              merrimack_19_03094798.img
|    |              merrimack_19_03094798.rrd
|    |              merrimack_19_03094800.img
|    |              merrimack_19_03094800.rrd
|    |              merrimack_19_03094802.img
|    |              merrimack_19_03094802.rrd
|    |              merrimack_19_03094803.img
|    |              merrimack_19_03094803.rrd
|    |              merrimack_19_03094804.img
|    |              merrimack_19_03094804.rrd
|    |              merrimack_19_03094806.img
|    |              merrimack_19_03094806.rrd
|    |              merrimack_19_03094808.img
|    |              merrimack_19_03094808.rrd
|    |              merrimack_19_03094809.img
|    |              merrimack_19_03094809.rrd
|    |              merrimack_19_03094810.img
|    |              merrimack_19_03094810.rrd
|    |              merrimack_19_03094812.img
|    |              merrimack_19_03094812.rrd
|    |              merrimack_19_03094814.img
|    |              merrimack_19_03094814.rrd
|    |              merrimack_19_03094815.img
|    |              merrimack_19_03094815.rrd
|    |              merrimack_19_03094816.img
|    |              merrimack_19_03094816.rrd
|    |              merrimack_19_03094818.img
|    |              merrimack_19_03094818.rrd
|    |              merrimack_19_03094820.img
|    |              merrimack_19_03094820.rrd
|    |              merrimack_19_03104700.img
|    |              merrimack_19_03104700.rrd
|    |              merrimack_19_03104701.img
|    |              merrimack_19_03104701.rrd
|    |              merrimack_19_03104702.img
|    |              merrimack_19_03104702.rrd
|    |              merrimack_19_03104704.img
|    |              merrimack_19_03104704.rrd
|    |              merrimack_19_03104706.img
|    |              merrimack_19_03104706.rrd
|    |              merrimack_19_03104707.img
|    |              merrimack_19_03104707.rrd
|    |              merrimack_19_03104730.img
```

```
|   |           merrimack_19_03104730.rrd
|   |           merrimack_19_03104731.img
|   |           merrimack_19_03104731.rrd
|   |           merrimack_19_03104732.img
|   |           merrimack_19_03104732.rrd
|   |           merrimack_19_03104734.img
|   |           merrimack_19_03104734.rrd
|   |           merrimack_19_03104736.img
|   |           merrimack_19_03104736.rrd
|   |           merrimack_19_03104737.img
|   |           merrimack_19_03104737.rrd
|   |           merrimack_19_03104778.img
|   |           merrimack_19_03104778.rrd
|   |           merrimack_19_03104779.img
|   |           merrimack_19_03104779.rrd
|   |           merrimack_19_03104780.img
|   |           merrimack_19_03104780.rrd
|   |           merrimack_19_03104782.img
|   |           merrimack_19_03104782.rrd
|   |           merrimack_19_03104784.img
|   |           merrimack_19_03104784.rrd
|   |           merrimack_19_03104785.img
|   |           merrimack_19_03104785.rrd
|   |           merrimack_19_03104786.img
|   |           merrimack_19_03104786.rrd
|   |           merrimack_19_03104788.img
|   |           merrimack_19_03104788.rrd
|   |           merrimack_19_03104790.img
|   |           merrimack_19_03104790.rrd
|   |           merrimack_19_03104791.img
|   |           merrimack_19_03104791.rrd
|   |           merrimack_19_03104792.img
|   |           merrimack_19_03104792.rrd
|   |           merrimack_19_03104794.img
|   |           merrimack_19_03104794.rrd
|   |           merrimack_19_03104796.img
|   |           merrimack_19_03104796.rrd
|   |           merrimack_19_03104797.img
|   |           merrimack_19_03104797.rrd
|   |           merrimack_19_03104798.img
|   |           merrimack_19_03104798.rrd
|   |           merrimack_19_03104800.img
|   |           merrimack_19_03104800.rrd
|   |           merrimack_19_03104802.img
|   |           merrimack_19_03104802.rrd
|   |           merrimack_19_03104803.img
|   |           merrimack_19_03104803.rrd
|   |           merrimack_19_03104804.img
|   |           merrimack_19_03104804.rrd
|   |           merrimack_19_03104806.img
|   |           merrimack_19_03104806.rrd
|   |           merrimack_19_03104808.img
|   |           merrimack_19_03104808.rrd
|   |           merrimack_19_03104809.img
```

```
|    |              merrimack_19_03104809.rrd
|    |              merrimack_19_03104810.img
|    |              merrimack_19_03104810.rrd
|    |              merrimack_19_03104812.img
|    |              merrimack_19_03104812.rrd
|    |              merrimack_19_03104814.img
|    |              merrimack_19_03104814.rrd
|    |              merrimack_19_03104815.img
|    |              merrimack_19_03104815.rrd
|    |              merrimack_19_03104816.img
|    |              merrimack_19_03104816.rrd
|    |              merrimack_19_03104818.img
|    |              merrimack_19_03104818.rrd
|    |              merrimack_19_03104820.img
|    |              merrimack_19_03104820.rrd
|    |              merrimack_19_03124701.img
|    |              merrimack_19_03124701.rrd
|    |              merrimack_19_03124702.img
|    |              merrimack_19_03124702.rrd
|    |              merrimack_19_03124704.img
|    |              merrimack_19_03124704.rrd
|    |              merrimack_19_03124706.img
|    |              merrimack_19_03124706.rrd
|    |              merrimack_19_03124707.img
|    |              merrimack_19_03124707.rrd
|    |              merrimack_19_03124708.img
|    |              merrimack_19_03124708.rrd
|    |              merrimack_19_03124710.img
|    |              merrimack_19_03124710.rrd
|    |              merrimack_19_03124730.img
|    |              merrimack_19_03124730.rrd
|    |              merrimack_19_03124731.img
|    |              merrimack_19_03124731.rrd
|    |              merrimack_19_03124732.img
|    |              merrimack_19_03124732.rrd
|    |              merrimack_19_03124734.img
|    |              merrimack_19_03124734.rrd
|    |              merrimack_19_03124736.img
|    |              merrimack_19_03124736.rrd
|    |              merrimack_19_03124737.img
|    |              merrimack_19_03124737.rrd
|    |              merrimack_19_03124780.img
|    |              merrimack_19_03124780.rrd
|    |              merrimack_19_03124782.img
|    |              merrimack_19_03124782.rrd
|    |              merrimack_19_03124784.img
|    |              merrimack_19_03124784.rrd
|    |              merrimack_19_03124785.img
|    |              merrimack_19_03124785.rrd
|    |              merrimack_19_03124786.img
|    |              merrimack_19_03124786.rrd
|    |              merrimack_19_03124788.img
|    |              merrimack_19_03124788.rrd
|    |              merrimack_19_03124790.img
```

```
|   |           merrimack_19_03124790.rrd
|   |           merrimack_19_03124791.img
|   |           merrimack_19_03124791.rrd
|   |           merrimack_19_03124792.img
|   |           merrimack_19_03124792.rrd
|   |           merrimack_19_03124794.img
|   |           merrimack_19_03124794.rrd
|   |           merrimack_19_03124796.img
|   |           merrimack_19_03124796.rrd
|   |           merrimack_19_03124797.img
|   |           merrimack_19_03124797.rrd
|   |           merrimack_19_03124798.img
|   |           merrimack_19_03124798.rrd
|   |           merrimack_19_03124800.img
|   |           merrimack_19_03124800.rrd
|   |           merrimack_19_03124802.img
|   |           merrimack_19_03124802.rrd
|   |           merrimack_19_03124803.img
|   |           merrimack_19_03124803.rrd
|   |           merrimack_19_03124804.img
|   |           merrimack_19_03124804.rrd
|   |           merrimack_19_03124806.img
|   |           merrimack_19_03124806.rrd
|   |           merrimack_19_03124808.img
|   |           merrimack_19_03124808.rrd
|   |           merrimack_19_03124809.img
|   |           merrimack_19_03124809.rrd
|   |           merrimack_19_03124810.img
|   |           merrimack_19_03124810.rrd
|   |           merrimack_19_03124812.img
|   |           merrimack_19_03124812.rrd
|   |           merrimack_19_03124814.img
|   |           merrimack_19_03124814.rrd
|   |           merrimack_19_03124815.img
|   |           merrimack_19_03124815.rrd
|   |           merrimack_19_03124816.img
|   |           merrimack_19_03124816.rrd
|   |           merrimack_19_03124818.img
|   |           merrimack_19_03124818.rrd
|   |           merrimack_19_03124820.img
|   |           merrimack_19_03124820.rrd
|   |           merrimack_19_03144700.img
|   |           merrimack_19_03144700.rrd
|   |           merrimack_19_03144701.img
|   |           merrimack_19_03144701.rrd
|   |           merrimack_19_03144702.img
|   |           merrimack_19_03144702.rrd
|   |           merrimack_19_03144704.img
|   |           merrimack_19_03144704.rrd
|   |           merrimack_19_03144706.img
|   |           merrimack_19_03144706.rrd
|   |           merrimack_19_03144707.img
|   |           merrimack_19_03144707.rrd
|   |           merrimack_19_03144708.img
```

```
|    |              merrimack_19_03144708.rrd
|    |              merrimack_19_03144710.img
|    |              merrimack_19_03144710.rrd
|    |              merrimack_19_03144731.img
|    |              merrimack_19_03144731.rrd
|    |              merrimack_19_03144732.img
|    |              merrimack_19_03144732.rrd
|    |              merrimack_19_03144734.img
|    |              merrimack_19_03144734.rrd
|    |              merrimack_19_03144736.img
|    |              merrimack_19_03144736.rrd
|    |              merrimack_19_03144784.img
|    |              merrimack_19_03144784.rrd
|    |              merrimack_19_03144785.img
|    |              merrimack_19_03144785.rrd
|    |              merrimack_19_03144786.img
|    |              merrimack_19_03144786.rrd
|    |              merrimack_19_03144788.img
|    |              merrimack_19_03144788.rrd
|    |              merrimack_19_03144790.img
|    |              merrimack_19_03144790.rrd
|    |              merrimack_19_03144791.img
|    |              merrimack_19_03144791.rrd
|    |              merrimack_19_03144792.img
|    |              merrimack_19_03144792.rrd
|    |              merrimack_19_03144794.img
|    |              merrimack_19_03144794.rrd
|    |              merrimack_19_03144796.img
|    |              merrimack_19_03144796.rrd
|    |              merrimack_19_03144797.img
|    |              merrimack_19_03144797.rrd
|    |              merrimack_19_03144798.img
|    |              merrimack_19_03144798.rrd
|    |              merrimack_19_03144800.img
|    |              merrimack_19_03144800.rrd
|    |              merrimack_19_03144802.img
|    |              merrimack_19_03144802.rrd
|    |              merrimack_19_03144803.img
|    |              merrimack_19_03144803.rrd
|    |              merrimack_19_03144804.img
|    |              merrimack_19_03144804.rrd
|    |              merrimack_19_03144806.img
|    |              merrimack_19_03144806.rrd
|    |              merrimack_19_03144808.img
|    |              merrimack_19_03144808.rrd
|    |              merrimack_19_03144809.img
|    |              merrimack_19_03144809.rrd
|    |              merrimack_19_03144810.img
|    |              merrimack_19_03144810.rrd
|    |              merrimack_19_03144812.img
|    |              merrimack_19_03144812.rrd
|    |              merrimack_19_03144814.img
|    |              merrimack_19_03144814.rrd
|    |              merrimack_19_03144815.img
```

```
|    |              merrimack_19_03144815.rrd
|    |              merrimack_19_03144816.img
|    |              merrimack_19_03144816.rrd
|    |              merrimack_19_03144818.img
|    |              merrimack_19_03144818.rrd
|    |              merrimack_19_03144820.img
|    |              merrimack_19_03144820.rrd
|    |              merrimack_19_03154700.img
|    |              merrimack_19_03154700.rrd
|    |              merrimack_19_03154701.img
|    |              merrimack_19_03154701.rrd
|    |              merrimack_19_03154702.img
|    |              merrimack_19_03154702.rrd
|    |              merrimack_19_03154704.img
|    |              merrimack_19_03154704.rrd
|    |              merrimack_19_03154706.img
|    |              merrimack_19_03154706.rrd
|    |              merrimack_19_03154707.img
|    |              merrimack_19_03154707.rrd
|    |              merrimack_19_03154708.img
|    |              merrimack_19_03154708.rrd
|    |              merrimack_19_03154710.img
|    |              merrimack_19_03154710.rrd
|    |              merrimack_19_03154732.img
|    |              merrimack_19_03154732.rrd
|    |              merrimack_19_03154734.img
|    |              merrimack_19_03154734.rrd
|    |              merrimack_19_03154736.img
|    |              merrimack_19_03154736.rrd
|    |              merrimack_19_03154786.img
|    |              merrimack_19_03154786.rrd
|    |              merrimack_19_03154788.img
|    |              merrimack_19_03154788.rrd
|    |              merrimack_19_03154790.img
|    |              merrimack_19_03154790.rrd
|    |              merrimack_19_03154791.img
|    |              merrimack_19_03154791.rrd
|    |              merrimack_19_03154792.img
|    |              merrimack_19_03154792.rrd
|    |              merrimack_19_03154794.img
|    |              merrimack_19_03154794.rrd
|    |              merrimack_19_03154796.img
|    |              merrimack_19_03154796.rrd
|    |              merrimack_19_03154797.img
|    |              merrimack_19_03154797.rrd
|    |              merrimack_19_03154798.img
|    |              merrimack_19_03154798.rrd
|    |              merrimack_19_03154800.img
|    |              merrimack_19_03154800.rrd
|    |              merrimack_19_03154802.img
|    |              merrimack_19_03154802.rrd
|    |              merrimack_19_03154803.img
|    |              merrimack_19_03154803.rrd
|    |              merrimack_19_03154804.img
```

```
|    |             merrimack_19_03154804.rrd
|    |             merrimack_19_03154806.img
|    |             merrimack_19_03154806.rrd
|    |             merrimack_19_03154808.img
|    |             merrimack_19_03154808.rrd
|    |             merrimack_19_03154809.img
|    |             merrimack_19_03154809.rrd
|    |             merrimack_19_03154810.img
|    |             merrimack_19_03154810.rrd
|    |             merrimack_19_03154812.img
|    |             merrimack_19_03154812.rrd
|    |             merrimack_19_03154814.img
|    |             merrimack_19_03154814.rrd
|    |             merrimack_19_03154815.img
|    |             merrimack_19_03154815.rrd
|    |             merrimack_19_03154816.img
|    |             merrimack_19_03154816.rrd
|    |             merrimack_19_03154818.img
|    |             merrimack_19_03154818.rrd
|    |             merrimack_19_03164700.img
|    |             merrimack_19_03164700.rrd
|    |             merrimack_19_03164701.img
|    |             merrimack_19_03164701.rrd
|    |             merrimack_19_03164702.img
|    |             merrimack_19_03164702.rrd
|    |             merrimack_19_03164704.img
|    |             merrimack_19_03164704.rrd
|    |             merrimack_19_03164706.img
|    |             merrimack_19_03164706.rrd
|    |             merrimack_19_03164707.img
|    |             merrimack_19_03164707.rrd
|    |             merrimack_19_03164708.img
|    |             merrimack_19_03164708.rrd
|    |             merrimack_19_03164791.img
|    |             merrimack_19_03164791.rrd
|    |             merrimack_19_03164792.img
|    |             merrimack_19_03164792.rrd
|    |             merrimack_19_03164794.img
|    |             merrimack_19_03164794.rrd
|    |             merrimack_19_03164796.img
|    |             merrimack_19_03164796.rrd
|    |             merrimack_19_03164797.img
|    |             merrimack_19_03164797.rrd
|    |             merrimack_19_03164798.img
|    |             merrimack_19_03164798.rrd
|    |             merrimack_19_03164800.img
|    |             merrimack_19_03164800.rrd
|    |             merrimack_19_03164802.img
|    |             merrimack_19_03164802.rrd
|    |             merrimack_19_03164803.img
|    |             merrimack_19_03164803.rrd
|    |             merrimack_19_03164804.img
|    |             merrimack_19_03164804.rrd
|    |             merrimack_19_03164806.img
```

```
|    |             merrimack_19_03164806.rrd
|    |             merrimack_19_03164808.img
|    |             merrimack_19_03164808.rrd
|    |             merrimack_19_03164809.img
|    |             merrimack_19_03164809.rrd
|    |             merrimack_19_03164810.img
|    |             merrimack_19_03164810.rrd
|    |             merrimack_19_03164812.img
|    |             merrimack_19_03164812.rrd
|    |             merrimack_19_03164814.img
|    |             merrimack_19_03164814.rrd
|    |             merrimack_19_03164815.img
|    |             merrimack_19_03164815.rrd
|    |             merrimack_19_03184701.img
|    |             merrimack_19_03184701.rrd
|    |             merrimack_19_03184702.img
|    |             merrimack_19_03184702.rrd
|    |             merrimack_19_03184704.img
|    |             merrimack_19_03184704.rrd
|    |             merrimack_19_03184706.img
|    |             merrimack_19_03184706.rrd
|    |             merrimack_19_03184707.img
|    |             merrimack_19_03184707.rrd
|    |             merrimack_19_03184708.img
|    |             merrimack_19_03184708.rrd
|    |             merrimack_19_03184710.img
|    |             merrimack_19_03184710.rrd
|    |             merrimack_19_03184792.img
|    |             merrimack_19_03184792.rrd
|    |             merrimack_19_03184794.img
|    |             merrimack_19_03184794.rrd
|    |             merrimack_19_03184796.img
|    |             merrimack_19_03184796.rrd
|    |             merrimack_19_03184797.img
|    |             merrimack_19_03184797.rrd
|    |             merrimack_19_03184798.img
|    |             merrimack_19_03184798.rrd
|    |             merrimack_19_03184800.img
|    |             merrimack_19_03184800.rrd
|    |             merrimack_19_03184802.img
|    |             merrimack_19_03184802.rrd
|    |             merrimack_19_03184803.img
|    |             merrimack_19_03184803.rrd
|    |             merrimack_19_03184804.img
|    |             merrimack_19_03184804.rrd
|    |             merrimack_19_03184806.img
|    |             merrimack_19_03184806.rrd
|    |             merrimack_19_03184808.img
|    |             merrimack_19_03184808.rrd
|    |             merrimack_19_03204702.img
|    |             merrimack_19_03204702.rrd
|    |             merrimack_19_03204704.img
|    |             merrimack_19_03204704.rrd
|    |             merrimack_19_03204706.img
```

```
|    |              merrimack_19_03204706.rrd
|    |              merrimack_19_03204707.img
|    |              merrimack_19_03204707.rrd
|    |              merrimack_19_03204708.img
|    |              merrimack_19_03204708.rrd
|    |              merrimack_19_03204794.img
|    |              merrimack_19_03204794.rrd
|    |              merrimack_19_03204796.img
|    |              merrimack_19_03204796.rrd
|    |              merrimack_19_03204797.img
|    |              merrimack_19_03204797.rrd
|    |              merrimack_19_03204798.img
|    |              merrimack_19_03204798.rrd
|    |              merrimack_19_03204800.img
|    |              merrimack_19_03204800.rrd
|    |              merrimack_19_03204802.img
|    |              merrimack_19_03204802.rrd
|    |              merrimack_19_03204803.img
|    |              merrimack_19_03204803.rrd
|    |              merrimack_19_03204804.img
|    |              merrimack_19_03204804.rrd
|    |              merrimack_19_03204806.img
|    |              merrimack_19_03204806.rrd
|    |              merrimack_19_03204808.img
|    |              merrimack_19_03204808.rrd
|    |              merrimack_19_03214792.img
|    |              merrimack_19_03214792.rrd
|    |              merrimack_19_03214794.img
|    |              merrimack_19_03214794.rrd
|    |              merrimack_19_03214796.img
|    |              merrimack_19_03214796.rrd
|    |              merrimack_19_03214797.img
|    |              merrimack_19_03214797.rrd
|    |              merrimack_19_03214798.img
|    |              merrimack_19_03214798.rrd
|    |              merrimack_19_03214800.img
|    |              merrimack_19_03214800.rrd
|    |              merrimack_19_03214802.img
|    |              merrimack_19_03214802.rrd
|    |              merrimack_19_03214803.img
|    |              merrimack_19_03214803.rrd
|    |              merrimack_19_03214804.img
|    |              merrimack_19_03214804.rrd
|    |              merrimack_19_03214806.img
|    |              merrimack_19_03214806.rrd
|    |              merrimack_19_03214808.img
|    |              merrimack_19_03214808.rrd
|    |              merrimack_19_03224792.img
|    |              merrimack_19_03224792.rrd
|    |              merrimack_19_03224794.img
|    |              merrimack_19_03224794.rrd
|    |              merrimack_19_03224796.img
|    |              merrimack_19_03224796.rrd
|    |              merrimack_19_03224797.img
```

```
|    |             merrimack_19_03224797.rrd
|    |             merrimack_19_03224798.img
|    |             merrimack_19_03224798.rrd
|    |             merrimack_19_03224800.img
|    |             merrimack_19_03224800.rrd
|    |             merrimack_19_03224802.img
|    |             merrimack_19_03224802.rrd
|    |             merrimack_19_03224803.img
|    |             merrimack_19_03224803.rrd
|    |             merrimack_19_03224804.img
|    |             merrimack_19_03224804.rrd
|    |             merrimack_19_03224806.img
|    |             merrimack_19_03224806.rrd
|    |             merrimack_19_03224808.img
|    |             merrimack_19_03224808.rrd
|    |             merrimack_19_03244794.img
|    |             merrimack_19_03244794.rrd
|    |             merrimack_19_03244796.img
|    |             merrimack_19_03244796.rrd
|    |             merrimack_19_03244797.img
|    |             merrimack_19_03244797.rrd
|    |             merrimack_19_03244798.img
|    |             merrimack_19_03244798.rrd
|    |             merrimack_19_03244800.img
|    |             merrimack_19_03244800.rrd
|    |             merrimack_19_03244802.img
|    |             merrimack_19_03244802.rrd
|    |             merrimack_19_03244803.img
|    |             merrimack_19_03244803.rrd
|    |             merrimack_19_03244804.img
|    |             merrimack_19_03244804.rrd
|    |             merrimack_19_03244806.img
|    |             merrimack_19_03244806.rrd
|    |             merrimack_19_03264796.img
|    |             merrimack_19_03264796.rrd
|    |             merrimack_19_03264797.img
|    |             merrimack_19_03264797.rrd
|    |             merrimack_19_03264798.img
|    |             merrimack_19_03264798.rrd
|    |             merrimack_19_03264800.img
|    |             merrimack_19_03264800.rrd
|    |             merrimack_19_03264802.img
|    |             merrimack_19_03264802.rrd
|    |             merrimack_19_03264803.img
|    |             merrimack_19_03264803.rrd
|    |             merrimack_19_03264804.img
|    |             merrimack_19_03264804.rrd
|    |             merrimack_19_03274797.img
|    |             merrimack_19_03274797.rrd
|    |             merrimack_19_03274798.img
|    |             merrimack_19_03274798.rrd
|    |             merrimack_19_03274800.img
|    |             merrimack_19_03274800.rrd
|    |             merrimack_19_03274802.img
```

```
|   |           merrimack_19_03274802.rrd
|   |           merrimack_19_03284798.img
|   |           merrimack_19_03284798.rrd
|   |           merrimack_19_03284800.img
|   |           merrimack_19_03284800.rrd
|   |
|   +---Breaklines
|   |       Merrimack_HydroBreaklines_USFeet_Vertical.dbf
|   |       Merrimack_HydroBreaklines_USFeet_Vertical.prj
|   |       Merrimack_HydroBreaklines_USFeet_Vertical.shp
|   |       Merrimack_HydroBreaklines_USFeet_Vertical.shp.xml
|   |       Merrimack_HydroBreaklines_USFeet_Vertical.shx
|   |
|   +---Classified Point Cloud Data
|   +---Contours
|   |   \---Merrimack_2ft_Contours.gdb
|   +---HDEM
|   \---TIN
|       \---Merrimack_Terrain.gdb
+---General
|       33013C_Terrain_Metadata.txt
|       33013C_Terrain_Metadata.xml
|       Merrimack_River_HUC_8_01080202_Terrain_TSDN.pdf
+---Source
|   +---Bare Earth DEM
|   +---Breaklines
|   +---Classified Point Cloud Data
|   |       19_02604734.las
|   |       19_02604736.las
|   |       19_02614728.las
|   |       19_02614730.las
|   |       19_02614731.las
|   |       19_02614732.las
|   |       19_02614734.las
|   |       19_02614736.las
|   |       19_02614737.las
|   |       19_02614738.las
|   |       19_02624725.las
|   |       19_02624726.las
|   |       19_02624728.las
|   |       19_02624730.las
|   |       19_02624731.las
|   |       19_02624732.las
|   |       19_02624734.las
|   |       19_02624736.las
|   |       19_02624737.las
|   |       19_02624738.las
|   |       19_02624740.las
|   |       19_02624742.las
|   |       19_02624743.las
|   |       19_02624744.las
|   |       19_02624746.las
|   |       19_02624748.las
|   |       19_02644725.las
```

```
|    |        19_02644726.las
|    |        19_02644728.las
|    |        19_02644730.las
|    |        19_02644731.las
|    |        19_02644732.las
|    |        19_02644734.las
|    |        19_02644736.las
|    |        19_02644737.las
|    |        19_02644738.las
|    |        19_02644740.las
|    |        19_02644742.las
|    |        19_02644743.las
|    |        19_02644744.las
|    |        19_02644746.las
|    |        19_02644748.las
|    |        19_02644749.las
|    |        19_02644750.las
|    |        19_02644752.las
|    |        19_02644754.las
|    |        19_02644755.las
|    |        19_02644760.las
|    |        19_02644761.las
|    |        19_02644762.las
|    |        19_02644764.las
|    |        19_02644766.las
|    |        19_02644767.las
|    |        19_02644772.las
|    |        19_02664726.las
|    |        19_02664728.las
|    |        19_02664730.las
|    |        19_02664731.las
|    |        19_02664732.las
|    |        19_02664734.las
|    |        19_02664736.las
|    |        19_02664737.las
|    |        19_02664738.las
|    |        19_02664740.las
|    |        19_02664742.las
|    |        19_02664743.las
|    |        19_02664744.las
|    |        19_02664746.las
|    |        19_02664748.las
|    |        19_02664749.las
|    |        19_02664750.las
|    |        19_02664752.las
|    |        19_02664754.las
|    |        19_02664755.las
|    |        19_02664756.las
|    |        19_02664758.las
|    |        19_02664760.las
|    |        19_02664761.las
|    |        19_02664762.las
|    |        19_02664764.las
|    |        19_02664766.las
```

```
|    |        19_02664767.las
|    |        19_02664768.las
|    |        19_02664770.las
|    |        19_02664772.las
|    |        19_02664773.las
|    |        19_02664774.las
|    |        19_02664776.las
|    |        19_02674730.las
|    |        19_02674731.las
|    |        19_02674732.las
|    |        19_02674734.las
|    |        19_02674736.las
|    |        19_02674737.las
|    |        19_02674738.las
|    |        19_02674740.las
|    |        19_02674742.las
|    |        19_02674743.las
|    |        19_02674744.las
|    |        19_02674746.las
|    |        19_02674748.las
|    |        19_02674749.las
|    |        19_02674750.las
|    |        19_02674752.las
|    |        19_02674754.las
|    |        19_02674755.las
|    |        19_02674756.las
|    |        19_02674758.las
|    |        19_02674760.las
|    |        19_02674761.las
|    |        19_02674762.las
|    |        19_02674764.las
|    |        19_02674766.las
|    |        19_02674767.las
|    |        19_02674768.las
|    |        19_02674770.las
|    |        19_02674772.las
|    |        19_02674773.las
|    |        19_02674774.las
|    |        19_02674776.las
|    |        19_02674778.las
|    |        19_02674779.las
|    |        19_02684732.las
|    |        19_02684734.las
|    |        19_02684736.las
|    |        19_02684737.las
|    |        19_02684738.las
|    |        19_02684740.las
|    |        19_02684742.las
|    |        19_02684743.las
|    |        19_02684744.las
|    |        19_02684746.las
|    |        19_02684748.las
|    |        19_02684749.las
|    |        19_02684750.las
```

```
|    |        19_02684752.las
|    |        19_02684754.las
|    |        19_02684755.las
|    |        19_02684756.las
|    |        19_02684758.las
|    |        19_02684760.las
|    |        19_02684761.las
|    |        19_02684762.las
|    |        19_02684764.las
|    |        19_02684766.las
|    |        19_02684767.las
|    |        19_02684768.las
|    |        19_02684770.las
|    |        19_02684772.las
|    |        19_02684773.las
|    |        19_02684774.las
|    |        19_02684776.las
|    |        19_02684778.las
|    |        19_02684779.las
|    |        19_02684780.las
|    |        19_02704737.las
|    |        19_02704738.las
|    |        19_02704740.las
|    |        19_02704742.las
|    |        19_02704743.las
|    |        19_02704744.las
|    |        19_02704746.las
|    |        19_02704748.las
|    |        19_02704749.las
|    |        19_02704750.las
|    |        19_02704752.las
|    |        19_02704754.las
|    |        19_02704755.las
|    |        19_02704756.las
|    |        19_02704758.las
|    |        19_02704760.las
|    |        19_02704761.las
|    |        19_02704762.las
|    |        19_02704764.las
|    |        19_02704766.las
|    |        19_02704767.las
|    |        19_02704768.las
|    |        19_02704770.las
|    |        19_02704772.las
|    |        19_02704773.las
|    |        19_02704774.las
|    |        19_02704776.las
|    |        19_02704778.las
|    |        19_02704779.las
|    |        19_02704780.las
|    |        19_02724737.las
|    |        19_02724738.las
|    |        19_02724740.las
|    |        19_02724742.las
```

```
|   |       19_02724743.las
|   |       19_02724744.las
|   |       19_02724746.las
|   |       19_02724748.las
|   |       19_02724749.las
|   |       19_02724750.las
|   |       19_02724752.las
|   |       19_02724754.las
|   |       19_02724755.las
|   |       19_02724756.las
|   |       19_02724758.las
|   |       19_02724760.las
|   |       19_02724761.las
|   |       19_02724762.las
|   |       19_02724764.las
|   |       19_02724766.las
|   |       19_02724767.las
|   |       19_02724768.las
|   |       19_02724770.las
|   |       19_02724772.las
|   |       19_02724773.las
|   |       19_02724774.las
|   |       19_02724776.las
|   |       19_02724778.las
|   |       19_02724779.las
|   |       19_02724780.las
|   |       19_02734740.las
|   |       19_02734742.las
|   |       19_02734743.las
|   |       19_02734744.las
|   |       19_02734746.las
|   |       19_02734748.las
|   |       19_02734749.las
|   |       19_02734750.las
|   |       19_02734752.las
|   |       19_02734754.las
|   |       19_02734755.las
|   |       19_02734756.las
|   |       19_02734758.las
|   |       19_02734760.las
|   |       19_02734761.las
|   |       19_02734762.las
|   |       19_02734764.las
|   |       19_02734766.las
|   |       19_02734767.las
|   |       19_02734768.las
|   |       19_02734770.las
|   |       19_02734772.las
|   |       19_02734773.las
|   |       19_02734774.las
|   |       19_02734776.las
|   |       19_02734778.las
|   |       19_02734779.las
|   |       19_02734780.las
```

```
|    |        19_02744742.las
|    |        19_02744743.las
|    |        19_02744744.las
|    |        19_02744746.las
|    |        19_02744748.las
|    |        19_02744749.las
|    |        19_02744750.las
|    |        19_02744752.las
|    |        19_02744754.las
|    |        19_02744755.las
|    |        19_02744756.las
|    |        19_02744758.las
|    |        19_02744760.las
|    |        19_02744761.las
|    |        19_02744762.las
|    |        19_02744764.las
|    |        19_02744766.las
|    |        19_02744767.las
|    |        19_02744768.las
|    |        19_02744770.las
|    |        19_02744772.las
|    |        19_02744773.las
|    |        19_02744774.las
|    |        19_02744776.las
|    |        19_02744778.las
|    |        19_02744779.las
|    |        19_02764742.las
|    |        19_02764743.las
|    |        19_02764744.las
|    |        19_02764746.las
|    |        19_02764748.las
|    |        19_02764749.las
|    |        19_02764750.las
|    |        19_02764752.las
|    |        19_02764754.las
|    |        19_02764755.las
|    |        19_02764756.las
|    |        19_02764758.las
|    |        19_02764760.las
|    |        19_02764761.las
|    |        19_02764762.las
|    |        19_02764764.las
|    |        19_02764766.las
|    |        19_02764767.las
|    |        19_02764768.las
|    |        19_02764770.las
|    |        19_02764772.las
|    |        19_02764773.las
|    |        19_02764774.las
|    |        19_02764776.las
|    |        19_02764778.las
|    |        19_02764779.las
|    |        19_02764809.las
|    |        19_02764810.las
```

```
|    |        19_02784740.las
|    |        19_02784742.las
|    |        19_02784743.las
|    |        19_02784744.las
|    |        19_02784746.las
|    |        19_02784748.las
|    |        19_02784749.las
|    |        19_02784750.las
|    |        19_02784752.las
|    |        19_02784754.las
|    |        19_02784755.las
|    |        19_02784756.las
|    |        19_02784758.las
|    |        19_02784760.las
|    |        19_02784761.las
|    |        19_02784762.las
|    |        19_02784764.las
|    |        19_02784766.las
|    |        19_02784767.las
|    |        19_02784768.las
|    |        19_02784770.las
|    |        19_02784772.las
|    |        19_02784773.las
|    |        19_02784774.las
|    |        19_02784776.las
|    |        19_02784778.las
|    |        19_02784779.las
|    |        19_02784808.las
|    |        19_02784809.las
|    |        19_02784810.las
|    |        19_02784812.las
|    |        19_02784814.las
|    |        19_02794740.las
|    |        19_02794742.las
|    |        19_02794743.las
|    |        19_02794744.las
|    |        19_02794746.las
|    |        19_02794748.las
|    |        19_02794749.las
|    |        19_02794750.las
|    |        19_02794752.las
|    |        19_02794754.las
|    |        19_02794755.las
|    |        19_02794756.las
|    |        19_02794758.las
|    |        19_02794760.las
|    |        19_02794761.las
|    |        19_02794762.las
|    |        19_02794764.las
|    |        19_02794766.las
|    |        19_02794767.las
|    |        19_02794768.las
|    |        19_02794770.las
|    |        19_02794772.las
```

```
|    |        19_02794773.las
|    |        19_02794774.las
|    |        19_02794776.las
|    |        19_02794778.las
|    |        19_02794779.las
|    |        19_02794780.las
|    |        19_02794804.las
|    |        19_02794806.las
|    |        19_02794808.las
|    |        19_02794809.las
|    |        19_02794810.las
|    |        19_02794812.las
|    |        19_02794814.las
|    |        19_02804740.las
|    |        19_02804742.las
|    |        19_02804743.las
|    |        19_02804744.las
|    |        19_02804746.las
|    |        19_02804748.las
|    |        19_02804749.las
|    |        19_02804750.las
|    |        19_02804752.las
|    |        19_02804754.las
|    |        19_02804755.las
|    |        19_02804756.las
|    |        19_02804758.las
|    |        19_02804760.las
|    |        19_02804761.las
|    |        19_02804762.las
|    |        19_02804764.las
|    |        19_02804766.las
|    |        19_02804767.las
|    |        19_02804768.las
|    |        19_02804770.las
|    |        19_02804772.las
|    |        19_02804773.las
|    |        19_02804774.las
|    |        19_02804776.las
|    |        19_02804778.las
|    |        19_02804779.las
|    |        19_02804780.las
|    |        19_02804800.las
|    |        19_02804802.las
|    |        19_02804803.las
|    |        19_02804804.las
|    |        19_02804806.las
|    |        19_02804808.las
|    |        19_02804809.las
|    |        19_02804810.las
|    |        19_02804812.las
|    |        19_02804814.las
|    |        19_02824740.las
|    |        19_02824742.las
|    |        19_02824743.las
```

```
|    |         19_02824744.las
|    |         19_02824746.las
|    |         19_02824748.las
|    |         19_02824749.las
|    |         19_02824750.las
|    |         19_02824752.las
|    |         19_02824754.las
|    |         19_02824755.las
|    |         19_02824756.las
|    |         19_02824758.las
|    |         19_02824760.las
|    |         19_02824761.las
|    |         19_02824762.las
|    |         19_02824764.las
|    |         19_02824766.las
|    |         19_02824767.las
|    |         19_02824768.las
|    |         19_02824770.las
|    |         19_02824772.las
|    |         19_02824773.las
|    |         19_02824774.las
|    |         19_02824776.las
|    |         19_02824778.las
|    |         19_02824779.las
|    |         19_02824780.las
|    |         19_02824782.las
|    |         19_02824784.las
|    |         19_02824798.las
|    |         19_02824800.las
|    |         19_02824802.las
|    |         19_02824803.las
|    |         19_02824804.las
|    |         19_02824806.las
|    |         19_02824808.las
|    |         19_02824809.las
|    |         19_02824810.las
|    |         19_02824812.las
|    |         19_02824814.las
|    |         19_02844737.las
|    |         19_02844738.las
|    |         19_02844740.las
|    |         19_02844742.las
|    |         19_02844743.las
|    |         19_02844744.las
|    |         19_02844746.las
|    |         19_02844748.las
|    |         19_02844749.las
|    |         19_02844750.las
|    |         19_02844752.las
|    |         19_02844754.las
|    |         19_02844755.las
|    |         19_02844756.las
|    |         19_02844758.las
|    |         19_02844760.las
```

```
|   |       19_02844761.las
|   |       19_02844762.las
|   |       19_02844764.las
|   |       19_02844766.las
|   |       19_02844767.las
|   |       19_02844768.las
|   |       19_02844770.las
|   |       19_02844772.las
|   |       19_02844773.las
|   |       19_02844774.las
|   |       19_02844776.las
|   |       19_02844778.las
|   |       19_02844779.las
|   |       19_02844780.las
|   |       19_02844782.las
|   |       19_02844784.las
|   |       19_02844785.las
|   |       19_02844786.las
|   |       19_02844796.las
|   |       19_02844797.las
|   |       19_02844798.las
|   |       19_02844800.las
|   |       19_02844802.las
|   |       19_02844803.las
|   |       19_02844804.las
|   |       19_02844806.las
|   |       19_02844808.las
|   |       19_02844809.las
|   |       19_02844810.las
|   |       19_02844812.las
|   |       19_02844814.las
|   |       19_02854736.las
|   |       19_02854737.las
|   |       19_02854738.las
|   |       19_02854740.las
|   |       19_02854742.las
|   |       19_02854743.las
|   |       19_02854744.las
|   |       19_02854746.las
|   |       19_02854748.las
|   |       19_02854749.las
|   |       19_02854750.las
|   |       19_02854752.las
|   |       19_02854754.las
|   |       19_02854755.las
|   |       19_02854756.las
|   |       19_02854758.las
|   |       19_02854760.las
|   |       19_02854761.las
|   |       19_02854762.las
|   |       19_02854764.las
|   |       19_02854766.las
|   |       19_02854767.las
|   |       19_02854768.las
```

```
|    |         19_02854770.las
|    |         19_02854772.las
|    |         19_02854773.las
|    |         19_02854774.las
|    |         19_02854776.las
|    |         19_02854778.las
|    |         19_02854779.las
|    |         19_02854780.las
|    |         19_02854782.las
|    |         19_02854784.las
|    |         19_02854785.las
|    |         19_02854786.las
|    |         19_02854788.las
|    |         19_02854796.las
|    |         19_02854797.las
|    |         19_02854798.las
|    |         19_02854800.las
|    |         19_02854802.las
|    |         19_02854803.las
|    |         19_02854804.las
|    |         19_02854806.las
|    |         19_02854808.las
|    |         19_02854809.las
|    |         19_02854810.las
|    |         19_02854812.las
|    |         19_02864736.las
|    |         19_02864737.las
|    |         19_02864738.las
|    |         19_02864740.las
|    |         19_02864742.las
|    |         19_02864743.las
|    |         19_02864744.las
|    |         19_02864746.las
|    |         19_02864748.las
|    |         19_02864749.las
|    |         19_02864750.las
|    |         19_02864752.las
|    |         19_02864754.las
|    |         19_02864755.las
|    |         19_02864756.las
|    |         19_02864758.las
|    |         19_02864760.las
|    |         19_02864761.las
|    |         19_02864762.las
|    |         19_02864764.las
|    |         19_02864766.las
|    |         19_02864767.las
|    |         19_02864768.las
|    |         19_02864770.las
|    |         19_02864772.las
|    |         19_02864773.las
|    |         19_02864774.las
|    |         19_02864776.las
|    |         19_02864778.las
```

```
|    |        19_02864779.las
|    |        19_02864780.las
|    |        19_02864782.las
|    |        19_02864784.las
|    |        19_02864785.las
|    |        19_02864786.las
|    |        19_02864788.las
|    |        19_02864790.las
|    |        19_02864796.las
|    |        19_02864797.las
|    |        19_02864798.las
|    |        19_02864800.las
|    |        19_02864802.las
|    |        19_02864803.las
|    |        19_02864804.las
|    |        19_02864806.las
|    |        19_02864808.las
|    |        19_02864809.las
|    |        19_02864810.las
|    |        19_02864812.las
|    |        19_02884710.las
|    |        19_02884712.las
|    |        19_02884713.las
|    |        19_02884719.las
|    |        19_02884736.las
|    |        19_02884737.las
|    |        19_02884738.las
|    |        19_02884740.las
|    |        19_02884742.las
|    |        19_02884743.las
|    |        19_02884744.las
|    |        19_02884746.las
|    |        19_02884748.las
|    |        19_02884749.las
|    |        19_02884750.las
|    |        19_02884752.las
|    |        19_02884754.las
|    |        19_02884755.las
|    |        19_02884756.las
|    |        19_02884758.las
|    |        19_02884760.las
|    |        19_02884761.las
|    |        19_02884762.las
|    |        19_02884764.las
|    |        19_02884766.las
|    |        19_02884767.las
|    |        19_02884768.las
|    |        19_02884770.las
|    |        19_02884772.las
|    |        19_02884773.las
|    |        19_02884774.las
|    |        19_02884776.las
|    |        19_02884778.las
|    |        19_02884779.las
```

```
|    |        19_02884780.las
|    |        19_02884782.las
|    |        19_02884784.las
|    |        19_02884785.las
|    |        19_02884786.las
|    |        19_02884788.las
|    |        19_02884790.las
|    |        19_02884791.las
|    |        19_02884792.las
|    |        19_02884794.las
|    |        19_02884796.las
|    |        19_02884797.las
|    |        19_02884798.las
|    |        19_02884800.las
|    |        19_02884802.las
|    |        19_02884803.las
|    |        19_02884804.las
|    |        19_02884806.las
|    |        19_02884808.las
|    |        19_02884809.las
|    |        19_02884810.las
|    |        19_02904704.las
|    |        19_02904706.las
|    |        19_02904707.las
|    |        19_02904708.las
|    |        19_02904710.las
|    |        19_02904712.las
|    |        19_02904713.las
|    |        19_02904714.las
|    |        19_02904716.las
|    |        19_02904718.las
|    |        19_02904719.las
|    |        19_02904720.las
|    |        19_02904722.las
|    |        19_02904736.las
|    |        19_02904737.las
|    |        19_02904738.las
|    |        19_02904740.las
|    |        19_02904742.las
|    |        19_02904743.las
|    |        19_02904744.las
|    |        19_02904746.las
|    |        19_02904748.las
|    |        19_02904749.las
|    |        19_02904750.las
|    |        19_02904752.las
|    |        19_02904754.las
|    |        19_02904755.las
|    |        19_02904756.las
|    |        19_02904758.las
|    |        19_02904760.las
|    |        19_02904761.las
|    |        19_02904762.las
|    |        19_02904764.las
```

```
|    |       19_02904766.las
|    |       19_02904767.las
|    |       19_02904768.las
|    |       19_02904770.las
|    |       19_02904772.las
|    |       19_02904773.las
|    |       19_02904774.las
|    |       19_02904776.las
|    |       19_02904778.las
|    |       19_02904779.las
|    |       19_02904780.las
|    |       19_02904782.las
|    |       19_02904784.las
|    |       19_02904785.las
|    |       19_02904786.las
|    |       19_02904788.las
|    |       19_02904790.las
|    |       19_02904791.las
|    |       19_02904792.las
|    |       19_02904794.las
|    |       19_02904796.las
|    |       19_02904797.las
|    |       19_02904798.las
|    |       19_02904800.las
|    |       19_02904802.las
|    |       19_02904803.las
|    |       19_02904804.las
|    |       19_02904806.las
|    |       19_02904808.las
|    |       19_02904809.las
|    |       19_02914704.las
|    |       19_02914706.las
|    |       19_02914707.las
|    |       19_02914708.las
|    |       19_02914710.las
|    |       19_02914712.las
|    |       19_02914713.las
|    |       19_02914714.las
|    |       19_02914716.las
|    |       19_02914718.las
|    |       19_02914719.las
|    |       19_02914720.las
|    |       19_02914722.las
|    |       19_02914728.las
|    |       19_02914730.las
|    |       19_02914731.las
|    |       19_02914736.las
|    |       19_02914737.las
|    |       19_02914738.las
|    |       19_02914740.las
|    |       19_02914742.las
|    |       19_02914743.las
|    |       19_02914744.las
|    |       19_02914746.las
```

```
|    |        19_02914748.las
|    |        19_02914749.las
|    |        19_02914750.las
|    |        19_02914752.las
|    |        19_02914754.las
|    |        19_02914755.las
|    |        19_02914756.las
|    |        19_02914758.las
|    |        19_02914760.las
|    |        19_02914761.las
|    |        19_02914762.las
|    |        19_02914764.las
|    |        19_02914766.las
|    |        19_02914767.las
|    |        19_02914768.las
|    |        19_02914770.las
|    |        19_02914772.las
|    |        19_02914773.las
|    |        19_02914774.las
|    |        19_02914776.las
|    |        19_02914778.las
|    |        19_02914779.las
|    |        19_02914780.las
|    |        19_02914782.las
|    |        19_02914784.las
|    |        19_02914785.las
|    |        19_02914786.las
|    |        19_02914788.las
|    |        19_02914790.las
|    |        19_02914791.las
|    |        19_02914792.las
|    |        19_02914794.las
|    |        19_02914796.las
|    |        19_02914797.las
|    |        19_02914798.las
|    |        19_02914800.las
|    |        19_02914802.las
|    |        19_02914803.las
|    |        19_02914804.las
|    |        19_02914806.las
|    |        19_02914808.las
|    |        19_02914809.las
|    |        19_02924706.las
|    |        19_02924707.las
|    |        19_02924708.las
|    |        19_02924710.las
|    |        19_02924712.las
|    |        19_02924713.las
|    |        19_02924714.las
|    |        19_02924716.las
|    |        19_02924718.las
|    |        19_02924719.las
|    |        19_02924720.las
|    |        19_02924722.las
```

```
|    |        19_02924724.las
|    |        19_02924725.las
|    |        19_02924726.las
|    |        19_02924728.las
|    |        19_02924730.las
|    |        19_02924731.las
|    |        19_02924732.las
|    |        19_02924737.las
|    |        19_02924738.las
|    |        19_02924740.las
|    |        19_02924742.las
|    |        19_02924743.las
|    |        19_02924744.las
|    |        19_02924746.las
|    |        19_02924748.las
|    |        19_02924749.las
|    |        19_02924750.las
|    |        19_02924752.las
|    |        19_02924754.las
|    |        19_02924755.las
|    |        19_02924756.las
|    |        19_02924758.las
|    |        19_02924760.las
|    |        19_02924761.las
|    |        19_02924762.las
|    |        19_02924764.las
|    |        19_02924766.las
|    |        19_02924767.las
|    |        19_02924768.las
|    |        19_02924770.las
|    |        19_02924772.las
|    |        19_02924773.las
|    |        19_02924774.las
|    |        19_02924776.las
|    |        19_02924778.las
|    |        19_02924779.las
|    |        19_02924780.las
|    |        19_02924782.las
|    |        19_02924784.las
|    |        19_02924785.las
|    |        19_02924786.las
|    |        19_02924788.las
|    |        19_02924790.las
|    |        19_02924791.las
|    |        19_02924792.las
|    |        19_02924794.las
|    |        19_02924796.las
|    |        19_02924797.las
|    |        19_02924798.las
|    |        19_02924800.las
|    |        19_02924802.las
|    |        19_02924803.las
|    |        19_02924804.las
|    |        19_02924806.las
```

```
|   |       19_02924808.las
|   |       19_02944708.las
|   |       19_02944710.las
|   |       19_02944712.las
|   |       19_02944713.las
|   |       19_02944714.las
|   |       19_02944716.las
|   |       19_02944718.las
|   |       19_02944719.las
|   |       19_02944720.las
|   |       19_02944722.las
|   |       19_02944724.las
|   |       19_02944725.las
|   |       19_02944726.las
|   |       19_02944728.las
|   |       19_02944730.las
|   |       19_02944731.las
|   |       19_02944732.las
|   |       19_02944734.las
|   |       19_02944736.las
|   |       19_02944738.las
|   |       19_02944740.las
|   |       19_02944742.las
|   |       19_02944743.las
|   |       19_02944744.las
|   |       19_02944746.las
|   |       19_02944748.las
|   |       19_02944749.las
|   |       19_02944750.las
|   |       19_02944752.las
|   |       19_02944754.las
|   |       19_02944755.las
|   |       19_02944756.las
|   |       19_02944758.las
|   |       19_02944760.las
|   |       19_02944761.las
|   |       19_02944762.las
|   |       19_02944764.las
|   |       19_02944766.las
|   |       19_02944767.las
|   |       19_02944768.las
|   |       19_02944770.las
|   |       19_02944772.las
|   |       19_02944773.las
|   |       19_02944774.las
|   |       19_02944776.las
|   |       19_02944778.las
|   |       19_02944779.las
|   |       19_02944780.las
|   |       19_02944782.las
|   |       19_02944784.las
|   |       19_02944785.las
|   |       19_02944786.las
|   |       19_02944788.las
```

```
|    |        19_02944790.las
|    |        19_02944791.las
|    |        19_02944792.las
|    |        19_02944794.las
|    |        19_02944796.las
|    |        19_02944797.las
|    |        19_02944798.las
|    |        19_02944800.las
|    |        19_02944802.las
|    |        19_02944803.las
|    |        19_02944804.las
|    |        19_02944806.las
|    |        19_02944808.las
|    |        19_02944809.las
|    |        19_02964710.las
|    |        19_02964712.las
|    |        19_02964713.las
|    |        19_02964714.las
|    |        19_02964716.las
|    |        19_02964718.las
|    |        19_02964719.las
|    |        19_02964720.las
|    |        19_02964722.las
|    |        19_02964724.las
|    |        19_02964725.las
|    |        19_02964726.las
|    |        19_02964728.las
|    |        19_02964730.las
|    |        19_02964731.las
|    |        19_02964732.las
|    |        19_02964734.las
|    |        19_02964736.las
|    |        19_02964738.las
|    |        19_02964740.las
|    |        19_02964742.las
|    |        19_02964743.las
|    |        19_02964744.las
|    |        19_02964746.las
|    |        19_02964748.las
|    |        19_02964749.las
|    |        19_02964750.las
|    |        19_02964752.las
|    |        19_02964754.las
|    |        19_02964755.las
|    |        19_02964756.las
|    |        19_02964758.las
|    |        19_02964760.las
|    |        19_02964761.las
|    |        19_02964762.las
|    |        19_02964764.las
|    |        19_02964766.las
|    |        19_02964767.las
|    |        19_02964768.las
|    |        19_02964770.las
```

```
|    |        19_02964772.las
|    |        19_02964773.las
|    |        19_02964774.las
|    |        19_02964776.las
|    |        19_02964778.las
|    |        19_02964779.las
|    |        19_02964780.las
|    |        19_02964782.las
|    |        19_02964784.las
|    |        19_02964785.las
|    |        19_02964786.las
|    |        19_02964788.las
|    |        19_02964790.las
|    |        19_02964791.las
|    |        19_02964792.las
|    |        19_02964794.las
|    |        19_02964796.las
|    |        19_02964797.las
|    |        19_02964798.las
|    |        19_02964800.las
|    |        19_02964802.las
|    |        19_02964803.las
|    |        19_02964804.las
|    |        19_02964806.las
|    |        19_02964808.las
|    |        19_02964809.las
|    |        19_02974712.las
|    |        19_02974713.las
|    |        19_02974714.las
|    |        19_02974716.las
|    |        19_02974718.las
|    |        19_02974719.las
|    |        19_02974720.las
|    |        19_02974722.las
|    |        19_02974724.las
|    |        19_02974725.las
|    |        19_02974726.las
|    |        19_02974728.las
|    |        19_02974730.las
|    |        19_02974731.las
|    |        19_02974732.las
|    |        19_02974734.las
|    |        19_02974736.las
|    |        19_02974737.las
|    |        19_02974738.las
|    |        19_02974740.las
|    |        19_02974742.las
|    |        19_02974743.las
|    |        19_02974744.las
|    |        19_02974746.las
|    |        19_02974748.las
|    |        19_02974749.las
|    |        19_02974750.las
|    |        19_02974752.las
```

```
|    |        19_02974754.las
|    |        19_02974755.las
|    |        19_02974756.las
|    |        19_02974758.las
|    |        19_02974760.las
|    |        19_02974761.las
|    |        19_02974762.las
|    |        19_02974764.las
|    |        19_02974766.las
|    |        19_02974767.las
|    |        19_02974768.las
|    |        19_02974770.las
|    |        19_02974772.las
|    |        19_02974773.las
|    |        19_02974774.las
|    |        19_02974776.las
|    |        19_02974778.las
|    |        19_02974779.las
|    |        19_02974780.las
|    |        19_02974782.las
|    |        19_02974784.las
|    |        19_02974785.las
|    |        19_02974786.las
|    |        19_02974788.las
|    |        19_02974790.las
|    |        19_02974791.las
|    |        19_02974792.las
|    |        19_02974794.las
|    |        19_02974796.las
|    |        19_02974797.las
|    |        19_02974798.las
|    |        19_02974800.las
|    |        19_02974802.las
|    |        19_02974803.las
|    |        19_02974804.las
|    |        19_02974806.las
|    |        19_02974808.las
|    |        19_02974809.las
|    |        19_02984714.las
|    |        19_02984716.las
|    |        19_02984718.las
|    |        19_02984719.las
|    |        19_02984720.las
|    |        19_02984722.las
|    |        19_02984724.las
|    |        19_02984725.las
|    |        19_02984726.las
|    |        19_02984728.las
|    |        19_02984730.las
|    |        19_02984731.las
|    |        19_02984732.las
|    |        19_02984734.las
|    |        19_02984736.las
|    |        19_02984737.las
```

```
|    |        19_02984738.las
|    |        19_02984740.las
|    |        19_02984742.las
|    |        19_02984743.las
|    |        19_02984744.las
|    |        19_02984746.las
|    |        19_02984748.las
|    |        19_02984749.las
|    |        19_02984750.las
|    |        19_02984752.las
|    |        19_02984754.las
|    |        19_02984755.las
|    |        19_02984756.las
|    |        19_02984758.las
|    |        19_02984760.las
|    |        19_02984761.las
|    |        19_02984762.las
|    |        19_02984764.las
|    |        19_02984766.las
|    |        19_02984767.las
|    |        19_02984768.las
|    |        19_02984770.las
|    |        19_02984772.las
|    |        19_02984773.las
|    |        19_02984774.las
|    |        19_02984776.las
|    |        19_02984778.las
|    |        19_02984779.las
|    |        19_02984780.las
|    |        19_02984782.las
|    |        19_02984784.las
|    |        19_02984785.las
|    |        19_02984786.las
|    |        19_02984788.las
|    |        19_02984790.las
|    |        19_02984791.las
|    |        19_02984792.las
|    |        19_02984794.las
|    |        19_02984796.las
|    |        19_02984797.las
|    |        19_02984798.las
|    |        19_02984800.las
|    |        19_02984802.las
|    |        19_02984803.las
|    |        19_02984804.las
|    |        19_02984806.las
|    |        19_02984808.las
|    |        19_02984809.las
|    |        19_03004714.las
|    |        19_03004716.las
|    |        19_03004718.las
|    |        19_03004719.las
|    |        19_03004720.las
|    |        19_03004722.las
```

```
|    |        19_03004724.las
|    |        19_03004725.las
|    |        19_03004726.las
|    |        19_03004728.las
|    |        19_03004730.las
|    |        19_03004731.las
|    |        19_03004732.las
|    |        19_03004734.las
|    |        19_03004736.las
|    |        19_03004737.las
|    |        19_03004738.las
|    |        19_03004740.las
|    |        19_03004742.las
|    |        19_03004743.las
|    |        19_03004744.las
|    |        19_03004746.las
|    |        19_03004748.las
|    |        19_03004749.las
|    |        19_03004750.las
|    |        19_03004752.las
|    |        19_03004754.las
|    |        19_03004755.las
|    |        19_03004756.las
|    |        19_03004758.las
|    |        19_03004760.las
|    |        19_03004761.las
|    |        19_03004762.las
|    |        19_03004764.las
|    |        19_03004766.las
|    |        19_03004767.las
|    |        19_03004768.las
|    |        19_03004770.las
|    |        19_03004772.las
|    |        19_03004773.las
|    |        19_03004774.las
|    |        19_03004776.las
|    |        19_03004778.las
|    |        19_03004779.las
|    |        19_03004780.las
|    |        19_03004782.las
|    |        19_03004784.las
|    |        19_03004785.las
|    |        19_03004786.las
|    |        19_03004788.las
|    |        19_03004790.las
|    |        19_03004791.las
|    |        19_03004792.las
|    |        19_03004794.las
|    |        19_03004796.las
|    |        19_03004797.las
|    |        19_03004798.las
|    |        19_03004800.las
|    |        19_03004802.las
|    |        19_03004803.las
```

```
|   |       19_03004804.las
|   |       19_03004806.las
|   |       19_03004808.las
|   |       19_03004809.las
|   |       19_03004810.las
|   |       19_03004812.las
|   |       19_03024714.las
|   |       19_03024716.las
|   |       19_03024718.las
|   |       19_03024719.las
|   |       19_03024720.las
|   |       19_03024722.las
|   |       19_03024724.las
|   |       19_03024725.las
|   |       19_03024726.las
|   |       19_03024728.las
|   |       19_03024730.las
|   |       19_03024731.las
|   |       19_03024732.las
|   |       19_03024734.las
|   |       19_03024736.las
|   |       19_03024737.las
|   |       19_03024738.las
|   |       19_03024740.las
|   |       19_03024742.las
|   |       19_03024743.las
|   |       19_03024744.las
|   |       19_03024746.las
|   |       19_03024748.las
|   |       19_03024749.las
|   |       19_03024750.las
|   |       19_03024752.las
|   |       19_03024754.las
|   |       19_03024755.las
|   |       19_03024756.las
|   |       19_03024758.las
|   |       19_03024760.las
|   |       19_03024761.las
|   |       19_03024762.las
|   |       19_03024764.las
|   |       19_03024766.las
|   |       19_03024767.las
|   |       19_03024768.las
|   |       19_03024770.las
|   |       19_03024772.las
|   |       19_03024773.las
|   |       19_03024774.las
|   |       19_03024776.las
|   |       19_03024778.las
|   |       19_03024779.las
|   |       19_03024780.las
|   |       19_03024782.las
|   |       19_03024784.las
|   |       19_03024785.las
```

```
|    |        19_03024786.las
|    |        19_03024788.las
|    |        19_03024790.las
|    |        19_03024791.las
|    |        19_03024792.las
|    |        19_03024794.las
|    |        19_03024796.las
|    |        19_03024797.las
|    |        19_03024798.las
|    |        19_03024800.las
|    |        19_03024802.las
|    |        19_03024803.las
|    |        19_03024804.las
|    |        19_03024806.las
|    |        19_03024808.las
|    |        19_03024809.las
|    |        19_03024810.las
|    |        19_03024812.las
|    |        19_03034718.las
|    |        19_03034719.las
|    |        19_03034720.las
|    |        19_03034722.las
|    |        19_03034724.las
|    |        19_03034725.las
|    |        19_03034726.las
|    |        19_03034728.las
|    |        19_03034730.las
|    |        19_03034731.las
|    |        19_03034732.las
|    |        19_03034734.las
|    |        19_03034736.las
|    |        19_03034737.las
|    |        19_03034738.las
|    |        19_03034740.las
|    |        19_03034742.las
|    |        19_03034743.las
|    |        19_03034744.las
|    |        19_03034746.las
|    |        19_03034748.las
|    |        19_03034749.las
|    |        19_03034750.las
|    |        19_03034752.las
|    |        19_03034754.las
|    |        19_03034755.las
|    |        19_03034756.las
|    |        19_03034758.las
|    |        19_03034760.las
|    |        19_03034761.las
|    |        19_03034762.las
|    |        19_03034764.las
|    |        19_03034766.las
|    |        19_03034767.las
|    |        19_03034768.las
|    |        19_03034770.las
```

```
|    |        19_03034772.las
|    |        19_03034773.las
|    |        19_03034774.las
|    |        19_03034776.las
|    |        19_03034778.las
|    |        19_03034779.las
|    |        19_03034780.las
|    |        19_03034782.las
|    |        19_03034784.las
|    |        19_03034785.las
|    |        19_03034786.las
|    |        19_03034788.las
|    |        19_03034790.las
|    |        19_03034791.las
|    |        19_03034792.las
|    |        19_03034794.las
|    |        19_03034796.las
|    |        19_03034797.las
|    |        19_03034798.las
|    |        19_03034800.las
|    |        19_03034802.las
|    |        19_03034803.las
|    |        19_03034804.las
|    |        19_03034806.las
|    |        19_03034808.las
|    |        19_03034809.las
|    |        19_03034810.las
|    |        19_03034812.las
|    |        19_03044719.las
|    |        19_03044720.las
|    |        19_03044722.las
|    |        19_03044724.las
|    |        19_03044725.las
|    |        19_03044726.las
|    |        19_03044728.las
|    |        19_03044730.las
|    |        19_03044731.las
|    |        19_03044732.las
|    |        19_03044734.las
|    |        19_03044736.las
|    |        19_03044737.las
|    |        19_03044738.las
|    |        19_03044740.las
|    |        19_03044742.las
|    |        19_03044743.las
|    |        19_03044744.las
|    |        19_03044746.las
|    |        19_03044748.las
|    |        19_03044749.las
|    |        19_03044750.las
|    |        19_03044752.las
|    |        19_03044754.las
|    |        19_03044755.las
|    |        19_03044756.las
```

```
|    |        19_03044758.las
|    |        19_03044760.las
|    |        19_03044761.las
|    |        19_03044762.las
|    |        19_03044764.las
|    |        19_03044766.las
|    |        19_03044767.las
|    |        19_03044768.las
|    |        19_03044770.las
|    |        19_03044772.las
|    |        19_03044773.las
|    |        19_03044774.las
|    |        19_03044776.las
|    |        19_03044778.las
|    |        19_03044779.las
|    |        19_03044780.las
|    |        19_03044782.las
|    |        19_03044784.las
|    |        19_03044785.las
|    |        19_03044786.las
|    |        19_03044788.las
|    |        19_03044790.las
|    |        19_03044791.las
|    |        19_03044792.las
|    |        19_03044794.las
|    |        19_03044796.las
|    |        19_03044797.las
|    |        19_03044798.las
|    |        19_03044800.las
|    |        19_03044802.las
|    |        19_03044803.las
|    |        19_03044804.las
|    |        19_03044806.las
|    |        19_03044808.las
|    |        19_03044809.las
|    |        19_03044810.las
|    |        19_03044812.las
|    |        19_03064719.las
|    |        19_03064720.las
|    |        19_03064722.las
|    |        19_03064725.las
|    |        19_03064726.las
|    |        19_03064730.las
|    |        19_03064731.las
|    |        19_03064732.las
|    |        19_03064734.las
|    |        19_03064736.las
|    |        19_03064737.las
|    |        19_03064738.las
|    |        19_03064740.las
|    |        19_03064742.las
|    |        19_03064754.las
|    |        19_03064755.las
|    |        19_03064756.las
```

```
|    |         19_03064758.las
|    |         19_03064768.las
|    |         19_03064770.las
|    |         19_03064772.las
|    |         19_03064773.las
|    |         19_03064774.las
|    |         19_03064776.las
|    |         19_03064778.las
|    |         19_03064779.las
|    |         19_03064780.las
|    |         19_03064782.las
|    |         19_03064784.las
|    |         19_03064785.las
|    |         19_03064786.las
|    |         19_03064788.las
|    |         19_03064790.las
|    |         19_03064791.las
|    |         19_03064792.las
|    |         19_03064794.las
|    |         19_03064796.las
|    |         19_03064797.las
|    |         19_03064798.las
|    |         19_03064800.las
|    |         19_03064802.las
|    |         19_03064803.las
|    |         19_03064804.las
|    |         19_03064806.las
|    |         19_03064808.las
|    |         19_03064809.las
|    |         19_03064810.las
|    |         19_03064812.las
|    |         19_03064814.las
|    |         19_03064815.las
|    |         19_03064816.las
|    |         19_03064818.las
|    |         19_03084702.las
|    |         19_03084704.las
|    |         19_03084719.las
|    |         19_03084720.las
|    |         19_03084730.las
|    |         19_03084731.las
|    |         19_03084732.las
|    |         19_03084734.las
|    |         19_03084736.las
|    |         19_03084737.las
|    |         19_03084738.las
|    |         19_03084772.las
|    |         19_03084773.las
|    |         19_03084774.las
|    |         19_03084776.las
|    |         19_03084778.las
|    |         19_03084779.las
|    |         19_03084780.las
|    |         19_03084782.las
```

```
|    |        19_03084784.las
|    |        19_03084785.las
|    |        19_03084786.las
|    |        19_03084788.las
|    |        19_03084790.las
|    |        19_03084791.las
|    |        19_03084792.las
|    |        19_03084794.las
|    |        19_03084796.las
|    |        19_03084797.las
|    |        19_03084798.las
|    |        19_03084800.las
|    |        19_03084802.las
|    |        19_03084803.las
|    |        19_03084804.las
|    |        19_03084806.las
|    |        19_03084808.las
|    |        19_03084809.las
|    |        19_03084810.las
|    |        19_03084812.las
|    |        19_03084814.las
|    |        19_03084815.las
|    |        19_03084816.las
|    |        19_03084818.las
|    |        19_03084820.las
|    |        19_03094700.las
|    |        19_03094701.las
|    |        19_03094702.las
|    |        19_03094704.las
|    |        19_03094706.las
|    |        19_03094730.las
|    |        19_03094731.las
|    |        19_03094732.las
|    |        19_03094734.las
|    |        19_03094736.las
|    |        19_03094737.las
|    |        19_03094776.las
|    |        19_03094778.las
|    |        19_03094779.las
|    |        19_03094780.las
|    |        19_03094782.las
|    |        19_03094784.las
|    |        19_03094785.las
|    |        19_03094786.las
|    |        19_03094788.las
|    |        19_03094790.las
|    |        19_03094791.las
|    |        19_03094792.las
|    |        19_03094794.las
|    |        19_03094796.las
|    |        19_03094797.las
|    |        19_03094798.las
|    |        19_03094800.las
|    |        19_03094802.las
```

```
|    |        19_03094803.las
|    |        19_03094804.las
|    |        19_03094806.las
|    |        19_03094808.las
|    |        19_03094809.las
|    |        19_03094810.las
|    |        19_03094812.las
|    |        19_03094814.las
|    |        19_03094815.las
|    |        19_03094816.las
|    |        19_03094818.las
|    |        19_03094820.las
|    |        19_03104700.las
|    |        19_03104701.las
|    |        19_03104702.las
|    |        19_03104704.las
|    |        19_03104706.las
|    |        19_03104707.las
|    |        19_03104730.las
|    |        19_03104731.las
|    |        19_03104732.las
|    |        19_03104734.las
|    |        19_03104736.las
|    |        19_03104737.las
|    |        19_03104778.las
|    |        19_03104779.las
|    |        19_03104780.las
|    |        19_03104782.las
|    |        19_03104784.las
|    |        19_03104785.las
|    |        19_03104786.las
|    |        19_03104788.las
|    |        19_03104790.las
|    |        19_03104791.las
|    |        19_03104792.las
|    |        19_03104794.las
|    |        19_03104796.las
|    |        19_03104797.las
|    |        19_03104798.las
|    |        19_03104800.las
|    |        19_03104802.las
|    |        19_03104803.las
|    |        19_03104804.las
|    |        19_03104806.las
|    |        19_03104808.las
|    |        19_03104809.las
|    |        19_03104810.las
|    |        19_03104812.las
|    |        19_03104814.las
|    |        19_03104815.las
|    |        19_03104816.las
|    |        19_03104818.las
|    |        19_03104820.las
|    |        19_03124701.las
```

```
|   |       19_03124702.las
|   |       19_03124704.las
|   |       19_03124706.las
|   |       19_03124707.las
|   |       19_03124708.las
|   |       19_03124710.las
|   |       19_03124730.las
|   |       19_03124731.las
|   |       19_03124732.las
|   |       19_03124734.las
|   |       19_03124736.las
|   |       19_03124737.las
|   |       19_03124780.las
|   |       19_03124782.las
|   |       19_03124784.las
|   |       19_03124785.las
|   |       19_03124786.las
|   |       19_03124788.las
|   |       19_03124790.las
|   |       19_03124791.las
|   |       19_03124792.las
|   |       19_03124794.las
|   |       19_03124796.las
|   |       19_03124797.las
|   |       19_03124798.las
|   |       19_03124800.las
|   |       19_03124802.las
|   |       19_03124803.las
|   |       19_03124804.las
|   |       19_03124806.las
|   |       19_03124808.las
|   |       19_03124809.las
|   |       19_03124810.las
|   |       19_03124812.las
|   |       19_03124814.las
|   |       19_03124815.las
|   |       19_03124816.las
|   |       19_03124818.las
|   |       19_03124820.las
|   |       19_03144700.las
|   |       19_03144701.las
|   |       19_03144702.las
|   |       19_03144704.las
|   |       19_03144706.las
|   |       19_03144707.las
|   |       19_03144708.las
|   |       19_03144710.las
|   |       19_03144731.las
|   |       19_03144732.las
|   |       19_03144734.las
|   |       19_03144736.las
|   |       19_03144784.las
|   |       19_03144785.las
|   |       19_03144786.las
```

```
|    |        19_03144788.las
|    |        19_03144790.las
|    |        19_03144791.las
|    |        19_03144792.las
|    |        19_03144794.las
|    |        19_03144796.las
|    |        19_03144797.las
|    |        19_03144798.las
|    |        19_03144800.las
|    |        19_03144802.las
|    |        19_03144803.las
|    |        19_03144804.las
|    |        19_03144806.las
|    |        19_03144808.las
|    |        19_03144809.las
|    |        19_03144810.las
|    |        19_03144812.las
|    |        19_03144814.las
|    |        19_03144815.las
|    |        19_03144816.las
|    |        19_03144818.las
|    |        19_03144820.las
|    |        19_03154700.las
|    |        19_03154701.las
|    |        19_03154702.las
|    |        19_03154704.las
|    |        19_03154706.las
|    |        19_03154707.las
|    |        19_03154708.las
|    |        19_03154710.las
|    |        19_03154732.las
|    |        19_03154734.las
|    |        19_03154736.las
|    |        19_03154786.las
|    |        19_03154788.las
|    |        19_03154790.las
|    |        19_03154791.las
|    |        19_03154792.las
|    |        19_03154794.las
|    |        19_03154796.las
|    |        19_03154797.las
|    |        19_03154798.las
|    |        19_03154800.las
|    |        19_03154802.las
|    |        19_03154803.las
|    |        19_03154804.las
|    |        19_03154806.las
|    |        19_03154808.las
|    |        19_03154809.las
|    |        19_03154810.las
|    |        19_03154812.las
|    |        19_03154814.las
|    |        19_03154815.las
|    |        19_03154816.las
```

```
|    |        19_03154818.las
|    |        19_03164700.las
|    |        19_03164701.las
|    |        19_03164702.las
|    |        19_03164704.las
|    |        19_03164706.las
|    |        19_03164707.las
|    |        19_03164708.las
|    |        19_03164791.las
|    |        19_03164792.las
|    |        19_03164794.las
|    |        19_03164796.las
|    |        19_03164797.las
|    |        19_03164798.las
|    |        19_03164800.las
|    |        19_03164802.las
|    |        19_03164803.las
|    |        19_03164804.las
|    |        19_03164806.las
|    |        19_03164808.las
|    |        19_03164809.las
|    |        19_03164810.las
|    |        19_03164812.las
|    |        19_03164814.las
|    |        19_03164815.las
|    |        19_03184701.las
|    |        19_03184702.las
|    |        19_03184704.las
|    |        19_03184706.las
|    |        19_03184707.las
|    |        19_03184708.las
|    |        19_03184710.las
|    |        19_03184792.las
|    |        19_03184794.las
|    |        19_03184796.las
|    |        19_03184797.las
|    |        19_03184798.las
|    |        19_03184800.las
|    |        19_03184802.las
|    |        19_03184803.las
|    |        19_03184804.las
|    |        19_03184806.las
|    |        19_03184808.las
|    |        19_03204702.las
|    |        19_03204704.las
|    |        19_03204706.las
|    |        19_03204707.las
|    |        19_03204708.las
|    |        19_03204794.las
|    |        19_03204796.las
|    |        19_03204797.las
|    |        19_03204798.las
|    |        19_03204800.las
|    |        19_03204802.las
```

```
|    |        19_03204803.las
|    |        19_03204804.las
|    |        19_03204806.las
|    |        19_03204808.las
|    |        19_03214792.las
|    |        19_03214794.las
|    |        19_03214796.las
|    |        19_03214797.las
|    |        19_03214798.las
|    |        19_03214800.las
|    |        19_03214802.las
|    |        19_03214803.las
|    |        19_03214804.las
|    |        19_03214806.las
|    |        19_03214808.las
|    |        19_03224792.las
|    |        19_03224794.las
|    |        19_03224796.las
|    |        19_03224797.las
|    |        19_03224798.las
|    |        19_03224800.las
|    |        19_03224802.las
|    |        19_03224803.las
|    |        19_03224804.las
|    |        19_03224806.las
|    |        19_03224808.las
|    |        19_03244794.las
|    |        19_03244796.las
|    |        19_03244797.las
|    |        19_03244798.las
|    |        19_03244800.las
|    |        19_03244802.las
|    |        19_03244803.las
|    |        19_03244804.las
|    |        19_03244806.las
|    |        19_03264796.las
|    |        19_03264797.las
|    |        19_03264798.las
|    |        19_03264800.las
|    |        19_03264802.las
|    |        19_03264803.las
|    |        19_03264804.las
|    |        19_03274797.las
|    |        19_03274798.las
|    |        19_03274800.las
|    |        19_03274802.las
|    |        19_03284798.las
|    |        19_03284800.las
|    |        Merrimack_Classified_LAS_Index.dbf
|    |        Merrimack_Classified_LAS_Index.prj
|    |        Merrimack_Classified_LAS_Index.sbn
|    |        Merrimack_Classified_LAS_Index.sbx
|    |        Merrimack_Classified_LAS_Index.shp
|    |        Merrimack_Classified_LAS_Index.shp.xml
```

```
|   |       Merrimack_Classified_LAS_Index.shx
|   |
|   +---Contours
|   +---HDEM
|   +---Raw Point Cloud Data
|   |       19_02604734.las
|   |       19_02604736.las
|   |       19_02614728.las
|   |       19_02614730.las
|   |       19_02614731.las
|   |       19_02614732.las
|   |       19_02614734.las
|   |       19_02614736.las
|   |       19_02614737.las
|   |       19_02614738.las
|   |       19_02624725.las
|   |       19_02624726.las
|   |       19_02624728.las
|   |       19_02624730.las
|   |       19_02624731.las
|   |       19_02624732.las
|   |       19_02624734.las
|   |       19_02624736.las
|   |       19_02624737.las
|   |       19_02624738.las
|   |       19_02624740.las
|   |       19_02624742.las
|   |       19_02624743.las
|   |       19_02624744.las
|   |       19_02624746.las
|   |       19_02624748.las
|   |       19_02644725.las
|   |       19_02644726.las
|   |       19_02644728.las
|   |       19_02644730.las
|   |       19_02644731.las
|   |       19_02644732.las
|   |       19_02644734.las
|   |       19_02644736.las
|   |       19_02644737.las
|   |       19_02644738.las
|   |       19_02644740.las
|   |       19_02644742.las
|   |       19_02644743.las
|   |       19_02644744.las
|   |       19_02644746.las
|   |       19_02644748.las
|   |       19_02644749.las
|   |       19_02644750.las
|   |       19_02644752.las
|   |       19_02644754.las
|   |       19_02644755.las
|   |       19_02644760.las
|   |       19_02644761.las
```

```
|    |        19_02644762.las
|    |        19_02644764.las
|    |        19_02644766.las
|    |        19_02644767.las
|    |        19_02644772.las
|    |        19_02664726.las
|    |        19_02664728.las
|    |        19_02664730.las
|    |        19_02664731.las
|    |        19_02664732.las
|    |        19_02664734.las
|    |        19_02664736.las
|    |        19_02664737.las
|    |        19_02664738.las
|    |        19_02664740.las
|    |        19_02664742.las
|    |        19_02664743.las
|    |        19_02664744.las
|    |        19_02664746.las
|    |        19_02664748.las
|    |        19_02664749.las
|    |        19_02664750.las
|    |        19_02664752.las
|    |        19_02664754.las
|    |        19_02664755.las
|    |        19_02664756.las
|    |        19_02664758.las
|    |        19_02664760.las
|    |        19_02664761.las
|    |        19_02664762.las
|    |        19_02664764.las
|    |        19_02664766.las
|    |        19_02664767.las
|    |        19_02664768.las
|    |        19_02664770.las
|    |        19_02664772.las
|    |        19_02664773.las
|    |        19_02664774.las
|    |        19_02664776.las
|    |        19_02674730.las
|    |        19_02674731.las
|    |        19_02674732.las
|    |        19_02674734.las
|    |        19_02674736.las
|    |        19_02674737.las
|    |        19_02674738.las
|    |        19_02674740.las
|    |        19_02674742.las
|    |        19_02674743.las
|    |        19_02674744.las
|    |        19_02674746.las
|    |        19_02674748.las
|    |        19_02674749.las
|    |        19_02674750.las
```

```
|    |        19_02674752.las
|    |        19_02674754.las
|    |        19_02674755.las
|    |        19_02674756.las
|    |        19_02674758.las
|    |        19_02674760.las
|    |        19_02674761.las
|    |        19_02674762.las
|    |        19_02674764.las
|    |        19_02674766.las
|    |        19_02674767.las
|    |        19_02674768.las
|    |        19_02674770.las
|    |        19_02674772.las
|    |        19_02674773.las
|    |        19_02674774.las
|    |        19_02674776.las
|    |        19_02674778.las
|    |        19_02674779.las
|    |        19_02684732.las
|    |        19_02684734.las
|    |        19_02684736.las
|    |        19_02684737.las
|    |        19_02684738.las
|    |        19_02684740.las
|    |        19_02684742.las
|    |        19_02684743.las
|    |        19_02684744.las
|    |        19_02684746.las
|    |        19_02684748.las
|    |        19_02684749.las
|    |        19_02684750.las
|    |        19_02684752.las
|    |        19_02684754.las
|    |        19_02684755.las
|    |        19_02684756.las
|    |        19_02684758.las
|    |        19_02684760.las
|    |        19_02684761.las
|    |        19_02684762.las
|    |        19_02684764.las
|    |        19_02684766.las
|    |        19_02684767.las
|    |        19_02684768.las
|    |        19_02684770.las
|    |        19_02684772.las
|    |        19_02684773.las
|    |        19_02684774.las
|    |        19_02684776.las
|    |        19_02684778.las
|    |        19_02684779.las
|    |        19_02684780.las
|    |        19_02704737.las
|    |        19_02704738.las
```

```
|    |        19_02704740.las
|    |        19_02704742.las
|    |        19_02704743.las
|    |        19_02704744.las
|    |        19_02704746.las
|    |        19_02704748.las
|    |        19_02704749.las
|    |        19_02704750.las
|    |        19_02704752.las
|    |        19_02704754.las
|    |        19_02704755.las
|    |        19_02704756.las
|    |        19_02704758.las
|    |        19_02704760.las
|    |        19_02704761.las
|    |        19_02704762.las
|    |        19_02704764.las
|    |        19_02704766.las
|    |        19_02704767.las
|    |        19_02704768.las
|    |        19_02704770.las
|    |        19_02704772.las
|    |        19_02704773.las
|    |        19_02704774.las
|    |        19_02704776.las
|    |        19_02704778.las
|    |        19_02704779.las
|    |        19_02704780.las
|    |        19_02724737.las
|    |        19_02724738.las
|    |        19_02724740.las
|    |        19_02724742.las
|    |        19_02724743.las
|    |        19_02724744.las
|    |        19_02724746.las
|    |        19_02724748.las
|    |        19_02724749.las
|    |        19_02724750.las
|    |        19_02724752.las
|    |        19_02724754.las
|    |        19_02724755.las
|    |        19_02724756.las
|    |        19_02724758.las
|    |        19_02724760.las
|    |        19_02724761.las
|    |        19_02724762.las
|    |        19_02724764.las
|    |        19_02724766.las
|    |        19_02724767.las
|    |        19_02724768.las
|    |        19_02724770.las
|    |        19_02724772.las
|    |        19_02724773.las
|    |        19_02724774.las
```

```
|    |        19_02724776.las
|    |        19_02724778.las
|    |        19_02724779.las
|    |        19_02724780.las
|    |        19_02734740.las
|    |        19_02734742.las
|    |        19_02734743.las
|    |        19_02734744.las
|    |        19_02734746.las
|    |        19_02734748.las
|    |        19_02734749.las
|    |        19_02734750.las
|    |        19_02734752.las
|    |        19_02734754.las
|    |        19_02734755.las
|    |        19_02734756.las
|    |        19_02734758.las
|    |        19_02734760.las
|    |        19_02734761.las
|    |        19_02734762.las
|    |        19_02734764.las
|    |        19_02734766.las
|    |        19_02734767.las
|    |        19_02734768.las
|    |        19_02734770.las
|    |        19_02734772.las
|    |        19_02734773.las
|    |        19_02734774.las
|    |        19_02734776.las
|    |        19_02734778.las
|    |        19_02734779.las
|    |        19_02734780.las
|    |        19_02744742.las
|    |        19_02744743.las
|    |        19_02744744.las
|    |        19_02744746.las
|    |        19_02744748.las
|    |        19_02744749.las
|    |        19_02744750.las
|    |        19_02744752.las
|    |        19_02744754.las
|    |        19_02744755.las
|    |        19_02744756.las
|    |        19_02744758.las
|    |        19_02744760.las
|    |        19_02744761.las
|    |        19_02744762.las
|    |        19_02744764.las
|    |        19_02744766.las
|    |        19_02744767.las
|    |        19_02744768.las
|    |        19_02744770.las
|    |        19_02744772.las
|    |        19_02744773.las
```

```
|    |        19_02744774.las
|    |        19_02744776.las
|    |        19_02744778.las
|    |        19_02744779.las
|    |        19_02764742.las
|    |        19_02764743.las
|    |        19_02764744.las
|    |        19_02764746.las
|    |        19_02764748.las
|    |        19_02764749.las
|    |        19_02764750.las
|    |        19_02764752.las
|    |        19_02764754.las
|    |        19_02764755.las
|    |        19_02764756.las
|    |        19_02764758.las
|    |        19_02764760.las
|    |        19_02764761.las
|    |        19_02764762.las
|    |        19_02764764.las
|    |        19_02764766.las
|    |        19_02764767.las
|    |        19_02764768.las
|    |        19_02764770.las
|    |        19_02764772.las
|    |        19_02764773.las
|    |        19_02764774.las
|    |        19_02764776.las
|    |        19_02764778.las
|    |        19_02764779.las
|    |        19_02764809.las
|    |        19_02764810.las
|    |        19_02784740.las
|    |        19_02784742.las
|    |        19_02784743.las
|    |        19_02784744.las
|    |        19_02784746.las
|    |        19_02784748.las
|    |        19_02784749.las
|    |        19_02784750.las
|    |        19_02784752.las
|    |        19_02784754.las
|    |        19_02784755.las
|    |        19_02784756.las
|    |        19_02784758.las
|    |        19_02784760.las
|    |        19_02784761.las
|    |        19_02784762.las
|    |        19_02784764.las
|    |        19_02784766.las
|    |        19_02784767.las
|    |        19_02784768.las
|    |        19_02784770.las
|    |        19_02784772.las
```

```
|    |        19_02784773.las
|    |        19_02784774.las
|    |        19_02784776.las
|    |        19_02784778.las
|    |        19_02784779.las
|    |        19_02784808.las
|    |        19_02784809.las
|    |        19_02784810.las
|    |        19_02784812.las
|    |        19_02784814.las
|    |        19_02794740.las
|    |        19_02794742.las
|    |        19_02794743.las
|    |        19_02794744.las
|    |        19_02794746.las
|    |        19_02794748.las
|    |        19_02794749.las
|    |        19_02794750.las
|    |        19_02794752.las
|    |        19_02794754.las
|    |        19_02794755.las
|    |        19_02794756.las
|    |        19_02794758.las
|    |        19_02794760.las
|    |        19_02794761.las
|    |        19_02794762.las
|    |        19_02794764.las
|    |        19_02794766.las
|    |        19_02794767.las
|    |        19_02794768.las
|    |        19_02794770.las
|    |        19_02794772.las
|    |        19_02794773.las
|    |        19_02794774.las
|    |        19_02794776.las
|    |        19_02794778.las
|    |        19_02794779.las
|    |        19_02794780.las
|    |        19_02794804.las
|    |        19_02794806.las
|    |        19_02794808.las
|    |        19_02794809.las
|    |        19_02794810.las
|    |        19_02794812.las
|    |        19_02794814.las
|    |        19_02804740.las
|    |        19_02804742.las
|    |        19_02804743.las
|    |        19_02804744.las
|    |        19_02804746.las
|    |        19_02804748.las
|    |        19_02804749.las
|    |        19_02804750.las
|    |        19_02804752.las
```

```
|    |         19_02804754.las
|    |         19_02804755.las
|    |         19_02804756.las
|    |         19_02804758.las
|    |         19_02804760.las
|    |         19_02804761.las
|    |         19_02804762.las
|    |         19_02804764.las
|    |         19_02804766.las
|    |         19_02804767.las
|    |         19_02804768.las
|    |         19_02804770.las
|    |         19_02804772.las
|    |         19_02804773.las
|    |         19_02804774.las
|    |         19_02804776.las
|    |         19_02804778.las
|    |         19_02804779.las
|    |         19_02804780.las
|    |         19_02804800.las
|    |         19_02804802.las
|    |         19_02804803.las
|    |         19_02804804.las
|    |         19_02804806.las
|    |         19_02804808.las
|    |         19_02804809.las
|    |         19_02804810.las
|    |         19_02804812.las
|    |         19_02804814.las
|    |         19_02824740.las
|    |         19_02824742.las
|    |         19_02824743.las
|    |         19_02824744.las
|    |         19_02824746.las
|    |         19_02824748.las
|    |         19_02824749.las
|    |         19_02824750.las
|    |         19_02824752.las
|    |         19_02824754.las
|    |         19_02824755.las
|    |         19_02824756.las
|    |         19_02824758.las
|    |         19_02824760.las
|    |         19_02824761.las
|    |         19_02824762.las
|    |         19_02824764.las
|    |         19_02824766.las
|    |         19_02824767.las
|    |         19_02824768.las
|    |         19_02824770.las
|    |         19_02824772.las
|    |         19_02824773.las
|    |         19_02824774.las
|    |         19_02824776.las
```

```
|    |        19_02824778.las
|    |        19_02824779.las
|    |        19_02824780.las
|    |        19_02824782.las
|    |        19_02824784.las
|    |        19_02824798.las
|    |        19_02824800.las
|    |        19_02824802.las
|    |        19_02824803.las
|    |        19_02824804.las
|    |        19_02824806.las
|    |        19_02824808.las
|    |        19_02824809.las
|    |        19_02824810.las
|    |        19_02824812.las
|    |        19_02824814.las
|    |        19_02844737.las
|    |        19_02844738.las
|    |        19_02844740.las
|    |        19_02844742.las
|    |        19_02844743.las
|    |        19_02844744.las
|    |        19_02844746.las
|    |        19_02844748.las
|    |        19_02844749.las
|    |        19_02844750.las
|    |        19_02844752.las
|    |        19_02844754.las
|    |        19_02844755.las
|    |        19_02844756.las
|    |        19_02844758.las
|    |        19_02844760.las
|    |        19_02844761.las
|    |        19_02844762.las
|    |        19_02844764.las
|    |        19_02844766.las
|    |        19_02844767.las
|    |        19_02844768.las
|    |        19_02844770.las
|    |        19_02844772.las
|    |        19_02844773.las
|    |        19_02844774.las
|    |        19_02844776.las
|    |        19_02844778.las
|    |        19_02844779.las
|    |        19_02844780.las
|    |        19_02844782.las
|    |        19_02844784.las
|    |        19_02844785.las
|    |        19_02844786.las
|    |        19_02844796.las
|    |        19_02844797.las
|    |        19_02844798.las
|    |        19_02844800.las
```

```
|   |       19_02844802.las
|   |       19_02844803.las
|   |       19_02844804.las
|   |       19_02844806.las
|   |       19_02844808.las
|   |       19_02844809.las
|   |       19_02844810.las
|   |       19_02844812.las
|   |       19_02844814.las
|   |       19_02854736.las
|   |       19_02854737.las
|   |       19_02854738.las
|   |       19_02854740.las
|   |       19_02854742.las
|   |       19_02854743.las
|   |       19_02854744.las
|   |       19_02854746.las
|   |       19_02854748.las
|   |       19_02854749.las
|   |       19_02854750.las
|   |       19_02854752.las
|   |       19_02854754.las
|   |       19_02854755.las
|   |       19_02854756.las
|   |       19_02854758.las
|   |       19_02854760.las
|   |       19_02854761.las
|   |       19_02854762.las
|   |       19_02854764.las
|   |       19_02854766.las
|   |       19_02854767.las
|   |       19_02854768.las
|   |       19_02854770.las
|   |       19_02854772.las
|   |       19_02854773.las
|   |       19_02854774.las
|   |       19_02854776.las
|   |       19_02854778.las
|   |       19_02854779.las
|   |       19_02854780.las
|   |       19_02854782.las
|   |       19_02854784.las
|   |       19_02854785.las
|   |       19_02854786.las
|   |       19_02854788.las
|   |       19_02854796.las
|   |       19_02854797.las
|   |       19_02854798.las
|   |       19_02854800.las
|   |       19_02854802.las
|   |       19_02854803.las
|   |       19_02854804.las
|   |       19_02854806.las
|   |       19_02854808.las
```

```
|    |        19_02854809.las
|    |        19_02854810.las
|    |        19_02854812.las
|    |        19_02864736.las
|    |        19_02864737.las
|    |        19_02864738.las
|    |        19_02864740.las
|    |        19_02864742.las
|    |        19_02864743.las
|    |        19_02864744.las
|    |        19_02864746.las
|    |        19_02864748.las
|    |        19_02864749.las
|    |        19_02864750.las
|    |        19_02864752.las
|    |        19_02864754.las
|    |        19_02864755.las
|    |        19_02864756.las
|    |        19_02864758.las
|    |        19_02864760.las
|    |        19_02864761.las
|    |        19_02864762.las
|    |        19_02864764.las
|    |        19_02864766.las
|    |        19_02864767.las
|    |        19_02864768.las
|    |        19_02864770.las
|    |        19_02864772.las
|    |        19_02864773.las
|    |        19_02864774.las
|    |        19_02864776.las
|    |        19_02864778.las
|    |        19_02864779.las
|    |        19_02864780.las
|    |        19_02864782.las
|    |        19_02864784.las
|    |        19_02864785.las
|    |        19_02864786.las
|    |        19_02864788.las
|    |        19_02864790.las
|    |        19_02864796.las
|    |        19_02864797.las
|    |        19_02864798.las
|    |        19_02864800.las
|    |        19_02864802.las
|    |        19_02864803.las
|    |        19_02864804.las
|    |        19_02864806.las
|    |        19_02864808.las
|    |        19_02864809.las
|    |        19_02864810.las
|    |        19_02864812.las
|    |        19_02884710.las
|    |        19_02884712.las
```

```
|    |        19_02884713.las
|    |        19_02884719.las
|    |        19_02884736.las
|    |        19_02884737.las
|    |        19_02884738.las
|    |        19_02884740.las
|    |        19_02884742.las
|    |        19_02884743.las
|    |        19_02884744.las
|    |        19_02884746.las
|    |        19_02884748.las
|    |        19_02884749.las
|    |        19_02884750.las
|    |        19_02884752.las
|    |        19_02884754.las
|    |        19_02884755.las
|    |        19_02884756.las
|    |        19_02884758.las
|    |        19_02884760.las
|    |        19_02884761.las
|    |        19_02884762.las
|    |        19_02884764.las
|    |        19_02884766.las
|    |        19_02884767.las
|    |        19_02884768.las
|    |        19_02884770.las
|    |        19_02884772.las
|    |        19_02884773.las
|    |        19_02884774.las
|    |        19_02884776.las
|    |        19_02884778.las
|    |        19_02884779.las
|    |        19_02884780.las
|    |        19_02884782.las
|    |        19_02884784.las
|    |        19_02884785.las
|    |        19_02884786.las
|    |        19_02884788.las
|    |        19_02884790.las
|    |        19_02884791.las
|    |        19_02884792.las
|    |        19_02884794.las
|    |        19_02884796.las
|    |        19_02884797.las
|    |        19_02884798.las
|    |        19_02884800.las
|    |        19_02884802.las
|    |        19_02884803.las
|    |        19_02884804.las
|    |        19_02884806.las
|    |        19_02884808.las
|    |        19_02884809.las
|    |        19_02884810.las
|    |        19_02904704.las
```

```
|    |        19_02904706.las
|    |        19_02904707.las
|    |        19_02904708.las
|    |        19_02904710.las
|    |        19_02904712.las
|    |        19_02904713.las
|    |        19_02904714.las
|    |        19_02904716.las
|    |        19_02904718.las
|    |        19_02904719.las
|    |        19_02904720.las
|    |        19_02904722.las
|    |        19_02904736.las
|    |        19_02904737.las
|    |        19_02904738.las
|    |        19_02904740.las
|    |        19_02904742.las
|    |        19_02904743.las
|    |        19_02904744.las
|    |        19_02904746.las
|    |        19_02904748.las
|    |        19_02904749.las
|    |        19_02904750.las
|    |        19_02904752.las
|    |        19_02904754.las
|    |        19_02904755.las
|    |        19_02904756.las
|    |        19_02904758.las
|    |        19_02904760.las
|    |        19_02904761.las
|    |        19_02904762.las
|    |        19_02904764.las
|    |        19_02904766.las
|    |        19_02904767.las
|    |        19_02904768.las
|    |        19_02904770.las
|    |        19_02904772.las
|    |        19_02904773.las
|    |        19_02904774.las
|    |        19_02904776.las
|    |        19_02904778.las
|    |        19_02904779.las
|    |        19_02904780.las
|    |        19_02904782.las
|    |        19_02904784.las
|    |        19_02904785.las
|    |        19_02904786.las
|    |        19_02904788.las
|    |        19_02904790.las
|    |        19_02904791.las
|    |        19_02904792.las
|    |        19_02904794.las
|    |        19_02904796.las
|    |        19_02904797.las
```

```
|    |        19_02904798.las
|    |        19_02904800.las
|    |        19_02904802.las
|    |        19_02904803.las
|    |        19_02904804.las
|    |        19_02904806.las
|    |        19_02904808.las
|    |        19_02904809.las
|    |        19_02914704.las
|    |        19_02914706.las
|    |        19_02914707.las
|    |        19_02914708.las
|    |        19_02914710.las
|    |        19_02914712.las
|    |        19_02914713.las
|    |        19_02914714.las
|    |        19_02914716.las
|    |        19_02914718.las
|    |        19_02914719.las
|    |        19_02914720.las
|    |        19_02914722.las
|    |        19_02914728.las
|    |        19_02914730.las
|    |        19_02914731.las
|    |        19_02914736.las
|    |        19_02914737.las
|    |        19_02914738.las
|    |        19_02914740.las
|    |        19_02914742.las
|    |        19_02914743.las
|    |        19_02914744.las
|    |        19_02914746.las
|    |        19_02914748.las
|    |        19_02914749.las
|    |        19_02914750.las
|    |        19_02914752.las
|    |        19_02914754.las
|    |        19_02914755.las
|    |        19_02914756.las
|    |        19_02914758.las
|    |        19_02914760.las
|    |        19_02914761.las
|    |        19_02914762.las
|    |        19_02914764.las
|    |        19_02914766.las
|    |        19_02914767.las
|    |        19_02914768.las
|    |        19_02914770.las
|    |        19_02914772.las
|    |        19_02914773.las
|    |        19_02914774.las
|    |        19_02914776.las
|    |        19_02914778.las
|    |        19_02914779.las
```

```
|    |        19_02914780.las
|    |        19_02914782.las
|    |        19_02914784.las
|    |        19_02914785.las
|    |        19_02914786.las
|    |        19_02914788.las
|    |        19_02914790.las
|    |        19_02914791.las
|    |        19_02914792.las
|    |        19_02914794.las
|    |        19_02914796.las
|    |        19_02914797.las
|    |        19_02914798.las
|    |        19_02914800.las
|    |        19_02914802.las
|    |        19_02914803.las
|    |        19_02914804.las
|    |        19_02914806.las
|    |        19_02914808.las
|    |        19_02914809.las
|    |        19_02924706.las
|    |        19_02924707.las
|    |        19_02924708.las
|    |        19_02924710.las
|    |        19_02924712.las
|    |        19_02924713.las
|    |        19_02924714.las
|    |        19_02924716.las
|    |        19_02924718.las
|    |        19_02924719.las
|    |        19_02924720.las
|    |        19_02924722.las
|    |        19_02924724.las
|    |        19_02924725.las
|    |        19_02924726.las
|    |        19_02924728.las
|    |        19_02924730.las
|    |        19_02924731.las
|    |        19_02924732.las
|    |        19_02924737.las
|    |        19_02924738.las
|    |        19_02924740.las
|    |        19_02924742.las
|    |        19_02924743.las
|    |        19_02924744.las
|    |        19_02924746.las
|    |        19_02924748.las
|    |        19_02924749.las
|    |        19_02924750.las
|    |        19_02924752.las
|    |        19_02924754.las
|    |        19_02924755.las
|    |        19_02924756.las
|    |        19_02924758.las
```

```
|    |       19_02924760.las
|    |       19_02924761.las
|    |       19_02924762.las
|    |       19_02924764.las
|    |       19_02924766.las
|    |       19_02924767.las
|    |       19_02924768.las
|    |       19_02924770.las
|    |       19_02924772.las
|    |       19_02924773.las
|    |       19_02924774.las
|    |       19_02924776.las
|    |       19_02924778.las
|    |       19_02924779.las
|    |       19_02924780.las
|    |       19_02924782.las
|    |       19_02924784.las
|    |       19_02924785.las
|    |       19_02924786.las
|    |       19_02924788.las
|    |       19_02924790.las
|    |       19_02924791.las
|    |       19_02924792.las
|    |       19_02924794.las
|    |       19_02924796.las
|    |       19_02924797.las
|    |       19_02924798.las
|    |       19_02924800.las
|    |       19_02924802.las
|    |       19_02924803.las
|    |       19_02924804.las
|    |       19_02924806.las
|    |       19_02924808.las
|    |       19_02944708.las
|    |       19_02944710.las
|    |       19_02944712.las
|    |       19_02944713.las
|    |       19_02944714.las
|    |       19_02944716.las
|    |       19_02944718.las
|    |       19_02944719.las
|    |       19_02944720.las
|    |       19_02944722.las
|    |       19_02944724.las
|    |       19_02944725.las
|    |       19_02944726.las
|    |       19_02944728.las
|    |       19_02944730.las
|    |       19_02944731.las
|    |       19_02944732.las
|    |       19_02944734.las
|    |       19_02944736.las
|    |       19_02944738.las
|    |       19_02944740.las
```

```
|    |        19_02944742.las
|    |        19_02944743.las
|    |        19_02944744.las
|    |        19_02944746.las
|    |        19_02944748.las
|    |        19_02944749.las
|    |        19_02944750.las
|    |        19_02944752.las
|    |        19_02944754.las
|    |        19_02944755.las
|    |        19_02944756.las
|    |        19_02944758.las
|    |        19_02944760.las
|    |        19_02944761.las
|    |        19_02944762.las
|    |        19_02944764.las
|    |        19_02944766.las
|    |        19_02944767.las
|    |        19_02944768.las
|    |        19_02944770.las
|    |        19_02944772.las
|    |        19_02944773.las
|    |        19_02944774.las
|    |        19_02944776.las
|    |        19_02944778.las
|    |        19_02944779.las
|    |        19_02944780.las
|    |        19_02944782.las
|    |        19_02944784.las
|    |        19_02944785.las
|    |        19_02944786.las
|    |        19_02944788.las
|    |        19_02944790.las
|    |        19_02944791.las
|    |        19_02944792.las
|    |        19_02944794.las
|    |        19_02944796.las
|    |        19_02944797.las
|    |        19_02944798.las
|    |        19_02944800.las
|    |        19_02944802.las
|    |        19_02944803.las
|    |        19_02944804.las
|    |        19_02944806.las
|    |        19_02944808.las
|    |        19_02944809.las
|    |        19_02964710.las
|    |        19_02964712.las
|    |        19_02964713.las
|    |        19_02964714.las
|    |        19_02964716.las
|    |        19_02964718.las
|    |        19_02964719.las
|    |        19_02964720.las
```

```
|    |        19_02964722.las
|    |        19_02964724.las
|    |        19_02964725.las
|    |        19_02964726.las
|    |        19_02964728.las
|    |        19_02964730.las
|    |        19_02964731.las
|    |        19_02964732.las
|    |        19_02964734.las
|    |        19_02964736.las
|    |        19_02964738.las
|    |        19_02964740.las
|    |        19_02964742.las
|    |        19_02964743.las
|    |        19_02964744.las
|    |        19_02964746.las
|    |        19_02964748.las
|    |        19_02964749.las
|    |        19_02964750.las
|    |        19_02964752.las
|    |        19_02964754.las
|    |        19_02964755.las
|    |        19_02964756.las
|    |        19_02964758.las
|    |        19_02964760.las
|    |        19_02964761.las
|    |        19_02964762.las
|    |        19_02964764.las
|    |        19_02964766.las
|    |        19_02964767.las
|    |        19_02964768.las
|    |        19_02964770.las
|    |        19_02964772.las
|    |        19_02964773.las
|    |        19_02964774.las
|    |        19_02964776.las
|    |        19_02964778.las
|    |        19_02964779.las
|    |        19_02964780.las
|    |        19_02964782.las
|    |        19_02964784.las
|    |        19_02964785.las
|    |        19_02964786.las
|    |        19_02964788.las
|    |        19_02964790.las
|    |        19_02964791.las
|    |        19_02964792.las
|    |        19_02964794.las
|    |        19_02964796.las
|    |        19_02964797.las
|    |        19_02964798.las
|    |        19_02964800.las
|    |        19_02964802.las
|    |        19_02964803.las
```

```
|    |        19_02964804.las
|    |        19_02964806.las
|    |        19_02964808.las
|    |        19_02964809.las
|    |        19_02974712.las
|    |        19_02974713.las
|    |        19_02974714.las
|    |        19_02974716.las
|    |        19_02974718.las
|    |        19_02974719.las
|    |        19_02974720.las
|    |        19_02974722.las
|    |        19_02974724.las
|    |        19_02974725.las
|    |        19_02974726.las
|    |        19_02974728.las
|    |        19_02974730.las
|    |        19_02974731.las
|    |        19_02974732.las
|    |        19_02974734.las
|    |        19_02974736.las
|    |        19_02974737.las
|    |        19_02974738.las
|    |        19_02974740.las
|    |        19_02974742.las
|    |        19_02974743.las
|    |        19_02974744.las
|    |        19_02974746.las
|    |        19_02974748.las
|    |        19_02974749.las
|    |        19_02974750.las
|    |        19_02974752.las
|    |        19_02974754.las
|    |        19_02974755.las
|    |        19_02974756.las
|    |        19_02974758.las
|    |        19_02974760.las
|    |        19_02974761.las
|    |        19_02974762.las
|    |        19_02974764.las
|    |        19_02974766.las
|    |        19_02974767.las
|    |        19_02974768.las
|    |        19_02974770.las
|    |        19_02974772.las
|    |        19_02974773.las
|    |        19_02974774.las
|    |        19_02974776.las
|    |        19_02974778.las
|    |        19_02974779.las
|    |        19_02974780.las
|    |        19_02974782.las
|    |        19_02974784.las
|    |        19_02974785.las
```

```
|    |        19_02974786.las
|    |        19_02974788.las
|    |        19_02974790.las
|    |        19_02974791.las
|    |        19_02974792.las
|    |        19_02974794.las
|    |        19_02974796.las
|    |        19_02974797.las
|    |        19_02974798.las
|    |        19_02974800.las
|    |        19_02974802.las
|    |        19_02974803.las
|    |        19_02974804.las
|    |        19_02974806.las
|    |        19_02974808.las
|    |        19_02974809.las
|    |        19_02984714.las
|    |        19_02984716.las
|    |        19_02984718.las
|    |        19_02984719.las
|    |        19_02984720.las
|    |        19_02984722.las
|    |        19_02984724.las
|    |        19_02984725.las
|    |        19_02984726.las
|    |        19_02984728.las
|    |        19_02984730.las
|    |        19_02984731.las
|    |        19_02984732.las
|    |        19_02984734.las
|    |        19_02984736.las
|    |        19_02984737.las
|    |        19_02984738.las
|    |        19_02984740.las
|    |        19_02984742.las
|    |        19_02984743.las
|    |        19_02984744.las
|    |        19_02984746.las
|    |        19_02984748.las
|    |        19_02984749.las
|    |        19_02984750.las
|    |        19_02984752.las
|    |        19_02984754.las
|    |        19_02984755.las
|    |        19_02984756.las
|    |        19_02984758.las
|    |        19_02984760.las
|    |        19_02984761.las
|    |        19_02984762.las
|    |        19_02984764.las
|    |        19_02984766.las
|    |        19_02984767.las
|    |        19_02984768.las
|    |        19_02984770.las
```

```
|    |        19_02984772.las
|    |        19_02984773.las
|    |        19_02984774.las
|    |        19_02984776.las
|    |        19_02984778.las
|    |        19_02984779.las
|    |        19_02984780.las
|    |        19_02984782.las
|    |        19_02984784.las
|    |        19_02984785.las
|    |        19_02984786.las
|    |        19_02984788.las
|    |        19_02984790.las
|    |        19_02984791.las
|    |        19_02984792.las
|    |        19_02984794.las
|    |        19_02984796.las
|    |        19_02984797.las
|    |        19_02984798.las
|    |        19_02984800.las
|    |        19_02984802.las
|    |        19_02984803.las
|    |        19_02984804.las
|    |        19_02984806.las
|    |        19_02984808.las
|    |        19_02984809.las
|    |        19_03004714.las
|    |        19_03004716.las
|    |        19_03004718.las
|    |        19_03004719.las
|    |        19_03004720.las
|    |        19_03004722.las
|    |        19_03004724.las
|    |        19_03004725.las
|    |        19_03004726.las
|    |        19_03004728.las
|    |        19_03004730.las
|    |        19_03004731.las
|    |        19_03004732.las
|    |        19_03004734.las
|    |        19_03004736.las
|    |        19_03004737.las
|    |        19_03004738.las
|    |        19_03004740.las
|    |        19_03004742.las
|    |        19_03004743.las
|    |        19_03004744.las
|    |        19_03004746.las
|    |        19_03004748.las
|    |        19_03004749.las
|    |        19_03004750.las
|    |        19_03004752.las
|    |        19_03004754.las
|    |        19_03004755.las
```

```
|    |        19_03004756.las
|    |        19_03004758.las
|    |        19_03004760.las
|    |        19_03004761.las
|    |        19_03004762.las
|    |        19_03004764.las
|    |        19_03004766.las
|    |        19_03004767.las
|    |        19_03004768.las
|    |        19_03004770.las
|    |        19_03004772.las
|    |        19_03004773.las
|    |        19_03004774.las
|    |        19_03004776.las
|    |        19_03004778.las
|    |        19_03004779.las
|    |        19_03004780.las
|    |        19_03004782.las
|    |        19_03004784.las
|    |        19_03004785.las
|    |        19_03004786.las
|    |        19_03004788.las
|    |        19_03004790.las
|    |        19_03004791.las
|    |        19_03004792.las
|    |        19_03004794.las
|    |        19_03004796.las
|    |        19_03004797.las
|    |        19_03004798.las
|    |        19_03004800.las
|    |        19_03004802.las
|    |        19_03004803.las
|    |        19_03004804.las
|    |        19_03004806.las
|    |        19_03004808.las
|    |        19_03004809.las
|    |        19_03004810.las
|    |        19_03004812.las
|    |        19_03024714.las
|    |        19_03024716.las
|    |        19_03024718.las
|    |        19_03024719.las
|    |        19_03024720.las
|    |        19_03024722.las
|    |        19_03024724.las
|    |        19_03024725.las
|    |        19_03024726.las
|    |        19_03024728.las
|    |        19_03024730.las
|    |        19_03024731.las
|    |        19_03024732.las
|    |        19_03024734.las
|    |        19_03024736.las
|    |        19_03024737.las
```

```
|   |        19_03024738.las
|   |        19_03024740.las
|   |        19_03024742.las
|   |        19_03024743.las
|   |        19_03024744.las
|   |        19_03024746.las
|   |        19_03024748.las
|   |        19_03024749.las
|   |        19_03024750.las
|   |        19_03024752.las
|   |        19_03024754.las
|   |        19_03024755.las
|   |        19_03024756.las
|   |        19_03024758.las
|   |        19_03024760.las
|   |        19_03024761.las
|   |        19_03024762.las
|   |        19_03024764.las
|   |        19_03024766.las
|   |        19_03024767.las
|   |        19_03024768.las
|   |        19_03024770.las
|   |        19_03024772.las
|   |        19_03024773.las
|   |        19_03024774.las
|   |        19_03024776.las
|   |        19_03024778.las
|   |        19_03024779.las
|   |        19_03024780.las
|   |        19_03024782.las
|   |        19_03024784.las
|   |        19_03024785.las
|   |        19_03024786.las
|   |        19_03024788.las
|   |        19_03024790.las
|   |        19_03024791.las
|   |        19_03024792.las
|   |        19_03024794.las
|   |        19_03024796.las
|   |        19_03024797.las
|   |        19_03024798.las
|   |        19_03024800.las
|   |        19_03024802.las
|   |        19_03024803.las
|   |        19_03024804.las
|   |        19_03024806.las
|   |        19_03024808.las
|   |        19_03024809.las
|   |        19_03024810.las
|   |        19_03024812.las
|   |        19_03034718.las
|   |        19_03034719.las
|   |        19_03034720.las
|   |        19_03034722.las
```

```
|    |        19_03034724.las
|    |        19_03034725.las
|    |        19_03034726.las
|    |        19_03034728.las
|    |        19_03034730.las
|    |        19_03034731.las
|    |        19_03034732.las
|    |        19_03034734.las
|    |        19_03034736.las
|    |        19_03034737.las
|    |        19_03034738.las
|    |        19_03034740.las
|    |        19_03034742.las
|    |        19_03034743.las
|    |        19_03034744.las
|    |        19_03034746.las
|    |        19_03034748.las
|    |        19_03034749.las
|    |        19_03034750.las
|    |        19_03034752.las
|    |        19_03034754.las
|    |        19_03034755.las
|    |        19_03034756.las
|    |        19_03034758.las
|    |        19_03034760.las
|    |        19_03034761.las
|    |        19_03034762.las
|    |        19_03034764.las
|    |        19_03034766.las
|    |        19_03034767.las
|    |        19_03034768.las
|    |        19_03034770.las
|    |        19_03034772.las
|    |        19_03034773.las
|    |        19_03034774.las
|    |        19_03034776.las
|    |        19_03034778.las
|    |        19_03034779.las
|    |        19_03034780.las
|    |        19_03034782.las
|    |        19_03034784.las
|    |        19_03034785.las
|    |        19_03034786.las
|    |        19_03034788.las
|    |        19_03034790.las
|    |        19_03034791.las
|    |        19_03034792.las
|    |        19_03034794.las
|    |        19_03034796.las
|    |        19_03034797.las
|    |        19_03034798.las
|    |        19_03034800.las
|    |        19_03034802.las
|    |        19_03034803.las
```

```
|    |        19_03034804.las
|    |        19_03034806.las
|    |        19_03034808.las
|    |        19_03034809.las
|    |        19_03034810.las
|    |        19_03034812.las
|    |        19_03044719.las
|    |        19_03044720.las
|    |        19_03044722.las
|    |        19_03044724.las
|    |        19_03044725.las
|    |        19_03044726.las
|    |        19_03044728.las
|    |        19_03044730.las
|    |        19_03044731.las
|    |        19_03044732.las
|    |        19_03044734.las
|    |        19_03044736.las
|    |        19_03044737.las
|    |        19_03044738.las
|    |        19_03044740.las
|    |        19_03044742.las
|    |        19_03044743.las
|    |        19_03044744.las
|    |        19_03044746.las
|    |        19_03044748.las
|    |        19_03044749.las
|    |        19_03044750.las
|    |        19_03044752.las
|    |        19_03044754.las
|    |        19_03044755.las
|    |        19_03044756.las
|    |        19_03044758.las
|    |        19_03044760.las
|    |        19_03044761.las
|    |        19_03044762.las
|    |        19_03044764.las
|    |        19_03044766.las
|    |        19_03044767.las
|    |        19_03044768.las
|    |        19_03044770.las
|    |        19_03044772.las
|    |        19_03044773.las
|    |        19_03044774.las
|    |        19_03044776.las
|    |        19_03044778.las
|    |        19_03044779.las
|    |        19_03044780.las
|    |        19_03044782.las
|    |        19_03044784.las
|    |        19_03044785.las
|    |        19_03044786.las
|    |        19_03044788.las
|    |        19_03044790.las
```

```
|    |        19_03044791.las
|    |        19_03044792.las
|    |        19_03044794.las
|    |        19_03044796.las
|    |        19_03044797.las
|    |        19_03044798.las
|    |        19_03044800.las
|    |        19_03044802.las
|    |        19_03044803.las
|    |        19_03044804.las
|    |        19_03044806.las
|    |        19_03044808.las
|    |        19_03044809.las
|    |        19_03044810.las
|    |        19_03044812.las
|    |        19_03064719.las
|    |        19_03064720.las
|    |        19_03064722.las
|    |        19_03064725.las
|    |        19_03064726.las
|    |        19_03064730.las
|    |        19_03064731.las
|    |        19_03064732.las
|    |        19_03064734.las
|    |        19_03064736.las
|    |        19_03064737.las
|    |        19_03064738.las
|    |        19_03064740.las
|    |        19_03064742.las
|    |        19_03064754.las
|    |        19_03064755.las
|    |        19_03064756.las
|    |        19_03064758.las
|    |        19_03064768.las
|    |        19_03064770.las
|    |        19_03064772.las
|    |        19_03064773.las
|    |        19_03064774.las
|    |        19_03064776.las
|    |        19_03064778.las
|    |        19_03064779.las
|    |        19_03064780.las
|    |        19_03064782.las
|    |        19_03064784.las
|    |        19_03064785.las
|    |        19_03064786.las
|    |        19_03064788.las
|    |        19_03064790.las
|    |        19_03064791.las
|    |        19_03064792.las
|    |        19_03064794.las
|    |        19_03064796.las
|    |        19_03064797.las
|    |        19_03064798.las
```

```
|   |       19_03064800.las
|   |       19_03064802.las
|   |       19_03064803.las
|   |       19_03064804.las
|   |       19_03064806.las
|   |       19_03064808.las
|   |       19_03064809.las
|   |       19_03064810.las
|   |       19_03064812.las
|   |       19_03064814.las
|   |       19_03064815.las
|   |       19_03064816.las
|   |       19_03064818.las
|   |       19_03084702.las
|   |       19_03084704.las
|   |       19_03084719.las
|   |       19_03084720.las
|   |       19_03084730.las
|   |       19_03084731.las
|   |       19_03084732.las
|   |       19_03084734.las
|   |       19_03084736.las
|   |       19_03084737.las
|   |       19_03084738.las
|   |       19_03084772.las
|   |       19_03084773.las
|   |       19_03084774.las
|   |       19_03084776.las
|   |       19_03084778.las
|   |       19_03084779.las
|   |       19_03084780.las
|   |       19_03084782.las
|   |       19_03084784.las
|   |       19_03084785.las
|   |       19_03084786.las
|   |       19_03084788.las
|   |       19_03084790.las
|   |       19_03084791.las
|   |       19_03084792.las
|   |       19_03084794.las
|   |       19_03084796.las
|   |       19_03084797.las
|   |       19_03084798.las
|   |       19_03084800.las
|   |       19_03084802.las
|   |       19_03084803.las
|   |       19_03084804.las
|   |       19_03084806.las
|   |       19_03084808.las
|   |       19_03084809.las
|   |       19_03084810.las
|   |       19_03084812.las
|   |       19_03084814.las
|   |       19_03084815.las
```

```
|    |        19_03084816.las
|    |        19_03084818.las
|    |        19_03084820.las
|    |        19_03094700.las
|    |        19_03094701.las
|    |        19_03094702.las
|    |        19_03094704.las
|    |        19_03094706.las
|    |        19_03094730.las
|    |        19_03094731.las
|    |        19_03094732.las
|    |        19_03094734.las
|    |        19_03094736.las
|    |        19_03094737.las
|    |        19_03094776.las
|    |        19_03094778.las
|    |        19_03094779.las
|    |        19_03094780.las
|    |        19_03094782.las
|    |        19_03094784.las
|    |        19_03094785.las
|    |        19_03094786.las
|    |        19_03094788.las
|    |        19_03094790.las
|    |        19_03094791.las
|    |        19_03094792.las
|    |        19_03094794.las
|    |        19_03094796.las
|    |        19_03094797.las
|    |        19_03094798.las
|    |        19_03094800.las
|    |        19_03094802.las
|    |        19_03094803.las
|    |        19_03094804.las
|    |        19_03094806.las
|    |        19_03094808.las
|    |        19_03094809.las
|    |        19_03094810.las
|    |        19_03094812.las
|    |        19_03094814.las
|    |        19_03094815.las
|    |        19_03094816.las
|    |        19_03094818.las
|    |        19_03094820.las
|    |        19_03104700.las
|    |        19_03104701.las
|    |        19_03104702.las
|    |        19_03104704.las
|    |        19_03104706.las
|    |        19_03104707.las
|    |        19_03104730.las
|    |        19_03104731.las
|    |        19_03104732.las
|    |        19_03104734.las
```

```
|    |        19_03104736.las
|    |        19_03104737.las
|    |        19_03104778.las
|    |        19_03104779.las
|    |        19_03104780.las
|    |        19_03104782.las
|    |        19_03104784.las
|    |        19_03104785.las
|    |        19_03104786.las
|    |        19_03104788.las
|    |        19_03104790.las
|    |        19_03104791.las
|    |        19_03104792.las
|    |        19_03104794.las
|    |        19_03104796.las
|    |        19_03104797.las
|    |        19_03104798.las
|    |        19_03104800.las
|    |        19_03104802.las
|    |        19_03104803.las
|    |        19_03104804.las
|    |        19_03104806.las
|    |        19_03104808.las
|    |        19_03104809.las
|    |        19_03104810.las
|    |        19_03104812.las
|    |        19_03104814.las
|    |        19_03104815.las
|    |        19_03104816.las
|    |        19_03104818.las
|    |        19_03104820.las
|    |        19_03124701.las
|    |        19_03124702.las
|    |        19_03124704.las
|    |        19_03124706.las
|    |        19_03124707.las
|    |        19_03124708.las
|    |        19_03124710.las
|    |        19_03124730.las
|    |        19_03124731.las
|    |        19_03124732.las
|    |        19_03124734.las
|    |        19_03124736.las
|    |        19_03124737.las
|    |        19_03124780.las
|    |        19_03124782.las
|    |        19_03124784.las
|    |        19_03124785.las
|    |        19_03124786.las
|    |        19_03124788.las
|    |        19_03124790.las
|    |        19_03124791.las
|    |        19_03124792.las
|    |        19_03124794.las
```

```
|    |        19_03124796.las
|    |        19_03124797.las
|    |        19_03124798.las
|    |        19_03124800.las
|    |        19_03124802.las
|    |        19_03124803.las
|    |        19_03124804.las
|    |        19_03124806.las
|    |        19_03124808.las
|    |        19_03124809.las
|    |        19_03124810.las
|    |        19_03124812.las
|    |        19_03124814.las
|    |        19_03124815.las
|    |        19_03124816.las
|    |        19_03124818.las
|    |        19_03124820.las
|    |        19_03144700.las
|    |        19_03144701.las
|    |        19_03144702.las
|    |        19_03144704.las
|    |        19_03144706.las
|    |        19_03144707.las
|    |        19_03144708.las
|    |        19_03144710.las
|    |        19_03144731.las
|    |        19_03144732.las
|    |        19_03144734.las
|    |        19_03144736.las
|    |        19_03144784.las
|    |        19_03144785.las
|    |        19_03144786.las
|    |        19_03144788.las
|    |        19_03144790.las
|    |        19_03144791.las
|    |        19_03144792.las
|    |        19_03144794.las
|    |        19_03144796.las
|    |        19_03144797.las
|    |        19_03144798.las
|    |        19_03144800.las
|    |        19_03144802.las
|    |        19_03144803.las
|    |        19_03144804.las
|    |        19_03144806.las
|    |        19_03144808.las
|    |        19_03144809.las
|    |        19_03144810.las
|    |        19_03144812.las
|    |        19_03144814.las
|    |        19_03144815.las
|    |        19_03144816.las
|    |        19_03144818.las
|    |        19_03144820.las
```

```
|   |       19_03154700.las
|   |       19_03154701.las
|   |       19_03154702.las
|   |       19_03154704.las
|   |       19_03154706.las
|   |       19_03154707.las
|   |       19_03154708.las
|   |       19_03154710.las
|   |       19_03154732.las
|   |       19_03154734.las
|   |       19_03154736.las
|   |       19_03154786.las
|   |       19_03154788.las
|   |       19_03154790.las
|   |       19_03154791.las
|   |       19_03154792.las
|   |       19_03154794.las
|   |       19_03154796.las
|   |       19_03154797.las
|   |       19_03154798.las
|   |       19_03154800.las
|   |       19_03154802.las
|   |       19_03154803.las
|   |       19_03154804.las
|   |       19_03154806.las
|   |       19_03154808.las
|   |       19_03154809.las
|   |       19_03154810.las
|   |       19_03154812.las
|   |       19_03154814.las
|   |       19_03154815.las
|   |       19_03154816.las
|   |       19_03154818.las
|   |       19_03164700.las
|   |       19_03164701.las
|   |       19_03164702.las
|   |       19_03164704.las
|   |       19_03164706.las
|   |       19_03164707.las
|   |       19_03164708.las
|   |       19_03164791.las
|   |       19_03164792.las
|   |       19_03164794.las
|   |       19_03164796.las
|   |       19_03164797.las
|   |       19_03164798.las
|   |       19_03164800.las
|   |       19_03164802.las
|   |       19_03164803.las
|   |       19_03164804.las
|   |       19_03164806.las
|   |       19_03164808.las
|   |       19_03164809.las
|   |       19_03164810.las
```

```
|    |         19_03164812.las
|    |         19_03164814.las
|    |         19_03164815.las
|    |         19_03184701.las
|    |         19_03184702.las
|    |         19_03184704.las
|    |         19_03184706.las
|    |         19_03184707.las
|    |         19_03184708.las
|    |         19_03184710.las
|    |         19_03184792.las
|    |         19_03184794.las
|    |         19_03184796.las
|    |         19_03184797.las
|    |         19_03184798.las
|    |         19_03184800.las
|    |         19_03184802.las
|    |         19_03184803.las
|    |         19_03184804.las
|    |         19_03184806.las
|    |         19_03184808.las
|    |         19_03204702.las
|    |         19_03204704.las
|    |         19_03204706.las
|    |         19_03204707.las
|    |         19_03204708.las
|    |         19_03204794.las
|    |         19_03204796.las
|    |         19_03204797.las
|    |         19_03204798.las
|    |         19_03204800.las
|    |         19_03204802.las
|    |         19_03204803.las
|    |         19_03204804.las
|    |         19_03204806.las
|    |         19_03204808.las
|    |         19_03214792.las
|    |         19_03214794.las
|    |         19_03214796.las
|    |         19_03214797.las
|    |         19_03214798.las
|    |         19_03214800.las
|    |         19_03214802.las
|    |         19_03214803.las
|    |         19_03214804.las
|    |         19_03214806.las
|    |         19_03214808.las
|    |         19_03224792.las
|    |         19_03224794.las
|    |         19_03224796.las
|    |         19_03224797.las
|    |         19_03224798.las
|    |         19_03224800.las
|    |         19_03224802.las
```

```
|   |       19_03224803.las
|   |       19_03224804.las
|   |       19_03224806.las
|   |       19_03224808.las
|   |       19_03244794.las
|   |       19_03244796.las
|   |       19_03244797.las
|   |       19_03244798.las
|   |       19_03244800.las
|   |       19_03244802.las
|   |       19_03244803.las
|   |       19_03244804.las
|   |       19_03244806.las
|   |       19_03264796.las
|   |       19_03264797.las
|   |       19_03264798.las
|   |       19_03264800.las
|   |       19_03264802.las
|   |       19_03264803.las
|   |       19_03264804.las
|   |       19_03274797.las
|   |       19_03274798.las
|   |       19_03274800.las
|   |       19_03274802.las
|   |       19_03284798.las
|   |       19_03284800.las
|   |       Merrimack_Unclassified_LAS_Index.dbf
|   |       Merrimack_Unclassified_LAS_Index.prj
|   |       Merrimack_Unclassified_LAS_Index.sbn
|   |       Merrimack_Unclassified_LAS_Index.sbx
|   |       Merrimack_Unclassified_LAS_Index.shp
|   |       Merrimack_Unclassified_LAS_Index.shp.xml
|   |       Merrimack_Unclassified_LAS_Index.shx
|   |
|   \---TIN
\---Supplemental Data
    |   Merrimack Certification of Compliance LiDAR.pdf
    |   Merrimack Certification of Compliance Survey.pdf
    |   Merrimack Pre-Flight Operations Plan.pdf
    |   Merrimack_LAS_Index.dbf
    |   Merrimack_LAS_Index.prj
    |   Merrimack_LAS_Index.sbn
    |   Merrimack_LAS_Index.sbx
    |   Merrimack_LAS_Index.shp
    |   Merrimack_LAS_Index.shp.xml
    |   Merrimack_LAS_Index.shx
    |
    +---Merrimack Post-Flight Report
    |   |   Merrimack_PostFlight_Report.doc
    |   |
    |   +---Appendix A - Flight Logs
    |   |       111119a&b-6156-flight&GPSlogs.PDF
    |   |       111120a-6156-flight&GPSlogs.PDF
    |   |       111121a-6156-flight&GPSlogs.PDF
```

```
    |   |       120107a&b-6156-ABGPSlog.jpg
    |   |       120107a-6156-inplaneflightlog.jpg
    |   |       120107b-6156-inplaneflightlog.jpg
    |   |       120109a-6156-inplaneflightlog-1of2.jpg
    |   |       120109a-6156-inplaneflightlog-2of2.jpg
    |   |       120109ab-6156-ABGPSlog.jpg
    |   |       120109b-6156-inplaneflightlog.jpg
    |   |       120111a-6156-inplaneflightlog.jpg
    |   |       120111b-6156-ABGPSlog.jpg
    |   |       120111b-6156-inplaneflightlog-1of2.jpg
    |   |       120111b-6156-inplaneflightlog-2of2.jpg
    |   |
    |   +---Appendix B - Ground Control
    |   |       Merrimack_HUC8_Base_Stations.dbf
    |   |       Merrimack_HUC8_Base_Stations.prj
    |   |       Merrimack_HUC8_Base_Stations.shp
    |   |       Merrimack_HUC8_Base_Stations.shx
    |   |       Merrimack_HUC8_Base_Stations_dbf.txt
    |   |       Merrimack_HUC8_Base_Stations_metadata.htm
    |   |
    |   +---Appendix C - Trajectory and Associated Plots
    |   |   |   Merrimack_HUC8_Flight_Lines_7556008FL_MDB.DBF
    |   |   |   Merrimack_HUC8_Flight_Lines_7556008FL_MDB.PRJ
    |   |   |   Merrimack_HUC8_Flight_Lines_7556008FL_MDB.SHP
    |   |   |   Merrimack_HUC8_Flight_Lines_7556008FL_MDB.shp.xml
    |   |   |   Merrimack_HUC8_Flight_Lines_7556008FL_MDB.SHX
    |   |   |   SN240_LiDAR_SOURCE.dbf
    |   |   |   SN240_LiDAR_SOURCE.prj
    |   |   |   SN240_LiDAR_SOURCE.shp
    |   |   |   SN240_LiDAR_SOURCE.shx
    |   |   |   SN6156_LiDAR_SOURCE.dbf
    |   |   |   SN6156_LiDAR_SOURCE.prj
    |   |   |   SN6156_LiDAR_SOURCE.shp
    |   |   |   SN6156_LiDAR_SOURCE.shx
    |   |   |
    |   |   +---111029a
    |   |   |       111029a-6156-#ofsats.jpg
    |   |   |       111029a-6156-basecoordinate.jpg
    |   |   |       111029a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111029a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111029a-6156-positionaccuracy&PDOP-noGLONASS-
20deg.jpg
    |   |   |       111029a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111029a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111029a-6156-positionaccuracy&PDOP-withGLONASS-
20deg.jpg
    |   |   |       111029a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111029a-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       111029a-6156-positionseparation-noGLONASS-20deg.jpg
    |   |   |       111029a-6156-positionseparation-withGLONASS-10deg.jpg
```

```
    |   |   |       111029a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111029a-6156-positionseparation-withGLONASS-20deg.jpg
    |   |   |       111029a-6156-RPH.jpg
    |   |   |       111029a-6156-trajectory.jpg
    |   |   |
    |   |   +---111112a
    |   |   |       111112a-240_Baseline.bmp
    |   |   |       111112a-240_ForwardProcessPerformance_NED.bmp
    |   |   |       111112a-240_ProcessMode.bmp
    |   |   |       111112a-240_ScreenShot.jpg
    |   |   |       111112a-240_SmoothPerformance_NED.bmp
    |   |   |       111112a-240_SV&PDOP.bmp
    |   |   |
    |   |   +---111112b
    |   |   |       111112b-240_Baseline.bmp
    |   |   |       111112b-240_ForwardProcessPerformance_NED.bmp
    |   |   |       111112b-240_ProcessMode.bmp
    |   |   |       111112b-240_ScreenShot.jpg
    |   |   |       111112b-240_SmoothPerformance_NED.bmp
    |   |   |       111112b-240_SV&PDOP.bmp
    |   |   |
    |   |   +---111113a
    |   |   |       111113a-240_baseline.bmp
    |   |   |       111113a-240_NEDpositionerror-forward.bmp
    |   |   |       111113a-240_NEDpositionerror-smoothed.bmp
    |   |   |       111113a-240_procmode.bmp
    |   |   |       111113a-240_SSDfail.jpg
    |   |   |       111113a-240_SV&PDOP.bmp
    |   |   |       111113a-240_trajectory.bmp
    |   |   |
    |   |   +---111113b
    |   |   |       111113b-240_baselinelength.bmp
    |   |   |       111113b-240_nedpositionerror-forward.bmp
    |   |   |       111113b-240_nedpositionerror.bmp
    |   |   |       111113b-240_PDOP&SVs.bmp
    |   |   |       111113b-240_procmode.bmp
    |   |   |
    |   |   +---111119a
    |   |   |       111119a-6156-#ofsats.jpg
    |   |   |       111119a-6156-basecoordinate.jpg
    |   |   |       111119a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111119a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111119a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111119a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111119a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111119a-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       111119a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111119a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111119a-6156-RPH.jpg
    |   |   |       111119a-6156-trajectory.jpg
```

```
    |   |   |
    |   |   +---111119b
    |   |   |       111119b-6156-#ofsats.jpg
    |   |   |       111119b-6156-basecoordinate.jpg
    |   |   |       111119b-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111119b-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111119b-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111119b-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111119b-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111119b-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       111119b-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111119b-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111119b-6156-RPH.jpg
    |   |   |       111119b-6156-trajectory.jpg
    |   |   |
    |   |   +---111120a
    |   |   |       111120a-6156-calibration@CON-#ofsats.jpg
    |   |   |       111120a-6156-calibration@CON-basecoordinate.jpg
    |   |   |       111120a-6156-calibration@CON-positionaccuracy&PDOP-
noGLONASS-10deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionaccuracy&PDOP-
noGLONASS-15deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionaccuracy&PDOP-
withGLONASS-10deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionaccuracy&PDOP-
withGLONASS-15deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionseparation-
noGLONASS-10deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionseparation-
noGLONASS-15deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionseparation-
withGLONASS-10deg.jpg
    |   |   |       111120a-6156-calibration@CON-positionseparation-
withGLONASS-15deg.jpg
    |   |   |       111120a-6156-calibration@CON-RPH.jpg
    |   |   |       111120a-6156-calibration@CON-trajectory.jpg
    |   |   |
    |   |   +---111121a
    |   |   |       111121a-6156-#ofsats.jpg
    |   |   |       111121a-6156-basecoordinate.jpg
    |   |   |       111121a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111121a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111121a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111121a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111121a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111121a-6156-positionseparation-noGLONASS-15deg.jpg
```

```
    |   |   |       111121a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111121a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111121a-6156-RPH.jpg
    |   |   |       111121a-6156-trajectory.jpg
    |   |   |
    |   |   +---111218a
    |   |   |       111218a-6156-#ofsats.jpg
    |   |   |       111218a-6156-basecoordinate.jpg
    |   |   |       111218a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111218a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111218a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111218a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111218a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111218a-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       111218a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111218a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111218a-6156-RPH.jpg
    |   |   |       111218a-6156-trajectory.jpg
    |   |   |
    |   |   +---111218b
    |   |   |       111218b-6156-#ofsats.jpg
    |   |   |       111218b-6156-basecoordinate.jpg
    |   |   |       111218b-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111218b-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111218b-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111218b-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111218b-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111218b-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       111218b-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111218b-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111218b-6156-RPH.jpg
    |   |   |       111218b-6156-trajectory.jpg
    |   |   |
    |   |   +---111219a
    |   |   |       111219a-6156-#ofsats.jpg
    |   |   |       111219a-6156-basecoordinate.jpg
    |   |   |       111219a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111219a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111219a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111219a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111219a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111219a-6156-positionseparation-noGLONASS-15deg.jpg
```

```
    |   |   |       111219a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111219a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111219a-6156-RPH.jpg
    |   |   |       111219a-6156-trajectory.jpg
    |   |   |
    |   |   +---111219b
    |   |   |       111219b-6156-#ofsats.jpg
    |   |   |       111219b-6156-basecoordinate.jpg
    |   |   |       111219b-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       111219b-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       111219b-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       111219b-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       111219b-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       111219b-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       111219b-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       111219b-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       111219b-6156-RPH.jpg
    |   |   |       111219b-6156-trajectory.jpg
    |   |   |
    |   |   +---120107a
    |   |   |       120107a&b-6156-ABGPSlog.jpg
    |   |   |       120107a-6156-#ofsats.jpg
    |   |   |       120107a-6156-basecoordinate.jpg
    |   |   |       120107a-6156-inplaneflightlog.jpg
    |   |   |       120107a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       120107a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       120107a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       120107a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       120107a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       120107a-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       120107a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       120107a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       120107a-6156-RPH.jpg
    |   |   |       120107a-6156-trajectory.jpg
    |   |   |       120107b-6156-inplaneflightlog.jpg
    |   |   |
    |   |   +---120109a
    |   |   |       120109a-6156-#ofsats.jpg
    |   |   |       120109a-6156-basecoordinate.jpg
    |   |   |       120109a-6156-inplaneflightlog-1of2.jpg
    |   |   |       120109a-6156-inplaneflightlog-2of2.jpg
    |   |   |       120109a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       120109a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
```

```
    |   |   |       120109a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       120109a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       120109a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       120109a-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       120109a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       120109a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       120109a-6156-RPH.jpg
    |   |   |       120109a-6156-trajectory.jpg
    |   |   |       120109ab-6156-ABGPSlog.jpg
    |   |   |
    |   |   +---120109b
    |   |   |       120109b-6156-#ofsats.jpg
    |   |   |       120109b-6156-basecoordinate.jpg
    |   |   |       120109b-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       120109b-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       120109b-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       120109b-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       120109b-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       120109b-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       120109b-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       120109b-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       120109b-6156-RPH.jpg
    |   |   |       120109b-6156-trajectory.jpg
    |   |   |
    |   |   +---120111a
    |   |   |       120111a-6156-#ofsats.jpg
    |   |   |       120111a-6156-ABGPSlog.jpg
    |   |   |       120111a-6156-basecoordinate.jpg
    |   |   |       120111a-6156-inplaneflightlog.jpg
    |   |   |       120111a-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |   |       120111a-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |   |       120111a-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |   |       120111a-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |   |       120111a-6156-positionseparation-noGLONASS-10deg.jpg
    |   |   |       120111a-6156-positionseparation-noGLONASS-15deg.jpg
    |   |   |       120111a-6156-positionseparation-withGLONASS-10deg.jpg
    |   |   |       120111a-6156-positionseparation-withGLONASS-15deg.jpg
    |   |   |       120111a-6156-RPH.jpg
    |   |   |       120111a-6156-trajectory.jpg
    |   |   |
    |   |   \---120111b
    |   |           120111b-6156-#ofsats.jpg
    |   |           120111b-6156-ABGPSlog.jpg
    |   |           120111b-6156-basecoordinate.jpg
```

```
    |   |           120111b-6156-inplaneflightlog-1of2.jpg
    |   |           120111b-6156-inplaneflightlog-2of2.jpg
    |   |           120111b-6156-positionaccuracy&PDOP-noGLONASS-
10deg.jpg
    |   |           120111b-6156-positionaccuracy&PDOP-noGLONASS-
15deg.jpg
    |   |           120111b-6156-positionaccuracy&PDOP-withGLONASS-
10deg.jpg
    |   |           120111b-6156-positionaccuracy&PDOP-withGLONASS-
15deg.jpg
    |   |           120111b-6156-positionseparation-noGLONASS-10deg.jpg
    |   |           120111b-6156-positionseparation-noGLONASS-15deg.jpg
    |   |           120111b-6156-positionseparation-withGLONASS-10deg.jpg
    |   |           120111b-6156-positionseparation-withGLONASS-15deg.jpg
    |   |           120111b-6156-RPH.jpg
    |   |           120111b-6156-trajectory.jpg
    |   |
    |   \---Appendix D - Calibration Information
    |           111029a-6156-calibrationcheck.xml
    |
    +---Merrimack_Collection_Area
    |       Merrimack_Collection_Area.dbf
    |       Merrimack_Collection_Area.prj
    |       Merrimack_Collection_Area.sbn
    |       Merrimack_Collection_Area.sbx
    |       Merrimack_Collection_Area.shp
    |       Merrimack_Collection_Area.shp.xml
    |       Merrimack_Collection_Area.shx
    |
    +---Merrimack_FVA_CVA
    |   +---01_Final_Statistics
    |   |       TheAccuracyReport_11_10_2011.pdf
    |   |       TheAccuracyReport_11_10_2011_Merrimack.pdf
    |   |       TheAccuracyReport_11_14_2011.pdf
    |   |       TheAccuracyReport_11_14_2011_Merrimack.pdf
    |   |       TheAccuracyReport_11_15_2011.pdf
    |   |       TheAccuracyReport_11_15_2011_Merrimack.pdf
    |   |       TheAccuracyReport_11_16_2011.pdf
    |   |       TheAccuracyReport_11_16_2011_Merrimack.pdf
    |   |       TheAccuracyReport_11_17_2011.pdf
    |   |       TheAccuracyReport_11_17_2011_Merrimack.pdf
    |   |       TheAccuracyReport_11_18_2011.pdf
    |   |       TheAccuracyReport_11_18_2011_Merrimack--ONLY_VERTICAL.pdf
    |   |       TheAccuracyReport_11_20_2011.pdf
    |   |       TheAccuracyReport_11_20_2011_Merrimack--ONLY VERTICAL.pdf
    |   |
    |   +---02_Final_Image_Chips
    |   |   +---CVAs
    |   |   |       MER401_c.jpg
    |   |   |       MER402_c.jpg
    |   |   |       MER404_c.jpg
    |   |   |       MER405_c.jpg
    |   |   |       MER406_c.jpg
    |   |   |       MER407_c.jpg
```

```
|    |    |        MER408_c.jpg
|    |    |        MER409_c.jpg
|    |    |        MER410_c.jpg
|    |    |        MER411_c.jpg
|    |    |        MER412_c.jpg
|    |    |        MER413_c.jpg
|    |    |        MER414_c.jpg
|    |    |        MER415_c.jpg
|    |    |        MER416_c.jpg
|    |    |        MER417_c.jpg
|    |    |        MER418_c.jpg
|    |    |        MER419_c.jpg
|    |    |        MER420_c.jpg
|    |    |        MER421A_c.jpg
|    |    |        MER421_c.jpg
|    |    |        MER701_c.jpg
|    |    |        MER702B_c.jpg
|    |    |        MER702_c.jpg
|    |    |        MER703B_c.jpg
|    |    |        MER703_c.jpg
|    |    |        MER704A_c.jpg
|    |    |        MER704_c.jpg
|    |    |        MER705_c.jpg
|    |    |        MER706A_c.jpg
|    |    |        MER706_c.jpg
|    |    |        MER707A_c.jpg
|    |    |        MER707_c.jpg
|    |    |        MER708A_c.jpg
|    |    |        MER708_c.jpg
|    |    |        MER709A_c.jpg
|    |    |        MER709_c.jpg
|    |    |        MER710_c.jpg
|    |    |        MER711A_c.jpg
|    |    |        MER711_c.jpg
|    |    |        MER712A_c.jpg
|    |    |        MER712_c.jpg
|    |    |        MER713A_c.jpg
|    |    |        MER713_c.jpg
|    |    |        MER714A_c.jpg
|    |    |        MER714_c.jpg
|    |    |        MER715_c.jpg
|    |    |        MER716A_c.jpg
|    |    |        MER717_c.jpg
|    |    |        MER718_c.jpg
|    |    |        MER719A_c.jpg
|    |    |        MER719_c.jpg
|    |    |        MER720A_c.jpg
|    |    |        MER720_c.jpg
|    |    |        MER721_c.jpg
|    |    |        MER801_c.jpg
|    |    |        MER802A_c.jpg
|    |    |        MER802_c.jpg
|    |    |        MER803_c.jpg
|    |    |        MER804_c.jpg
```

```
|   |   |       MER805_c.jpg
|   |   |       MER806_c.jpg
|   |   |       MER807_c.jpg
|   |   |       MER808_c.jpg
|   |   |       MER809_c.jpg
|   |   |       MER810_c.jpg
|   |   |       MER811_c.jpg
|   |   |       MER812_c.jpg
|   |   |       MER813_c.jpg
|   |   |       MER814_c.jpg
|   |   |       MER815_c.jpg
|   |   |       MER816_c.jpg
|   |   |       MER817_c.jpg
|   |   |       MER818_c.jpg
|   |   |       MER819_c.jpg
|   |   |       MER820_c.jpg
|   |   |
|   |   \---FVAs
|   |           MER301_c.jpg
|   |           MER302_c.jpg
|   |           MER303_c.jpg
|   |           MER304_c.jpg
|   |           MER305_c.jpg
|   |           MER306_c.jpg
|   |           MER307_c.jpg
|   |           MER308_c.jpg
|   |           MER309_c.jpg
|   |           MER310_c.jpg
|   |           MER311_c.jpg
|   |           MER312_c.jpg
|   |           MER313_c.jpg
|   |           MER314_c.jpg
|   |           MER315_c.jpg
|   |           MER316_c.jpg
|   |           MER317_c.jpg
|   |           MER318_c.jpg
|   |           MER319_c.jpg
|   |           MER320_c.jpg
|   |
|   +---03_Final_Pictures
|   |   |   Thumbs.db
|   |   |
|   |   +---CVAs
|   |   |       MER401_E.JPG
|   |   |       MER401_N.JPG
|   |   |       MER401_S.JPG
|   |   |       MER401_W.JPG
|   |   |       MER402_E.JPG
|   |   |       MER402_N.JPG
|   |   |       MER402_S.JPG
|   |   |       MER402_W.JPG
|   |   |       MER404_E.JPG
|   |   |       MER404_N.JPG
|   |   |       MER404_S.JPG
```

```
|    |    |        MER404_W.JPG
|    |    |        MER405_E.JPG
|    |    |        MER405_N.JPG
|    |    |        MER405_S.JPG
|    |    |        MER405_W.JPG
|    |    |        MER406_E.JPG
|    |    |        MER406_N.JPG
|    |    |        MER406_S.JPG
|    |    |        MER406_W.JPG
|    |    |        MER407_E.JPG
|    |    |        MER407_N.JPG
|    |    |        MER407_S.JPG
|    |    |        MER407_W.JPG
|    |    |        MER408_E.JPG
|    |    |        MER408_N.JPG
|    |    |        MER408_S.JPG
|    |    |        MER408_W.JPG
|    |    |        MER409_E.JPG
|    |    |        MER409_N.JPG
|    |    |        MER409_S.JPG
|    |    |        MER409_W.JPG
|    |    |        MER410_E.JPG
|    |    |        MER410_N.JPG
|    |    |        MER410_S.JPG
|    |    |        MER410_W.JPG
|    |    |        MER411_E.JPG
|    |    |        MER411_N.JPG
|    |    |        MER411_S.JPG
|    |    |        MER411_W.JPG
|    |    |        MER412_E.JPG
|    |    |        MER412_N.JPG
|    |    |        MER412_S.JPG
|    |    |        MER412_W.JPG
|    |    |        MER413_E.JPG
|    |    |        MER413_N.JPG
|    |    |        MER413_S.JPG
|    |    |        MER413_W.JPG
|    |    |        MER414_E.JPG
|    |    |        MER414_N.JPG
|    |    |        MER414_S.JPG
|    |    |        MER414_W.JPG
|    |    |        MER415_E.JPG
|    |    |        MER415_N.JPG
|    |    |        MER415_S.JPG
|    |    |        MER415_W.JPG
|    |    |        MER416_E.JPG
|    |    |        MER416_N.JPG
|    |    |        MER416_S.JPG
|    |    |        MER416_W.JPG
|    |    |        MER417_E.JPG
|    |    |        MER417_N.JPG
|    |    |        MER417_S.JPG
|    |    |        MER417_W.JPG
|    |    |        MER418_E.JPG
```

```
|    |    |        MER418_N.JPG
|    |    |        MER418_S.JPG
|    |    |        MER418_W.JPG
|    |    |        MER419_E.JPG
|    |    |        MER419_N.JPG
|    |    |        MER419_S.JPG
|    |    |        MER419_W.JPG
|    |    |        MER420_E.JPG
|    |    |        MER420_N.JPG
|    |    |        MER420_S.JPG
|    |    |        MER420_W.JPG
|    |    |        MER421A_E.JPG
|    |    |        MER421A_N.JPG
|    |    |        MER421A_S.JPG
|    |    |        MER421A_W.JPG
|    |    |        MER421_E.JPG
|    |    |        MER421_N.JPG
|    |    |        MER421_S.JPG
|    |    |        MER421_W.JPG
|    |    |        MER701_E.JPG
|    |    |        MER701_N.JPG
|    |    |        MER701_S.JPG
|    |    |        MER701_W.JPG
|    |    |        MER702B_E.JPG
|    |    |        MER702B_N.JPG
|    |    |        MER702B_S.JPG
|    |    |        MER702B_W.JPG
|    |    |        MER702_E.JPG
|    |    |        MER702_N.JPG
|    |    |        MER702_S.JPG
|    |    |        MER702_W.JPG
|    |    |        MER703B_E.JPG
|    |    |        MER703B_N.JPG
|    |    |        MER703B_S.JPG
|    |    |        MER703B_W.JPG
|    |    |        MER703_E.JPG
|    |    |        MER703_N.JPG
|    |    |        MER703_S.JPG
|    |    |        MER703_W.JPG
|    |    |        MER704A_E.JPG
|    |    |        MER704A_N.JPG
|    |    |        MER704A_S.JPG
|    |    |        MER704A_W.JPG
|    |    |        MER704_E.JPG
|    |    |        MER704_N.JPG
|    |    |        MER704_S.JPG
|    |    |        MER704_W.JPG
|    |    |        MER705_E.JPG
|    |    |        MER705_N.JPG
|    |    |        MER705_S.JPG
|    |    |        MER705_W.JPG
|    |    |        MER706A_E.JPG
|    |    |        MER706A_N.JPG
|    |    |        MER706A_S.JPG
```

```
|    |    |        MER706A_W.JPG
|    |    |        MER706_E.JPG
|    |    |        MER706_N.JPG
|    |    |        MER706_S.JPG
|    |    |        MER706_W.JPG
|    |    |        MER707A_E.JPG
|    |    |        MER707A_N.JPG
|    |    |        MER707A_S.JPG
|    |    |        MER707A_W.JPG
|    |    |        MER707_E.JPG
|    |    |        MER707_N.JPG
|    |    |        MER707_S.JPG
|    |    |        MER707_W.JPG
|    |    |        MER708A_E.JPG
|    |    |        MER708A_N.JPG
|    |    |        MER708A_S.JPG
|    |    |        MER708A_W.JPG
|    |    |        MER708_E.JPG
|    |    |        MER708_N.JPG
|    |    |        MER708_S.JPG
|    |    |        MER708_W.JPG
|    |    |        MER709A_E.JPG
|    |    |        MER709A_N.JPG
|    |    |        MER709A_S.JPG
|    |    |        MER709A_W.JPG
|    |    |        MER709_E.JPG
|    |    |        MER709_N.JPG
|    |    |        MER709_S.JPG
|    |    |        MER709_W.JPG
|    |    |        MER710_E.JPG
|    |    |        MER710_N.JPG
|    |    |        MER710_S.JPG
|    |    |        MER710_W.JPG
|    |    |        MER711A_E.JPG
|    |    |        MER711A_N.JPG
|    |    |        MER711A_S.JPG
|    |    |        MER711A_W.JPG
|    |    |        MER711_E.JPG
|    |    |        MER711_N.JPG
|    |    |        MER711_S.JPG
|    |    |        MER711_W.JPG
|    |    |        MER712A_E.JPG
|    |    |        MER712A_N.JPG
|    |    |        MER712A_S.JPG
|    |    |        MER712A_W.JPG
|    |    |        MER712_E.JPG
|    |    |        MER712_N.JPG
|    |    |        MER712_S.JPG
|    |    |        MER712_W.JPG
|    |    |        MER713A_E.JPG
|    |    |        MER713A_N.JPG
|    |    |        MER713A_S.JPG
|    |    |        MER713A_W.JPG
|    |    |        MER713_E.JPG
```

```
|    |    |        MER713_N.JPG
|    |    |        MER713_S.JPG
|    |    |        MER713_W.JPG
|    |    |        MER714A_E.JPG
|    |    |        MER714A_N.JPG
|    |    |        MER714A_S.JPG
|    |    |        MER714A_W.JPG
|    |    |        MER714_E.JPG
|    |    |        MER714_N.JPG
|    |    |        MER714_S.JPG
|    |    |        MER714_W.JPG
|    |    |        MER715_E.JPG
|    |    |        MER715_N.JPG
|    |    |        MER715_S.JPG
|    |    |        MER715_W.JPG
|    |    |        MER716A_E.JPG
|    |    |        MER716A_N.JPG
|    |    |        MER716A_S.JPG
|    |    |        MER716A_W.JPG
|    |    |        MER717_E.JPG
|    |    |        MER717_N.JPG
|    |    |        MER717_S.JPG
|    |    |        MER717_W.JPG
|    |    |        MER718_E.JPG
|    |    |        MER718_N.JPG
|    |    |        MER718_S.JPG
|    |    |        MER718_W.JPG
|    |    |        MER719_E.JPG
|    |    |        MER719_N.JPG
|    |    |        MER719_S.JPG
|    |    |        MER719_W.JPG
|    |    |        MER720A_E.JPG
|    |    |        MER720A_N.JPG
|    |    |        MER720A_S.JPG
|    |    |        MER720A_W.JPG
|    |    |        MER720_E.JPG
|    |    |        MER720_N.JPG
|    |    |        MER720_S.JPG
|    |    |        MER720_W.JPG
|    |    |        MER721_E.JPG
|    |    |        MER721_N.JPG
|    |    |        MER721_S.JPG
|    |    |        MER721_W.JPG
|    |    |        MER801_E.JPG
|    |    |        MER801_N.JPG
|    |    |        MER801_S.JPG
|    |    |        MER801_W.JPG
|    |    |        MER802A_E.JPG
|    |    |        MER802A_N.JPG
|    |    |        MER802A_S.JPG
|    |    |        MER802A_W.JPG
|    |    |        MER802_E.JPG
|    |    |        MER802_N.JPG
|    |    |        MER802_S.JPG
```

```
|    |    |        MER802_W.JPG
|    |    |        MER803_E.JPG
|    |    |        MER803_N.JPG
|    |    |        MER803_S.JPG
|    |    |        MER803_W.JPG
|    |    |        MER804_E.JPG
|    |    |        MER804_N.JPG
|    |    |        MER804_S.JPG
|    |    |        MER804_W.JPG
|    |    |        MER805_E.JPG
|    |    |        MER805_N.JPG
|    |    |        MER805_S.JPG
|    |    |        MER805_W.JPG
|    |    |        MER806_E.JPG
|    |    |        MER806_N.JPG
|    |    |        MER806_S.JPG
|    |    |        MER806_W.JPG
|    |    |        MER807_E.JPG
|    |    |        MER807_N.JPG
|    |    |        MER807_S.JPG
|    |    |        MER807_W.JPG
|    |    |        MER808_E.JPG
|    |    |        MER808_N.JPG
|    |    |        MER808_S.JPG
|    |    |        MER808_W.JPG
|    |    |        MER809_E.JPG
|    |    |        MER809_N.JPG
|    |    |        MER809_S.JPG
|    |    |        MER809_W.JPG
|    |    |        MER810_E.JPG
|    |    |        MER810_N.JPG
|    |    |        MER810_S.JPG
|    |    |        MER810_W.JPG
|    |    |        MER811_E.JPG
|    |    |        MER811_N.JPG
|    |    |        MER811_S.JPG
|    |    |        MER811_W.JPG
|    |    |        MER812_E.JPG
|    |    |        MER812_N.JPG
|    |    |        MER812_S.JPG
|    |    |        MER812_W.JPG
|    |    |        MER813_E.JPG
|    |    |        MER813_N.JPG
|    |    |        MER813_S.JPG
|    |    |        MER813_W.JPG
|    |    |        MER814_E.JPG
|    |    |        MER814_N.JPG
|    |    |        MER814_S.JPG
|    |    |        MER814_W.JPG
|    |    |        MER815_E.JPG
|    |    |        MER815_N.JPG
|    |    |        MER815_S.JPG
|    |    |        MER815_W.JPG
|    |    |        MER816_E.JPG
```

```
|   |   |       MER816_N.JPG
|   |   |       MER816_S.JPG
|   |   |       MER816_W.JPG
|   |   |       MER817_E.JPG
|   |   |       MER817_N.JPG
|   |   |       MER817_S.JPG
|   |   |       MER817_W.JPG
|   |   |       MER818_E.JPG
|   |   |       MER818_N.JPG
|   |   |       MER818_S.JPG
|   |   |       MER818_W.JPG
|   |   |       MER819_E.JPG
|   |   |       MER819_N.JPG
|   |   |       MER819_S.JPG
|   |   |       MER819_W.JPG
|   |   |       MER820_E.JPG
|   |   |       MER820_N.JPG
|   |   |       MER820_S.JPG
|   |   |       MER820_W.JPG
|   |   |       Thumbs.db
|   |   |
|   |   \---FVAs
|   |           MER301_E.JPG
|   |           MER301_N.JPG
|   |           MER301_S.JPG
|   |           MER301_W.JPG
|   |           MER302_E.JPG
|   |           MER302_N.JPG
|   |           MER302_S.JPG
|   |           MER302_W.JPG
|   |           MER303_E.JPG
|   |           MER303_N.JPG
|   |           MER303_S.JPG
|   |           MER303_W.JPG
|   |           MER304_E.JPG
|   |           MER304_N.JPG
|   |           MER304_S.JPG
|   |           MER304_W.JPG
|   |           MER305_E.JPG
|   |           MER305_N.JPG
|   |           MER305_S.JPG
|   |           MER305_W.JPG
|   |           MER306_E.JPG
|   |           MER306_N.JPG
|   |           MER306_S.JPG
|   |           MER306_W.JPG
|   |           MER307_E.JPG
|   |           MER307_N.JPG
|   |           MER307_S.JPG
|   |           MER307_W.JPG
|   |           MER308_E.JPG
|   |           MER308_N.JPG
|   |           MER308_S.JPG
|   |           MER308_W.JPG
```

```
|   |           MER309_E.JPG
|   |           MER309_N.JPG
|   |           MER309_S.JPG
|   |           MER309_W.JPG
|   |           MER310_E.JPG
|   |           MER310_N.JPG
|   |           MER310_S.JPG
|   |           MER310_W.JPG
|   |           MER311_E.JPG
|   |           MER311_N.JPG
|   |           MER311_S.JPG
|   |           MER311_W.JPG
|   |           MER312_E.JPG
|   |           MER312_N.JPG
|   |           MER312_S.JPG
|   |           MER312_W.JPG
|   |           MER313_E.JPG
|   |           MER313_N.JPG
|   |           MER313_S.JPG
|   |           MER313_W.JPG
|   |           MER314_E.JPG
|   |           MER314_N.JPG
|   |           MER314_S.JPG
|   |           MER314_W.JPG
|   |           MER315_E.JPG
|   |           MER315_N.JPG
|   |           MER315_S.JPG
|   |           MER315_W.JPG
|   |           MER316_E.JPG
|   |           MER316_N.JPG
|   |           MER316_S.JPG
|   |           MER316_W.JPG
|   |           MER317_E.JPG
|   |           MER317_N.JPG
|   |           MER317_S.JPG
|   |           MER317_W.JPG
|   |           MER318_E.JPG
|   |           MER318_N.JPG
|   |           MER318_S.JPG
|   |           MER318_W.JPG
|   |           MER319_E.JPG
|   |           MER319_N.JPG
|   |           MER319_S.JPG
|   |           MER319_W.JPG
|   |           MER320_E.JPG
|   |           MER320_N.JPG
|   |           MER320_S.JPG
|   |           MER320_W.JPG
|   |           Thumbs.db
|   |
|   +---04_Final_GeoFiles
|   |   +---CVAs
|   |   |       Merrimack_CVA_NAD83.dbf
|   |   |       Merrimack_CVA_NAD83.kmz
```

```
    |   |   |       Merrimack_CVA_NAD83.prj
    |   |   |       Merrimack_CVA_NAD83.sbn
    |   |   |       Merrimack_CVA_NAD83.sbx
    |   |   |       Merrimack_CVA_NAD83.shp
    |   |   |       Merrimack_CVA_NAD83.shx
    |   |   |
    |   |   \---FVAs
    |   |           Merrimack_FVA_NAD83.dbf
    |   |           Merrimack_FVA_NAD83.kmz
    |   |           Merrimack_FVA_NAD83.prj
    |   |           Merrimack_FVA_NAD83.sbn
    |   |           Merrimack_FVA_NAD83.sbx
    |   |           Merrimack_FVA_NAD83.shp
    |   |           Merrimack_FVA_NAD83.shx
    |   |
    |   +---05_Final_Report
    |   |       Final_Report FEMA Region 1.doc
    |   |
    |   +---06_Final_Coordinates
    |   |       Merrimack_CVA_NAD83.xls
    |   |       Merrimack_CVA_NAD83_No_Elevations.xls
    |   |       Merrimack_FVA_NAD83.xls
    |   |       Merrimack_FVA_NAD83_No_Elevations.xls
    |   |
    |   \---08_Testing
    |           Compliance Form Merrimack.pdf
    |           Merrimack_CVA_NAD83_Passed.xls
    |           Merrimack_Distribution.jpg
    |           Merrimack_FVA_NAD83_Passed.xls
    |           Region 1 Merrimack Testing Results FVA CVA.doc
    |           Region 1 Merrimack Testing Results FVA CVA.pdf
    |
    +---Merrimack_Ground_Control
    |   \---01_Control
    |       +---01_Final_Statistics
    |       |       TheAccuracyReport_11_10_2011.pdf
    |       |       TheAccuracyReport_11_10_2011_Merrimack.pdf
    |       |       TheAccuracyReport_11_14_2011.pdf
    |       |       TheAccuracyReport_11_14_2011_Merrimack.pdf
    |       |       TheAccuracyReport_11_15_2011.pdf
    |       |       TheAccuracyReport_11_15_2011_Merrimack.pdf
    |       |       TheAccuracyReport_11_16_2011.pdf
    |       |       TheAccuracyReport_11_16_2011_Merrimack.pdf
    |       |       TheAccuracyReport_11_17_2011.pdf
    |       |       TheAccuracyReport_11_17_2011_Merrimack.pdf
    |       |       TheAccuracyReport_11_18_2011.pdf
    |       |       TheAccuracyReport_11_18_2011_Merrimack--
ONLY_VERTICAL.pdf
    |       |       TheAccuracyReport_11_20_2011.pdf
    |       |       TheAccuracyReport_11_20_2011_Merrimack--ONLY
VERTICAL.pdf
    |       |
    |       +---02_Final_Image_Chips
    |       |       MER101_c.jpg
```

```
|       |       MER102_c.jpg
|       |       MER103_c.jpg
|       |       MER104_c.jpg
|       |       MER105_c.jpg
|       |       MER106_c.jpg
|       |       MER107_c.jpg
|       |       MER108_c.jpg
|       |       MER109_c.jpg
|       |       MER110_c.jpg
|       |       MER111_c.jpg
|       |       MER112_c.jpg
|       |       MER113_c.jpg
|       |       MER114_c.jpg
|       |       MER115_c.jpg
|       |       MER116_c.jpg
|       |       MER117_c.jpg
|       |       MER118_c.jpg
|       |       MER119_c.jpg
|       |       MER120_c.jpg
|       |       MER121_c.jpg
|       |       MER122_c.jpg
|       |       MER123_c.jpg
|       |       MER124_c.jpg
|       |       MER125_c.jpg
|       |       MER126_c.jpg
|       |       MER127_c.jpg
|       |       MER128A_c.jpg
|       |       MER129A_c.jpg
|       |       MER130_c.jpg
|       |       MER131_c.jpg
|       |       MER132_c.jpg
|       |       MER133_c.jpg
|       |       MER134_c.jpg
|       |       MER135_c.jpg
|       |       MER136_c.jpg
|       |       MER137_c.jpg
|       |       MER138_c.jpg
|       |       MER139_c.jpg
|       |       MER140_c.jpg
|       |       MER141_c.jpg
|       |       MER142_c.jpg
|       |       MER143_c.jpg
|       |       MER144_c.jpg
|       |       MER145_c.jpg
|       |       MER146_c.jpg
|       |       MER147_c.jpg
|       |       MER148_c.jpg
|       |       MER149_c.jpg
|       |       MER150_c.jpg
|       |       MER151A_c.jpg
|       |       MER151_c.jpg
|       |       MER152A_c.jpg
|       |       MER152_c.jpg
|       |       MER153A_c.jpg
```

```
|       |       MER153_c.jpg
|       |       MER154_c.jpg
|       |       MER155_c.jpg
|       |       MER156_c.jpg
|       |       MER157_c.jpg
|       |       MER158A_c.jpg
|       |       MER158_c.jpg
|       |       MER159_c.jpg
|       |       MER160_c.jpg
|       |       MER161_c.jpg
|       |       MER162_c.jpg
|       |       MER163_c.jpg
|       |       MER164_c.jpg
|       |       MER165_c.jpg
|       |       MER166_c.jpg
|       |       MER167_c.jpg
|       |       MER168A_c.jpg
|       |       MER169A_c.jpg
|       |       MER169_c.jpg
|       |       MER170_c.jpg
|       |       MER171A_c.jpg
|       |       MER171_c.jpg
|       |       MER172_c.jpg
|       |       MER173_c.jpg
|       |       MER174_c.jpg
|       |       MER175_c.jpg
|       |       Thumbs.db
|       |
|       +---03_Final_Pictures
|       |       MER101_E.JPG
|       |       MER101_N.JPG
|       |       MER101_S.JPG
|       |       MER101_W.JPG
|       |       MER102_E.JPG
|       |       MER102_N.JPG
|       |       MER102_S.JPG
|       |       MER102_W.JPG
|       |       MER103_E.JPG
|       |       MER103_N.JPG
|       |       MER103_S.JPG
|       |       MER103_W.JPG
|       |       MER104_E.JPG
|       |       MER104_N.JPG
|       |       MER104_S.JPG
|       |       MER104_W.JPG
|       |       MER105_E.JPG
|       |       MER105_N.JPG
|       |       MER105_S.JPG
|       |       MER105_W.JPG
|       |       MER106_E.JPG
|       |       MER106_N.JPG
|       |       MER106_S.JPG
|       |       MER106_W.JPG
|       |       MER107_E.JPG
```

```
|       |       MER107_N.JPG
|       |       MER107_S.JPG
|       |       MER107_W.JPG
|       |       MER108_E.JPG
|       |       MER108_N.JPG
|       |       MER108_S.JPG
|       |       MER108_W.JPG
|       |       MER109_E.JPG
|       |       MER109_N.JPG
|       |       MER109_S.JPG
|       |       MER109_W.JPG
|       |       MER110_E.JPG
|       |       MER110_N.JPG
|       |       MER110_S.JPG
|       |       MER110_W.JPG
|       |       MER111_E.JPG
|       |       MER111_N.JPG
|       |       MER111_S.JPG
|       |       MER111_W.JPG
|       |       MER112_E.JPG
|       |       MER112_N.JPG
|       |       MER112_S.JPG
|       |       MER112_W.JPG
|       |       MER113_E.JPG
|       |       MER113_N.JPG
|       |       MER113_S.JPG
|       |       MER113_W.JPG
|       |       MER114_E.JPG
|       |       MER114_N.JPG
|       |       MER114_S.JPG
|       |       MER114_W.JPG
|       |       MER115_E.JPG
|       |       MER115_N.JPG
|       |       MER115_S.JPG
|       |       MER115_W.JPG
|       |       MER116_E.JPG
|       |       MER116_N.JPG
|       |       MER116_S.JPG
|       |       MER116_W.JPG
|       |       MER117_E.JPG
|       |       MER117_N.JPG
|       |       MER117_S.JPG
|       |       MER117_W.JPG
|       |       MER118_E.JPG
|       |       MER118_N.JPG
|       |       MER118_S.JPG
|       |       MER118_W.JPG
|       |       MER119_E.JPG
|       |       MER119_N.JPG
|       |       MER119_S.JPG
|       |       MER119_W.JPG
|       |       MER120_E.JPG
|       |       MER120_N.JPG
|       |       MER120_S.JPG
```

```
|       |       MER120_W.JPG
|       |       MER121_E.JPG
|       |       MER121_N.JPG
|       |       MER121_S.JPG
|       |       MER121_W.JPG
|       |       MER122_E.JPG
|       |       MER122_N.JPG
|       |       MER122_S.JPG
|       |       MER122_W.JPG
|       |       MER123_E.JPG
|       |       MER123_N.JPG
|       |       MER123_S.JPG
|       |       MER123_W.JPG
|       |       MER124_E.JPG
|       |       MER124_N.JPG
|       |       MER124_S.JPG
|       |       MER124_W.JPG
|       |       MER125_E.JPG
|       |       MER125_N.JPG
|       |       MER125_S.JPG
|       |       MER125_W.JPG
|       |       MER126_E.JPG
|       |       MER126_N.JPG
|       |       MER126_S.JPG
|       |       MER126_W.JPG
|       |       MER127_E.JPG
|       |       MER127_N.JPG
|       |       MER127_S.JPG
|       |       MER127_W.JPG
|       |       MER128_E.JPG
|       |       MER128_N.JPG
|       |       MER128_S.JPG
|       |       MER128_W.JPG
|       |       MER129_E.JPG
|       |       MER129_N.JPG
|       |       MER129_S.JPG
|       |       MER129_W.JPG
|       |       MER130_E.JPG
|       |       MER130_N.JPG
|       |       MER130_S.JPG
|       |       MER130_W.JPG
|       |       MER131_E.JPG
|       |       MER131_N.JPG
|       |       MER131_S.JPG
|       |       MER131_W.JPG
|       |       MER132_E.JPG
|       |       MER132_N.JPG
|       |       MER132_S.JPG
|       |       MER132_W.JPG
|       |       MER133_E.JPG
|       |       MER133_N.JPG
|       |       MER133_S.JPG
|       |       MER133_W.JPG
|       |       MER134_E.JPG
```

```
|       |      MER134_N.JPG
|       |      MER134_S.JPG
|       |      MER134_W.JPG
|       |      MER135_E.JPG
|       |      MER135_N.JPG
|       |      MER135_S.JPG
|       |      MER135_W.JPG
|       |      MER136_E.JPG
|       |      MER136_N.JPG
|       |      MER136_S.JPG
|       |      MER136_W.JPG
|       |      MER137_E.JPG
|       |      MER137_N.JPG
|       |      MER137_S.JPG
|       |      MER137_W.JPG
|       |      MER138_E.JPG
|       |      MER138_N.JPG
|       |      MER138_S.JPG
|       |      MER138_W.JPG
|       |      MER139_E.JPG
|       |      MER139_N.JPG
|       |      MER139_S.JPG
|       |      MER139_W.JPG
|       |      MER140_E.JPG
|       |      MER140_N.JPG
|       |      MER140_S.JPG
|       |      MER140_W.JPG
|       |      MER141_E.JPG
|       |      MER141_N.JPG
|       |      MER141_S.JPG
|       |      MER141_W.JPG
|       |      MER142_E.JPG
|       |      MER142_N.JPG
|       |      MER142_S.JPG
|       |      MER142_W.JPG
|       |      MER143_E.JPG
|       |      MER143_N.JPG
|       |      MER143_S.JPG
|       |      MER143_W.JPG
|       |      MER144_E.JPG
|       |      MER144_N.JPG
|       |      MER144_S.JPG
|       |      MER144_W.JPG
|       |      MER145_E.JPG
|       |      MER145_N.JPG
|       |      MER145_S.JPG
|       |      MER145_W.JPG
|       |      MER146_E.JPG
|       |      MER146_N.JPG
|       |      MER146_S.JPG
|       |      MER146_W.JPG
|       |      MER147_E.JPG
|       |      MER147_N.JPG
|       |      MER147_S.JPG
```

```
|       |       MER147_W.JPG
|       |       MER148_E.JPG
|       |       MER148_N.JPG
|       |       MER148_S.JPG
|       |       MER148_W.JPG
|       |       MER149_E.JPG
|       |       MER149_N.JPG
|       |       MER149_S.JPG
|       |       MER149_W.JPG
|       |       MER150_E.JPG
|       |       MER150_N.JPG
|       |       MER150_S.JPG
|       |       MER150_W.JPG
|       |       MER151_E.JPG
|       |       MER151_N.JPG
|       |       MER151_S.JPG
|       |       MER151_W.JPG
|       |       MER152_E (2).JPG
|       |       MER152_E.JPG
|       |       MER152_N (2).JPG
|       |       MER152_N.JPG
|       |       MER152_S (2).JPG
|       |       MER152_S.JPG
|       |       MER152_W (2).JPG
|       |       MER152_W.JPG
|       |       MER153_E (2).JPG
|       |       MER153_E.JPG
|       |       MER153_N (2).JPG
|       |       MER153_N.JPG
|       |       MER153_S (2).JPG
|       |       MER153_S.JPG
|       |       MER153_W (2).JPG
|       |       MER153_W.JPG
|       |       MER154_E.JPG
|       |       MER154_N.JPG
|       |       MER154_S.JPG
|       |       MER154_W.JPG
|       |       MER155_E.JPG
|       |       MER155_N.JPG
|       |       MER155_S.JPG
|       |       MER155_W.JPG
|       |       MER156_E.JPG
|       |       MER156_N.JPG
|       |       MER156_S.JPG
|       |       MER156_W.JPG
|       |       MER157_E.JPG
|       |       MER157_N.JPG
|       |       MER157_S.JPG
|       |       MER157_W.JPG
|       |       MER158_E (2).JPG
|       |       MER158_E.JPG
|       |       MER158_N (2).JPG
|       |       MER158_N.JPG
|       |       MER158_S (2).JPG
```

```
|         |        MER158_S.JPG
|         |        MER158_W (2).JPG
|         |        MER158_W.JPG
|         |        MER159_E.JPG
|         |        MER159_N.JPG
|         |        MER159_S.JPG
|         |        MER159_W.JPG
|         |        MER160_E.JPG
|         |        MER160_N.JPG
|         |        MER160_S.JPG
|         |        MER160_W.JPG
|         |        MER161_E.JPG
|         |        MER161_N.JPG
|         |        MER161_S.JPG
|         |        MER161_W.JPG
|         |        MER162_E.JPG
|         |        MER162_N.JPG
|         |        MER162_S.JPG
|         |        MER162_W.JPG
|         |        MER163_E.JPG
|         |        MER163_N.JPG
|         |        MER163_S.JPG
|         |        MER163_W.JPG
|         |        MER164_E.JPG
|         |        MER164_N.JPG
|         |        MER164_S.JPG
|         |        MER164_W.JPG
|         |        MER165_E.JPG
|         |        MER165_N.JPG
|         |        MER165_S.JPG
|         |        MER165_W.JPG
|         |        MER166_E.JPG
|         |        MER166_N.JPG
|         |        MER166_S.JPG
|         |        MER166_W.JPG
|         |        MER167_E.JPG
|         |        MER167_N.JPG
|         |        MER167_S.JPG
|         |        MER167_W.JPG
|         |        MER168_E (2).JPG
|         |        MER168_E.JPG
|         |        MER168_N (2).JPG
|         |        MER168_N.JPG
|         |        MER168_S (2).JPG
|         |        MER168_S.JPG
|         |        MER168_W (2).JPG
|         |        MER168_W.JPG
|         |        MER169_E.JPG
|         |        MER169_N.JPG
|         |        MER169_S.JPG
|         |        MER169_W.JPG
|         |        MER170_E.JPG
|         |        MER170_N.JPG
|         |        MER170_S.JPG
```

```
|       |       MER170_W.JPG
|       |       MER171_E.JPG
|       |       MER171_N.JPG
|       |       MER171_S.JPG
|       |       MER171_W.JPG
|       |       MER172_E.JPG
|       |       MER172_N.JPG
|       |       MER172_S.JPG
|       |       MER172_W.JPG
|       |       MER173_E.JPG
|       |       MER173_N.JPG
|       |       MER173_S.JPG
|       |       MER173_W.JPG
|       |       MER174_E.JPG
|       |       MER174_N.JPG
|       |       MER174_S.JPG
|       |       MER174_W.JPG
|       |       MER175_E.JPG
|       |       MER175_N.JPG
|       |       MER175_S.JPG
|       |       MER175_W.JPG
|       |       Thumbs.db
|       |
|       +---04_Final_GeoFiles
|       |       Merrimack_Control_NAD83.dbf
|       |       Merrimack_Control_NAD83.kmz
|       |       Merrimack_Control_NAD83.prj
|       |       Merrimack_Control_NAD83.sbn
|       |       Merrimack_Control_NAD83.sbx
|       |       Merrimack_Control_NAD83.shp
|       |       Merrimack_Control_NAD83.shx
|       |
|       +---05_Final_Station_Diagrams
|       |       MER101_d.gif
|       |       MER102_d.gif
|       |       MER103_d.gif
|       |       MER104_d.gif
|       |       MER105_d.gif
|       |       MER106_d.gif
|       |       MER107_d.gif
|       |       MER108_d.gif
|       |       MER109_d.gif
|       |       MER110_d.gif
|       |       MER111_d.gif
|       |       MER112_d.gif
|       |       MER113_d.gif
|       |       MER114_d.gif
|       |       MER115_d.gif
|       |       MER116_d.gif
|       |       MER117_d.gif
|       |       MER118_d.gif
|       |       MER119_d.gif
|       |       MER120_d.gif
|       |       MER121_d.gif
```

```
|         |        MER122_d.gif
|         |        MER123_d.gif
|         |        MER124_d.gif
|         |        MER125_d.gif
|         |        MER126_d.gif
|         |        MER127_d.gif
|         |        MER128A_d.gif
|         |        MER129A_d.gif
|         |        MER130_d.gif
|         |        MER131_d.gif
|         |        MER132_d.gif
|         |        MER133_d.gif
|         |        MER134_d.gif
|         |        MER135_d.gif
|         |        MER136_d.gif
|         |        MER137_d.gif
|         |        MER138_d.gif
|         |        MER139_d.gif
|         |        MER140_d.gif
|         |        MER141_d.gif
|         |        MER142_d.gif
|         |        MER143_d.gif
|         |        MER144_d.gif
|         |        MER145_d.gif
|         |        MER146_d.gif
|         |        MER147_d.gif
|         |        MER148_d.gif
|         |        MER149_d.gif
|         |        MER150_d.gif
|         |        MER151A_d.gif
|         |        MER151_d.gif
|         |        MER152A_d.gif
|         |        MER152_d.gif
|         |        MER153A_d.gif
|         |        MER153_d.gif
|         |        MER154_d.gif
|         |        MER155_d.gif
|         |        MER156_d.gif
|         |        MER157_d.gif
|         |        MER158A_d.gif
|         |        MER158_d.gif
|         |        MER159_d.gif
|         |        MER160_d.gif
|         |        MER161_d.gif
|         |        MER162_d.gif
|         |        MER163_d.gif
|         |        MER164_d.gif
|         |        MER165_d.gif
|         |        MER166_d.gif
|         |        MER167_d.gif
|         |        MER168A_d.gif
|         |        MER169A_d.gif
|         |        MER169_d.gif
|         |        MER170_d.gif
```

```
|       |       MER171A_d.gif
|       |       MER171_d.gif
|       |       MER172_d.gif
|       |       MER173_d.gif
|       |       MER174_d.gif
|       |       MER175_d.gif
|       |       Thumbs.db
|       |
|       +---06_Final_Report
|       |       Final_Report FEMA Region 1.pdf
|       |
|       \---07_Final_Coordinates
|               Merrimack_Control_NAD83.xls
|
+---Merrimack_TestingResults
|       Merrimack_CVA_NAD83_Passed.xls
|       Merrimack_FVA_NAD83_Passed.xls
|       Region 1 Merrimack Testing Results FVA CVA.pdf
|
+---QA
|   |   QA Report for Merrimack.docx
|   |
|   \---QA_Forms
|           1-Merrimack Watershed Vendor Submittal Checklist.docx
|           2-Merrimack Watershed Flight Report Checklist.docx
|           3a-Merrimack Watershed LAS Header Checklist.docx
|           3b-LTE-LAS_INFO_Results.xlsx
|           3c-Merrimack_Classified_LasAnalysis.xls
|           4-TopoAnalyst_2108201213211.pdf
|           5-Unclassified Point Cloud Data Micro Review.docx
|           6-Classified Point Cloud Data Micro Review.docx
|
\---TSDN
        Appendix A.pdf
        Appendix B.pdf
        Appendix C.pdf
        Appendix D.pdf
        Appendix E.pdf
        Appendix F.pdf
      Appendix G.pdf
        Appendix H.pdf
        Appendix I.pdf
        Merrimack_River_HUC_8_01080202_Terrain_TSDN.doc
        Merrimack_River_HUC_8_01080202_Terrain_TSDN.pdf
```

Merrimack MIP Locations:

Belknap County, New Hampshire
J:\FEMA\R01\NEW_HAMPSHIRE_33\BELKNAP_33001\BELKNAP_001C\12-01-1080S\SubmissionUpload\Terrain\2152674

Hillsborough County, New Hampshire
J:\FEMA\R01\NEW_HAMPSHIRE_33\HILLSBOROUGH_33011\HILLSBOROUGH_011C\12-01-1080S\SubmissionUpload\Terrain\2152674

Merrimack County, New Hampshire
J:\FEMA\R01\NEW_HAMPSHIRE_33\MERRIMACK_33013\MERRIMACK_013C\12-01-1080S\SubmissionUpload\Terrain\2152674

Rockingham County, New Hampshire
J:\FEMA\R01\NEW_HAMPSHIRE_33\ROCKINGHAM_33015\ROCKINGHAM_015C\12-01-1080S\SubmissionUpload\Terrain\2152674

Strafford County, New Hampshire
J:\FEMA\R01\NEW_HAMPSHIRE_33\STRAFFORD_33017\STRAFFORD_017C\12-01-1080S\SubmissionUpload\Terrain\2152674

Essex County, Massachusetts
J:\FEMA\R01\MASSACHUSETTS_25\ESSEX_25009\ESSEX_009C\12-01-1080S\SubmissionUpload\Terrain\2152674

Middlesex County, Massachusetts
J:\FEMA\R01\MASSACHUSETTS_25\MIDDLESEX_25017\MIDDLESEX_017C\12-01-1080S\SubmissionUpload\Terrain\2152674

Worcester County, Massachusetts
J:\FEMA\R01\MASSACHUSETTS_25\WORCESTER_25027\WORCESTER_027C\12-01-1080S\SubmissionUpload\Terrain\2152674

NOTE:
In the interest of saving storage space on the MIP, the Merrimack County MIP location will include all supporting project data. Every other location contains the metadata and a read me text file that directs users to the Merrimack Terrain submittal directory.

Appendix H: Guidance Documents

US. Department of Homeland Security
500 C Street, SW
Washington, DC 20472

FEMA

September 27, 2010

MEMORANDUM FOR: Regional Risk Analysis Branch Chiefs

FROM: Doug A. Bellomo
Director, Risk Analysis Division
Federal Insurance and Mitigation Administration

SUBJECT: Procedure Memorandum No. 61—Standards for Lidar and Other High Quality Digital Topography

EFFECTIVE DATES: Immediately for all FY10 procured and collected data

Background: Beginning in Fiscal Year (FY) 2010, Federal Emergency Management Agency (FEMA) initiated a five-year program for Risk Mapping, Assessment, and Planning (Risk MAP). FEMA's vision for the Risk MAP program is to deliver quality data that increases public awareness and leads to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA will transform its traditional flood identification and mapping efforts into a more integrated process of accurately identifying, assessing, communicating, planning for, and mitigating flood risks.

Under Risk MAP, FEMA seeks to:

- Deliver new data and products that expand risk awareness and promote mitigation planning that leads to risk reduction actions.
- Increase production efficiencies for Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs).

Issue: To implement FEMA's Risk MAP vision and provide the high quality topographic data necessary to meet Risk MAP's goals, FEMA Regions and Mapping Partners need upgraded guidance concerning the accuracy and processing of high quality topographic data including Light Detection and Ranging (LIDAR) data. This Procedure Memorandum supersedes Appendix A: Guidance for Aerial Mapping and Surveying of the *Guidelines and Specifications for Flood Hazard Mapping Partners* (Guidelines) in key areas (defined in the Procedure Memorandum Attachments), and must be implemented beginning with all topographic data collected or procured by FEMA in FY 2010.

Actions Taken: When procuring topographic data under the Risk MAP Program, the Mapping Partner assigned to obtain topographic data or perform independent QA of topographic data must meet the specifications detailed in this Procedure Memorandum's attachments. The attachments align FEMA's high quality topographic specifications, found in Appendix A of the Guidelines, with the United States Geological Survey (USGS) *Lidar Guidelines and Base Specifications* v13 so that data procured and used by the Federal government is consistent across agencies and is updated to industry standards. Further, adherence to these specifications will support the Risk MAP Program by closing gaps in existing flood hazard data; supporting risk assessments; and better communicating risks to community officials and the public.

Existing elevation data, not acquired by FEMA, but planned for use in a new flood hazard analysis for National Flood Insurance Program (NFIP) regulatory products must comply with the accuracy, density and the final product metadata requirements detailed in the attachments, but is not required to comply with the other specifications included and referenced below.

Consistent with FEMA's overall approach to flood hazard identification, this Procedure Memorandum aligns FEMA topographic data specifications to level of risk, and accounts for different slopes in the terrain that can affect the accuracy of base flood elevations and the delineation of mapped floodplains. These specifications represent the minimum requirements. Where involved project is jointly funded by FEMA and external partners or where the engineering requirements dictate, projects may use higher specification levels or include additional processing. Quality assurance requirements for high quality topographic data are also provided.

Attachments:
Attachment 1 – Definitions
Attachment 2 – Alignment of FEMA Appendix A to USGS *Lidar Guidelines and Base Specification* v13
Attachment 3 – Topographic Breakline and Hydro-Enforcement Specifications
Attachment 4 – Topographic Data Quality Review Process

Distribution List (electronic distribution only):

Office of the Acting Assistant Administrator for Flood Insurance and Mitigation
Risk Analysis Division
Risk Reduction Division
Risk Insurance Division
Regional Mitigation Division Directors
Regional Risk Analysis Branch Chiefs
Legislative Affairs
Office of Chief Counsel
Indefinite Delivery Indefinite Quantity Contractors
Cooperating Technical Partners
Program Management Contractor
Customer and Data Services Contractor
Production and Technical Services Contractors

Attachment 1 – Definitions

1) **Digital Elevation Data –** Includes all of the following terms: mass points, point clouds, breaklines, contours, TINs, DEMs, DTMs or DSMs.

- **Breakline –** A linear feature demarking a change in the smoothness or continuity of a surface such as abrupt elevation changes or a stream line. The two most common forms of breaklines are as follows:
    - A **soft breakline** ensures that known elevations, or z-values, along a linear feature are maintained (e.g., elevations along a pipeline, road centerline or drainage ditch), and ensures the boundary of natural and man-made features on the Earth's surface are appropriately represented in the digital terrain data by use of linear features and polygon edges They are generally synonymous with 3-D breaklines because they are depicted with series of x/y/z coordinates.
    - A **hard breakline** defines interruptions in surface smoothness, e.g., to define streams, shorelines, dams, ridges, building footprints, and other locations with abrupt surface changes. Although some hard breaklines are three dimensional (3-D) breaklines, they are often depicted as two dimensional (2-D) breaklines because features such as shorelines and building footprints are normally depicted with a series of horizontal coordinates only which are often digitized from digital orthophotographs that include no elevation data.

- **Contours –** Lines of equal elevation on a surface. An imaginary line on the ground, all points of which are at the same elevation above or below a specified vertical datum.

- **Digital Elevation Model (DEM) –** An elevation model created for use in computer software where bare-earth elevation values have regularly spaced intervals in latitude and longitude (x and y). The Δx and Δy values are normally measured in feet or meters to even units; however, the National Elevation Dataset (NED) defines the spacing interval in terms of arc-seconds of latitude and longitude, e.g., 1/3rd arc-second.

- **Digital Surface Model (DSM) –** An elevation model created for use in computer software that is similar to DEMs or DTMs except that DSMs depict the elevations of the top surfaces of buildings, trees, towers, and other features elevated above the bare earth.

- **Digital Terrain Model (DTM) –** An elevation model created for use in computer software of bare-earth mass points and breaklines. DTMs are technically superior to a gridded DEM for many applications because distinctive terrain features are more clearly defined and precisely located, and contours generated from DTMs more closely approximate the real shape of the terrain.

- **Mass Points –** Irregularly spaced points, each with latitude and longitude location coordinates and elevation values typically used to form a TIN.

- **Metadata –** Project descriptive information about the elevation dataset.

- **Point Cloud –** Often referred to as the “raw point cloud”, this is the first data product of a lidar instrument. In its crudest form, a lidar raw point cloud is a collection of range measurements and sensor orientation parameters. After initial processing, the range and orientation of each laser value is converted to a position in a three dimensional frame of reference and this spatially coherent cloud of points is the base for further processing and analysis. The raw point cloud typically includes first, last, and intermediate returns for each laser pulse. In addition to spatial information, lidar intensity returns provide texture or color information. The combination of three dimensional spatial information and spectral information contained in the lidar dataset allows great flexibility for data manipulation and extraction. As used in this procedure memorandum, two additional lidar data processing terms are defined as follows:
    - **Lidar Preliminary Processing –** The initial processing and analysis of laser data to fully “calibrated point clouds” in some specified tile format. All lidar data will be set to American Society for Photogrammetry and Remote Sensing (ASPRS) LAS Class 1 (unclassified) and must include testing for Fundamental Vertical Accuracy (FVA). The tile format can change later, if necessary.
    - **Lidar Post-Processing –** The final processing and classification of lidar data to the required ASPRS LAS classes, per project specifications. This must include testing for Consolidated Vertical Accuracy (CVA). At this point, the datasets are referred to as the “classified point cloud.”

- **Triangulated Irregular Network (TIN) –** A set of adjacent, non-overlapping triangles computed from irregularly-spaced points with lattitude, longitude, and elevation values. The TIN data structure is based on irregularly-spaced point, line, and polygon data interpreted as mass points and breaklines and stores the topological relationship between triangles and their adjacent neighbors. The TIN model may be preferable to a DEM when it is critical to preserve the precise location of narrow or small features, such as levees, ditch or stream centerlines, isolated peaks or pits in the data model.

- **Z-Values –** The elevations of the 3-D surface above the vertical datum at designated x/y locations.

2) **Geospatial Accuracy Standard –** A common accuracy testing and reporting methodology that facilitates sharing and interoperability of geospatial data. Published in 1998, the National Standard for Spatial Data Accuracy (NSSDA) is the Federal Geographic Data Committee (FGDC) standard relevant to digital elevation data when assuming that errors follow a normal error distribution. However, after it was learned that lidar datasets do not necessarily follow a normal distribution in vegetated terrain, the National Digital Elevation Program (NDEP) published its “Guidelines for Digital Elevation Data” and the American Society for Photogrammetry and Remote Sensing (ASPRS) published the “ASPRS Guidelines: Vertical Accuracy Reporting for Lidar Data,” both of which were published in 2004 and use newer terms defined below as Fundamental Vertical Accuracy (FVA), Supplemental Vertical Accuracy (SVA) and Consolidated Vertical Accuracy (CVA). All of these standards, designed for digital elevation data, replace the National Map Accuracy Standard (NMAS) that is applicable only to graphic maps defined by map scale and contour interval.

3) **Accuracy –** The closeness of an estimated value (e.g., measured or computed) to a standard or accepted (true) value of a particular quantity. Note: With the exception of GPS Continuously Operating Reference Stations (CORS), assumed to be known with zero errors relative to established datums, the true locations of 3-D spatial coordinates or other points are not known, but only estimated. Therefore, the accuracy of other coordinate information is unknown and can only be estimated. Other accuracy definitions are as follows.

- **Absolute Accuracy –** A measure that accounts for all systematic and random errors in a data set. Absolute accuracy is stated with respect to a defied datum or reference system.

- **Accuracy$_r$ –** The NSSDA reporting standard in the horizontal component that equals the radius of a circle of uncertainty, such that the true or theoretical horizontal location of the point falls within that circle 95-percent of the time. Accuracy$_r$ = 1.7308 x RMSE$_r$. Horizontal accuracy is defined as the positional accuracy of a dataset with respect to a horizontal datum.

- **Accuracy$_z$ —** The NSSDA reporting standard in the vertical component that equals the linear uncertainty value, such that the true or theoretical vertical location of the point falls within that linear uncertainty value 95-percent of the time. Accuracy$_z$ = 1.9600 x RMSE$_z$. Vertical accuracy is defined as the positional accuracy of a dataset with respect to a vertical datum.

- **Consolidated Vertical Accuracy (CVA) –** The result of a test of the accuracy of vertical checkpoints (z-values) consolidated for two or more of the major land cover categories, representing both open terrain and other land cover categories. Computed by using the 95th percentile, CVA is always accompanied by Fundamental Vertical Accuracy (FVA).

- **Fundamental Vertical Accuracy (FVA) –** The value by which vertical accuracy can be equitably assessed and compared among datasets. The FVA is determined with vertical checkpoints located only in open terrain, where there is a very high probability that the sensor will have detected the ground surface. FVA is calculated at the 95% confidence level in open terrain only, using RMSE$_z$ x 1.9600,

- **Local Accuracy –** A value that represents the uncertainty in the coordinates of a control point relative to the coordinates of other directly-connected, adjacent control points at the 95-percent confidence level. The reported local accuracy is an approximate average of the individual local accuracy values between this control point and other observed control points used to establish the coordinates of the control point.

- **Network Accuracy –** A value that represents the uncertainty in the coordinates of a control point with respect to the geodetic datum at the 95-percent confidence level. For National Spatial Reference System (NSRS) network accuracy classification in the U.S., the datum is considered to be best expressed by the geodetic values at the CORS supported by the National Geodetic Survey (NGS). By this definition, the local and network accuracy values at CORS sites are considered to be infinitesimal, i.e., to approach zero.

- **Percentile –** Any of the values in a dataset of errors dividing the distribution of the individual errors in the dataset into one hundred groups of equal frequency. Any of those groups can specify a specific percentile, e.g., the 95th percentile as defined below.

- **Precision –** A statistical measure of the tendency of a set of random numbers to cluster about a number determined by the dataset. *Precision* relates to the quality of the method by which the measurements were made and is distinguished from *accuracy* which relates to the quality of the result. The term "precision" not only applies to the fidelity with which required operations are performed, but, by custom, has been applied to methods and instruments employed in obtaining results of a high order of precision. Precision is exemplified by the number of decimal places to which a computation is carried and a result stated.

- **Positional Accuracy** – The accuracy of the position of features, including horizontal and/or vertical positions.

- **Relative Accuracy** – A measure that accounts for random errors in a data set. Relative accuracy may also be referred to as point-to-point accuracy. The general measure of relative accuracy is an evaluation of the random errors (systematic errors and blunders removed) in determining the positional orientation (e.g., distance, azimuth) of one point or feature with respect to another.

- **Root Mean Square Error (RMSE) –** The square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points. The vertical RMSE ($RMSE_z$), for example, is calculated as the square root of $\sum(Z_n - Z'_n)^2/N$, where:
    - Z_n is the set of N z-values (elevations) being evaluated, normally interpolated (for TINs and DEMs) from dataset elevations of points surrounding the x/y coordinates of checkpoints
    - Z'_n is the corresponding set of checkpoint elevations for the points being evaluated
    - N is the number of checkpoints
    - n is the identification number of each of the checkpoints from 1 through N.

- **Supplemental Vertical Accuracy (SVA) –** The result of a test of the accuracy of z-values over areas with ground cover categories or combination of categories other than open terrain. Computed by using the 95th percentile, SVA is always accompanied by Fundamental Vertical Accuracy (FVA). SVA values are computed individually for different land cover categories. Each land cover type representing 10% of more of the total project area is typically tested and reported as an SVA. SVA specifications are normally target values that may be exceeded so long as overall CVA requirements are satisfied.

- **95% Confidence Level** – Accuracy reported at the 95% confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product. Where errors follow a normal error distribution, $Accuracy_z$ defines vertical accuracy at the 95% confidence level (computed as $RMSE_z$ x 1.9600), and $Accuracy_r$ defines horizontal (radial) accuracy at the 95% confidence level (computed as $RMSE_r$ x 1.7308).

- **95th Percentile –** Accuracy reported at the 95th percentile indicates that 95% of the errors will be of equal or lesser value and 5% of the errors will be of larger value. This term is used when errors may not follow a normal error distribution, e.g., in forested areas where the classification of bare-earth elevations may have a positive bias. Vertical accuracy at the 95% confidence level and 95th percentile may be compared to evaluate the degree to which actual errors approach a normal error distribution.

4) Resolution – In the context of elevation data, resolution is synonymous with the horizontal density of elevation data points for which two similar terms are used:

- **Nominal Pulse Spacing (NPS) –** The estimated average spacing of irregularly-spaced lidar points in both the along-track and cross-track directions resulting from: the laser pulse repetition frequency (e.g., 100,000 pulses of laser energy emitted in one second from a 100 kHz sensor); scan rate (sometimes viewed as the number of zigzags per second for this common scanning pattern); field-of-view; and flight airspeed. Lidar system developers currently provide “design NPS” as part of the design pulse density, although the American Society for Photogrammetry and Remote Sensing (ASPRS) is currently developing standard procedures to compute the “empirical NPS” which should be approximately the same as the “design NPS” when accepting statistically insignificant loss of returns and disregarding void areas, from water for example. The NPS assessment is made against single swath first return data located within the geometrically usable center portion (typically ~90%) of each swath. Average along-track and cross-track pulse spacing should be comparable. When point density is increased by relying on overlap or double-coverage it should be documented in metadata and not by changing the project’s reported NPS. The NPS should be equal to or less than the Digital Elevation Model (DEM) post spacing when gridded DEMs are required as part of project specifications. This same definition for NPS could similarly apply to irregularly-spaced mass points from photogrammetry or Interferometric Synthetic Aperture Radar (IFSAR) data. NPS pertains to lidar only and is not intended to pertain to photogrammetry or IFSAR.

- **DEM Post Spacing –** Sometimes confused with Nominal Pulse Spacing, the DEM Post Spacing is defined as the constant sampling interval in x- and y-directions of a DEM lattice or grid. This is also called the horizontal resolution of a gridded DEM or the DEM grid spacing. It is standard industry practice to have:

  - 1-meter DEM post spacing for elevation data with 1-foot equivalent contour accuracy;
  - 2-meter DEM post spacing for elevation data with 2-foot equivalent contour accuracy;
  - 5-meter DEM post spacing for elevation data with 5-foot equivalent contour accuracy.

Attachment 2 – Alignment of FEMA Appendix A to USGS Lidar Specification v13

FEMA is aligning Appendix A of the *Guidelines and Specifications for Flood Hazard Mapping Partners* (Guidelines) to the USGS *Lidar Guidelines and Base Specification* v13 to modernize the FEMA specifications to current industry practice, leverage the expertise of the USGS Geography discipline, maintain Federal standards across agencies, and support the use of elevation products acquired as part of Risk MAP by other agencies for other purposes thus maximizing the Government's investment.

Overall, new elevation data purchased by FEMA must comply with the USGS *Lidar Guidelines and Base Specification* v13, except where specifically noted in this Procedure Memorandum.

Because FEMA's needs for elevation data are specific to NFIP floodplain mapping, FEMA has some unique requirements that differ from the USGS specifications. To supplement the existing USGS specifications, FEMA-specific items such as cross section surveys, bridges, and other features in Appendix A of the Guidelines remain valid except where superseded by more current information provided in this attachment. Table 1 summarizes the sections in Appendix A that are fully superseded, partially superseded or not superseded by this Procedure Memorandum.

Table 2.1 Currency of Major Sections within FEMA's Appendix A: Guidance for Aerial Mapping and Surveying

Section	Name	Status
A.1	Introduction	Is not superseded and remains valid.
A.2	Industry Geospatial Standards	Remains valid but is appended by additional standards which use newer standards from the National Digital Elevation Program (NDEP) and American Society for Photogrammetry and Remote Sensing (ASPRS) to test elevation data for Fundamental Vertical Accuracy (FVA), Supplemental Vertical Accuracy (SVA), and Consolidated Vertical Accuracy (CVA).
A.3	Accuracy Guidelines	Partly superseded, especially Table 2, below, that specifies variable vertical accuracy standards and nominal pulse spacing (NPS), depending on the risk level and terrain slope within the floodplain being mapped.
A.4	Data Requirements	Major portions are superseded. Subsection A.4.2.3 pertaining to breaklines, subsection A.4.3 pertaining to elevation data vertical accuracy, and subsection A.4.5 pertaining to mapping area, are superseded. Subsection A.4.11 pertaining to other digital topographic data requirements, including Table A-3, Digital Topographic Data Requirements Checklist, is now superseded by other FEMA procurement guidelines. Subsection A.4.9 on data formats is partially superseded by the addition of lidar LAS formatted datasets. Subsections pertaining to cross sections (A.4.6) and hydraulic structures (A.4.7) remain valid.
A.5	Ground Control	Is not superseded and remains valid.
A.6	Ground Surveys	Is not superseded and remains valid.

Section	Name	Status
A.7	Photogrammetric Surveys	Remains valid but is appended by additional standards which require low confidence areas to be delineated for photogrammetry as well as lidar and interferometric synthetic aperture radar (IFSAR). The vast majority of section A.7 remains valid and unchanged.
A.8	Airborne LiDAR	Superseded with references the USGS *Lidar Guidelines and Base Specification* v13; and by NDEP and ASPRS guidelines for accuracy testing and reporting of lidar data.

2.1 Elevation Specifications Based on Risk Levels

FEMA maintains a national dataset that estimates flood risk. The data is calculated at the Census Block Group level, and is also aggregated to the sub-watershed, watershed and county levels. These data assign a risk value and a risk rank to each area. The areas are grouped into 10 classes with an equal number of members based on risk rank. These 10 classes are called risk deciles.

The table below provides the minimum elevation standards for new engineering analyses produced by FEMA. The highest and high specifications are suitable for all types of engineering analyses. The medium and low specifications are suitable for deciles and terrain as outlined in table below. Careful consideration and balance among cost, need, risk, and vertical accuracy is important. Where more than 20% of the project area covered by the new elevation will have enhanced engineering analyses, the next higher elevation specification level may be appropriate. When the scope of the enhanced engineering analyses is not sufficient to justify increasing the overall project specification level, the bulk elevation data collection may be enhanced by field survey in areas of enhanced engineering analyses if necessary.

Table 2.2. Vertical Accuracy Requirements based on Flood Risk and Terrain Slope within the Floodplain being mapped

Level of Flood Risk	Typical Slopes	Specification Level	Vertical Accuracy, 95% Confidence Level FVA/CVA	Lidar Nominal Pulse Spacing (NPS)
High (Deciles 1,2,3)	Flattest	Highest	24.5 cm/36.3 cm	≤1 meter
High (Deciles 1,2,3)	Rolling or Hilly	High	49.0 cm/72.6 cm	≤2 meters
High (Deciles 2,3,4,5)	Hilly	Medium	98.0 cm/145 cm	≤3.5 meters
Medium (Deciles 3,4,5,6,7)	Flattest	High	49.0 cm/72.6 cm	≤2 meters
Medium (Deciles 3,4,5,6,7)	Rolling	Medium	98.0 cm/145 cm	≤3.5 meters

Medium (Deciles 4,5,6,7)	Hilly	Low	147 cm/218 cm	≤5 meters
Low (Deciles 7,8,9,10)	All	Low	147 cm/218 cm	≤5 meters

Whereas contour lines are for visual interpretation and are unnecessary for FEMA's automated hydrologic and hydraulic analyses, the term "equivalent contour accuracy" is used to show the accuracy of contour lines that could be produced from a DEM if needed for manual analysis; this is also for the benefit of those who do not understand NSSDA terminology that defines vertical accuracy at the 95% confidence level. Table 3 explains "equivalent contour accuracy" for various standard contour intervals, referenced also in terms of vertical root mean square error (RMSE$_z$), National Standard for Spatial Data Accuracy (NSSDA) Accuracy$_z$, SVA and CVA.

Table 2.3. Accuracy Terms that Equal "Equivalent Contour Accuracy"

Equivalent Contour Accuracy	FEMA Specification Level	RMSE$_z$	NSSDA Accuracy$_z$ 95% confidence level	SVA (target)	CVA (mandatory)
1 ft		0.30 ft or 9.25 cm	0.60 ft or18.2 cm	0.60 ft or18.2 cm	0.60 ft or18.2 cm
2 ft	Highest	0.61 ft or 18.5 cm	1.19 ft or 36.3 cm	1.19 ft or 36.3 cm	1.19 ft or 36.3 cm
4 ft	High	1.22 ft or 37.1 cm	2.38 ft or 72.6 cm	2.38 ft or 72.6 cm	2.38 ft or 72.6 cm
5 ft		1.52 ft or 46.3 cm	2.98 ft or 90.8 cm	2.98 ft or 90.8 cm	2.98 ft or 90.8 cm
8 ft	Medium	2.43 ft or 73.9 cm	4.77 ft or 1.45 m	4.77 ft or 1.45 m	4.77 ft or 1.45 m
10 ft		3.04 ft or 92.7 cm	5.96 ft or1.82 m	5.96 ft or1.82 m	5.96 ft or1.82 m
12 ft	Low	3.65 ft or 1.11m	7.15 ft or 2.18 m	7.15 ft or 2.18 m	7.15 ft or 2.18 m

FEMA's requirements for elevation data are specific to flood risk analysis. As a result, FEMA's requirements diverge from the USGS specification which is intended to serve a different purpose. Two of the key differences with the FEMA specifications are the requirements for vertical accuracy and nominal pulse spacing. The FEMA requirements in these areas are only similar to the USGS requirements in the highest specification level, but otherwise differ for the lower accuracy levels.

All data collected must go through lidar preliminary processing and the unclassified point cloud must be tested as specified in the USGS specification. Where the Mapping Activity Statement (MAS) requires bare earth post-processing of the floodplain area of interest (AOI), the elevation data must be tested and comply with both the FVA and CVA requirements. Where no bare earth post-processing is specified, only the FVA requirements apply for lidar preliminary processing.

Many other organizations require higher-accuracy lidar data for diverse applications and combine their resources to solve multiple needs with lidar. FEMA prefers to acquire elevation data through partnerships so that the resulting data will meet a broader variety of end user needs and be more consistent with the overall USGS specification. These partnership elevation collection activities will frequently utilize specifications that exceed the minimums described above in Table 2. Before committing funds to a new elevation mapping project, FEMA Regional staff should first determine whether funds could be spent more effectively by cooperating with other agencies to more cost-effectively acquire elevation data. FEMA is a member of the National Digital Elevation Program (NDEP) which was formed, in part, to avoid duplication of effort among state and federal government agencies acquiring digital elevation data. USGS maintains state geospatial liaisons that are a good source of information regarding the status of existing and/or planned mapping activities in their states.

2.2 Light Detection and Ranging (lidar)

Lidar is capable of delivering 1-foot equivalent contour accuracy with sub-meter NPS used to produce DEMs with 1-meter DEM gridded post spacing. Therefore, lidar could satisfy FEMA's requirements for elevation data in high risk, moderate risk, and low risk areas. Lidar is often the best technology for mapping the elevations of the bare earth terrain in dense vegetation.

If this technology is selected for high risk areas, lidar will be collected in accordance with the USGS *Lidar Guidelines and Base Specification*, v13, for the National Geospatial Program except as noted. FEMA does not require the data to be hydro-flattened, as specified in v13. Also, FEMA does not require all data to be processed to the bare earth terrain, but instead limits the area to be processed to areas in the vicinity of floodplains that will require hydraulic modeling. See FEMA's Procurement Guidelines for specifics on this topic.

The following USGS specifications are most relevant to FEMA and are consistent with FEMA requirements:

- Fundamental Vertical Accuracy (FVA) pertains only to open, non-vegetated terrain. The FVA is specified at a higher level of accuracy than other land cover categories. The FVA is a mandatory specification that must be satisfied in order to be usable by FEMA for flood risk mapping within the specified level of flood risk.
- Supplemental Vertical Accuracy (SVA) pertains to other major land cover categories representative of the floodplain being mapped. SVA values are target values, where one SVA category can test higher and another lower than the target SVA value so long as the overall CVA is satisfied for the consolidated equivalent contour accuracy.
- Consolidated Vertical Accuracy (CVA) pertains to all land cover categories combined. Compliance with the CVA specification is mandatory in order for an elevation dataset to qualify for satisfaction of a specified equivalent contour accuracy.
- For the highest specification level equivalent to 2 foot contour accuracy, the relative accuracy should be ≤ 7 cm $RMSE_z$ within individual swaths; ≤ 10 cm $RMSE_z$ within swath overlap (between adjacent swaths). These relative accuracy specifications double to 14 and 20 cm, respectively, for risk areas that utilize the high elevation specification with 4 foot equivalent contour accuracy. This specification is not applicable to lower risk areas.
- Consistent with USGS *Lidar Guidelines and Base Specification*, v13, a regular grid, with cell size equal to the design NPS*2 will be laid over the first return data within the geometrically usable center portion of each swath. At least 90% of the cells in the grid shall contain at least one lidar point.

- All data collected will be delivered consistent with the USGS Raw Point Cloud deliverable requirements.
- Where lidar post-processing is performed, the deliverables must also include the classified point cloud deliverable. The data will be delivered in full compliance with LAS classes 1 (processed, but unclassified), 2 (bare-earth ground), 7 (noise), 9 (water), 10 (ignored), and 11 (withheld). All points not identified as "withheld" are to be classified. "Overlap" classification (Class 12) shall not be used.
- The horizontal datum shall be referenced to the latest adjustment of the North American Datum of 1983 (NAD83 [NSRS2007]).
- The vertical datum shall be referenced to the North American Vertical Datum of 1988 (NAVD88) whenever available. Areas outside of the continental U.S. where NAVD88 is not available should be referenced to a reproducible local datum that can be used to support floodplain management.
- The most recent approved Geoid model from the National Geodetic Survey (NGS) shall be used to perform conversions from ellipsoidal heights to orthometric heights.
- The standard coordinate reference system and units shall be Universal Transverse Mercator (UTM), meters. Considerations for other standard coordinate systems such as State Plane can be made for projects which are contributed to by mapping partners.
- The single non-overlapped tiling scheme shall be established and agreed upon by the data producer and FEMA prior to collection, consistent with the USGS *Lidar Guidelines and Base Specifications*, v13.
- Specifications for breaklines and hydro-enforcement are addressed in Attachment B.
- Specifications for lidar accuracy testing by land cover categories within the floodplain being mapped are addressed in Attachment C.

Lidar dataset deliverables shall include the following:

1. Metadata should comply with the requirements in the USGS *Lidar Guidelines and Base Specification*, v13. The QA/QC report provided must include the vertical accuracy calculations as a Microsoft Excel spreadsheet. In addition, the finished elevation product for hydraulic modeling should be documented by a FGDC-compliant metadata file that complies with the FEMA Elevation Metadata Profile. Project documentation must also include a Pre-flight Operations Plan and Post-flight Aerial Survey and Calibration Report as described in Attachment 4.
2. Raw point cloud data shall comply with the requirements in the USGS Lidar Guidelines and Base Specification, v13.
3. Classified point cloud data shall comply with requirements in the USGS Lidar Guidelines and Base Specification, v13.
4. Optional breaklines, when produced, shall be delivered in compliance with guidance in Attachment 3

5. Optional digital bare earth elevation data product(s) (e.g., DEM, DTM, contours) in file formats specified in the Statement of Work.

2.3 Photogrammetry

Photogrammetry is also capable of delivering 1-foot equivalent contour accuracy and a DEM with 1-meter post spacing. Therefore, photogrammetry could also satisfy FEMA's requirements for elevation data in high risk, moderate risk, and low risk areas. Except for the new requirement to delineate areas of low confidence, existing guidance published in section A.7, Photogrammetric Surveys, in Appendix A of FEMA's Guidelines, remain current for new aerial image acquisition with either film or digital cameras.

The USGS annually contracts for leaf-off orthoimagery of selected areas under the National Geospatial Program, typically producing digital orthophotographs with pixel resolution of 30 cm (~1 foot) or 15 cm (~6 inches), as do many states and local governments; and the USDA contracts for leaf-on orthoimagery of major areas of the U.S. annually under the National Agricultural Imagery Program (NAIP) with pixel resolution of 1 meter. Although intended for production of digital orthophotos, those same images could be reused for production of digital elevation data because the aerotriangulation (AT) solution for production of orthophotos can be reused for establishing stereo models from which DEMs can be produced by photogrammetric auto-correlation and/or manual compilation. Elevation accuracies typically achievable by reuse of digital imagery and AT metrics are as follows:

- Typically acquired at an elevation of approximately 4,800 feet above mean terrain, imagery and AT solutions used to produce digital orthophotos with 6-inch pixel resolution should be acceptable for elevation data with 2.5-foot equivalent contour accuracy
- Typically acquired at an elevation of approximately 9,600 feet above mean terrain, imagery and AT solutions used to produce digital orthophotos with 1-foot pixel resolution should be acceptable for elevation data with 5-foot equivalent contour accuracy
- Typically acquired at an elevation of approximately 30,000 feet above mean terrain, imagery and AT solutions used to produce digital orthophotos with 1-meter pixel resolution should be acceptable for elevation data with 15-foot equivalent contour accuracy.

Photogrammetric dataset deliverables shall include the following:

1. Metadata:
    - Collection Report detailing mission planning and flight logs, flying heights, camera parameters, forward overlap and sidelap.
    - Survey Report detailing the collection of control and reference points used for calibration and QA/QC.

    - Aerial triangulation (AT) report detailing compliance with relevant accuracy statistics.
    - Processing Report detailing photogrammetric processed used to manually compile elevation data or to semi-automatically compile elevation data with automated image correlation or other techniques.
    - QA/QC reports.
    - Geo-referenced extents of each delivered dataset.
2. Digital bare earth elevation data product (DEM, DTM, mass points, breaklines, contours) specified in the Statement of Work.
3. Optional breaklines, when produced, shall be delivered in compliance with guidance in Attachment 3

2.4 Ground Surveys

All ground surveys must be performed in accordance with procedures in Section A.5, Ground Control, and Section A.6, Ground Surveys, in Appendix A of FEMA's Guidelines. Cross-section surveys and hydraulic structure surveys shall also be performed in accordance with sections A.4.6 and A.4.7, respectively, of Appendix A.

2.5 Low Confidence Areas

Regardless of the technology used, FEMA requires that low confidence areas be delineated by the data provider to indicate areas where the vertical data may not meet the data accuracy requirements due to heavy vegetation even though the specified nominal pulse spacing was met or exceeded in those areas. The metadata must include an explanation of steps taken to minimize the areas delineated as low confidence areas. Accuracy test points are normally retained within such areas and are not discarded. The data provider must take reasonable steps to minimize areas delineated as low confidence areas, taking into consideration the density of the vegetation in the floodplain being mapped and other factors.

These low confidence areas must be delivered as polygons in accordance with a database schema. The database schema for polygons defining low confidence areas is as follows.

Feature Dataset: TOPOGRAPHIC **Feature Class:** CONFIDENCE
Feature Type: Polygon
Contains M Values: No **Contains Z Values:** No
Annotation Subclass: None
XY Resolution: Accept Default Setting **Z Resolution:** Accept Default Setting
XY Tolerance: 0.003 **Z Tolerance:** N/A

2.5.1 Description

This polygon feature class will depict areas where the ground is obscured by dense vegetation, meaning that the resultant bare-earth digital terrain model (DTM) may not meet the required accuracy specifications in these obscured areas. Low confidence areas can pertain to lidar, photogrammetry or IFSAR.

2.5.2 Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
DATESTAMP_DT	Date	Yes			0	0	8	Assigned by Contractor
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Contractor
SHAPE_AREA	Double	Yes			0	0		Calculated by Contractor
TYPE	Long Integer	No	1	Obscure	0	0		Assigned by Contractor

2.5.3 Feature Definition

Code	Description	Definition	Capture Rules
1	Low Confidence Area	“Low confidence areas” are defined by the data provider to indicate areas where the vertical data may not meet the data accuracy requirements due to heavy vegetation even though the nominal pulse spacing was met or exceeded in those areas.	Capture as closed polygon. Compiler does not need t z-values of vertices; feature class will be 2-D only.

Attachment 3 – Topographic Breakline and Hydro-Enforcement Specifications

FEMA has no minimum breakline requirements; breaklines are optional and depend upon the procedures used to perform hydrologic and hydraulic modeling. The FEMA Project Manager should specify the breaklines requirements if desired based on the planned approach for hydraulic analysis or the mapping partner may propose breakline requirements based on the anticipated hydraulic modeling approach.

When optional breaklines are produced, the following breakline topology rules must be followed for the applicable feature classes. The topology must be validated by each contractor prior to delivery to FEMA.

Name: BREAKLINES_Topology			Cluster Tolerance: 0.003 Maximum Generated Error Count: Undefined State: Analyzed without errors	
Feature Class	**Weight**	**XY Rank**	**Z Rank**	**Event Notification**
COASTALSHORELINE	5	1	1	No
HYDROGRAPHICFEATURE	5	1	1	No
PONDS_AND_LAKES	5	1	1	No
HYDRAULICSTRUCTURE	5	1	1	No
ISLAND	5	1	1	No

Topology Rules

Name	Rule Type	Trigger Event	Orgin (FeatureClass::Subtype)	Destination (FeatureClass::Subtype)
Must not intersect	The rule is a line-no intersection rule	No	HYDRAULICSTRUCTURE::All	HYDRAULICSTRUCTURE::All
Must not intersect	The rule is a line-no intersection rule	No	HYDROGRAPHICFEATURE::All	HYDROGRAPHICFEATURE::All
Must not intersect	The rule is a line-no intersection rule	No	COASTALSHORELINE::All	COASTALSHORELINE::All
Must not intersect	The rule is a line-no intersection rule	No	PONDS_AND_LAKES::All	PONDS_AND_LAKES::All
Must not intersect	The rule is a line-no intersection rule	No	ISLAND::All	ISLAND::All
Must not overlap	The rule is a line-no overlap line rule	No	HYDROGRAPHICFEATURE::All	COASTALSHORELINE::All
Must not self-intersect	The rule is a line-no self intersect rule	No	HYDRAULICSTRUCTURE::All	HYDRAULICSTRUCTURE::All
Must not self-intersect	The rule is a line-no self intersect rule	No	HYDROGRAPHICFEATURE::All	HYDROGRAPHICFEATURE::All
Must not self-intersect	The rule is a line-no self intersect rule	No	COASTALSHORELINE::All	COASTALSHORELINE::All

Name	Rule Type	Trigger Event	Orgin (FeatureClass::Subtype)	Destination (FeatureClass::Subtype)
Must not self-intersect	The rule is a line-no self intersect rule	No	PONDS_AND_LAKES::All	PONDS_AND_LAKES::All
Must not self-intersect	The rule is a line-no self intersect rule	No	ISLAND::All	ISLAND::All

Attachment 4 – Topographic Data Quality Review and Reporting Process

To complement the topographic data specifications in this procedure memorandum, this attachment describes data quality review processes and reporting obligations to be performed on new topographic data procured by FEMA as part of a flood hazard study or Risk MAP project. The mapping partner responsible for producing the elevation data is responsible for the quality of the product. In addition, FEMA may assign another mapping partner to perform Independent QA/QC of Topographic Data

Existing topographic data leveraged by FEMA should be certified to meet or tested for the vertical accuracy requirements specified in this procedure memo. In addition, the quality reviews described here are best practices that may be applied to existing topographic data. However, some of the documentation needed to perform some of these reviews may not be readily available for existing data.

4.1 Quality Reviews and Reporting Performed by Data Provider

The mapping partner responsible for producing new elevation data must submit copies of QA reports as specified in USGS Lidar Guidelines and Base Specification version 13. Unless the responsibility for checkpoint surveys and vertical accuracy testing is specifically assigned to a different mapping partner performing Independent QA/QC, the mapping partner responsible for producing the elevation data must test the unclassified point cloud data for Fundamental Vertical Accuracy (FVA) and, when lidar post-processing is performed must also test the bare earth product for Supplemental Vertical Accuracy (SVA) and Consolidated Vertical Accuracy (CVA).

4.1.1 Ground Survey of Quality Review Checkpoints

Quality review checkpoint surveys shall be performed in accordance with procedures in Section A.6.4, Checkpoint Surveys and A.6.5 Survey Records, in Appendix A of FEMA's Guidelines.

Checkpoints surveyed for accuracy reporting shall not be used by the data provider in the calibration or adjustment of the topographic data.

4.1.2 Assessment of Initial Vertical Accuracy

Assessment of the fully calibrated, raw point cloud initial vertical accuracy is required to ensure data has successfully completed preliminary processing. The absolute and relative accuracy of the data, relative to known control, shall be verified prior to classification and subsequent product development , by calculating FVA, measured in open, non-vegetated terrain. The spatial distribution of checkpoints for FVA testing should be based on the entire project collection area, distributed to avoid clustering, and support vertical accuracy reporting that is representative of the whole project.

If the project area exceeds 2,000 square miles it must be divided into smaller blocks of 2,000 square miles or less and tested as individual areas. In addition, the division of large project areas should apply the following rules if applicable:

- Divide areas by vendor used
- Divide areas by sensor type (manufacturer)
- Divide areas by flight dates if significant temporal difference is present
- Other logical project divisions based factors that might have a systematic relationships to data quality.

Reporting of positional accuracy shall be in accordance with ASPRS/NDEP standards as well as the USGS *Lidar Guidelines and Base Specification*, v13, Section II.13 and shall use the following statement:

Tested ____ (meters) fundamental vertical accuracy at 95% confidence level

Reporting on the assessment of the point cloud initial vertical accuracy shall include the following at a minimum:

- ***A description of the process used to test the points***
- A graphic depicting the spatial distribution of the ground survey checkpoints
- Descriptive statistics and RMSEz in FVA calculations

4.1.3 Assessment of Bare Earth Vertical Accuracy

When bare earth post-processing is included in the project, assessment of the vertical accuracy for the delivered bare earth elevation product is required to ensure data has successfully completed post processing. Reporting of positional accuracy shall be in accordance with ASPRS/NDEP standards for FVA and CVA. Testing should be performed on the bare earth deliverable as specified in the mapping activity statement, along with the following guidance:

- If an assessment of initial vertical accuracy (FVA) was conducted prior to the processing of the data (section 4.1.2), the FVA checkpoints can again be used in the CVA computations if located within the area to be processed
- The SVA for up to three significant land cover categories, in terms of percentage of the project area covered, shall be tested in addition to the open/bare ground areas already tested for FVA Land cover categories making up 10% or more of the project area should be included in the SVA testing
- For smaller projects less than 1,000 square miles, fewer check points for SVA testing is acceptable. The number of checkpoints shall be reduced to control the QA cost to about 10% of the acquisition and processing cost. The checkpoints should be distributed evenly across the SVA land cover types.
- Processing areas greater than 2,000 square miles must be divided into smaller blocks of 2,000 square miles or less and tested as individual areas. In addition, the division of large processing areas should apply the following rules if applicable:

  - Divide areas by vendor used
  - Divide areas by sensor type (manufacturer)
  - Divide areas by flight dates if significant temporal difference is present
  - Other logical project divisions based on factors that might have a systematic relationships to data quality.

- Each block of 2,000 square miles or less shall be tested for FVA, SVA, and CVA

Checkpoints used for testing SVA of the bare earth elevation product must be located in the areas where bare earth post-processing was performed, distributed to avoid clustering, and support vertical accuracy reporting that is representative of the post processed areas. The SVA results will then be combined with the FVA results to compute CVA for the entire project area.

Reporting on the assessment of the vertical accuracy of the post-processed, delivered elevation data shall include the following at a minimum:

- ***A description of the process used to test the points***
- A graphic depicting the spatial distribution of the ground survey checkpoints
- An analysis of checkpoints that have errors exceeding the 95th percentile in SVA and CVA calculations
- Descriptive statistics and RMSEz in FVA calculations

4.1.4 Aerial Data Acquisition and Calibration

The mapping partner responsible for producing new elevation data must also submit a pre-flight Operations Plan and a post-flight Aerial Acquisition and Calibration Report will be provided to FEMA and/or their representatives by the data acquisition provider and uploaded to the MIP by the data provider. This information will aid future quality review efforts. The required reporting includes the following, outlined in Tables 4.1 and 4.2.

Table 4.1. Pre-flight Operations Plan

Item	Contents	Format
Flight Operations Plan	• Planned flight lines • Planned GPS stations • Planned control • Planned airport locations • Calibration plans • Quality procedures for flight crew (project-related for pilot and operator) • Planned scanset (sensor settings and altitude) • Type of aircraft • Procedure for tracking, executing, and checking reflights • Considerations for terrain, cover, and weather in project	MS Word or PDF

Table 4.2. Post-flight Aerial Acquisition and Calibration Report

Item	Contents	Format
GPS Base station info	• Base station name • Latitude/Longitude (ddd-mm-ss.sss) • Base height (Ellipsoidal meters) • Maximum Position Dilution of Precision PDOP • Map of locations	Excel, TXT, MS Word, or PDF for data; ESRI shape file for map of locations (data and info may be in attribute table)
GPS/IMU processing summary	• Max Horizontal GPS Variance (cm) • Max Vertical GPS Variance (cm) • Notes on GPS quality (High, Good, etc.) • GPS separation plot • GPS altitude plot • PDOP plot • Plot of GPS distance from base station/s	MS Word or PDF with screenshots
Coverage	• Verification of project coverage	ESRI shape files reflecting the actual coverage area and not the applicable tiles.
Flights	• As-flown trajectories • Calibration lines	ESRI shape files
Flight logs	• Incorporated as appendix Should include: • Job # / name • Lift # • Block or AOI designator • Date • Aircraft tail number, type • Flight line, line #, direction, start/stop, altitude, scan angle/rate, speed, conditions, comments • Pilot name • Operator name • AGC switch setting • Laser pulse rate • Mirror rate • Field of view • Airport of operations • GPS base station names or numbers Comments	
Control	• Ground control and base station layouts	ESRI shape files
Data verification/QC	• Description of data verification/QC process • Results of verification and QC steps	MS Word, Excel or PDF

4.2 Quality Reviews and Reporting Performed by Independent QA/QC

When a mapping partner is assigned to perform *Independent QA of Topographic Data* macro and micro reviews of the submitted reports and data shall be performed. Macro reviews are automated processes or are checks required to establish overall data quality and shall be applied to the entire project area. Micro reviews are typically manual in nature and shall be used to check no less than 3 project tiles or 5% of the total number of project tiles, whichever is the greater amount.

Tables 4.3 and 4.4 outline macro and micro reviews to be conducted on the raw point cloud and for data that is post-processed. Some reviews are duplicated between the raw point cloud and post-processing phases due to the potential for errors to be introduced into the data during post-processing.

Table 4.3. Review of fully calibrated raw point cloud

<table>
<tr><th colspan="2">Macro Reviews</th></tr>
<tr><th>Product</th><th>Reviewed for</th></tr>
<tr><td>Pre-flight Operations Plan</td><td>• Compliance with section 4.1.4 and checklists in 4.2.1
• Compliance with the specifications outlined in the Mapping Activity Statement</td></tr>
<tr><td>Post-flight Aerial Acquisition and Calibration Report</td><td>• Compliance with section 4.1.4 and checklists in 4.2.1
• Compliance with the specifications outlined in the Mapping Activity Statement</td></tr>
<tr><td>LAS Point Cloud Files</td><td>• Project area coverage – buffered by a minimum of 100 meters
• Data voids
• Inclusion of GPS time stamp
• Correct projection, datum and units
• Multiple Discrete Returns (at least 3 returns per pulse)
• Correct header information
• Other LAS attributes required by Mapping Activity Statement such as intensity values
• Correct nominal pulse spacing as required by specific risk and/or level of study and buy-up options.</td></tr>
<tr><td>Metadata</td><td>• Compliance with the FEMA Terrain Metadata Profile</td></tr>
<tr><th colspan="2">Micro Reviews</th></tr>
<tr><th>Product</th><th>Reviewed for</th></tr>
<tr><td>LAS Point Cloud Files</td><td>• Excessive noise
• Elevation steps
• Other anomalies present in the point cloud</td></tr>
</table>

Table 4.4. Review of post-processed data

Macro Reviews	
Product	**Reviewed for**
LAS Point Cloud Files	• Compliance with checklists in section 4.2.1 • Project area coverage – buffered by a minimum of 100 meters • Data voids • Inclusion of GPS time stamp • Correct projection, datum and units • Multiple Discrete Returns (at least 3 returns per pulse) • Correct header information • Other LAS attributes required by Mapping Activity Statement such as intensity values • Correct nominal pulse spacing as required by specific risk and/or level of study and buy-up options. • Easting, northing and elevation reported to nearest 0.01m or 0.01 ft • Correct file-naming convention
Metadata	• Compliance with the FEMA Terrain Metadata Profile
Micro Reviews	
Product	**Reviewed for**
LAS Point Cloud Files	• Excessive noise • Elevation steps • Other anomalies present in the point cloud • Correct classification and cleanliness: no more than 2% of the project area classified to bare ground shall contain artifacts such as buildings, trees, overpasses or other above-ground features in the ground point classification (Class 2). In addition, no more than 2% of the project area shall contain incorrect classifications of points. (USGS *Lidar Guidelines and Base Specification*, v13, Section IV.14. •
Optional - Breaklines	• Correct topology • Horizontal placement • Completeness • Continuity *See Attachment 3 for breakline topology rules to be checked against*

If the mapping partner responsible *Independent QA of Topographic Data* is tasked to perform assessment of vertical accuracy of the elevation data as described above in sections 4.1.2 and 4.1.3:

- Assessment of FVA only for pre-processed data to be stored and FVA, SVA, and CVA for post-processed data
- Review of data provider vertical accuracy assessment reports

4.2.1 Recommended Checklists

The following checklists are recommended for use during Independent QA/QC review to facilitate the process.

Pre-flight review checklist

Checklist	Pass / Fail	Comments
Planned lines – sufficient coverage, spacing, and length		
Planned GPS stations		
Planned ground control – sufficient to control and boresight		
Calibration plans		
Vendor quality procedures		
Lidar sensor scan set – planned for proper scan angle, sidelap, design pulse.		
Aircraft utilizes ABGPS		
Sensor supports project design pulse density		
Type of aircraft – supports project design parameters		
Reflight procedure – tracking, documenting, processing		
Project design supports accuracy requirements of project		
Project design accounts for land cover and terrain types		

Post-flight review checklists

Checklist for QA of Flight Logs

Checklist	Included Yes/No	Comments
Flight logs – job #/name		
Flight logs – block or AOI		
Flight logs – date		
Flight logs – aircraft tail #		
Flight logs – lines - #		
Flight logs – lines - direction		
Flight logs – lines – start/stop		
Flight logs – lines – altitude		
Flight logs – lines – scan angle		
Flight logs – lines – speed		
Flight logs – conditions		
Flight logs – comments		
Flight logs - pilot name		
Flight logs - operator name		
Flight logs - AGC switch		
Flight logs – GPS base stations		

Checklist for Aerial Acquisition Report

Checklist	Included? Yes/No	Comments
GPS base station – names		
GPS base station – lat/longs		
GPS base station – heights		
GPS base station – map		
GPS quality – separation plot		
GPS quality – PDOP plot		
GPS quality - horizontal Acc.		
GPS quality - vertical Acc.		
Sensor calibration process		
Verification of AOI coverage		
As-flown trajectories		
Ground control layout		
Data verification process documented		

Final terrain product review checklists

Checklist for QA of Terrain Products

Checklist	Pass/Fail	Comments
Vertical datum correct		
Horizontal datum correct		
Projection correct		
Vertical units correct		
Horizontal units correct		
Each return contains – GPS week, GPS second, easting, northing, elevation, intensity, return # and classification		
No duplicate entries		
GPS second reported to nearest microsecond		
Easting, northing, and elevation reported to nearest 0.01 m or 0.01 ft		
Classifications correct – 1. Unclassified; 2. Bare-earth ground; 7. Noise; 9. Water; 10. Ignored ground; 11. Withheld		
Cloud file structure conforms to project tile layout		
Naming conforms project requirements		
Deliverable tiles checked for significant gaps not covered by aerial acquisition checks and/or caused by data post-processing/filtering		

M.4 Terrain Submittal Standards

M.4.1 Overview [July 2011]

This section describes the format and type of terrain data required to be submitted to FEMA for the Flood Insurance Study (FIS). All data must be submitted in digital format. The mapping partner performing "Develop Topographic Data" is required to submit the data in this section.

The mapping partner should refer to Appendix A of these Guidelines and the USGS *LiDAR Guidelines and Base Specification*, v13 for guidance on terrain data production. This section is not intended to detail the specifications and procedures for coastal hydrographic surveys. The reader is referred to the following additional sources for details on coastal surveys:

- National Oceanic and Atmospheric Administration (NOAA) NOS Hydrographic Survey Specifications and Deliverables (April 2007);
- NOAA Office of Coast Survey Hydrographic Surveys Division Field Procedures Manual (March 2007); and
- U.S. Army Corps of Engineers (USACE) National Coastal Mapping Program Joint LiDAR Bathymetry Technical Center for Expertise.
- Appendix D of the *Guidelines and Specifications for Flood Hazard Mapping Partners* (February 2007).

The terrain data records and validation status within the CNMS database must be updated, as applicable, based on the information and data collected and revised as part of this section. The data model provided in the CNMS Database User's Guide must be used to enter the data and update CNMS.

The submitting mapping partner must retain copies of all project-related data for a period of three years. The submitting mapping partner will need these data for responding to the following:

- Questions from FEMA or the receiving mapping partner during the review of the final draft materials;
- Comments and appeals submitted to FEMA during the 90-day appeal period following the issuance of preliminary maps; and
- Other concerns and issues that may develop during the processing of the new or revised FIS report and FIRM.

M.4.2 Requirements [July 2011]

M.4.2.1 Data Files [July 2011]

The minimum data required for the terrain data submission are the source terrain and the processed terrain data used in the flood risk project. These data can be contained in a single file or in tiled files. When tiled files are submitted, they must be accompanied by a tiling index file. If any processing has been performed, the original and final files must be submitted as well. For instance, if terrain data were blended from three different sources to create the final terrain data, the original of the three sources and the final terrain file that results from the blending process must be submitted. This information is required to be a georeferenced, digital submittal. The following information must be submitted when it is used to perform a flood risk project:

- Light Detection and Ranging(LiDAR) data;
  - For projects that acquire new LiDAR data:
    - Metadata (must comply with the requirements in the USGS *LiDAR Guidelines and Base Specification*, v13). The QA/QC report provided must include the vertical accuracy calculations as a Microsoft Excel spreadsheet. In addition, the finished elevation product for hydraulic modeling should be documented by a FGDC-compliant metadata file that complies with the FEMA Elevation Metadata Profile. Project documentation must also include a Pre-flight Operations Plan and Post-flight Aerial Survey and Calibration Report.
    - Raw point cloud data must comply with the requirements in the USGS LiDAR Guidelines and Base Specification, v13
    - Classified point cloud data must comply with requirements in the USGS LiDAR Guidelines and Base Specification, v13
    - Optional breaklines, when produced, must be delivered in compliance with FEMA requirements
    - Optional digital bare earth elevation data product(s) (e.g., DEM, DTM, contours) in file formats specified in the Statement of Work
  - For existing LiDAR data not processed as part of the project, the bare earth data must be submitted, and the submittal of the all returns data (if available) is optional.
- Photogrammetric data;
  - Metadata
  - Collection Report detailing mission planning and flight logs, flying heights, camera parameters, forward overlap and sidelap
  - Survey Report detailing the collection of control and reference points used for calibration and QA/QC
  - Aerial triangulation (AT) report detailing compliance with relevant accuracy statistics.
  - Processing Report detailing photogrammetric processed used to manually compile elevation data or to semi-automatically compile elevation data with automated image correlation or other techniques
  - QA/QC reports
  - Geo-referenced extents of each delivered dataset
  - Digital bare earth elevation data product (DEM, DTM, mass points, breaklines, contours) specified in the Statement of Work
  - Optional breaklines, when produced, must be delivered in compliance with FEMA requirements
- Tiling index for data files;
- Contours;
- Bathymetry;

- Digital Elevation Models (DEMs);
- Triangulated Irregular Networks (TINs);
- Hydro-corrected DEMs;
- USGS topographic data;
- All other terrain data; and
- A project narrative describing the SOW, direction from FEMA, issues, information for next mapping partner, etc..

A spatial file is required for use whenever terrain data is submitted in a tiled format. A Tile Index spatial file must accompany each different set of tiled data. While all tiled terrain data may reference the same Tile Index, it is possible that each set of tiled data references a unique Tile Index based on different origins and cell sizes. (For example, natural DEMs, Hydro corrected DEMs, contours and flow vectors could each be based on a different Tile Index.) Tiles must have only one part, and cannot self-intersect (must be simple). Adjacent tiles should not overlap or have gaps between them.

M.4.2.2 General Correspondence [March 2009]

A file that compiles general correspondence must be submitted by the mapping partner assigned to "Develop Topographic Data." General correspondence is the written correspondence generated or received by the mapping partner to fulfill the requirements of developing topographic data. It includes any documentation generated during this task, such as letters, transmittals, memoranda, general status reports and queries, SPRs, technical issues that need to be documented, and direction given by FEMA. Contractual documents, such as a signed SOW or MAS, are not to be submitted as a part of this appendix.

M.4.2.3 Certification of Work [March 2009]

FEMA-funded (including CTP-funded projects if they are a part of FEMA's flood mapping program) terrain data development must be certified using the Certification of Compliance Form provided in Figure M.10-1 in Section M.10. Submittal of this certification at the "Develop Topographic Data" workflow step is required if this is the only task performed by the mapping partner. Mapping partners that are contracted to perform multiple mapping tasks can submit one certification form to certify all the work performed. A PDF file of this form with the original signature, date, and seal affixed to the form must be submitted digitally in the general directory identified in Section M.4.2.8. This form must be signed by a registered or certified professional from the firm contracted to perform the work, or by the responsible official of a government agency. A digital version of this form is available at www.fema.gov.

M.4.2.4 Acceptable File Formats [July 2011]

Terrain data used to perform the flood risk project must be submitted in a georeferenced, digital format as listed below. These data can be contained in a single file or in a tiled set of files. Any tiled data must have an accompanying index spatial file. Note that the FEMA and USGS LiDAR specifications include some specific file format requirements.

- Contours, Masspoints, and breaklines – Personal/file Geodatabase, DXF, or shapefile (2D or 3D)
- DEMs – Esri grid, GeoTIFF, or ASCII grid
- LiDAR – LAS file, ASCII x, y, z file (comma or space delimited)
- Terrain and/or TIN– Esri ArcGIS

- MS Word – project narrative
- PDF – correspondence and certification

PDF files must be created using the source file (e.g., MS Word file), if the source file is created by the mapping partner, rather than raster scans of hard copy text documents. Created PDF files must allow text to be copied and pasted to another document. In addition, Esri shapefiles and Geodatabases must be projected.

M.4.2.5 Metadata [July 2011]

A metadata file in XML format that complies with the NFIP Terrain Metadata Profiles must be included with the submittal. The profiles follow the FGDC Content Standard for metadata and define additional domains and business rules for some elements that are mandatory for FEMA, based on the specific submittal type. For each spatial data source in the metadata file, the mapping partner must assign a Source Citation Abbreviation. FEMA NFIP Metadata Profiles can be accessed on the MIP, in the "Guides & Documentation" tab, under "MIP User Care".

If metadata is available from an agency or organization that provided data for use in the flood risk project, it should be included in the metadata submittal in addition to the NFIP Terrain Metadata Profiles. Reference the data providers' original metadata record in the Lineage section of the NFIP metadata profile. If there is a web-accessible metadata record for the original data set, the URL to the metadata may be provided in the optional Source Citation - Online Linkage element. Otherwise, the Source Contribution [free text] element may include information on how to access the metadata record for the data sets obtained.

Metadata should also comply with the requirements in the USGS *LiDAR Guidelines and Base Specification*, v13. In addition, the finished elevation product for hydraulic modeling should be documented by a FGDC-compliant metadata file that complies with the FEMA Elevation Metadata Profile. Project documentation must also include a pre-flight Operations Plan and a post-flight Aerial Acquisition and Calibration Report per FEMA requirements.

M.4.2.6 Transfer Media [March 2009]

Mapping partners must submit files via the internet by uploading to the MIP (http://www.hazards.fema.gov) or by mailing the files to FEMA on one or more of the following electronic media:

- CD-ROM;
- DVD; or
- External Hard Drive (for very large data submissions, with a return label for shipment back to the mapping partner).

In special situations, or as technology changes, other media may be acceptable if coordinated with FEMA.

When data are mailed to FEMA, all submitted digital media must be labeled with at least the following information:

- Mapping partner's name;

- Community name and State for which the FIS was prepared;
- Terrain Data;
- Date of submission (formatted mm/dd/yyyy); and
- Disk [*sequential number*] of [*number of disks*]. The media must be numbered sequentially, starting at Disk 1. [Number of disks] represents the total number of disks in the submission.

M.4.2.7 Transfer Methodology [July 2011]

Terrain artifacts can be uploaded to the MIP by following the guidelines for Data Upload located on the MIP (https://hazards.fema.gov).

M.4.2.8 Directory Structure and Folder Naming Conventions [July 2011]

The files presented in Section M.4.2 – Requirements must be submitted to the MIP or mailed to FEMA within the following directory structure. For FEMA-funded LiDAR acquisition projects, LiDAR data must be submitted in its entirety to the MIP even if the collection footprint extends beyond the current Risk MAP project area. If Lidar data is obtained for a project from a third party (e.g., existing LiDAR data from a County), only LiDAR data used for that project must be submitted to the MIP. Third party LiDAR data outside the project area must not be submitted. The following folders can be created either on a local work space (e.g., a personal computer) or within the work space for the community on the MIP. If the following folders are generated locally, these newly created folders and their contents must be uploaded to the MIP. Terrain files are arranged into appropriate directories based on data type. Only directories appropriate to the project are required.

- \General
  - Project narrative
  - Certification
  - Flight plans and logs
  - Mapping partner and Independent QA/QC reports
  - Metadata File
- \Correspondence
  - Letters; transmittals; memoranda; general status reports and queries; SPRs; technical issues; direction by FEMA; and internal communications, routing slips, and notes.
- \ Terrain\Source\Raw Point Cloud Data
  - LiDAR data – Raw Point Cloud Data
  - LiDAR Tile Index spatial file (if used)
- \ Terrain\Source\Classified Point Cloud Data
  - LiDAR data – Classified Point Cloud Data
  - LiDAR Tile Index spatial file (if used)
- \ Terrain\Source\Breaklines
  - 3D breakline spatial files
  - 3D breakline Tile Index spatial file (if used)
  - 2D breakline spatial files
  - 2D breakline Tile Index spatial file (if used)

  - Mass Points
- \ Terrain\Source\Bare Earth DEM
  - Bare earth DEM files
  - Tile Index spatial file (if used)
- \ Terrain\Source\Contours
  - Contour spatial files
  - Contour Tile Index spatial file (if used)
  - Bathymetric files
  - Bathymetric Tile Index spatial file (if used)
- \ Terrain\Source\TIN
  - Uncorrected TIN files
  - Terrain (Esri ArcGIS format)
  - Tile index spatial file (if used)
- \ Terrain\Source\HDEM
  - Hydrologically corrected DEM files
  - Terrain (Esri ArcGIS format)
  - Tile Index spatial file (if used)
- \ Terrain\Final\Classified Point Cloud Data
  - LiDAR data – Classified Point Cloud Data
  - LiDAR Tile Index spatial file (if used)
- \ Terrain\Final\Breaklines
  - 3D breakline spatial files
  - 3D breakline Tile Index spatial file (if used)
  - 2D breakline spatial files
  - 2D breakline Tile Index spatial file (if used)
  - Mass Points
- \ Terrain\Final\Bare Earth DEM
  - Bare earth DEM files
  - Tile Index spatial file (if used)
- \ Terrain\Final\Contours
  - Contour spatial files
  - Contour Tile Index spatial file (if used)
  - Bathymetric files
  - Bathymetric Tile Index spatial file (if used)
- \ Terrain\Final\TIN
  - Uncorrected TIN files
  - Terrain (Esri ArcGIS format)
  - Tile index spatial file (if used)
- \ Terrain\Final\HDEM

  - Hydrologically corrected DEM files
  - Terrain (Esri ArcGIS format)
  - Tile Index spatial file (if used)

- \ Terrain\Supplemental Data
  - As-built drawings
  - GIS representation of structures

U.S. Geological Survey
National Geospatial Program
Lidar Guidelines and Base Specification

Version 13 – ILMF 2010

The U.S. Geological Survey National Geospatial Program (NGP) has cooperated in the collection of numerous lidar datasets across the nation for a wide array of applications. These collections have used a variety of specifications and required a diverse set of products, resulting in many incompatible datasets and making cross-project analysis extremely difficult. The need for a single base specification, defining minimum collection parameters and a consistent set of deliverables, is apparent.

Beginning in late 2009, an increase in the rate of lidar data collection due to American Reinvestment and Recovery Act (ARRA) funding for The National Map makes it imperative that a single data specification be implemented to ensure consistency and improve data utility. Although the development of this specification was prompted by the ARRA stimulus funding, the specification is intended to remain durable beyond ARRA funded NGP projects.

The primary intent of this specification is to create consistency across all NGP funded lidar collections, in particular those undertaken in support of the National Elevation Dataset (NED). Unlike most other "lidar specs" which focus on the derived bare-earth DEM product, this specification places unprecedented emphasis on the handling of the source lidar point cloud data. This is to assure that the complete source dataset collected remains intact and viable to support the wide variety of non-DEM science and mapping applications that benefit from lidar technology. In the absence of other comprehensive specifications or standards, it is hoped that this specification will, to the highest degree practical, be adopted by other USGS programs and disciplines, and by other Federal agencies.

Adherence to these minimum specifications ensures that bare-earth Digital Elevation Models (DEMs) derived from lidar data is suitable for ingestion into the NED (National Elevation Dataset) at the 1/9 arc-second resolution, and can be resampled for use in the 1/3 and 1 arc-second NED resolutions. It also ensures that the point cloud source data are handled in a consistent manner by all data providers and delivered to the USGS in clearly defined formats. This allows straight-forward ingest into CLICK (Center for Lidar Information, Coordination, and Knowledge) and simplifies subsequent use of the source data by the broader scientific community, particularly with regard to cross-collection analysis.

It must be stressed that this is a **base specification,** defining <u>minimum parameters</u>. It is expected that local conditions in any given project area, specialized applications for the data, or the preferences of cooperators, may mandate more stringent requirements. The

USGS encourages the collection of more detailed, accurate, or value-added data. A list of common upgrades to the minimum requirements defined here is provided in Appendix 1.

In addition, it is recognized that the USGS NGP also employs lidar technology for specialized scientific research and other projects whose requirements are incompatible with the provisions of this Specification. In such cases, and with properly documented justification supporting the need for the variance, waivers of any part or all of this Specification may be granted.

It is conceivable that in some cases, based on specific topography, land cover, intended application, or other factors, the USGS-NGP may require specifications more rigorous than those defined in this document. It is expected that this would be highly uncommon.

Lidar is still a relatively new technology; adolescent but not fully matured.. Advancements and improvements in instrumentation, software, processes, applications, and understanding are constantly being made. It would not be possible to develop a set of guidelines and specifications that address all of these advances. The current document is based on our understanding of and experience with the industry and technology at the present time. Furthermore, we acknowledge that there is a lack of commonly accepted “best practices” for numerous processes and technical assessments (i.e., measurement of NPS, point clustering, classification accuracy, etc.). The USGS encourages the development of such best practices through the appropriate industry and professional governance organizations, and we eagerly await the opportunity to include them in future revisions to this and other similar documents.

It is not the intention of the USGS to stifle the development of the lidar industry, nor to discourage innovation within the technology. Technical alternatives to any part of this document may be submitted with any proposal and will be given due professional consideration.

I. COLLECTION

1. Multiple Discrete Return, capable of at least 3 returns per pulse

   Note: Full waveform collection is both acceptable and welcomed; however, waveform data is regarded as supplemental information. The requirement for deriving and delivering multiple discrete returns remains in force in all cases.

2. Intensity values for each return.

3. Nominal **Pulse** Spacing (NPS) of 1-2 meters, dependent on the local terrain and landcover conditions. Assessment to be made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath. Average along-track and cross-track point spacings should be comparable.

4. Collections designed to achieve the NPS through swath overlap or multiple passes are generally discouraged. Such collections may be permitted with prior approval.

5. Data Voids [areas => $(4*\text{NPS})^2$, measured using 1^{st}-returns only] within a single swath are not acceptable, except:

   - where caused by water bodies
   - where caused by areas of low near infra-red (NIR) reflectivity such as asphalt or composition roofing.
   - where appropriately filled-in by another swath

6. The spatial distribution of geometrically usable points is expected to be uniform and free from clustering. In order to ensure uniform densities throughout the data set:

   - A regular grid, with cell size equal to the design NPS*2 will be laid over the data.
   - At least 90% of the cells in the grid shall contain at least 1 lidar point.
   - Assessment to be made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.
   - Acceptable data voids identified previously in this specification are excluded.

   Note: This requirement may be relaxed in areas of significant relief where it is impractical to maintain a consistent NPS.

7. Scan Angle: Total FOV should not exceed 40^o (+/-20^o from nadir) USGS quality assurance on collections performed using scan angles wider than 34^o will be particularly rigorous in the edge-of-swath areas. Horizontal and vertical accuracy shall remain within the requirements as specified below.

   Note: This requirement is primarily applicable to oscillating mirror lidar systems. Other instrument technologies may be exempt from this requirement.

8. Vertical Accuracy of the lidar data will be assessed and reported in accordance with the guidelines developed by the NDEP and subsequently adopted by the ASPRS. The complete guidelines may be found in Section 1.5 of the Guidelines document. See:

   http://www.ndep.gov/NDEP_Elevation_Guidelines_Ver1_10May2004.pdf

   Vertical accuracy requirements using the NDEP/ASPRS methodology are:
   FVA <= 24.5cm ACCz, 95% (12.5cm RMSEz)
   CVA <= 36.3cm, 95th Percentile
   SVA <= 36.3cm, 95th Percentile

   - Accuracy for the lidar point cloud data is to be reported independently from accuracies of derivative products (i.e., DEMs). Point cloud data accuracy is to be tested against a TIN constructed from bare-earth lidar points.
   - Each landcover type representing 10% or more of the total project area must be tested and reported as an SVA.
   - For SVAs, the value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded. Overall CVA requirements must be met in spite of "busts" in individual SVAs.

   Note: These requirements may be relaxed in cases:

   - *where there exists a demonstrable and substantial increase in cost to obtain this accuracy.*
   - *where an alternate specification is needed to conform to previously contracted phases of a single larger overall collection effort, i.e., multi-year statewide collections, etc.*
   - *where the USGS agrees that it is reasonable and in the best interest of all stakeholders to use an alternate specification.*

9. Relative accuracy <=7cm RMSE$_{Z}$ within individual swaths; <=10cm RMSEz within swath overlap (between adjacent swaths).
10. Flightline overlap 10% or greater, as required to ensure there are no data gaps between the usable portions of the swaths. Collections in high relief terrain are expected to require greater overlap. Any data with gaps between the geometrically usable portions of the swaths will be rejected.
11. Collection Area: Defined Project Area, buffered by a minimum of 100 meters.
12. Collection Conditions:
   - Atmospheric: Cloud and fog-free between the aircraft and ground
   - Ground:
     - Snow free. Very light, undrifted snow may be acceptable in special cases, with prior approval.

    - No unusual flooding or inundation, except in cases where the goal of the collection is to map the inundation.
- Vegetation: Leaf-off is preferred, however:
    - As numerous factors will affect vegetative condition at the time of any collection, the USGS NGP only requires that penetration to the ground must be adequate to produce an accurate and reliable bare-earth surface suitable for incorporation into the 1/9 (3-meter) NED.
    - Collections for specific scientific research projects may be exempted from this requirement, with prior approval.

II. DATA PROCESSING and HANDLING

1. All processing should be carried out with the understanding that all point deliverables are required to be in fully compliant LAS format, v1.2 or v1.3. Data producers are encouraged to review the LAS specification in detail.
2. If full waveform data is collected, delivery of the waveform packets is required. LAS v1.3 deliverables with waveform data are to use external "auxiliary" files with the extension ".wdp" for the storage of waveform packet data. See the LAS v1.3 Specification for additional information.
3. GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each pulse. Adjusted GPS Time is defined to be Standard (or satellite) GPS time minus $1*10^9$. See the LAS Specification for more detail.
4. Horizontal datum shall be referenced to the North American Datum of 1983/HARN adjustment. Vertical datum shall be referenced to the North American Vertical Datum of 1988 (NAVD 88). The most recent NGS-approved Geoid model shall be used to perform conversions from ellipsoidal heights to orthometric heights.
5. The USGS preferred Coordinate Reference System for the Conterminous United States (CONUS) is: UTM, NAD83, Meters. Each discrete project is to be processed using the predominant UTM zone for the overall collection area.

   State Plane Coordinate Reference Systems that have been accepted by the European Petroleum Survey Group (EPSG) and that are recognized by ESRI GIS software may be used by prior agreement with the USGS.

   Alternative projected coordinate systems for collections in Alaska, Hawaii, and other areas Outside the Conterminous United States (OCONUS) must be approved by the USGS prior to collection.
6. All references to the Unit of Measure "Feet" or "Foot" must specify either "International" or "U.S. Survey"
7. Long swaths (those which result in a LAS file larger than 2GB) should be split into segments no greater than 2GB each. Each segment will thenceforth be

regarded as a unique swath and shall be assigned a unique File Source ID. Other swath segmentation approaches may be acceptable, with prior approval. Renaming schemes for split swaths are at the discretion of the data producer. The Processing Report shall include detailed information on swath segmentation sufficient to allow reconstruction of the original swaths if needed.

8. Each swath shall be assigned a unique File Source ID. The Point Source ID field for each point within each LAS swath file shall be set equal to the File Source ID prior to any processing of the data. See the LAS Specification.
9. Point Families (multiple return "children" of a single "parent" pulse) shall be maintained intact through all processing prior to tiling. Multiple returns from a given pulse shall be stored in sequential (collected) order.
10. All collected swaths are to be delivered as part of the "Raw Data Deliverable". This includes calibration swaths and cross-ties. All collected points are to be delivered. No points are to be deleted from the swath LAS files. This in no way requires or implies that calibration swath data are to be included in product generation. Excepted from this are extraneous data outside of the buffered project area (aircraft turns, transit between the collection area and airport, transit between fill-in areas, etc.). These points may be permanently removed.
11. Outliers, blunders, noise points, geometrically unreliable points near the extreme edge of the swath, and other points deemed unusable are to be identified using the "Withheld" flag, as defined in the LAS specification.
    - This applies primarily to points which are identified during pre-processing or through automated post-processing routines.
    - If processing software is not capable of populating the "Withheld" bit, these points may be identified using Class=11.
    - "Noise points" subsequently identified during manual Classification and Quality Assurance/Quality Control (QA/QC) may be assigned the standard LAS classification value for "Noise" (Class=7), regardless of whether the noise is "low" or "high" relative to the ground surface.
12. The ASPRS/LAS "Overlap" classification (Class=12) shall not be used. ALL points not identified as "Withheld" are to be classified.
    - If overlap points are required to be differentiated by the data producer or cooperating partner, they must be identified using a method that does not interfere with their classification, such as:
        - Overlap points are tagged using Bit:0 of the User Data byte, as defined in the LAS specification. (SET=Overlap).
        - Overlap points are classified using the Standard Class values + 16.
        - Other techniques as agreed upon in advance
    - The technique utilized must be clearly described in the project metadata files.

Note: A standard bit setting for identification of overlap points has been planned for a future version of LAS.

13. Positional Accuracy Validation: The absolute and relative accuracy of the data, both horizontal and vertical, and relative to known control, shall be verified prior to classification and subsequent product development. This validation is obviously limited to the Fundamental Vertical Accuracy, measured in clear, open areas. A detailed report of this validation is a required deliverable.

14. Classification Accuracy: It is expected that due diligence in the classification process will produce data that meets the following test:

    Within any 1km x 1km area, no more than 2% of non-withheld points will possess a demonstrably erroneous classification value.

    This includes points in Classes 0 and 1 that should correctly be included in a different Class as required by the contract.

    Note: This requirement may be relaxed to accommodate collections in areas where the USGS agrees classification to be particularly difficult.

15. Classification Consistency: Point classification is to be consistent across the entire project. Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other non-natural divisions will be cause for rejection of the entire deliverable.

16. Tiles:

    Note: This section assumes a projected coordinate reference system.

    - A single non-overlapped tiling scheme will be established and agreed upon by the data producer and the USGS prior to collection. This scheme will be used for **all** tiled deliverables.
    - Tile size must be an integer multiple of the cell size of raster deliverables.
    - Tiles must be sized using the same units as the coordinate system of the data.
    - Tiled deliverables shall conform to the tiling scheme, without added overlap.
    - Tiled deliverables shall edge-match seamlessly and without gaps in both the horizontal and vertical.

III. HYDRO-FLATTENING REQUIREMENTS

Note: Please refer to Appendix 2 for reference information on hydro-flattening.

Hydro-flattening pertains only to the creation of derived DEMs. No manipulation of or changes to originally computed lidar point elevations are to be made. Breaklines may be used to help classify the point data.

1. Inland Ponds and Lakes:
    - ~2-acre or greater surface area (~350' diameter for a round pond) at the time of collection.
    - Flat and level water bodies (single elevation for every bank vertex defining a given water body).
    - The entire water surface edge must be at or below the immediately surrounding terrain.
    - Long impoundments such as reservoirs, inlets, and fjords, whose water surface elevations drop when moving downstream, should be treated as rivers.
2. Inland Streams and Rivers:
    - 100' **nominal** width: This should not unnecessarily break a stream or river into multiple segments. At times it may squeeze slightly below 100' for short segments. Data producers should use their best professional judgment.
    - Flat and level bank-to-bank (perpendicular to the apparent flow centerline); gradient to follow the immediately surrounding terrain.
    - The entire water surface edge must be at or below the immediately surrounding terrain.
    - Streams channels should break at road crossings (culvert locations). These road fills should not be removed from DEM. However, streams and rivers should **not** break at elevated bridges. Bridges should be removed from DEM. When the identification of a feature as a bridge or culvert cannot be made reliably, the feature should be regarded as a culvert.
3. Non-Tidal Boundary Waters:
    - Represented only as an edge or edges within the project area; collection does not include the opposing shore.
    - The entire water surface edge must be at or below the immediately surrounding terrain.
    - The elevation along the edge or edges should behave consistently throughout the project. May be a single elevation (i.e., lake) or gradient (i.e., river), as appropriate.

4. Tidal Waters:

    - Water bodies such as oceans, seas, gulfs, bays, inlets, salt marshes, very large lakes, etc. Includes any water body that is affected by tidal variations.
    - Tidal variations over the course of a collection or between different collections, will result in discontinuities along shorelines. This is considered normal and these “anomalies” should be retained. The final DEM should represent as much ground as the collected data permits.
    - Variations in water surface elevation resulting in tidal variations during a collection should NOT be removed or adjusted, as this would require either the removal of valid, measured ground points or the introduction of unmeasured ground into the DEM. The USGS NGP priority is on the ground surface, and accepts there may be occasional, unavoidable irregularities in water surface.
    - Scientific research projects in coastal areas often have very specific requirements with regard to how tidal land-water boundaries are to be handled. For such projects, the requirements of the research will take precedence.

Cooperating partners may require collection and integration of single-line streams within their lidar projects. While the USGS does not require these breaklines be collected or integrated, it does require that if used and incorporated into the DEMs, the following guidelines are met:

1. All vertices along single-line stream breaklines are at or below the immediately surrounding terrain.
2. Single-line stream breaklines are not to be used to introduce cuts into the DEM at road crossings (culverts), dams, or other such features. This is hydro-enforcement and as discussed in Section VI, creates a non-traditional DEM that is not suitable for integration into the NED.
3. All breaklines used to modify the surface are to be delivered to the USGS with the DEMs.

The USGS does not require any particular process or methodology be used for breakline collection, extraction, or integration. However, the following general guidelines must be adhered to:

1. Bare-earth lidar points that are in close proximity breaklines should be excluded from the DEM generation process. This is analogous to the removal of masspoints for the same reason in a traditional photogrammetrically compiled DTM.

    The proximity threshold for reclassification as “Ignored Ground” is at the discretion of the data producer, but in general should be approximately equal to the NPS.

2. These points are to be retained in the delivered lidar point dataset and shall be reclassified as “Ignored Ground” (class value = 10) so that they may be subsequently identified.
3. Delivered data must be sufficient for the USGS to effectively recreate the delivered DEMs using the lidar points and breaklines without significant further editing.

IV. DELIVERABLES

The USGS shall have unrestricted rights to all delivered data and reports, which will be placed in the public domain. This specification places no restrictions on the data provider's rights to resell data or derivative products as they see fit.

1. Metadata

Note: “Metadata” refers to all descriptive information about the project. This includes textual reports, graphics, supporting shapefiles, and FGDC-compliant metadata files.

- Collection Report detailing mission planning and flight logs.
- Survey Report detailing the collection of control and reference points used for calibration and QA/QC.
- Processing Report detailing calibration, classification, and product generation procedures including methodology used for breakline collection and hydro-flattening *(see Sections III and Appendix 1 for more information on hydro-flattening)*.
- QA/QC Reports (detailing the analysis, accuracy assessment and validation of:
    - The point data (absolute, within swath, and between swath)
    - The bare-earth surface (absolute)
    - Other optional deliverables as appropriate
- Control and Calibration points: All control and reference points used to calibrate, control, process, and validate the lidar point data or any derivative products are to be delivered.
- Geo-referenced, digital spatial representation of the precise extents of each delivered dataset. This should reflect the extents of the actual lidar source or derived product data, exclusive of Triangular Irregular Network (TIN) artifacts or raster NODATA areas. A union of tile boundaries or minimum bounding rectangle is not acceptable. ESRI Polygon shapefile or geodatabase is preferred.
- Product metadata (FGDC compliant, XML format metadata). One file for each:

    - Project
    - Lift
    - Tiled deliverable product group (classified point data, bare-earth DEMs, breaklines, etc.). Metadata files for individual tiles are not required.
- FGDC compliant metadata must pass the USGS metadata parser ("mp") with no errors or warnings.

2. Raw Point Cloud

- All returns, all collected points, fully calibrated and adjusted to ground, by swath.
- <u>Fully compliant</u> LAS v1.2 or v1.3, Point Record Format 1, 3, 4, or 5
- LAS v1.3 deliverables with waveform data are to use external "auxiliary" files with the extension ".wdp" for the storage of waveform packet data. See the LAS v1.3 Specification for additional information.
- Georeference information included in all LAS file headers
- GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each pulse.
- Intensity values (native radiometric resolution)
- 1 file per swath, 1 swath per file, file size not to exceed 2GB, as described in Section II, Paragraph 7.

3. Classified Point Cloud

Note: Delivery of a classified point cloud is a standard requirement for USGS NGP lidar projects. Specific scientific research projects may be exempted from this requirement.

- <u>Fully compliant</u> LAS v1.2 or v1.3, Point Record Format 1, 3, 4, or 5
- LAS v1.3 deliverables with waveform data are to use external "auxiliary" files with the extension ".wdp" for the storage of waveform packet data. See the LAS v1.3 Specification for additional information.
- Georeference information included in LAS header
- GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each pulse.
- Intensity values (native radiometric resolution)
- Tiled delivery, without overlap (tiling scheme TBD)

- Classification Scheme (minimum):

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high, manually identified, if needed)
9	Water
10	Ignored Ground (Breakline Proximity)
11	Withheld (if the "Withheld" bit is not implemented in processing software)

Note: Class 7, Noise, is included as an adjunct to the "Withheld" bit. All "noise points" are to be identified using one of these to methods.

Note: Class 10, Ignored Ground, is for points previously classified as bare-earth but whose proximity to a subsequently added breakline requires that it be excluded during Digital Elevation Model (DEM) generation.

4. **Bare Earth Surface (Raster DEM)**

Note: Delivery of a bare-earth DEM is a standard requirement for USGS NGP lidar projects. Specific scientific research projects may be exempted from this requirement.

- Cell Size no greater than 3 meters or 10 feet, and no less than the design Nominal Pulse Spacing (NPS).
- Delivery in an industry-standard, GIS-compatible, 32-bit floating point raster format (ERDAS .IMG preferred)
- Georeference information shall be included in each raster file
- Tiled delivery, without overlap
- DEM tiles will show no edge artifacts or mismatch. A quilted appearance in the overall project DEM surface, whether caused by differences in processing quality or character between tiles, swaths, lifts, or other non-natural divisions, will be cause for rejection of the entire DEM deliverable.
- Void areas (i.e., areas outside the project boundary but within the tiling scheme) shall be coded using a unique "NODATA" value. This value shall be identified in the appropriate location within the file header.
- Vertical Accuracy of the bare earth surface will be assessed and reported in accordance with the guidelines developed by the NDEP and subsequently adopted by the ASPRS. The complete guidelines may be found in Section 1.5 of the Guidelines document. See:

http://www.ndep.gov/NDEP_Elevation_Guidelines_Ver1_10May2004.pdf

Vertical accuracy requirements using the NDEP/ASPRS methodology are:
FVA <= 24.5cm ACCz, 95% (12.5cm RMSEz)
CVA <= 36.3cm, 95th Percentile
SVA <= 36.3cm, 95th Percentile

All QA/QC analysis materials and results are to be delivered to the USGS.

- Depressions (sinks), natural or man-made, are **not** to be filled (as in hydro-conditioning and hydro-enforcement).
- Water Bodies (ponds and lakes), wide streams and rivers ("double-line"), and other non-tidal water bodies as defined in Section III are to be hydro-flattened within the DEM. Hydro-flattening shall be applied to all water impoundments, natural or man-made, that are larger than ~2 acre in area (equivalent to a round pond ~350' in diameter), to all streams that are nominally wider than 100', and to all non-tidal boundary waters bordering the project area regardless of size. The methodology used for hydro-flattening is at the discretion of the data producer.

  Note: Please refer to the Sections III and VI for detailed discussions of hydro-flattening.

5. **Breaklines**

Note: Delivery of the breaklines used in hydro-flattening is a standard requirement for USGS NGP lidar projects. Specific scientific research projects may be exempted from this requirement. If hydro-flattening is achieved through other means, this section may not apply.

- All breaklines developed for use in hydro-flattening shall be delivered as an ESRI feature class (PolylineZ or PolygonZ format, as appropriate to the type of feature represented and the methodology used by the data producer). Shapefile or geodatabase is preferred.
- Each feature class or shapefile will include properly formatted and accurate georeference information in the standard location. All shapefiles must include the companion .prj file.
- Breaklines must use the same coordinate reference system (horizontal and vertical) and units as the lidar point delivery.
- Breakline delivery may be as a continuous layer or in tiles, at the discretion of the data producer. Tiled deliveries must edge-match seamlessly in both the horizontal and vertical.

APPENDIX 1

COMMON DATA UPGRADES

1. Independent 3rd-Party QA/QC by another AE Contractor (encouraged)
2. Higher Nominal Pulse Spacing (point density)
3. Increased Vertical Accuracy
4. Full Waveform collection and delivery
5. Additional Environmental Constraints
    - Tidal coordination, flood stages, crop/plant growth cycles, etc.
    - Shorelines corrected for tidal variations within a collection
6. Top-of Canopy (First-Return) Raster Surface (tiled). Raster representing the highest return within each cell is preferred.
7. Intensity Images (8-bit gray scale, tiled)
8. Detailed Classification (additional classes):

Code	Description
3	Low vegetation
4	Medium vegetation (use for single vegetation class)
5	High vegetation
6	Buildings, bridges, other man-made structures
n	additional Class(es) as agreed upon in advance

9. Hydro-Enforced and/or Hydro-Conditioned DEMs
10. Breaklines (PolylineZ and PolygonZ) for single-line hydrographic features (narrow streams not collected as double-line, culverts, etc.), including appropriate integration into delivered DEMs
11. Breaklines (PolylineZ and PolygonZ) for other features (TBD), including appropriate integration into delivered DEMs
12. Extracted Buildings (PolygonZ): Footprints with maximum elevation and/or height above ground as an attribute.
13. Other products as defined by requirements and agreed upon in advance of funding commitment.

APPENDIX 2

HYDRO-FLATTENING REFERENCE

The subject of modifications to lidar-based DEMs is somewhat new, and although authoritative references are available, there remains significant variation in the understanding of the topic across the industry. The following material was developed to provide a definitive reference on the subject only as it relates to the creation of DEMs intended to be integrated into the USGS NED. The information presented here is not meant to supplant other reference materials and it should not be considered authoritative beyond its intended scope.

The term "**hydro-flattening**" is also new, coined for this document and to convey our specific needs. It is not, at this time, a known or accepted term across the industry. It is our hope that its use and acceptance will expand beyond the USGS with the assistance of other industry leaders.

Hydro-flattening of DEMs is predominantly accomplished through the use of breaklines, and this method is considered standard. Although other techniques may exist to achieve similar results, this section assumes the use of breaklines. The USGS does not require the use of any specific technique.

The Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition (Maune *et al.*, 2007) provides the following definitions related to the adjustment of DEM surfaces for hydrologic analyses:

1. **Hydrologically-Conditioned (Hydro-Conditioned)** – Processing of a DEM or TIN so that the flow of water is continuous across the entire terrain surface, including the removal of all spurious sinks or pits. The only sinks that are retained are the real ones on the landscape. Whereas "hydrologically-enforced" is relevant to drainage features that are generally mapped, "hydrologically-conditioned" is relevant to the entire land surface and is done so that water flow is continuous across the surface, whether that flow is in a stream channel or not. The purpose for continuous flow is so that relationships/links among basins/catchments can be known for large areas. This term is specifically used when describing EDNA (see Chapter 4), the dataset of NED derivatives made specifically for hydrologic modeling purposes.
2. **Hydrologically-Enforced (Hydro-Enforced)** – Processing of mapped water bodies so that lakes and reservoirs are level and so that streams flow downhill. For example, a DEM, TIN or topographic contour dataset with elevations removed from the tops of selected drainage structures (bridges and culverts) so as to depict the terrain under those structures. Hydro-enforcement enables hydrologic and hydraulic models to depict water flowing under these structures, rather than appearing in the computer model to be dammed by them because of road deck elevations higher than the water levels. Hydro-enforced TINs also utilize breaklines along shorelines and stream centerlines, for example, where these breaklines form the edges of TIN triangles along the alignment of drainage features. Shore breaklines for streams would be 3-D breaklines

with elevations that decrease as the stream flows downstream; however, shore breaklines for lakes or reservoirs would have the same elevation for the entire shoreline if the water surface is known or assumed to be level throughout. See figures 1.21 through 1.24. See also the definition for "hydrologically-conditioned" which has a slightly different meaning.

While these are important and useful modifications, they both result in surfaces that differ significantly from a traditional DEM. A "hydro-conditioned" surface has had its sinks filled and may have had its water bodies flattened. This is necessary for correct flow modeling within and across large drainage basins. "Hydro-enforcement" extends this conditioning by requiring water bodies be leveled and streams flattened with the appropriate downhill gradient, and also by cutting through road crossings over streams (culvert locations) to allow a continuous flow path for water within the drainage. Both treatments result in a surface on which water behaves as it physically does in the real world, and both are invaluable for specific types of hydraulic and hydrologic (H&H) modeling activities. Neither of these treatments is typical of a traditional DEM surface.

A traditional DEM such as the NED, on the other hand, attempts to represent the ground surface more the way a bird, or person in an airplane, sees it. On this surface, natural depressions exist, and road fills create apparent sinks because the road fill and surface is depicted without regard to the culvert beneath. Bridges, it should be noted, are removed in most all types of DEMs because they are man-made, above-ground structures that have been added to the landscape.

Note: DEMs developed solely for orthophoto production may include bridges, as their presence can prevent the "smearing" of structures and reduce the amount of post-production correction of the final orthophoto. These are "special use DEMs" and are not relevant to this discussion.

For years, raster Digital Elevation Models (DEMs), have been created from a Digital Surface Model (DSM) of masspoints and breaklines, which in turn were created through photogrammetric compilation from stereo imagery. Photogrammetric DSMs inherently contain breaklines defining the edges of water bodies, coastlines, single-line streams, and double-line streams and rivers, as well as numerous other surface features.

Lidar technology, however, does not inherently collect the breaklines necessary to produce traditional DEMs. Breaklines have to be developed separately through a variety of techniques, and either used with the lidar points in the generation of the DEM, or applied as a correction to DEMs generated without breaklines.

In order to maintain the consistent character of the NED as a traditional DEM, the USGS NGP requires that all DEMs delivered have their inland water bodies flattened. This does not imply that a complete network of topologically correct hydrologic breaklines be developed for every dataset; only those breaklines necessary to ensure that the conditions defined in Section III exist in the final DEM.

APPENDIX 3

SAMPLE METADATA TEMPLATE

[to be added]

APPENDIX 4

REFERENCES

Maune, D.F., 2007. Definitions, in *Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition* (D.F. Maune, editor), American Society for Photogrammetry and Remote Sensing, Bethesda, MD pp. 550-551

National Digital Elevation Program, 2004. *Guidelines for Digital Elevation Data—Version 1*, 93 p., available online at: http://www.ndep.gov/NDEP_Elevation_Guidelines_Ver1_10May2004.pdf (last date accessed: 29 September 2009)

FEMA, 2003. *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying*, 59 p., available online at: http://www.fema.gov/library/viewRecord.do?id=2206 (last date accessed 29 September 2009)

USGS NED Website:	www.ned.usgs.gov
USGS CLICK Website:	www. lidar.cr.usgs.gov
MP-Metadata Parser:	http://geology.usgs.gov/tools/metadata

LAS SPECIFICATION

VERSION 1.3 – R10

Approved: JULY 14, 2009

Published by:
The American Society for Photogrammetry & Remote Sensing
5410 Grosvenor Lane, Suite 210
Bethesda, Maryland 20814-2160
Voice: 301-493-0290
Fax: 301-493-0208
Web: www.asprs.org

LAS FORMAT VERSION 1.3:

1 Purpose, scope, and applicability

The LAS file is intended to contain LIDAR point data records. The data will generally be put into this format from software (e.g. provided by LIDAR hardware vendors) which combines GPS, IMU, and laser pulse range data to produce X, Y, and Z point data. The intention of the data format is to provide an open format that allows different LIDAR hardware and software tools to output data in a common format.

This document reflects the third revision of the LAS format specification since its initial version 1.0 release.

THE ADDITIONS OF LAS 1.3 INCLUDE:

- Ability to store return pulse waveform data in the LAS file (and, optionally, in an external file) using new point record types 4 and 5
- Storage of parameters necessary to geospatially traverse waveforms
- Additional Global Encoding flag to indicate that the returns in the file are synthetically generated.

GOALS OF WAVEFORM DATA STORAGE:

- Waveform data are included in the same file as the LIDAR point data
- A return may or may not have an associated waveform packet
- Multiple returns from a single LIDAR pulse may point to the same waveform packet
- 2 through 32 bit waveform amplitude records are supported
- Multiple waveform digitizer configurations are accommodated (number of samples, sample spacing, bits per sample, etc.)
- Compression of waveform data is supported (although particular compression schemes are not provided in this version of the specification)

WAVFORM DATA STORAGE IMPLEMENTATION:

- Sections of the waveform in the vicinity of declared returns are stored (Waveform Data Packets, WDP)
- The raw waveform data packets are stored in one large, contiguous extended variable length record (EVLR) or, optionally, in an external auxiliary file
- The descriptions of the digitizer configurations are stored in one of up to 255 variable length records called Waveform Packet Descriptors (WPD)
- Each point record has new metadata that serves as an index into an associated WDP
- Each point record has additional information associated with it that indicates which WPD describes this point's waveform packet

COMPATIBILITY WITH LAS 1.2:

One unavoidable change has been made to the Public Header Block; Start of Waveform Data Packet Record. This long, long has been added to the end of the block and thus little or no change will be needed in LAS 1.2 readers that do not need waveform data.

There are no changes to Point Data Record types 0 through 3. The waveform encoded data types have been added as Point Data Record types 4 and 5.

2 Conformance

The data types used in the LAS format definition are conformant to the 1999 ANSI C Language Specification (ANSI/ISO/IEC 9899:1999 ("C99").

3 Authority

The American Society for Photogrammetry & Remote Sensing (ASPRS) is the owner of the LAS Specification. The standard is maintained by committees within the organization as directed by the ASPRS Board of Directors. Questions related to this standard can be directed to ASPRS at 301-493-0290, by email at asprs@asprs.org, or by mail at 5410 Grosvenor Lane, Suite 210, Bethesda, Maryland 20814-2160.

4 Requirements

LAS FORMAT DEFINITION:

The format contains binary data consisting of a header block, Variable Length Records, and point data.

Table 4.1 – LAS Format Definition

PUBLIC HEADER BLOCK
VARIABLE LENGTH RECORDS
POINT DATA RECORDS

A LAS file that contains waveform data (point record types 4 or 5) would be

Table 4.2 – LAS Format Definition Containing Waveform Data

PUBLIC HEADER BLOCK
VARIABLE LENGTH RECORDS INCLUDING WAVEFORM PACKET DESCRIPTORS (up to 255)
POINT DATA RECORDS
EXTENDED VARIABLE LENGTH RECORD (WAVEFORM DATA PACKETS)

All data is in little-endian format. The header block consists of a public block followed by Variable Length Records. The public block contains generic data such as point numbers and coordinate bounds. The Variable Length Records contain variable types of data including projection information, metadata, waveform packet information and user application data. Waveform Data Packets, if included, comprise the only record that can follow the Point Data Records. It is placed in this position to allow easy “stripping” or externalizing. This record is an Extended Variable Length Record (EVLR). The length of an EVLR is stored in an unsigned long long (8 byte field) allowing more storage area than a VLR.

DATA TYPES:

The following data types are used in the LAS format definition. Note that these data types are conformant to the 1999 ANSI C Language Specification (ANSI/ISO/IEC 9899:1999 ("C99").

- char (1 byte)
- unsigned char (1 byte)
- short (2 bytes)
- unsigned short (2 bytes)
- long (4 bytes)
- unsigned long (4 bytes)

- long long (8 bytes)
- unsigned long long (8 bytes)
- double (8 byte IEEE floating point format)

PUBLIC HEADER BLOCK:

Table 4.3 – Public Header Block

Item	**Format**	**Size**	**Required**
File Signature (“LASF”)	char[4]	4 bytes	*
File Source ID	unsigned short	2 bytes	*
Global Encoding	unsigned short	2 bytes	*
Project ID - GUID data 1	unsigned long	4 bytes	
Project ID - GUID data 2	unsigned short	2 byte	
Project ID - GUID data 3	unsigned short	2 byte	
Project ID - GUID data 4	unsigned char[8]	8 bytes	
Version Major	unsigned char	1 byte	*
Version Minor	unsigned char	1 byte	*
System Identifier	char[32]	32 bytes	*
Generating Software	char[32]	32 bytes	*
File Creation Day of Year	unsigned short	2 bytes	*
File Creation Year	unsigned short	2 bytes	*
Header Size	unsigned short	2 bytes	*
Offset to point data	unsigned long	4 bytes	*
Number of Variable Length Records	unsigned long	4 bytes	*
Point Data Format ID (0-99 for spec)	unsigned char	1 byte	*
Point Data Record Length	unsigned short	2 bytes	*
Number of point records	unsigned long	4 bytes	*
Number of points by return	unsigned long[7]	28 bytes	*
X scale factor	Double	8 bytes	*
Y scale factor	Double	8 bytes	*
Z scale factor	Double	8 bytes	*
X offset	Double	8 bytes	*
Y offset	Double	8 bytes	*
Z offset	Double	8 bytes	*
Max X	Double	8 bytes	*
Min X	Double	8 bytes	*
Max Y	Double	8 bytes	*
Min Y	Double	8 bytes	*
Max Z	Double	8 bytes	*
Min Z	Double	8 bytes	*
Start of Waveform Data Packet Record	Unsigned long long	8 bytes	*

Any field in the Public Header Block that is not required and is not used must be zero filled.

File Signature: The file signature must contain the four characters “LASF”, and it is required by the LAS specification. These four characters can be checked by user software as a quick look initial determination of file type.

File Source ID (Flight Line Number if this file was derived from an original flight line): This field should be set to a value between 1 and 65,535, inclusive. A value of zero (0) is interpreted to mean that an ID has not been assigned. In this case, processing software is free to assign any valid number. Note that this scheme allows a LIDAR project to contain up to 65,535 unique sources. A source can be considered an original flight line or it can be the result of merge and/or extract operations.

Global Encoding: This is a bit field used to indicate certain global properties about the file. In LAS 1.2 (the version in which this field was introduced), only the low bit is defined (this is the bit, that if set, would have the unsigned integer yield a value of 1). This bit field is defined as:

Table 4.4 - Global Encoding - Bit Field Encoding

Bits	***Field Name***	***Description***
0	GPS Time Type	The meaning of GPS Time in the Point Records 0 (not set) -> GPS time in the point record fields is GPS Week Time (the same as previous versions of LAS) 1 (set) -> GPS Time is standard GPS Time (satellite GPS Time) minus 1 x 10^9 (Adjusted Standard GPS Time). The offset moves the time back to near zero to improve floating point resolution.
1	Waveform Data Packets Internal	If this bit is set, the waveform data packets are located within this file (note that this bit is mutually exclusive with bit 2)
2	Waveform Data Packets External	If this bit is set, the waveform data packets are located external to this file in an auxiliary file with the same base name as this file and the extension ".wdp". (note that this bit is mutually exclusive with bit 1)
3	Return numbers have been synthetically generated	If set, the point return numbers in the Point Data Records have been synthetically generated. This could be the case, for example, when a composite file is created by combining a First Return File and a Last Return File. In this case, first return data will be labeled "1 of 2" and second return data will be labeled "2 of 2"
4:15	Reserved	Must be set to zero

Project ID (GUID data): The four fields that comprise a complete Globally Unique Identifier (GUID) are now reserved for use as a Project Identifier (Project ID). The field remains optional. The time of assignment of the Project ID is at the discretion of processing software. The Project ID should be the same for all files that are associated with a unique project. By assigning a Project ID and using a File Source ID (defined above) every file within a project and every point within a file can be uniquely identified, globally.

Version Number: The version number consists of a major and minor field. The major and minor fields combine to form the number that indicates the format number of the current specification itself. For example, specification number 1.2 would contain 1 in the major field and 2 in the minor field.

System Identifier: The version 1.0 specification assumes that LAS files are exclusively generated as a result of collection by a hardware sensor. Subsequent versions recognize that files often result from extraction, merging or modifying existing data files. Thus System ID becomes:

Table 4.5 – System Identifier

Generating Agent	**System ID**
Hardware system	String identifying hardware (e.g. "ALTM 1210" or "ALS50"
Merge of one or more files	"MERGE"
Modification of a single file	"MODIFICATION"

Generating Agent	**System ID**
Extraction from one or more files	“EXTRACTION”
Reprojection, rescaling, warping, etc.	“TRANSFORMATION”
Some other operation	“OTHER” or a string up to 32 characters identifying the operation

Generating Software: This information is ASCII data describing the generating software itself. This field provides a mechanism for specifying which generating software package and version was used during LAS file creation (e.g. “TerraScan V-10.8”, “REALM V-4.2” and etc.). If the character data is less than 16 characters, the remaining data must be null.

File Creation Day of Year: Day, expressed as an unsigned short, on which this file was created. Day is computed as the Greenwich Mean Time (GMT) day. January 1 is considered day 1.

File Creation Year: The year, expressed as a four digit number, in which the file was created.

Header Size: The size, in bytes, of the Public Header Block itself. In the event that the header is extended by a software application through the addition of data at the end of the header, the Header Size field must be updated with the new header size. Extension of the Public Header Block is discouraged; the Variable Length Records should be used whenever possible to add custom header data. In the event a generating software package adds data to the Public Header Block, this data must be placed at the end of the structure and the Header Size must be updated to reflect the new size.

Offset to point data: The actual number of bytes from the beginning of the file to the first field of the first point record data field. This data offset must be updated if any software adds data from the Public Header Block or adds/removes data to/from the Variable Length Records.

Number of Variable Length Records preceding the Point Data Records: This field contains the current number of Variable Length Records that occur in the file preceding the Point Data Records. This number must be updated if the number of Variable Length Records changes at any time.

Point Data Format ID: The point data format ID corresponds to the point data record format type. LAS 1.3 defines types 0 through 5.

Point Data Record Length: The size, in bytes, of the Point Data Record.

Number of point records: This field contains the total number of point records within the file.

Number of points by return: This field contains an array of the total point records per return. The first unsigned long value will be the total number of records from the first return, and the second contains the total number for return two, and so forth up to five returns.

X, Y, and Z scale factors: The scale factor fields contain a double floating point value that is used to scale the corresponding X, Y, and Z long values within the point records. The corresponding X, Y, and Z scale factor must be multiplied by the X, Y, or Z point record value to get the actual X, Y, or Z coordinate. For example, if the X, Y, and Z coordinates are intended to have two decimal point values, then each scale factor will contain the number 0.01.

X, Y, and Z offset: The offset fields should be used to set the overall offset for the point records. In general these numbers will be zero, but for certain cases the resolution of the point data may not be large enough for a given projection system. However, it should always be assumed that these numbers are used. So to scale a given X from the point record, take the point record X multiplied by the X scale factor, and then add the X offset.
$X_{coordinate} = (X_{record} * X_{scale}) + X_{offset}$

$Y_{coordinate} = (Y_{record} * Y_{scale}) + Y_{offset}$
$Z_{coordinate} = (Z_{record} * Z_{scale}) + Z_{offset}$

Max and Min X, Y, Z: The max and min data fields are the actual unscaled extents of the LAS point file data, specified in the coordinate system of the LAS data.

Start of Waveform Data Packet Record: This value provides the offset, in bytes, from the beginning of the LAS file to the first byte of the Waveform Data Package Record. Note that this will be the first byte of the Waveform Data Packet header.

The projection information for the point data is required for all data. The projection information will be placed in the Variable Length Records. Placing the projection information within the Variable Length Records allows for any projection to be defined including custom projections. The GeoTIff specification http://www.remotesensing.org/geotiff/geotiff.html is the model for representing the projection information, and the format is explicitly defined by this specification.

VARIABLE LENGTH RECORDS:

The Public Header Block is followed by one or more Variable Length Records (There is one mandatory Variable Length Record, **GeoKeyDirectoryTag**). The number of Variable Length Records is specified in the "Number of Variable Length Records" field in the Public Header Block. The Variable Length Records must be accessed sequentially since the size of each variable length record is contained in the Variable Length Record Header. Each Variable Length Record Header is 60 bytes in length.

Table 4.6 – Variable Length Record Header

Item	**Format**	**Size**	**Required**
Reserved	unsigned short	2 bytes	
User ID	char[16]	16 bytes	*
Record ID	unsigned short	2 bytes	*
Record Length After Header	Unsigned short	2 bytes	*
Description	char[32]	32 bytes	

User ID: The User ID field is ASCII character data that identifies the user which created the variable length record. It is possible to have many Variable Length Records from different sources with different User IDs. If the character data is less than 16 characters, the remaining data must be null. The User ID must be registered with the LAS specification managing body. The management of these User IDs ensures that no two individuals accidentally use the same User ID. The specification will initially use two IDs: one for globally specified records (LASF_Spec), and another for projection types (LASF_Projection). Keys may be requested at http://www.asprs.org/lasform/keyform.html.

Record ID: The Record ID is dependent upon the User ID. There can be 0 to 65535 Record IDs for every User ID. The LAS specification manages its own Record IDs (User IDs owned by the specification), otherwise Record IDs will be managed by the owner of the given User ID. Thus each User ID is allowed to assign 0 to 65535 Record IDs in any manner they desire. Publicizing the meaning of a given Record ID is left to the owner of the given User ID. Unknown User ID/Record ID combinations should be ignored.

Record Length after Header: The record length is the number of bytes for the record after the end of the standard part of the header. Thus the entire record length is 54 bytes (the header size in version 1.3) plus the number of bytes in the variable length portion of the record.

Description: Optional, null terminated text description of the data. Any remaining characters not used must be null.

Note that the record with User ID = LASF_Spec and Record ID = 65535 is the Waveform Packet Data Extended Variable Length Record (EVLR). Unlike all other Variable Length Records, this VLR (if present) is the only VLR that is placed after the Point Data Records. Thus, if present, it will be the last data record in the LAS file.

POINT DATA RECORD

NOTE: Point Data Start Signature was removed in LAS Version 1.1. LAS file I/O software must use the ***Offset to Point Data*** field in the Public Header Block to locate the starting position of the first Point Data Record. Note that all Point Data Records must be the same type.

POINT DATA RECORD FORMAT 0:

Table 4.7 – Point Data Record Format 0

Item	**Format**	**Size**	**Required**
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits (bits 0, 1, 2)	3 bits	*
Number of Returns (given pulse)	3 bits (bits 3, 4, 5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*

X, Y, and Z: The X, Y, and Z values are stored as long integers. The X, Y, and Z values are used in conjunction with the scale values and the offset values to determine the coordinate for each point as described in the Public Header Block section.

Intensity: The intensity value is the integer representation of the pulse return magnitude. This value is optional and system specific. However, it should always be included if available.

NOTE: The following four fields (Return Number, Number of Returns, Scan Direction Flag and Edge of Flight Line) are bit fields within a single byte.

Return Number: The Return Number is the pulse return number for a given output pulse. A given output laser pulse can have many returns, and they must be marked in sequence of return. The first return will have a Return Number of one, the second a Return Number of two, and so on up to five returns.

Number of Returns (for this emitted pulse): The Number of Returns is the total number of returns for a given pulse. For example, a laser data point may be return two (Return Number) within a total number of five returns.

Scan Direction Flag: The Scan Direction Flag denotes the direction at which the scanner mirror was traveling at the time of the output pulse. A bit value of 1 is a positive scan direction, and a bit value of 0 is a negative scan direction (where positive scan direction is a scan moving from the left side of the in-track direction to the right side and negative the opposite).

Edge of Flight Line: The Edge of Flight Line data bit has a value of 1 only when the point is at the end of a scan. It is the last point on a given scan line before it changes direction.

Classification: This filed represents the "class" attributes of a point. If a point has never been classified, this byte must be set to zero. There are no user defined classes since all point formats 0 supply 8 bits per point for user defined operations.

Note that the format for classification is a bit encoded field with the lower five bits used for class and the three high bits used for flags. The bit definitions are:

Table 4.8 - Classification Bit Field Encoding

Bits	***Field Name***	***Description***
0:4	Classification	Standard ASPRS classification as defined in the following classification table.
5	Synthetic	If set then this point was created by a technique other than LIDAR collection such as digitized from a photogrammetric stereo model or by traversing a waveform.
6	Key-point	If set, this point is considered to be a model key-point and thus generally should not be withheld in a thinning algorithm.
7	Withheld	If set, this point should not be included in processing (synonymous with Deleted).

Note that bits 5, 6 and 7 are treated as flags and can be set or clear in any combination. For example, a point with bits 5 and 6 both set to one and the lower five bits set to 2 (see table below) would be a *ground* point that had been *Synthetically* collected and marked as a *model key-point*.

Classification must adhere to the following standard:

Table 4.9 - ASPRS Standard LIDAR Point Classes

Classification Value (bits 0:4)	***Meaning***
0	Created, never classified
1	Unclassified[1]
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key-point (mass point)
9	Water
10	*Reserved for ASPRS Definition*
11	*Reserved for ASPRS Definition*
12	Overlap Points[2]
13-31	*Reserved for ASPRS Definition*

---

[1] We are using both 0 and 1 as ***Unclassified*** to maintain compatibility with current popular classification software such as TerraScan. We extend the idea of classification value 1 to include cases in which data have been subjected to a classification algorithm but emerged in an undefined state. For example, data with class 0 is sent through an algorithm to detect man-made structures – points that emerge without having been assigned as belonging to structures could be remapped from class 0 to class 1.

[2] Overlap Points are those points that were immediately culled during the merging of overlapping flight lines. In general, the *Withheld* bit should be set since these points are not subsequently classified.

[A note on Bit Fields – The LAS storage format is "Little Endian." This means that multi-byte data fields are stored in memory from least significant byte at the low address to most significant byte at the high address. Bit fields are always interpreted as bit 0 set to 1 equals 1, bit 1 set to 1 equals 2, bit 2 set to 1 equals 4 and so forth.]

Scan Angle Rank: The Scan Angle Rank is a signed one-byte number with a valid range from -90 to +90. The Scan Angle Rank is the angle (rounded to the nearest integer in the absolute value sense) at which the laser point was output from the laser system including the roll of the aircraft. The scan angle is within 1 degree of accuracy from +90 to –90 degrees. The scan angle is an angle based on 0 degrees being nadir, and –90 degrees to the left side of the aircraft in the direction of flight.

User Data: This field may be used at the user's discretion.

Point Source ID: This value indicates the file from which this point originated. Valid values for this field are 1 to 65,535 inclusive with zero being used for a special case discussed below. The numerical value corresponds to the File Source ID from which this point originated. Zero is reserved as a convenience to system implementers. A Point Source ID of zero implies that this point originated in this file. This implies that processing software should set the Point Source ID equal to the File Source ID of the file containing this point at some time during processing.

NOTE: The File Marker field in the LAS 1.0 structure was generally miscoded and/or not implemented by users. The entire concept was removed from LAS 1.1 and this single byte field has been renamed User Data and is available for any use. The extended records associated with this field in the original LAS 1.0 specification are removed. Please note that the field named User Bit Field has been renamed Point Source ID and is no longer available for general use.

POINT DATA RECORD FORMAT 1:

Point Data Record Format 1 is the same as Point Data Record Format 0 with the addition of GPS Time.

Table 4.10 – Point Data Record Format 1

Item	**Format**	**Size**	**Required**
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits (bits 0, 1, 2)	3 bits	*
Number of Returns (given pulse)	3 bits (bits 3, 4, 5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*
GPS Time	Double	8 bytes	*

GPS Time: The GPS Time is the double floating point time tag value at which the point was acquired. It is GPS Week Time if the Global Encoding low bit is clear and Adjusted Standard GPS Time if the Global Encoding low bit is set (*see Global Encoding in the Public Header Block description).*

POINT DATA RECORD FORMAT 2:

Point Data Record Format 2 is the same as Point Data Record Format 0 with the addition of three color channels. These fields are used when "colorizing" a LIDAR point using ancillary data, typically from a camera.

Table 4.11 – Point Data Record Format 2

Item	Format	Size	Required
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits (bits 0, 1, 2)	3 bits	*
Number of Returns (given pulse)	3 bits (bits 3, 4, 5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*
Red	unsigned short	2 bytes	*
Green	unsigned short	2 bytes	*
Blue	unsigned short	2 bytes	*

Red: The Red image channel value associated with this point

Green: The Green image channel value associated with this point

Blue: The Blue image channel value associated with this point

NOTE: Red, Green, Blue values should always be normalized to 16 bit values. For example, when encoding an 8 bit per channel pixel, multiply each channel value by 256 prior to storage in these fields. This normalization allows color values from different camera bit depths to be accurately merged.

POINT DATA RECORD FORMAT 3:

Point Data Record Format 3 is the same as Point Data Record Format 2 with the addition of GPS Time.

Table 4.12 – Point Data Record Format 3

Item	Format	Size	Required
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits (bits 0, 1, 2)	3 bits	*
Number of Returns (given pulse)	3 bits (bits 3, 4, 5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*

GPS Time	double	8 bytes	*
Red	unsigned short	2 bytes	*
Green	unsigned short	2 bytes	*
Blue	unsigned short	2 bytes	*

POINT DATA RECORD FORMAT 4:

Point Data Record Format 4 adds Wave Packets to Point Data Record Format 1.

Table 4.13 – Point Data Record Format 4

Item	**Format**	**Size**	**Required**
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits (bits 0-2)	3 bits	*
Number of Returns (given pulse)	3 bits (bits 3-5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	unsigned char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*
GPS Time	double	8 bytes	*
Wave Packet Descriptor Index	Unsigned char	1 byte	*
Byte offset to waveform data	Unsigned long long	8 bytes	*
Waveform packet size in bytes	Unsigned long	4 bytes	*
Return Point Waveform Location	float	4 bytes	*
X(t)	float	4 bytes	*
Y(t)	float	4 bytes	*
Z(t)	float	4 bytes	*

Point Data Record Format 4 is the same as Point Data Record Format 1 with the addition of the waveform packet information.

Wave Packet Descriptor Index: LAS 1.3 supports up to 255 User Defined Records which describe the waveform packet. This value indicates the User Defined Record that is used to describe the waveform packet associated with this LIDAR point. Note: A value of zero indicates that there is no waveform data associated with this LIDAR point record.

Byte offset to Waveform Packet Data: The waveform packet data are stored in the LAS file in an Extended Variable Length Record (or, optionally, in an auxiliary file). The Byte Offset represents the location of the start of this LIDAR points' waveform packet within the waveform data variable length record (or external file) relative to the beginning of the Waveform Packet Data header.

Note that the absolute location of the beginning of this waveform packet relative to the beginning of the file is given by:

Start of Waveform Data Packet Record + Byte offset to Waveform Packet Data

for waveform packets stored within the LAS file and

Byte offset to Waveform Packet Data

for data stored in an auxiliary file

Waveform packet size in bytes: The size, in bytes, of the waveform packet associated with this return. Note that each waveform can be of a different size (even those with the same Waveform Packet Descriptor index) due to packet compression. Also note that waveform packets can be located only via the Byte offset to Waveform Packet Data value since there is no requirement that records be stored sequentially.

Return Point location: The offset in picoseconds (10^{-12}) from the first digitized value to the location within the waveform packet that the associated return pulse was detected.

X(t), Y(t), Z(t): These parameters define a parametric line equation for extrapolating points along the associated waveform. The position along the wave is given by:

$X = X_0 + X(t)$

$Y = Y_0 + Y(t)$

$Z = Z_0 + Z(t)$

where X, Y and Z are the spatial position of the derived point, X_0, Y_0, Z_0 are the position of the "anchor" point (the X, Y, Z locations from this point's data record) and t is the time, in picoseconds, relative to the anchor point (i.e. t = zero at the anchor point). The units of X, Y and Z are the units of the coordinate systems of the LAS data. If the coordinate system is geographic, the horizontal units are decimal degrees and the vertical units are meters.

POINT DATA RECORD FORMAT 5:

Point Data Record Format 5 adds Wave Packets to Point Data Record Format 3.

Table 4.14 – Point Data Record Format 5

Item	Format	Size	Required
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits (bit 0 – 2)	3 bits	*
Number of Returns (given pulse)	3 bits (bit 3 – 5)	3 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	unsigned char	1 byte	*
User Data	unsigned char	1 byte	
Point Source ID	unsigned short	2 bytes	*
GPS Time	double	8 bytes	*
Red	unsigned short	2 bytes	*
Green	unsigned short	2 bytes	*
Blue	unsigned short	2 bytes	*

Item	Format	Size	Required
Wave Packet Descriptor Index	Unsigned char	1 byte	*
Byte offset to waveform data	Unsigned long long	8 bytes	*
Waveform packet size in bytes	Unsigned long	4 bytes	*
Return Point Waveform Location	float	4 bytes	*
X(t)	float	4 bytes	*
Y(t)	float	4 bytes	*
Z(t)	float	4 bytes	*

Point Data Record Format 5 is the same as Point Data Record Format 4 with the addition of RGB values.

DEFINED VARIABLE LENGTH RECORDS:

Georeferencing Information

Georeferencing for the LAS format will use the same robust mechanism that was developed for the GeoTIFF standard. The variable length header records section will contain the same data that would be contained in the GeoTIFF key tags of a TIFF file. With this approach, any vendor that has existing code to interpret the coordinate system information from GeoTIFF tags can simply feed the software with the information taken from the LAS file header. Since LAS is not a raster format and each point contains its own absolute location information, only 3 of the 6 GeoTIFF tags are necessary. The ModelTiePointTag (33922), ModelPixelScaleTag (33550), and ModelTransformationTag (34264) records can be excluded. The GeoKeyDirectoryTag (34735), GeoDoubleParamsTag (34736), and GeoASCIIParamsTag (34737) records are used.

Only the GeoKeyDirectoryTag record is required. The GeoDoubleParamsTag and GeoASCIIParamsTag records may or may not be present, depending on the content of the GeoKeyDirectoryTag record.

GeoKeyDirectoryTag Record: (mandatory)

User ID: LASF_Projection
Record ID: 34735

This record contains the key values that define the coordinate system. A complete description can be found in the GeoTIFF format specification. Here is a summary from a programmatic point of view for someone interested in implementation.

The GeoKeyDirectoryTag is defined as just an array of unsigned short values. But, programmatically, the data can be seen as something like this:

```
struct sGeoKeys
{
   unsigned short wKeyDirectoryVersion;
   unsigned short wKeyRevision;
   unsigned short wMinorRevision;
   unsigned short wNumberOfKeys;
   struct sKeyEntry
   {
      unsigned short wKeyID;
```

```
        unsigned short wTIFFTagLocation;
        unsigned short wCount;
        unsigned short wValue_Offset;
    } pKey[1];
};
```

Where:

```
wKeyDirectoryVersion = 1;       // Always
wKeyRevision = 1;               // Always
wMinorRevision = 0;             // Always
wNumberOfKeys           // Number of sets of 4 unsigned shorts to follow
```

Table 4.15 – GeoKey Four Unsigned Shorts

For each set of 4 unsigned shorts:

Name	**Definition**
wKeyID	Defined key ID for each piece of GeoTIFF data. IDs contained in the GeoTIFF specification.
wTIFFTagLocation	Indicates where the data for this key is located: 0 means data is in the wValue_Offset field as an unsigned short. 34736 means the data is located at index wValue_Offset of the GeoDoubleParamsTag record. 34737 means the data is located at index wValue_Offset of the GeoAsciiParamsTag record.
wCount	Number of characters in string for values of GeoAsciiParamsTag , otherwise is 1
wValue_Offset	Contents vary depending on value for wTIFFTagLocation above

GeoDoubleParamsTag Record: (optional)

User ID: LASF_Projection
Record ID: 34736

This record is simply an array of doubles that contain values referenced by tag sets in the GeoKeyDirectoryTag record.

GeoAsciiParamsTag Record: (Optional)

User ID: LASF_Projection
Record ID: 34737

This record is simply an array of ASCII data. It contains many strings separated by null terminator characters which are referenced by position from data in the GeoKeyDirectoryTag record.

Classification lookup: (optional)

User ID: LASF_Spec
Record ID: 0
Record Length after Header: 255 recs X 16 byte struct len

```
struct CLASSIFICATION
{
        unsigned char ClassNumber;
        char Description[15];
};
```

Header lookup for flight-lines:
(Removed with Version 1.1 - Point Source ID in combination with Source ID provides the new scheme for directly encoding flight line number. Thus variable Record ID 1 now becomes reserved for future use.)

User ID: LASF_Spec
Record ID: 1

Histogram: (optional)

User ID: LASF_Spec
Record ID: 2

Text area description: (optional)

User ID: LASF_Spec
Record ID: 3

Waveform Packet Descriptor: (required when using Point format 4 or 5)

User ID: LASF_Spec
Record ID: n

Where n >=100 and n<356

These records contain information that describes the configuration of the waveform packets. Since systems may be configured differently at different times throughout a job, the LAS file supports 255 Waveform Packet Descriptors.

Table 4.16 – Waveform Packet Descriptor User Defined Record

Item	**Format**	**Size**	**Required**
Bits per sample	Unsigned char	1 byte	*
Waveform compression type	Unsigned char	1 byte	*
Number of samples	Unsigned long	4 bytes	*
Temporal Sample Spacing	Unsigned long	4 bytes	*
Digitizer Gain	double	8 bits	*
Digitizer Offset	double	8 bits	*

Bits per sample: 2 through 32 bits are supported.

Waveform Compression type: It is expected that in the future standard compression types will be adopted by the LAS committee. This field will indicate the compression algorithm used for the waveform packets associated with this descriptor. A value of 0 indicates no compression. Zero is the only value currently supported.

Number of Samples: The number of samples associated with this waveform packet type. This value always represents the fully decompressed waveform packet.

Temporal Sample Spacing: The temporal sample spacing in picoseconds. Example values might be 500, 1000, 2000 and so on, representing digitizer frequencies of 2 GHz, 1 GHz and 500 MHz respectively.

Digitizer Gain: The gain and offset are used to convert the raw digitized value to an absolute digitizer voltage using the formula: VOLTS = OFFSET + GAIN * Raw_Waveform_Amplitude

Digitizer Offset: The gain and voltage offset are used to convert the raw digitized value to a voltage using the formula: VOLTS = OFFSET + GAIN * Raw_Waveform_Amplitude

EXTENDED VARIABLE LENGTH RECORD (EVLR)

Extended Variable Length Records occur *after* the Point Data Records. The record header differs from a VLR in that the Record Length After Header field is 8 bytes.

Table 4.17 – Extended Variable Length Record Header

Item	Format	Size	Required
Reserved	unsigned short	2 bytes	
User ID	char[16]	16 bytes	*
Record ID	unsigned short	2 bytes	*
Record Length After Header	Unsigned long long	8 bytes	*
Description	char[32]	32 bytes	

LAS 1.3 allows only a single EVLR; Waveform Data Packets.

Waveform Data Packets: (required when using Point format 4 or 5)

User ID: LASF_Spec
Record ID: 65,535

The packet of Raw Waveform Amplitude values for all records immediately follow this variable length header.

This is the last Reserved Record for the LASF Specification. This extended variable length record must always be the last record in an LAS file. Unlike all other Variable Length Records, this record and its associated data *follow* the Point Data Records.

NOTE: When using a bit resolution that is not an even increment of 8, the last byte of each waveform packet must be padded such that the next waveform record will start on an even byte boundary.

Appendix I: Topographic Data Products

TABLE OF CONTENTS

1. Introduction

1.1 Purpose

Terrain data, as defined in FEMA Guidelines and Specifications, Appendix M: Data Capture Standards describes the digital topographic data that was used to create the elevation data representing the terrain environment of a watershed and/or floodplain. Terrain data requirements allow for flexibility in the types of information provided as sources used to produce final terrain deliverables. Once this type of data is provided, FEMA will be able to account for the origins of the flood study elevation data.

The purpose of these terrain datasets is to represent the topography of a watershed and/or floodplain environment for riverine hydraulic and hydrologic modeling in the Merrimack River Watershed in the states of Massachusetts and New Hampshire. All terrain data collected for hydrologic analysis, hydraulic analysis, floodplain boundary delineation, and/or testing of floodplain boundary standard compliance meets the requirements outlined in FEMA Procedure Memorandum 61 and Appendix A: Guidance for Aerial Mapping and Survey.

1.2 Project Synopsis

Base LiDAR point cloud data provided for this project is compliant with FEMA Guidelines and Specifications Procedure Memorandum 61. LiDAR acquisition and post processing was completed for the Merrimack River Watershed under FEMA Task Order No. HSFE01-11-J-0010 for FEMA case number 12-01-1080S. The LiDAR acquisition for the Merrimack River Watershed, consisting of 1302 square miles, was captured to the “Highest” vertical accuracy requirement. This collection specification is the equivalent of a 2-foot contour accuracy with a nominal pulse spacing of 1-meter. Topographic datasets delivered to FEMA under Task Order No. HSFE01-11-J-0010 were used as the basis for topographic data development for the watershed to support riverine H&H analysis and floodplain boundary delineation.

2. Information for the next Mapping Partner

The Merrimack Watershed area of interest consists of Essex, Middlesex and Worcester Counties in Massachusetts and Belknap, Hillsborough, Merrimack, Rockingham and Strafford Counties in New Hampshire. LiDAR collected under FEMA Task Order No. HSFE01-11-J-0010 was collected and processed by STARR. Compass Data, Inc. performed the ground control survey and RMSE vertical quality control. Photo Science, Inc. performed the LiDAR Acquisition and LiDAR post processing. Greenhorne and O'Mara, Inc. performed Independent Quality Assurance of the base LiDAR products and produced the LiDAR derived products. All firms performed duties under task order contract to STARR.

All LiDAR derived products for this project has been collected using the following spatial reference information:

Projection: Universal Transverse Mercator
UTM Zone: 19
Linear units: Meter
Horizontal Datum: North American Datum 1983
Vertical Datum: North American Vertical Datum of 1988
Vertical units: US Survey Foot

2.1 LAS processing

Classified LAS data for the Merrimack Watershed was used as the basis for topographic products. Due to automated processing procedures and quality reviews the LAS was selected as the base LiDAR product. LAS header files were checked to insure data consistency. By spot checking several tiles it was determined that the LAS files had a standard projection, linear units were identical, ASPRS classifications are present, and the elevation minimum and maximum values meet expectations for the project area.

Using the Point File Information tool in ArcGIS 3D Analyst, a LiDAR boundary grid was created that contains the file name, point count, point spacing, elevation minimum, and elevation maximum for each LAS file. This is compared with the header files to insure data reliability between the information in the header files and the actual spatial information. This grid is also used to determine the average point spacing by viewing the statistics of the point spacing field. The mean value is captured and compared with LAS metadata.

Once it is determined that the LAS files are ready to be used in terrain processing they are converted to a multipoint feature class and stored within a file geodatabase featuredataset. The featuredataset has the projection information matching the LiDAR collection. The ArcGIS 3D Analyst tool LAS to multipoint is used to accomplish this task. Once the dataset is created, the LAS tiles are only used as a backup in the event of errors in processing.

2.2 DEM processing

Once all of the LAS files have been converted to a multipoint feature class digital elevation modeling is accomplished. The first step in creating a DEM for the project is to determine the actual LiDAR extent. This area represents the actual area covered by points and not the LAS boundary. LAS files may not include “full” point coverage. ArcGIS Spatial Analyst is used to accomplish this by converting the multipoint feature class to a raster. From there a series of Spatial Analyst tools are used to create the LiDAR coverage polygon. Once the extent has been created the next process is to create an ESRI terrain dataset.

The terrain is composed of the multipoint feature class as mass points, hydro flattened breaklines as hard lines, and the LiDAR collection extent as a soft clip. After the terrain has been created it is reviewed. This terrain is then converted to a floating point raster with a cell size of 1 meter. The 1 meter DEM is then loaded into ERDAS Imagine 2011 Mosaic Pro toolset. Using the LAS index shapefile, the DEM is split into 1749 individual imagine (*.img) raster files. The raster files are spot checked for consistency and stored as a deliverable to FEMA.

2.3 Contour processing

Once the DEM has been created the next step in the data processing is to generate contours. Two foot contours are created from the DEM and clipped to the USGS Hydrologic Code 12 basin boundaries located within the Merrimack HUC 8 watershed.

2.4 Quality Assurance

All products created under the “develop topographic information” task are carefully reviewed to make sure datasets meet the needs for detailed riverine analysis. Datasets are organized and stored in Appendix M data capture standards formatting for delivery to FEMA.

2.5 Deliverables

Products delivered under this task order include:

- ESRI file geodatabase that contains LAS multipoint, breaklines, LiDAR extent, LAS Index, and ESRI terrains.
- 1,749 - 1 meter floating point DEMs in ERDAS Imagine format
- 1 and 2 meter DEMs in Geotif format covering entire watershed.
- ESRI file geodatabase that contains 2ft contours and index
- FEMA FGDC compliant terrain metadata record

Data will be uploaded to the MIP at this location:

J:\FEMA\R01\NEW_HAMPSHIRE_33\MERRIMACK_33013\MERRIMACK_013C\12-01-1080S\SubmissionUpload\Terrain\2152674

Process Steps:
1-Convert LAS to Multipoint
2-Create Terrain
3-Convert Terrain to 1m Raster
4-Split 1m Raster into 1749 imagine files
5-Contour

Convert LAS to multipoint:

1. Create file geodatabase and create a feature dataset to store terrain information with appropriate projection and spatial domain.
2. Run LAS to multipoint tool in 3D analyst for the classified LAS files and select class 2 and 8.
3. Store results in file geodatabase feature dataset for terrain data

Create Terrain

1. Create Terrain using multipoint as masspoints and LiDAR coverage area as soft clip
2. Build Terrain and store in file geodatabase feature dataset for terrain data

Convert Terrain to 10ft Raster

1. Run the Terrain to raster tool in 3D analyst
2. Float output data type, Linear as the method, CELLSIZE 10 as sampling distance, and Pyramid Level Resolution 0
3. Save results as a ESRI GRID dataset.

Create contours

1. Extract by mask from the 1m DEM using a HUC12 area. Save this raster as HUC12 Name 1m.
2. Focal Statistics using Extracted 1m DEM as input, Intermediate Focal Raster as Output, Neighborhood should be set to weighted kernel, and the statistic should be sum.
3. Create contours using focal stats raster as input, output polyline should be based on HUC12 name, Contour Interval of 2ft, Set base contour to DEM minimum z value
4. Check results and store in file geodatabase under the Analysis Contours feature dataset.
5. Focal Statistics using Extracted 1m DEM as input, Intermediate Focal Raster as Output, Neighborhood should be set to circle, and the statistic should be mean.
6. Create contours using focal stats raster as input, output polyline should be based on HUC12 name, Contour Interval of 2ft, Set base contour to DEM minimum z value
7. Check results and store in file geodatabase under the Cartographic Contours feature dataset.