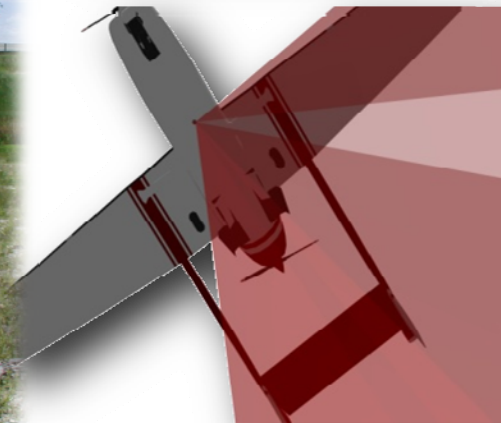
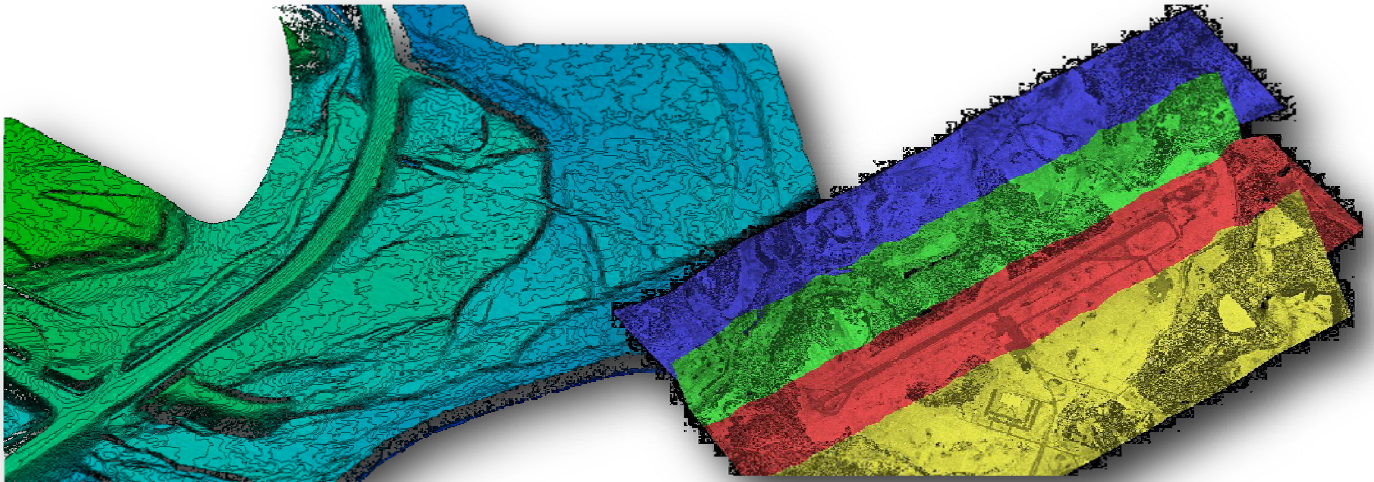


Region 8- Granite 4-ft Area

GRANITE COUNTY, MONTANA

Accuracy Assessment and QC Report

SEPTEMBER 2012



Submitted by:

BakerAECOM
An Integrated Production Team



TABLE OF CONTENTS

1. INTRODUCTION	0
1.1 PROJECT SITES AND PARAMTERS	1
1.2 LIDAR PRELIMINARY PROCESSING (ACQUISITION AREA)	2
1.3 LIDAR POST- PROCESSING (BARE EARTH AREA)	3
1.4 HYDROLOGICALLY-ENFORCED WATER BODIES.....	3
1.5 BREAKLINES.....	3
1.6 SURVEY FOR CHECK POINTS	4
1.7 QA/QC PROCESS.....	4
2. MILESTONE 1 – LiDAR DATA QA/QC for ACQUISITION AREA.....	5
2.1 PROJECT BACKGROUND INFORMATION.....	5
2.2 SURVEY RELATED.....	6
2.3 COMPLETENESS OF DATA – VISUAL	7
2.4 DATA VOID CHECK	10
2.5 CHECK POINT ANALYSIS	10
2.6 FUNDAMENTAL VERTICAL ACCURACY.....	10
3. MILESTONE 2 – LiDAR DATA QA/QC for PROCESSED AREA.....	13
3.1 QUANTITATIVE ANALYSIS	13
3.2 QUALITATIVE ANALYSIS	19
3.2.1 LiDAR Macro Review.....	19
3.3 LOW CONFIDENCE AREAS.....	21
3.4 BREAKLINES.....	21
3.5 METADATA	24
3.6 LIST OF DELIVERABLES.....	24
4. SUMMARY	24
5. REFERENCES	24

TABLE	PAGE	TABLE	PAGE
1. Parameters for Region 8 Project Sites	1	9. Analysis of Checkpoint	10
2. Check Point Survey for QA/QC	4	10. Fundamental Vertical Accuracy	12
3. Project Background Info	5	11. Supplemental Vertical Accuracy	15
4. Milestone 1 Check List	5	12. Consolidated Vertical Accuracy	18
5. Control Points used in Data Acquisition	6	13. Checklist for Quality Assurance of Terrain Products	19
6. Pre-flight Operations Plan	7	14. Qualitative Analysis of DTM	20
7. Post Flight Aerial Acquisition and Calibration Report	8	15. Breakline Acceptance	21
8. Completeness Table	9	16. Major Deliverables	24

Figure	Page
Fig 1: The project site map.	2
Fig 2: The FVA points' distribution is shown in the above diagram and results are summarized in the following table.	11
Fig 3: The SVA points' distribution is shown in the above diagram and results are summarized in the following table.	14
Fig 4: The CVA points' distribution is shown in the above diagram and results are summarized in the following table.	17
Fig 5. Breakline Review process diagram.	23

Appendix	Page
Appendix 1 Data Density and Data Void check results	26

1. INTRODUCTION

BakerAECOM performed an independent accuracy assessment and quality control review of the bare-earth randomly spaced LIDAR data collected and processed in 2 areas in Region 8 by Photo Science Inc. The project was carried out using the specifications and the guidelines provided in the following documents.

- 1) FEMA’s Flood Hazard Mapping Program; Guidelines and Specifications for Flood Hazard Mapping Partners - Appendix A, Guidance for Aerial Mapping and Surveying,
- 2) FEMA’s Memorandum for Regional Risk Analysis Branch Chiefs, Procedure Memorandum No. 61: Standards for LiDAR and Other High Quality Digital Topography, Effective Date September 27, 2010;
- 3) U.S. Geological Survey (USGS), National Geospatial Program, LiDAR Guidelines and Base Specification, vers. 13, Effective Date February 22, 2010;
- 4) American Society for Photogrammetry and Remote Sensing (ASPRS), ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data, vers. 1.0, May 24, 2004.
- 5) National Geodetic Survey (NGS), NOAA Technical Memorandum NOS NGS-58, Guidelines for establishing GPS-Derived Ellipsoid Heights, (Standards: 2cm and 5 cm), Vers. 4.3., November, 1997.

This document presents the results of the accuracy assessment and quality review.

1.1 PROJECT SITE AND PARAMETERS

The following table provides a summary of the project area and related parameters.

Table 1 Parameters for Region 8 Project Sites

PROJECT SITE PARAMETERS	GRANITE, MT
Nominal Pulse Spacing (NPS)	< 2 m
FEMA Project Area (Sq. Miles)	100
Acquisition Area (Sq. Miles)*	103
Equivalent Contour Accuracy	4 ft
Bare Earth Processing Area (Sq. Miles)	6

*The Acquisition Area contains the original FEMA Project Area and the required 100 meter buffer as defined in PM No. 61.

The study area has been shown in Fig 1.

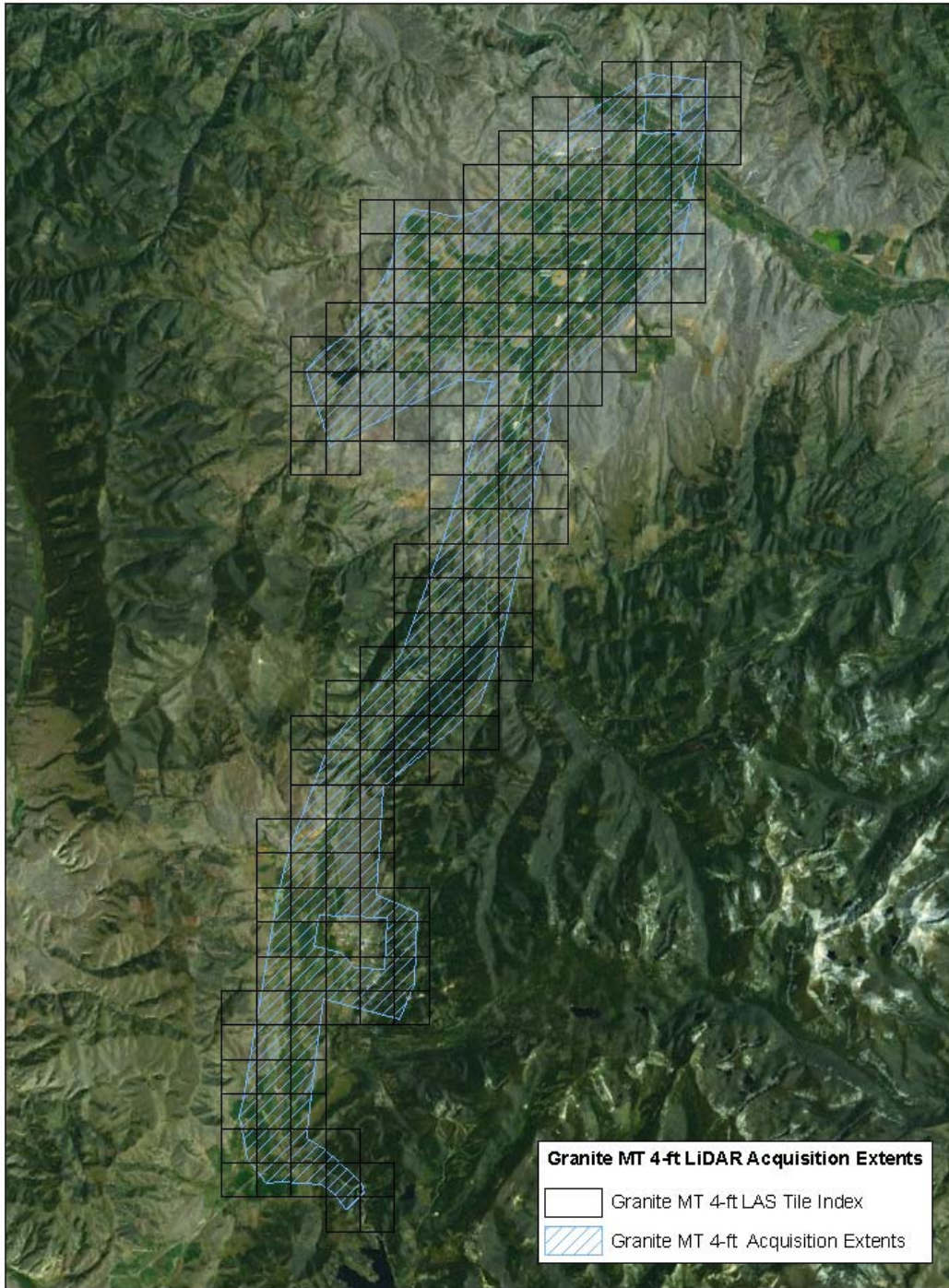


FIG 1: PROJECT SITE MAP

1.2 LIDAR PRELIMINARY PROCESSING (ACQUISITION AREA)

LiDAR Preliminary Processing was performed by Photo Science Inc for the entire acquisition area. Preliminary processing involves filtering the data for noise, differentially correcting, and assembling data into flight lines by “return layer.” This processing computes the laser point coordinates from the independent data parameters: scanner position, orientation parameters, scanner angular deflection, and the laser pulse time of flight, or slant range. The deliverable of the preliminary processing task is a fully calibrated point cloud data set, unclassified, which has been tiled and prepared for delivery in LAS v. 1.2 format.

1.3 LIDAR POST- PROCESSING (BARE EARTH AREA)

LiDAR Post-Processing consists of classifying the LiDAR data’s first and last return data points to remove vegetation and buildings. This process is restricted to the floodplain areas as defined by the Bare Earth Processing Areas. Points were filtered, and those representing above ground features (such as trees and buildings) have been classified “out” to obtain points that represent the ground surface. Acceptable data with voids (e.g., water or low near infrared reflectivity, such as freshly laid asphalt) are excluded from the final data.

The deliverable of the post-processing task is a classified point cloud delivered in full compliance with LAS classes:

- | | |
|----|---|
| 1 | processed, but unclassified |
| 2 | bare-earth ground |
| 7 | noise |
| 9 | water |
| 10 | ignored |
| 11 | withheld (all points not identified as “withheld” are to be classified) |
| 12 | Overlap (Shall not be used) |

1.4 HYDROLOGICALLY-ENFORCED WATER BODIES

Hydro break lines were compiled at a minimum, for inland ponds and lakes that are 2 acres or larger; for inland streams with a nominal width of 100 feet or greater; and for tidal waters, such as oceans, seas, gulfs, bays, inlets, salt marshes, and very large lakes. FEMA will use this break lines to generate hydrologically-enforced products.

1.5 BREAKLINES

As part of the terrain deliverable, topologically structured, 3-dimensional (3-D) hydrology coverage in ESRI personal geodatabase format created from newly generated 3-D breaklines is required. The primary function of the hydrology dataset is to supplement and constrain TINs created from the LIDAR data; however it is also provides additional benefits to the engineers for hydrologic and hydraulic (H&H)

modeling. Because LIDAR data contains only points, the ability of a LIDAR-only terrain model to capture detailed linear features in their precise 3-D location is limited in some locations.

1.6 SURVEY FOR CHECK POINTS

To perform accuracy assessments of the LiDAR data, BakerAECOM acquired survey field checkpoints.

The following table lists the project site and the number of check points acquired.

Table 2 Check Point Survey for QA/QC

	GRANITE, MT
Acquisition Area (square miles)	103
FVA Check Points*	25
Bare Earth Processing Area (square miles)	6
SVA Check Points (weeds and crops)**	5
SVA Check Points (brush and trees)	5
SVA Check Points (forested)	5
SVA Check Points (urban)	5
Total Number of Check Points	45

*FVA – Fundamental Vertical Accuracy

**SVA – Supplemental Vertical Accuracy

1.7 QA/QC PROCESS

As part of the LIDAR acquisition proposed through Task Order HSFEHQ-10-J-0010, BakerAECOM performed the following QA/QC efforts under two mile stones:

Milestone 1 – LiDAR data QA/QC for acquisition area

Milestone 2 – LiDAR data QA/QC for processing area

2. MILESTONE 1 – LIDAR DATA QA/QC FOR ACQUISITION AREA

2.1 PROJECT BACKGROUND INFORMATION

The project background info for Granite is given in Table 3.

Table 3 Project Background Info (All Predefined Information)

PROJECT AREA	SQUARE MILES
Points Spacing	1M
Point Density	1.08 average
Multiple Returns	Yes
Altitude	1625 m
Overlap	50%
Pulse Rate	70 KHz
Scan Freq	33.8 Hz
Desired Resolution	0.963 m
Cross Track Resolution	0.960 m
Down Track Resolution	0.966 m
Points / Square Meter	1.08 m2
ASPRS Classification Scheme	Class 1 = Unclassified; and Class 11 = Withheld

Upon receipt of milestone 1 deliverables from Photo Science Inc, BAKERAECON performed the inventory of the deliverables based on the check list given in Table 4.

Table 4 Milestone 1 Check List

	NOT DELIVERED	PARTIAL DELIVERY	COMPLETE DELIVERY	COMMENTS
Pre-flight Operations Plan (Table 4.1, PM 61 Page 21)			X	
Pre-flight Review Checklist (PM 61 Page 25)			X	
Field Survey Control Report in accordance with FEMA Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying; Sec. A.6.5, Page A-29.			X	
Post- flight Aerial Survey and Calibration Report (Table 4.2, PM 61 Page 22)			X	
Post-flight Review Checklist (PM 61, Page 25)			X	
Checklist for Aerial Acquisition Report (PM 61, Page 26)			X	

	NOT DELIVERED	PARTIAL DELIVERY	COMPLETE DELIVERY	COMMENTS
Macro Review of Fully Calibrated Raw Point Cloud (Table 4.3, PM 61, Page 23)			X	
SBET File (Smoothed Best Estimate of Trajectory)			X	
All Raw Range Files (.range)				
Fully calibrated, unclassified point cloud data in LAS v 1.2 format in compliance with USGS LiDAR Guidelines and Base Specification, v13.			X	
Raw Flight Data Path Screen Shots Showing Data Coverage			X	
Tiling Scheme used as a Shapefile with tile names			X	
Milestone 1 MetaData			X	

2.2 SURVEY RELATED

The QA/QC process for survey control was performed based on the check list given in Table 5.

Table 5 Control Points used in Data Acquisition

CONTROL POINTS USED IN DATA ACQUISITION	
1. Check survey report for completeness.	Yes
2. Check proper order, distribution, type and stability of NGS NSRS stations, both horizontal and vertical.	Yes
3. Check baseline lengths to determine if proper network stations have been set up, local, secondary, primary, etc.	Yes
4. Check each baseline vector has been observed twice and to agree to 5 cm vertically.	Yes
5. Check processing computation results for outlying vectors, large residuals, observations failing tests, etc.	Yes

2.3 COMPLETENESS OF DATA – VISUAL

Examination of Pre-flight Operations Plan as given in Table 6.

Table 6 Pre-flight Operations Plan

ITEM	CONTENT	FORMAT	PASS/FAIL/MINOR	COMMENTS (COMPLETED/NOT COMPLETED)
Flight Operations Plan	Planned flight lines – sufficient coverage, spacing and length		Pass	
	Planned GPS stations		Pass	
	Planned ground control- sufficient to control and boresight.		Pass	
	Planned Airport location		Pass	
	Calibration plan		Pass	
	Planned Sensor setting and altitude		Pass	
	Procedure for tracking, executing and checking reflights.		Pass	
	Type of Aircraft and use of ABGPS		Pass	
	Project design supports accuracy requirements.		Pass	
	Project design supports diff land cover and terrain.		Pass	

Examination of Post-flight Aerial Acquisition and Calibration Reports as given in **Table 7**.

Table 7 Post Flight Aerial Acquisition and Calibration Report

ITEM	CONTENT	FORMAT	REPORTS INCLUDED	COMMENTS
GPS base station info	Base station name	ESRI shape file along with attributes.	Yes	
	Latitude & Longitude			
	Base Height,			
	PDOP			
	Map of location			
GPS and IMU processing summary	Maximum horizontal and vertical GPS variance	MS Word/Excel report	Yes	
	GPS separation plot			
	Altitude plot			
	PDOP plot			
	Plot of GPS base station from base station.			
Coverage	Verification of Project coverage	ESRI shape file	Yes	
Flight lines	As flown trajectories	ESRI shape file	Yes	
	Calibration lines			
Flight logs	Pilot, Operator name	MS Word/Excel	Yes	
	AGC switch setting			
	LASER Pulse			
	Mirror rate			
	Field of view			
	Date			
Control	Ground control and Base station layouts	ESRI shape files	Yes	
Data Verification/QC	Description of Data verification QC process	MS Word/Excel/Pdf	Yes	
	Results of Verification and QC steps			

Examine completeness of data on the following and summarized in Table 8:

- Naming convention
- File format
- Vertical and Horizontal coordinate system
- Classification
- Georeferencing

Table 8 Completeness Table

LIDAR DTM AND COMPLETENESS/USABILITY ACCEPTANCE	CHARACTERISTICS	METHOD OF CHECKING
Format and post spacing of LiDAR Mass Points	.LAS with 1.08 m/ sq m	Automatic
Units - Horizontal	U.S. Survey Feet	Automatic
Units - Vertical	U.S. Survey Feet	Automatic
Datum - Horizontal	NAD 83	Automatic
Datum - Vertical	NAVD 88, processed with Geoid03	Automatic
Classification used	Class 1 = unclassified; Class 11 = Withheld	Automatic
Flight lines	Flight lines flown as planned with 50-% overlap between flight swaths, correct altitude (1625' above mean terrain), PDOP < 4; no holidays; periodic, local, calibration checks.	Visual
Filename and Organization	Tiling scheme and 5000 X 5000 ft	Visual
Georeferencing	Opens in the correct location based on the tile grid provided by the Client.	Visual
Conformance of sheet to index grid (Las files to tile scheme polygon)	No gaps between the tiles and matches at grid line at 1:1 view.	Visual

2.4 DATA DENSITY AND DATA VOID CHECK

The data density for this data is expected to be 1 point in 1mX1m grid as the data has been collected with 1m NPS. The data void in the data was checked based on the guidelines given in USGS V13. 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.

The results on Data Density and Data Void are summarized in Appendix 1. Both the results are within the specs and the data is accepted.

2.5 CHECK POINT ANALYSIS

The check points collected independently were validated and are provided in Table 9.

Table 9 Analysis of Checkpoint

Check number of FVA points and their distribution	Yes
Check number of SVA points within each class category	Yes
Check the photographs of the all points to the appropriateness	Yes
Check Type, order and stability of the base stations used.	Yes
Check baseline vectors for length (20KM)	Yes
Check adjustment for reliability.	Yes
Check duplicated baseline vectors for 5 cm rule	Yes
Check survey report for completeness	Yes

2.6 FUNDAMENTAL VERTICAL ACCURACY

Fundamental Vertical Accuracy (FVA) is defined as “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.” (FEMA Procedure Memorandum No. 61- Standards for LiDAR and Other High Quality Digital topography, September, 27, 2010, Page 6) The twenty-five (25) points are to be evenly distributed throughout the project area.

The FVA has been computed and the results are given in Table 10.

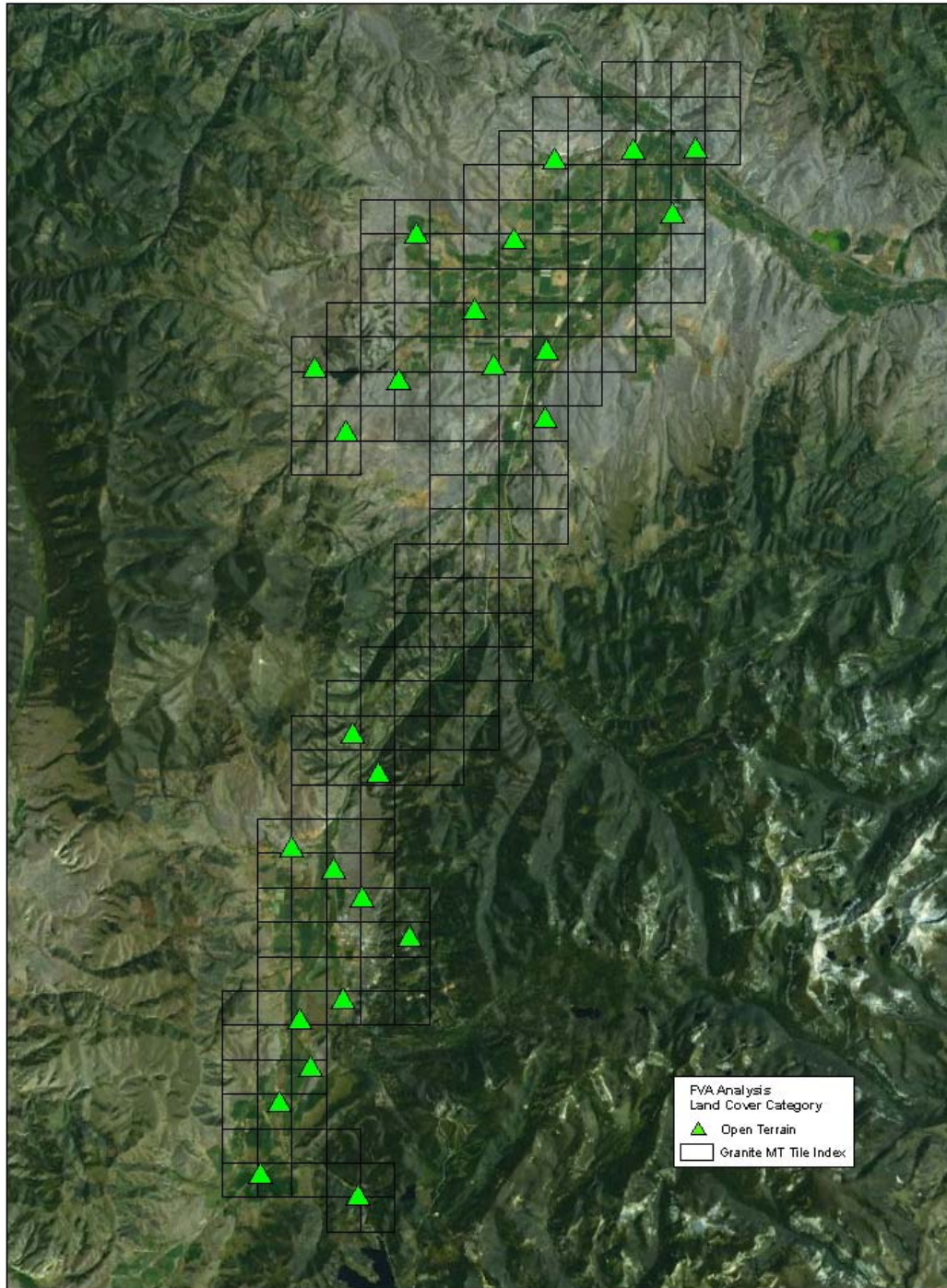


Fig 2: The FVA point's distribution is shown in the above diagram and results are summarized in the following table.

Table 10 Fundamental Vertical Accuracy

POINT	ALIAS	X (CONTROL)	X (LIDAR)	Y (CONTROL)	Y (LIDAR)	Z (CONTROL)	Z (LIDAR)	ΔZ	ΔZ^2
GRA_FVA1	GRA_FVA1	1009695.563	1009695.563	745378.041	745378.041	5975.640	5975.539	0.101	0.101
GRA_FVA2	GRA_FVA2	995590.181	995590.181	748512.619	748512.619	5428.640	5428.444	0.196	0.196
GRA_FVA3	GRA_FVA3	998406.559	998406.559	758912.394	758912.394	5331.560	5331.335	0.225	0.225
GRA_FVA4	GRA_FVA4	1002857.849	1002857.849	763885.324	763885.324	5323.514	5323.557	-0.043	0.043
GRA_FVA5	GRA_FVA5	1001236.032	1001236.032	770959.803	770959.803	5227.300	5227.345	-0.045	0.045
GRA_FVA6	GRA_FVA6	1017255.736	1017255.736	782795.379	782795.379	5761.444	5761.326	0.118	0.118
GRA_FVA7	GRA_FVA7	1010403.000	1010403.000	788669.741	788669.741	5329.610	5329.548	0.062	0.062
GRA_FVA8	GRA_FVA8	1006212.658	1006212.658	792721.344	792721.344	5040.665	5040.655	0.010	0.010
GRA_FVA9	GRA_FVA9	1000157.551	1000157.551	795772.784	795772.784	5161.834	5161.948	-0.114	0.114
GRA_FVA10	GRA_FVA10	1007640.435	1007640.435	773903.729	773903.729	5233.380	5233.367	0.013	0.013
GRA_FVA11	GRA_FVA11	1058757.553	1058757.553	897359.473	897359.473	3979.593	3979.459	0.134	0.134
GRA_FVA12	GRA_FVA12	1049776.446	1049776.446	897217.629	897217.629	4007.223	4007.243	-0.020	0.020
GRA_FVA13	GRA_FVA13	1038364.064	1038364.064	895961.383	895961.383	4151.403	4151.304	0.099	0.099
GRA_FVA14	GRA_FVA14	1055534.336	1055534.336	887957.764	887957.764	4114.490	4114.446	0.044	0.044
GRA_FVA15	GRA_FVA15	1026732.704	1026732.704	873966.776	873966.776	4372.522	4372.353	0.169	0.169
GRA_FVA16	GRA_FVA16	1018254.522	1018254.522	885053.138	885053.138	4507.386	4507.379	0.007	0.007
GRA_FVA17	GRA_FVA17	1032465.547	1032465.547	884333.973	884333.973	4353.299	4353.266	0.033	0.033
GRA_FVA18	GRA_FVA18	1003409.869	1003409.869	865588.307	865588.307	4781.906	4782.027	-0.121	0.121
GRA_FVA19	GRA_FVA19	1008070.854	1008070.854	856294.143	856294.143	4927.846	4927.795	0.051	0.051
GRA_FVA20	GRA_FVA20	1015607.853	1015607.853	863764.729	863764.729	4659.274	4659.438	-0.164	0.164
GRA_FVA21	GRA_FVA21	1036941.291	1036941.291	858309.043	858309.043	4394.726	4394.824	-0.098	0.098
GRA_FVA22	GRA_FVA22	1037222.218	1037222.218	868197.238	868197.238	4246.939	4246.963	-0.024	0.024
GRA_FVA23	GRA_FVA23	1029409.806	1029409.806	865966.526	865966.526	4413.995	4413.996	-0.001	0.001
GRA_FVA24	GRA_FVA24	1012824.264	1012824.264	806778.067	806778.067	5346.711	5347.027	-0.316	0.316
GRA_FVA25	GRA_FVA25	1008943.652	1008943.652	812455.192	812455.192	5293.133	5292.991	0.142	0.142
Sum									0.369
Average									0.015
RMSEr									0.121
FVA (ft)									0.238
FVA (cm)									7.254

Granite 4-ft area tested 0.238 ft (7.254 centimeters) Fundamental Vertical Accuracy at 95% confidence level in open terrain using RMSEr x 1.9600. The Granite 4-ft area FVA value passes the minimum requirement of 49.0 centimeters. The table above describes the points and statistics associated with the FVA testing.

3. MILESTONE 2 – LIDAR DATA QA/QC FOR PROCESSED AREA

Milestone 2 review consists of a quantitative analysis of the supplemental and consolidated vertical accuracy as well as a qualitative review of classified bare earth LiDAR and breaklines. Supplemental and consolidated vertical accuracies are checked by comparing the elevation differences from surveyed points in a variety of land cover categories to the bare earth TIN surface created from the classified LiDAR. Qualitative review of the LiDAR is a visual inspection of the data for voids or gaps, noise, artifacts, aggressive filtering, continuity between swaths, breakline connectivity, monotonicity, topology, etc.

3.1 QUANTITATIVE ANALYSIS

Supplemental Vertical Accuracy (SVA) is the result of a test of accuracy of z-values over areas with ground cover categories or combination of categories other than open terrain. Each land cover type representing 10% or more of the total project area was tested and reported as an SVA.

The SVA has been computed and the results are given in Table 11.

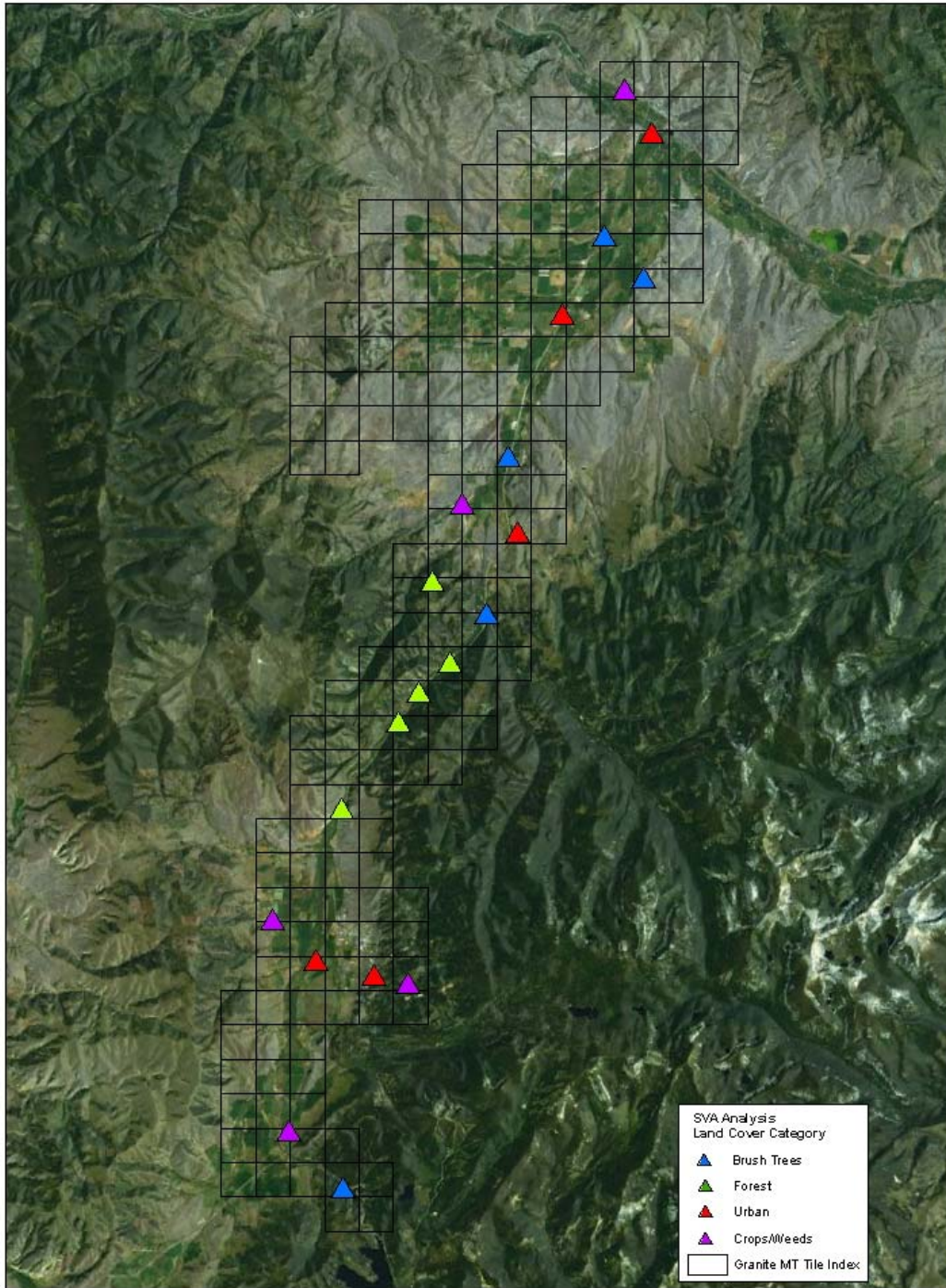


Fig 3: The SVA points' distribution is shown in the above diagram and results are summarized in the following table.

Table 11 Supplemental Vertical Accuracy

POINT	ALIAS	X (CONTROL)	X (LIDAR)	Y (CONTROL)	Y (LIDAR)	Z (CONTROL)	Z (LIDAR)	ΔZ	Abs ΔZ	
GRA_SVABT1	GRA_SVABT1	1007821.834	1007821.834	746328.360	746328.360	5594.180	5594.519	-0.339	0.339	
GRA_SVABT2	GRA_SVABT2	1051457.687	1051457.687	878629.767	878629.767	4182.780	4183.478	-0.698	0.698	
GRA_SVABT3	GRA_SVABT3	1045800.082	1045800.082	884557.311	884557.311	4106.180	4106.838	-0.658	0.658	
GRA_SVABT4	GRA_SVABT4	1031840.004	1031840.004	852611.560	852611.560	4409.140	4409.135	0.005	0.005	
GRA_SVABT5	GRA_SVABT5	1028635.744	1028635.744	829768.493	829768.493	4845.260	4845.977	-0.717	0.717	
GRA_SVAF1	GRA_SVAF1	1007572.696	1007572.696	801357.950	801357.950	5030.400	5030.239	0.161	0.161	
GRA_SVAF2	GRA_SVAF2	1020741.282	1020741.282	834521.617	834521.617	5763.630	5761.896	1.734	1.734	
GRA_SVAF3	GRA_SVAF3	1015913.224	1015913.224	813911.490	813911.490	4984.550	4984.387	0.163	0.163	
GRA_SVAF4	GRA_SVAF4	1018903.047	1018903.047	818377.026	818377.026	4938.310	4938.827	-0.517	0.517	
GRA_SVAF5	GRA_SVAF5	1023441.464	1023441.464	822682.371	822682.371	4971.570	4971.662	-0.092	0.092	
GRA_SVAU1	GRA_SVAU1	1012434.283	1012434.283	777147.207	777147.207	5427.220	5427.155	0.065	0.065	
GRA_SVAU2	GRA_SVAU2	1003837.784	1003837.784	779372.400	779372.400	5153.900	5153.733	0.167	0.167	
GRA_SVAU3	GRA_SVAU3	1039758.457	1039758.457	873288.693	873288.693	4212.800	4210.868	1.932	1.932	
GRA_SVAU4	GRA_SVAU4	1052747.995	1052747.995	899546.807	899546.807	3952.990	3953.041	-0.051	0.051	
GRA_SVAU5	GRA_SVAU5	1033157.197	1033157.197	841447.663	841447.663	4618.950	4618.957	-0.007	0.007	
GRA_SVAWC1	GRA_SVAWC1	1000014.722	1000014.722	754487.063	754487.063	5389.100	5389.094	0.006	0.006	
GRA_SVAWC2	GRA_SVAWC2	997679.973	997679.973	785256.983	785256.983	5215.840	5215.925	-0.085	0.085	
GRA_SVAWC3	GRA_SVAWC3	1017218.336	1017218.336	775993.677	775993.677	6201.110	6201.186	-0.076	0.076	
GRA_SVAWC4	GRA_SVAWC4	1048776.751	1048776.751	905870.124	905870.124	3943.270	3943.788	-0.518	0.518	
GRA_SVAWC5	GRA_SVAWC5	1025238.110	1025238.110	845681.818	845681.818	4537.300	4537.295	0.005	0.005	
									SVA (ft)	1.744
									SVA (cm)	53.16

Granite 4-ft area tested 1.744 ft (53.169 centimeters) supplemental vertical accuracy at 95th percentile in urban areas and brush lands and low trees. The Granite 4-ft area SVA value passes the minimum requirement of 72.6 centimeters. The table above describes the points and statistics associated with the SVA testing.

Consolidated Vertical Accuracy (CVA) is the result of a test of accuracy z-values consolidated for two or more of the major land cover categories, representing both open terrain and other land cover categories.

The CVA has been computed and the results are given in Table 12.

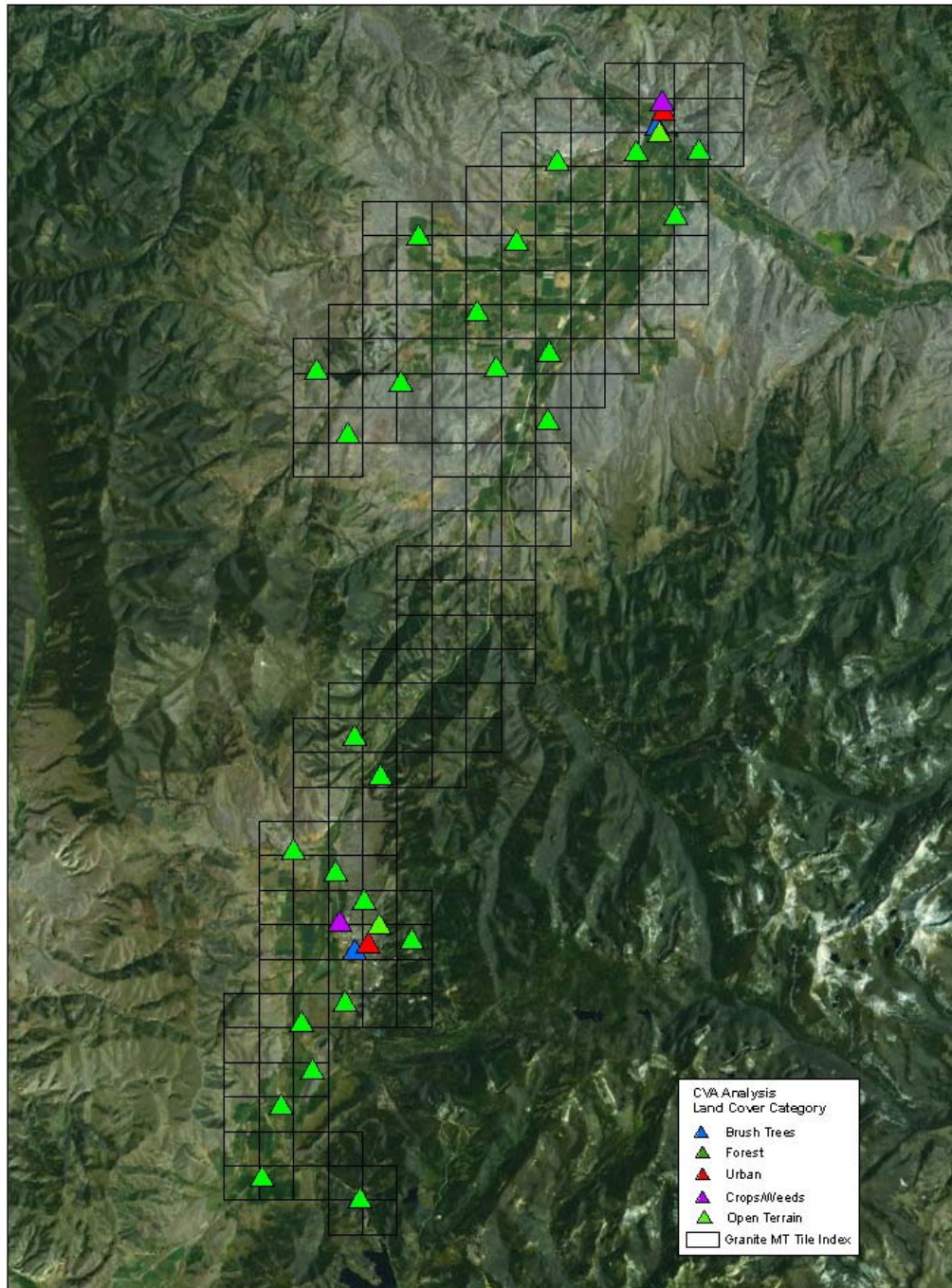


Fig 4: The CVA points' distribution is shown in the above diagram and results are summarized in the following table.

Table 12 Consolidated Vertical Accuracy

POINT	ALIAS	X (CONTROL)	X (LIDAR)	Y (CONTROL)	Y (LIDAR)	Z (CONTROL)	Z (LIDAR)	ΔZ	Abs ΔZ
GRA_FVA1	GRA_FVA1	1009695.563	1009695.563	745378.041	745378.041	5975.640	5975.539	0.101	0.101
GRA_FVA2	GRA_FVA2	995590.181	995590.181	748512.619	748512.619	5428.640	5428.444	0.196	0.196
GRA_FVA3	GRA_FVA3	998406.559	998406.559	758912.394	758912.394	5331.560	5331.335	0.225	0.225
GRA_FVA4	GRA_FVA4	1002857.849	1002857.849	763885.324	763885.324	5323.514	5323.557	-0.043	0.043
GRA_FVA5	GRA_FVA5	1001236.032	1001236.032	770959.803	770959.803	5227.300	5227.345	-0.045	0.045
GRA_FVA6	GRA_FVA6	1017255.736	1017255.736	782795.379	782795.379	5761.444	5761.326	0.118	0.118
GRA_FVA7	GRA_FVA7	1010403.000	1010403.000	788669.741	788669.741	5329.610	5329.548	0.062	0.062
GRA_FVA8	GRA_FVA8	1006212.658	1006212.658	792721.344	792721.344	5040.665	5040.655	0.010	0.010
GRA_FVA9	GRA_FVA9	1000157.551	1000157.551	795772.784	795772.784	5161.834	5161.948	-0.114	0.114
GRA_FVA10	GRA_FVA10	1007640.435	1007640.435	773903.729	773903.729	5233.380	5233.367	0.013	0.013
GRA_FVA11	GRA_FVA11	1058757.553	1058757.553	897359.473	897359.473	3979.593	3979.459	0.134	0.134
GRA_FVA12	GRA_FVA12	1049776.446	1049776.446	897217.629	897217.629	4007.223	4007.243	-0.020	0.020
GRA_FVA13	GRA_FVA13	1038364.064	1038364.064	895961.383	895961.383	4151.403	4151.304	0.099	0.099
GRA_FVA14	GRA_FVA14	1055534.336	1055534.336	887957.764	887957.764	4114.490	4114.446	0.044	0.044
GRA_FVA15	GRA_FVA15	1026732.704	1026732.704	873966.776	873966.776	4372.522	4372.353	0.169	0.169
GRA_FVA16	GRA_FVA16	1018254.522	1018254.522	885053.138	885053.138	4507.386	4507.379	0.007	0.007
GRA_FVA17	GRA_FVA17	1032465.547	1032465.547	884333.973	884333.973	4353.299	4353.266	0.033	0.033
GRA_FVA18	GRA_FVA18	1003409.869	1003409.869	865588.307	865588.307	4781.906	4782.027	-0.121	0.121
GRA_FVA19	GRA_FVA19	1008070.854	1008070.854	856294.143	856294.143	4927.846	4927.795	0.051	0.051
GRA_FVA20	GRA_FVA20	1015607.853	1015607.853	863764.729	863764.729	4659.274	4659.438	-0.164	0.164
GRA_FVA21	GRA_FVA21	1036941.291	1036941.291	858309.043	858309.043	4394.726	4394.824	-0.098	0.098
GRA_FVA22	GRA_FVA22	1037222.218	1037222.218	868197.238	868197.238	4246.939	4246.963	-0.024	0.024
GRA_FVA23	GRA_FVA23	1029409.806	1029409.806	865966.526	865966.526	4413.995	4413.996	-0.001	0.001
GRA_FVA24	GRA_FVA24	1012824.264	1012824.264	806778.067	806778.067	5346.711	5347.027	-0.316	0.316
GRA_FVA25	GRA_FVA25	1008943.652	1008943.652	812455.192	812455.192	5293.133	5292.991	0.142	0.142
GRA_SVABT1	GRA_SVABT1	1007821.834	1007821.834	746328.360	746328.360	5594.180	5594.519	-0.339	0.339
GRA_SVABT2	GRA_SVABT2	1051457.687	1051457.687	878629.767	878629.767	4182.780	4183.478	-0.698	0.698
GRA_SVABT3	GRA_SVABT3	1045800.082	1045800.082	884557.311	884557.311	4106.180	4106.838	-0.658	0.658
GRA_SVABT4	GRA_SVABT4	1031840.004	1031840.004	852611.560	852611.560	4409.140	4409.135	0.005	0.005
GRA_SVABT5	GRA_SVABT5	1028635.744	1028635.744	829768.493	829768.493	4845.260	4845.977	-0.717	0.717
GRA_SVAF1	GRA_SVAF1	1007572.696	1007572.696	801357.950	801357.950	5030.400	5030.239	0.161	0.161
GRA_SVAF2	GRA_SVAF2	1020741.282	1020741.282	834521.617	834521.617	5763.630	5761.896	1.734	1.734
GRA_SVAF3	GRA_SVAF3	1015913.224	1015913.224	813911.490	813911.490	4984.550	4984.387	0.163	0.163
GRA_SVAF4	GRA_SVAF4	1018903.047	1018903.047	818377.026	818377.026	4938.310	4938.827	-0.517	0.517

POINT	ALIAS	X (CONTROL)	X (LIDAR)	Y (CONTROL)	Y (LIDAR)	Z (CONTROL)	Z (LIDAR)	ΔZ	Abs ΔZ
GRA_SVAF5	GRA_SVAF5	1023441.464	1023441.464	822682.371	822682.371	4971.570	4971.662	-0.092	0.092
GRA_SVAU1	GRA_SVAU1	1012434.283	1012434.283	777147.207	777147.207	5427.220	5427.155	0.065	0.065
GRA_SVAU2	GRA_SVAU2	1003837.784	1003837.784	779372.400	779372.400	5153.900	5153.733	0.167	0.167
GRA_SVAU3	GRA_SVAU3	1039758.457	1039758.457	873288.693	873288.693	4212.800	4210.868	1.932	1.932
GRA_SVAU4	GRA_SVAU4	1052747.995	1052747.995	899546.807	899546.807	3952.990	3953.041	-0.051	0.051
GRA_SVAU5	GRA_SVAU5	1033157.197	1033157.197	841447.663	841447.663	4618.950	4618.957	-0.007	0.007
GRA_SVAWC1	GRA_SVAWC1	1000014.722	1000014.722	754487.063	754487.063	5389.100	5389.094	0.006	0.006
GRA_SVAWC2	GRA_SVAWC2	997679.973	997679.973	785256.983	785256.983	5215.840	5215.925	-0.085	0.085
GRA_SVAWC3	GRA_SVAWC3	1017218.336	1017218.336	775993.677	775993.677	6201.110	6201.186	-0.076	0.076
GRA_SVAWC4	GRA_SVAWC4	1048776.751	1048776.751	905870.124	905870.124	3943.270	3943.788	-0.518	0.518
GRA_SVAWC5	GRA_SVAWC5	1025238.110	1025238.110	845681.818	845681.818	4537.300	4537.295	0.005	0.005
								CVA (ft)	0.713
								CVA (cm)	21.746

Granite 4-ft area tested 0.713 ft (21.746 centimeters) consolidated vertical accuracy at the 95th percentile in open terrain, urban areas, brush lands and low trees. The Granite 4-ft area CVA value passes the minimum requirement of 72.6 centimeters. The table below describes the points and statistics associated with the CVA testing.

3.2 QUALITATIVE ANALYSIS

3.2.1 LiDAR Macro Review

During the macro review, the Pre Flight Operations Plan, the Post Flight Aerial Acquisition and Calibration Report, and the Checklist for Aerial Acquisition Report were reviewed from Milestone 1 and confirmed to be complete and passed.

Table 13 Checklist for Quality Assurance of Terrain Products

CHECKLIST	PASS/FAIL	COMMENTS
Vertical datum correct	Pass	
Horizontal datum correct	Pass	
Projection correct	Pass	
Vertical units correct	Pass	
Horizontal units correct	Pass	
Each return contains – GPS week, GPS second, easting, northing, elevation, intensity, return # and classification	Pass	
No duplicate entries	Pass	
GPS second reported to nearest microsecond	Pass	
Easting, northing, and elevation reported to nearest 0.01 m or 0.01 ft	Pass	
Classifications correct – 1. Unclassified; 2. Bare-earth ground; 7. Noise; 9. Water; 10. Ignored ground; 11. Withheld	Pass	
Deliverable tiles checked for significant gaps not covered by aerial acquisition checks and/or caused by data post-processing/filtering	Pass	

The following table highlights the main components of the qualitative analysis as it pertains to the visual inspection of the bare earth LiDAR. For the ground points (bare earth) review, the data were checked for correct classification and cleanliness. No more than 2% of the project area classified to bare ground should 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 classification of points. The total classified project area was calculated and the total area of errors was calculated. The total area of errors was compared to the total processed area and the results were less than 2% of the total processed area contained errors.

Table 14 Qualitative Analysis of DTM

LIDAR ACCEPTANCE CATEGORY	DESCRIPTION	PASS/FAIL
Ground Points (Bare Earth)	Post-processed to remove structures and vegetation with <2 % residual artifacts	Pass – Error extent less than 2% of the processed tiles extent
Continuity	No gaps of sufficient size. No obvious vertical offsets between adjoining strips	Pass
Inconsistent Post Processing/Editing	No visible variations in DTM.	Pass
Over-smoothing	Smoothing techniques are not aggressive enough to remove topographic features necessary to define drainage features	Pass
Artifacts	No obvious artifacts, spikes, holes, or blunder.	Pass
Classification Used	Class 1 = unclassified; Class 2 = ground; Class 7 = Low point/noise Class 9 = Water Class 10 = Ignored Class 11 = Withheld	Pass
Low Confidence	2D Polygon shapefile meeting database specifications set forth in PM61_LIDAR Specs.	Pass

3.3 LOW CONFIDENCE AREAS

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. For the Granite 4-ft Area project area, there was not an area of low confidence noted.

3.4 BREAKLINES

Submitted breaklines were reviewed through a combination of automated processes along with a visual review. Detailed QC was performed on all breaklines in 20 out of 189 project tiles. Some of the automated review processes were applied to all breaklines. The single drain lines were compared to bare earth profiles to ensure that they fall within water channels. 3D centerlines profiles were checked visually for all breaklines that intersect sample tiles, along with visual line work checks. Breaklines vertices were converted to points and compared to each other's within and across breaklines and surrounding ground values. The breaklines follow a downstream trend with the first upstream vertex being higher than the last downstream vertex. The elevations for each vertex decrease steadily as the stream flows downstream. The following table highlights the main components of the qualitative analysis as it pertains to the visual inspection of the breakline submittal. This qualitative analysis includes verifying completeness, topology, consistency, and location of the breakline features.

Table 15 Breakline Acceptance

BREAKLINE ACCEPTANCE CATEGORY		PASS/FAIL
Check for monotonicity of hydro breaklines.	Visual	Pass
Verify that breakline vertices have z values equal to or less than the surrounding ground points.	Automated	Pass
Vertices should not have a 0 or null elevation	Automated	Pass
Vertices should not have excessive min or max z-values when compared to adjacent vertices	Visual	Pass
Double line stream breaklines elevations must match within 2 ft from each side of the stream	Visual	Pass
Check the metadata of the Milestone 2 delivery. Should include discussion on each delivered feature and a description of the creation process unique to that feature class. Should comply with FEMA Terrain Metadata Profile.	Visual	Pass
Verify ponding water breaklines have constant elevation and are equal to or less than the surrounding ground points.	Visual	Pass
Assure breaklines meet all specifications for completeness, size and feature type. Water body breaklines for polygons >2acres, stream centerline breaklines for streams <100' wide and shown on a USGS 7.5min Quads, and edge of water breaklines for streams >100' wide	Visual	Pass

BREAKLINE ACCEPTANCE CATEGORY		PASS/FAIL
Stream breaklines should break at culverts, and not break at bridges.	Visual	Pass
Run topology checks on all GIS lines and polygons.	Automated	Pass
Horizontal placement-stream should align horizontally with the LIDAR data	Visual	Pass
Culvert breaklines must snap to stream endpoints on both sides, and have the same elevation as the stream breakline at the snapping location.	Automated	Pass
Bridge breaklines should outline the bridge deck	Visual	N/A

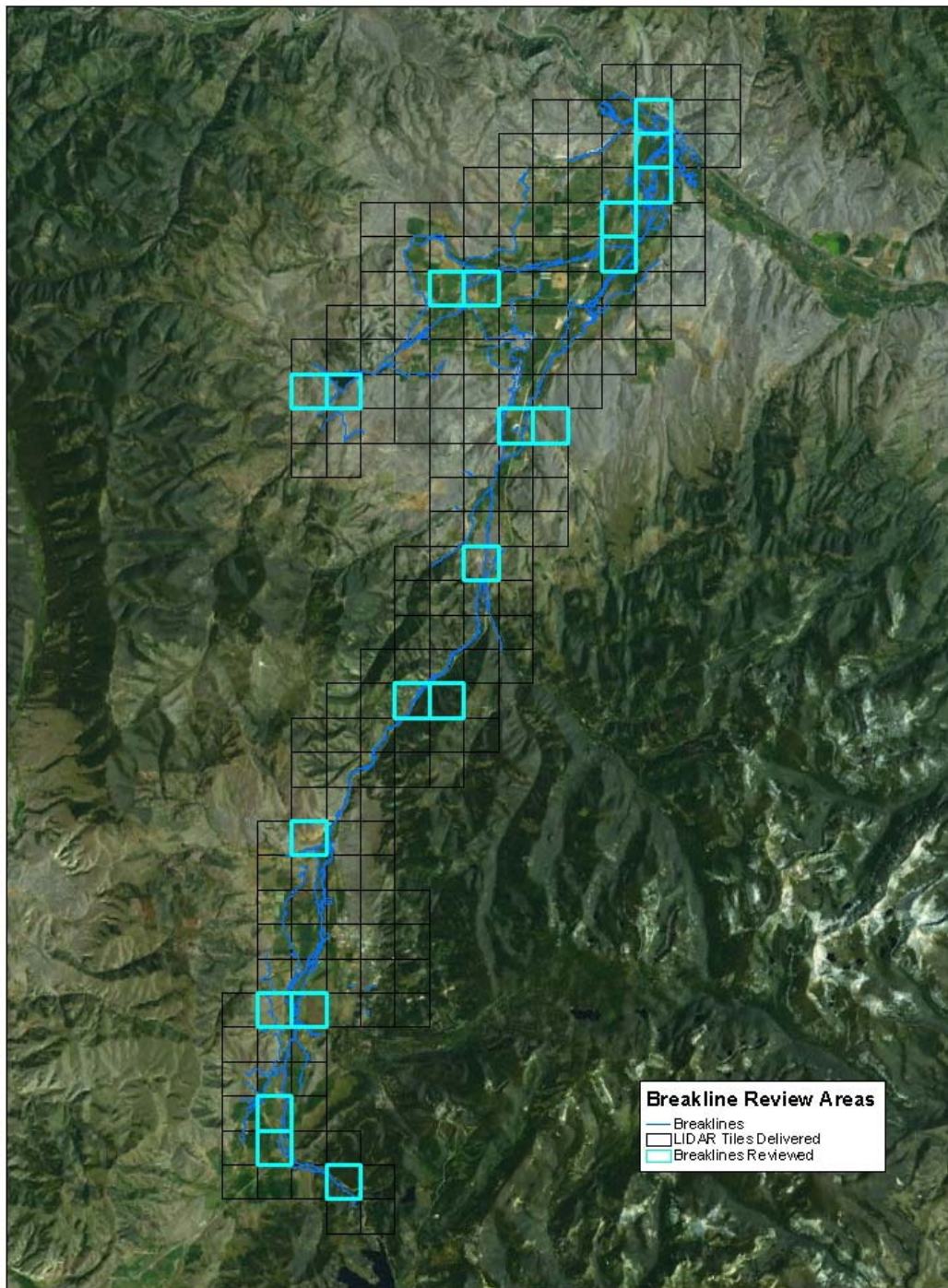


Fig 5. Breakline Review process diagram.

3.5 METADATA

Metadata were visually inspected and confirmed inclusion of documentation on classification methodology, breakline creation, low confidence area minimization, etc.

3.6 LIST OF DELIVERABLES

The major deliverables are provided in Table 16.

Table 16 Major Deliverables

FEDERAL GEOGRAPHIC DATA COMMITTEE COMPLIANT METADATA	METADATA FILE WAS PROVIDED
Reports (Collection, Survey, Processing, and QA/QC reports)	Yes
Raw point cloud in an LAS v 1.2 or 1.3 format	Yes
Classified point cloud in an LAS v 1.2 or 1.3 format	Yes
Break lines (Stream centerlines, drainage ditches, and tops and bottoms of stream banks in an ESRI shape file or geo database format)	Yes
Checklist documenting QC processing steps completed	Yes
QC Non-conformance documentation	

4. SUMMARY

The LiDAR data for the Granite 4-ft area, MT collection area meets all the FEMA specifications as given on PM 61 document. The data passes the accuracy assessment test for FVA, CVA and SVA. The final dataset passes all quality control specifications and the dataset has adequate documentation from the collection vendor.

5. REFERENCES

Bellamo, Doug A., Memorandum for Regional Risk Analysis Branch Chiefs, Procedure Memorandum No. 61 – Standards for LiDAR and Other High Quality Digital Topography, September, 2010.

Map Modernization Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying, Federal Emergency Management Agency (FEMA), April 2003, from http://www.fema.gov/plan/prevent/fhm/dl_cgs.shtm

U.S. Geological Survey (USGS), National Geospatial Program, LiDAR Guidelines and Base Specification, vers. 13, Effective Date February 22, 2010;

American Society for Photogrammetry and Remote Sensing (ASPRS), ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data, vers. 1.0, May 24, 2004.

Appendix 1 Data Density and Data Void check results

Table 9 Data Density Check

No. of Tiles			189			
No. of LAS Tiles			189			
NPS			2 Meter			
Tile Name	No. of Points	Z Min (feet)	Z Max (feet)	Z Mean (feet)	Point Density / Sq m	Comment
Granite_MT_001	1.6E+07	3882.07	4673.85	4048.68	6.7052961	Edge Tile
Granite_MT_002	2.5E+07	3717.61	5619.39	4310.61	10.630801	Edge Tile
Granite_MT_003	2.5E+07	4061.92	4917.8	4472.2	10.683941	Edge Tile
Granite_MT_004	8782440	4312.98	4912.43	4589.88	3.7813208	Edge Tile
Granite_MT_005	8375188	4092.32	4728.27	4289.87	3.6059765	Edge Tile
Granite_MT_006	9282614	3917.53	4412.78	4083.95	3.996673	Edge Tile
Granite_MT_007	2E+07	3886.09	4556.47	3954.99	8.4176117	Edge Tile
Granite_MT_008	2.5E+07	3708.73	5610.14	3973.79	10.745547	
Granite_MT_009	2.6E+07	3936.32	4556.24	4181.61	11.375125	Edge Tile
Granite_MT_010	1E+07	4197.34	4635.16	4347.34	4.3136806	Edge Tile
Granite_MT_011	1E+07	4248.47	4668.39	4440.51	4.4470935	Edge Tile
Granite_MT_012	1.2E+07	4091.87	4620.42	4227.5	4.9935402	Edge Tile
Granite_MT_013	1.1E+07	4022.73	4262.96	4139.75	4.6847365	
Granite_MT_014	1.1E+07	3965.59	5768.34	4088.1	4.7903825	
Granite_MT_015	1.3E+07	3878.78	5032.2	3974.37	5.4768361	
Granite_MT_016	2.3E+07	3916.4	4642.25	4003.93	10.083259	Edge Tile
Granite_MT_017	6801381	3862.89	4451.68	4166.64	2.9283665	Outside
Granite_MT_018	9364394	4572.47	5116.35	4812.6	4.0318838	Edge Tile

Granite_MT_019	1.1E+07	4232.15	4977.15	4421.83	4.9434628	Edge Tile
Granite_MT_020	1.2E+07	4112.37	4360.93	4225.45	5.0586792	
Granite_MT_021	1.2E+07	4106.51	6264.29	4185.18	5.0480105	
Granite_MT_022	1.1E+07	4001.19	4391.54	4071.67	4.7973954	
Granite_MT_023	1.1E+07	3969.28	4132.43	4003.63	4.8935762	
Granite_MT_024	1.5E+07	3938.93	4734.62	4010.12	6.3540427	Edge Tile
Granite_MT_025	1863503	4529.35	4664.13	4600.99	0.80234	Outside
Granite_MT_026	9052054	4455.54	5165.03	4523.69	3.8974043	Edge Tile
Granite_MT_027	1.1E+07	4425.55	5067.98	4604.44	4.5423701	Edge Tile
Granite_MT_028	1.1E+07	4419.61	5017.31	4580.15	4.7081836	Edge Tile
Granite_MT_029	1.1E+07	4283.37	4662.26	4365.71	4.7319253	
Granite_MT_030	1.1E+07	3643.17	6362.55	4258.83	4.8200056	
Granite_MT_031	1.1E+07	4117.11	4270.51	4193.17	4.837899	
Granite_MT_032	1.1E+07	3608.99	6326.62	4077.69	4.7163642	
Granite_MT_033	1.1E+07	3544.83	6406.9	4037.4	4.845097	
Granite_MT_034	1.1E+07	3977.66	4232.32	4116.52	4.8532487	Edge Tile
Granite_MT_035	9491719	4554.51	5156.9	4760.54	4.0867042	Edge Tile
Granite_MT_036	1.1E+07	4437.05	5026.25	4529.86	4.6333218	Edge Tile
Granite_MT_037	1.1E+07	4337.23	4923.16	4448.93	4.8567633	
Granite_MT_038	1.1E+07	4292.21	4999.86	4381.47	4.6598913	
Granite_MT_039	1.1E+07	4104.91	5321.78	4317.13	4.8422553	
Granite_MT_040	1.2E+07	4174.78	4369.81	4244.74	5.0996956	
Granite_MT_041	1.2E+07	4109.7	4395.79	4170.94	4.9609283	
Granite_MT_042	1.1E+07	3547.95	6286.22	4092.15	4.7109671	

Granite_MT_043	1.1E+07	4013.88	4827.43	4103.93	4.7654108	
Granite_MT_044	1.1E+07	4084.73	5184.88	4225.76	4.8921807	Edge Tile
Granite_MT_045	1.1E+07	4776.47	5660.1	5188.75	4.872575	Edge Tile
Granite_MT_046	1.1E+07	3711.81	6399.77	4607.26	4.9308734	
Granite_MT_047	1.2E+07	4361.8	5945.95	4413.3	5.0927671	
Granite_MT_048	1.1E+07	4291.72	5134.35	4343.54	4.7900704	
Granite_MT_049	1.1E+07	4236.03	4861.24	4312.89	4.7780153	
Granite_MT_050	1.1E+07	3623.87	6377.36	4260.32	4.8852428	
Granite_MT_051	1.1E+07	4120.4	4261.15	4174.09	4.8333243	
Granite_MT_052	1.1E+07	4088.34	5054.46	4119.55	4.7304541	
Granite_MT_053	1.1E+07	4088.38	4486.53	4293.72	4.750362	Edge Tile
Granite_MT_054	1E+07	4258.5	4562.28	4419.4	4.4100301	Edge Tile
Granite_MT_055	1.1E+07	4365.64	5847.21	5412.93	4.704985	Edge Tile
Granite_MT_056	1.2E+07	4767.48	5691.96	5305.06	5.0759273	Edge Tile
Granite_MT_057	1.2E+07	4448.47	5409.86	4625.77	5.0962878	
Granite_MT_058	1.2E+07	3834.48	6467.6	4439.76	4.9704211	
Granite_MT_059	1.1E+07	4328.82	5516.6	4372.88	4.8034524	
Granite_MT_060	1.1E+07	4265.59	4482.15	4322.34	4.7258773	
Granite_MT_061	1.2E+07	4191.09	4322.66	4237.87	4.9643245	
Granite_MT_062	1.1E+07	3759.05	6425.1	4180.39	4.8726133	
Granite_MT_063	1.2E+07	4132.86	4422.37	4240.77	4.9997677	Edge Tile
Granite_MT_064	1E+07	3720.38	6464.64	4283.26	4.334336	Edge Tile
Granite_MT_065	1.1E+07	4726.46	5670.11	4987.08	4.5897561	Edge Tile
Granite_MT_066	1.2E+07	4668.49	5812.45	5356.92	5.322766	Edge Tile

Granite_MT_067	1.3E+07	4565.52	6671.86	4894.37	5.4108635	
Granite_MT_068	1.1E+07	4490.97	5273.81	4565.17	4.8489638	
Granite_MT_069	1.2E+07	4137.63	4769.83	4530.84	5.0010887	
Granite_MT_070	1.1E+07	4352.24	5305.09	4437.06	4.9264701	
Granite_MT_071	1.1E+07	4258.64	4554.32	4337.4	4.7304243	
Granite_MT_072	1.1E+07	4199.03	4550.17	4266.74	4.8995213	
Granite_MT_073	1.2E+07	4188.66	5398.03	4320.51	5.0391424	Edge Tile
Granite_MT_074	1.1E+07	4235.3	4484.72	4363.23	4.7991813	Edge Tile
Granite_MT_075	1.1E+07	4726.35	5106.16	4928.82	4.8274981	Edge Tile
Granite_MT_076	1E+07	4709	4925.25	4792.49	4.3514604	
Granite_MT_077	1.1E+07	4627.73	4970.34	4738.99	4.7673259	
Granite_MT_078	1.1E+07	4606.87	5062.46	4732.01	4.5295271	Edge Tile
Granite_MT_079	1.1E+07	4549.11	5028.88	4810.4	4.5505097	Edge Tile
Granite_MT_080	1.2E+07	4436.68	4898.63	4639.16	5.0990747	Edge Tile
Granite_MT_081	1.2E+07	4272.8	5706.13	4394.36	5.2914466	
Granite_MT_082	1.2E+07	4230.7	4618.47	4444.82	5.0842322	Edge Tile
Granite_MT_083	1.3E+07	4351.58	4681.87	4535.59	5.6161933	Edge Tile
Granite_MT_084	1.1E+07	4786.01	5268.97	4972.84	4.827554	Edge Tile
Granite_MT_085	1.1E+07	4779.64	5298.65	4982.42	4.9157751	Edge Tile
Granite_MT_086	1.1E+07	4760.46	5086.82	4831.15	4.6715559	Edge Tile
Granite_MT_087	3704254	4753.96	4877.33	4822.15	1.5948839	Edge Tile
Granite_MT_088	9663732	4387.85	5320.35	4566.46	4.1607652	Edge Tile
Granite_MT_089	1.2E+07	4050.4	5616.63	4386.61	4.998399	
Granite_MT_090	1.1E+07	4322.36	5174.57	4554.58	4.6230001	Edge Tile

Granite_MT_091	4915810	4890.77	5225.71	5092.28	2.1165251	Outside
Granite_MT_092	7685816	4884.45	5588.11	5047.7	3.3091642	Outside
Granite_MT_093	2462776	4567.92	4784.21	4628.19	1.0603598	Edge Tile
Granite_MT_094	1.1E+07	4412.36	4806.34	4664.21	4.8399984	Edge Tile
Granite_MT_095	1.2E+07	4364.19	4894.1	4454.66	5.0887397	
Granite_MT_096	8820123	4468.59	4939.11	4761.95	3.7975454	Edge Tile
Granite_MT_097	5564983	4535.98	5527.05	4629.76	2.3960296	Edge Tile
Granite_MT_098	1.2E+07	4437.62	4877.27	4520.18	4.9523856	
Granite_MT_099	1.2E+07	4435.51	5481.68	4688.67	5.0300732	Edge Tile
Granite_MT_100	5406600	4733.24	5114.97	4975.05	2.327837	Edge Tile
Granite_MT_101	8751231	4547.24	5120.13	4718.23	3.7678836	Edge Tile
Granite_MT_102	1.1E+07	4502.63	4764.58	4571.78	4.88703	
Granite_MT_103	1.1E+07	3912	5285.13	4669.28	4.834284	Edge Tile
Granite_MT_104	2356002	4682.59	5160.2	4994.49	1.0143877	Outside
Granite_MT_105	2286073	4740.47	5525.56	5071.86	0.9842795	Outside
Granite_MT_106	1.2E+07	4626.14	5747.95	5061.1	5.2322854	Edge Tile
Granite_MT_107	1.2E+07	4600.92	5325.61	4779.67	5.0302196	
Granite_MT_108	9285323	4384.65	5361.76	4955.4	3.9978394	Edge Tile
Granite_MT_109	6192286	4888.47	6497.1	5361.44	2.6661178	Edge Tile
Granite_MT_110	1.3E+07	5124.02	6009.47	5570.83	5.5394848	Edge Tile
Granite_MT_111	1.3E+07	4701.94	5720.36	5004.72	5.597515	
Granite_MT_112	6833412	4795.9	5431.64	5083.17	2.9421576	Edge Tile
Granite_MT_113	1.3E+07	4937.22	6523.17	5659.09	5.7758602	Edge Tile
Granite_MT_114	1.4E+07	4854.89	5974.34	5441.21	5.8263449	

Granite_MT_115	1.3E+07	4818.42	6043.93	5139.91	5.5684668	
Granite_MT_116	1.1E+07	4893.05	5910.24	5421.67	4.7667266	Edge Tile
Granite_MT_117	1.3E+07	5086.3	6092.88	5670.63	5.4578779	Edge Tile
Granite_MT_118	1.3E+07	4886.07	6138.13	5640.21	5.619568	Edge Tile
Granite_MT_119	1.3E+07	4856.38	6491.62	5200.52	5.7342454	
Granite_MT_120	1.4E+07	4886.24	6699.49	5981.18	5.8979281	Edge Tile
Granite_MT_121	1.1E+07	4941.15	6285.13	5363.75	4.5594123	Edge Tile
Granite_MT_122	8650299	5273.8	6321.32	5723.42	3.7244268	Edge Tile
Granite_MT_123	1.3E+07	5044.72	6131.46	5746.68	5.4552322	Edge Tile
Granite_MT_124	1.2E+07	4887.42	6073.84	5227.79	5.2850494	
Granite_MT_125	1.4E+07	4887.86	6716.73	5932.19	6.0978665	
Granite_MT_126	1.2E+07	5324.35	6719	6178.26	5.2562677	Edge Tile
Granite_MT_127	7867318	5359.67	6441.18	5830.18	3.3873107	Outside
Granite_MT_128	1.2E+07	5002.9	5900.14	5421.35	5.0742145	Edge Tile
Granite_MT_129	1.2E+07	4918.74	6129.32	5233.65	5.0724673	
Granite_MT_130	1.3E+07	4908.48	6494.67	5581.73	5.8001121	Edge Tile
Granite_MT_131	1.3E+07	5729.32	6765.71	6389.17	5.6302763	Edge Tile
Granite_MT_132	4016118	5390.95	6375.71	5755.23	1.7291585	Edge Tile
Granite_MT_133	1.2E+07	5293.17	6408.38	5847.89	4.9607746	Edge Tile
Granite_MT_134	1.1E+07	4958.24	5685.98	5265.19	4.888819	Edge Tile
Granite_MT_135	1.2E+07	4943.37	6411.75	5317.98	5.2276009	Edge Tile
Granite_MT_136	1.3E+07	5391.03	6702.88	6136.09	5.4976526	Edge Tile
Granite_MT_137	6495812	5798.62	6609.44	6297.21	2.7968024	Outside
Granite_MT_138	1.4E+07	5140.74	6016.6	5544.31	6.0741373	Edge Tile

Granite_MT_139	1.4E+07	4974.2	6088.04	5195.64	6.0518355	
Granite_MT_140	1.3E+07	5130.27	5999.24	5480.97	5.6283591	Edge Tile
Granite_MT_141	8157023	5101.35	5339.28	5200.05	3.5120445	Edge Tile
Granite_MT_142	2.6E+07	4952.72	5368.22	5129.18	11.178907	Edge Tile
Granite_MT_143	2.6E+07	4987	5729.76	5119.36	11.333626	
Granite_MT_144	2.4E+07	5192.08	6122.9	5590.41	10.231121	Edge Tile
Granite_MT_145	1.3E+07	5102.64	5353.69	5204.47	5.5621277	Edge Tile
Granite_MT_146	2.5E+07	4993.89	5234.62	5104.05	10.819805	
Granite_MT_147	2.6E+07	4985.13	5554.73	5138.9	11.135474	
Granite_MT_148	2.6E+07	5255.23	6182.47	5634.39	11.269745	Edge Tile
Granite_MT_149	2.4E+07	5137.96	5417.1	5215.3	10.439431	Edge Tile
Granite_MT_150	2.6E+07	5025.53	6283.36	5101.34	11.076076	
Granite_MT_151	2.5E+07	5032.21	5333.9	5142.22	10.796642	
Granite_MT_152	2.8E+07	5273.73	6178.39	5639.65	12.257552	Edge Tile
Granite_MT_153	2.2E+07	5781.41	6541.82	6151.93	9.50893	Edge Tile
Granite_MT_154	2.4E+07	5134.59	5464.38	5255.97	10.381157	Edge Tile
Granite_MT_155	2.6E+07	5082.51	5663.38	5127.81	11.322715	
Granite_MT_156	2.6E+07	4911.94	6816.05	5176.09	11.132438	
Granite_MT_157	2.8E+07	5015.95	6945.09	5513.15	12.099885	
Granite_MT_158	2E+07	5524.81	7683.71	5982.11	8.7760454	Edge Tile
Granite_MT_159	2.4E+07	5164.71	5851.86	5298.13	10.437849	Edge Tile
Granite_MT_160	2.7E+07	4767.57	6666.67	5171.14	11.834306	
Granite_MT_161	2.5E+07	5147.32	5388.38	5205.59	10.868003	
Granite_MT_162	2.7E+07	5240.97	5973.82	5549.48	11.766421	

Granite_MT_163	2E+07	5644.2	6870.15	6194.76	8.65612	Edge Tile
Granite_MT_164	1.1E+07	5397.18	6325.66	5633.05	4.5679481	Edge Tile
Granite_MT_165	2.5E+07	5174.03	5713.44	5314.59	10.732285	Edge Tile
Granite_MT_166	2.6E+07	5170.33	5774.58	5221.76	11.260189	Edge Tile
Granite_MT_167	2.6E+07	5209.8	5750.94	5322.94	11.24358	Edge Tile
Granite_MT_168	2.7E+07	5355.53	6268.35	5720.26	11.80067	Edge Tile
Granite_MT_169	1.8E+07	5683.6	6536.01	6075.68	7.8958362	Edge Tile
Granite_MT_170	1.1E+07	5378.68	5915.26	5643.39	4.6145823	Edge Tile
Granite_MT_171	2.6E+07	5207.46	6148.72	5399.39	11.181506	
Granite_MT_172	2.5E+07	5190.37	5855.1	5301.37	10.694783	Edge Tile
Granite_MT_173	1.6E+07	5293.78	5981.23	5424.3	7.0092479	Edge Tile
Granite_MT_174	2.7E+07	5253.51	5543.2	5313.44	11.643975	
Granite_MT_175	2E+07	5224.82	5664.17	5359.43	8.4381026	Edge Tile
Granite_MT_176	1.8E+07	5295.4	5597.91	5361.03	7.9557419	Edge Tile
Granite_MT_177	2.8E+07	5291.25	5471.34	5349.52	12.036373	
Granite_MT_178	1.9E+07	5312.04	5940.52	5412	8.1145575	Edge Tile
Granite_MT_179	2E+07	5314.54	5594.61	5375.38	8.7107006	Edge Tile
Granite_MT_180	2.7E+07	4928.76	6356.47	5419.08	11.68352	
Granite_MT_181	2.5E+07	5384.35	6369.93	5635.61	10.918542	Edge Tile
Granite_MT_182	1.1E+07	5577.52	6404.16	5838.4	4.5842523	Edge Tile
Granite_MT_183	2.2E+07	5361.91	5508.04	5411.57	9.3757353	Edge Tile
Granite_MT_184	2.5E+07	5386.49	5657.08	5506.79	10.82502	Edge Tile
Granite_MT_185	2.5E+07	5454.56	6118.25	5616.12	10.712492	Edge Tile
Granite_MT_186	3.1E+07	5399.27	6475.01	5920.38	13.559391	Edge Tile

Granite_MT_187	1.5E+07	5723.18	6695.19	6240.42	6.6051512	Outside
Granite_MT_188	1.5E+07	5634.56	6633.39	6119.52	6.2640115	Outside
Granite_MT_189	6853393	5755.68	6590.01	6182.72	2.9507605	Outside

Table 10 Check for Data Void

Tile Size	5000x5000 Feet
Grid Size	4 Meters
Pass Percent	90

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_001	15485662	1565001	1094983	69.96692015	
Granite_MT_002	24552086	1565001	1558987	99.6157191	
Granite_MT_003	24606633	1565001	1560281	99.69840275	
Granite_MT_004	8756007	1565001	638236	40.78182698	
Granite_MT_005	8370896	1565001	1344386	85.9032039	
Granite_MT_006	9250084	1565001	1533939	98.01520894	
Granite_MT_007	18780457	1565001	1552187	99.18121458	
Granite_MT_008	24377586	1565001	1556990	99.48811534	Pass
Granite_MT_009	26272126	1565001	1559787	99.66683727	
Granite_MT_010	9985060	1565001	696944	44.53313448	
Granite_MT_011	10298824	1565001	1504440	96.13029001	
Granite_MT_012	11590494	1565001	1562376	99.83226848	
Granite_MT_013	10880459	1565001	1561949	99.80498415	Pass
Granite_MT_014	11120072	1565001	1562171	99.81916944	Pass
Granite_MT_015	12452950	1565001	1551235	99.12038395	Pass
Granite_MT_016	23104112	1565001	1531787	97.87770104	
Granite_MT_017	6792752				
Granite_MT_018	9330400	1565001	1384527	88.46812238	

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_019	11448015	1565001	1562206	99.82140586	
Granite_MT_020	11745250	1565001	1562001	99.80830683	Pass
Granite_MT_021	11722707	1565001	1561498	99.77616628	Pass
Granite_MT_022	11120525	1565001	1560831	99.7335465	Pass
Granite_MT_023	11294417	1565001	1553554	99.26856277	Pass
Granite_MT_024	14390631	1565001	1556383	99.44932943	
Granite_MT_025	1863503				
Granite_MT_026	9051777	1565001	1483527	94.79399694	
Granite_MT_027	10547183	1565001	1562222	99.82242823	
Granite_MT_028	10934710	1565001	1562113	99.81546338	
Granite_MT_029	10981789	1565001	1561531	99.7782749	Pass
Granite_MT_030	11184361	1565001	1562355	99.83092663	Pass
Granite_MT_031	11229464	1565001	1561030	99.74626214	Pass
Granite_MT_032	10922154	1565001	1557781	99.53865844	Pass
Granite_MT_033	11165993	1565001	1554891	99.35399402	Pass
Granite_MT_034	11270123	1565001	1562289	99.82670938	
Granite_MT_035	9390927	1565001	1445354	92.35482917	
Granite_MT_036	10751257	1565001	1560963	99.741981	
Granite_MT_037	11233602	1565001	1561186	99.75623019	Pass
Granite_MT_038	10805256	1565001	1559084	99.62191717	Pass
Granite_MT_039	11111166	1565001	1557844	99.542684	Pass
Granite_MT_040	11770206	1565001	1561330	99.76543146	Pass

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_041	11403413	1565001	1557318	99.5090738	Pass
Granite_MT_042	10809050	1565001	1552448	99.19789189	Pass
Granite_MT_043	11022011	1565001	1561422	99.77131005	Pass
Granite_MT_044	11361820	1565001	1562427	99.83552726	
Granite_MT_045	11287443	1565001	1558808	99.6042814	
Granite_MT_046	11448752	1565001	1561211	99.75782763	Pass
Granite_MT_047	11802926	1565001	1561279	99.76217268	Pass
Granite_MT_048	11063103	1565001	1558192	99.56492041	Pass
Granite_MT_049	11064314	1565001	1558891	99.60958491	Pass
Granite_MT_050	11333294	1565001	1561011	99.74504809	Pass
Granite_MT_051	11144155	1565001	1559040	99.61910567	Pass
Granite_MT_052	10909416	1565001	1557245	99.50440926	Pass
Granite_MT_053	10999745	1565001	1562193	99.82057519	
Granite_MT_054	10226162	1565001	1461856	93.40926939	
Granite_MT_055	10525872	1565001	1529243	97.71514523	
Granite_MT_056	11255295	1565001	1560738	99.72760401	
Granite_MT_057	11706531	1565001	1560767	99.72945704	Pass
Granite_MT_058	11303231	1565001	1560683	99.72408963	Pass
Granite_MT_059	11111406	1565001	1558440	99.58076704	Pass
Granite_MT_060	10949421	1565001	1555088	99.36658187	Pass
Granite_MT_061	11491519	1565001	1561378	99.76849855	Pass
Granite_MT_062	11183616	1565001	1551394	99.13054369	Pass

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_063	11604742	1565001	1562365	99.8315656	
Granite_MT_064	10046523	1565001	1479707	94.54990764	
Granite_MT_065	10445228	1565001	1505061	96.1699705	
Granite_MT_066	10888678	1565001	1549808	99.0292019	
Granite_MT_067	11725819	1565001	1559592	99.65437722	Pass
Granite_MT_068	11176964	1565001	1560755	99.72869027	Pass
Granite_MT_069	11573269	1565001	1561746	99.79201291	Pass
Granite_MT_070	11409570	1565001	1559596	99.65463281	Pass
Granite_MT_071	10949269	1565001	1558524	99.58613445	Pass
Granite_MT_072	11229153	1565001	1556859	99.47974474	Pass
Granite_MT_073	11662026	1565001	1561745	99.79194901	
Granite_MT_074	11144623	1565001	1562355	99.83092663	
Granite_MT_075	11169080	1565001	1561837	99.79782761	
Granite_MT_076	10048188	1565001	1522802	97.30358	Pass
Granite_MT_077	10975953	1565001	1562119	99.81584676	Pass
Granite_MT_078	10519798	1565001	1550630	99.08172583	
Granite_MT_079	10567719	1565001	1519309	97.08038525	
Granite_MT_080	11841990	1565001	1536763	98.19565611	
Granite_MT_081	12194485	1565001	1557600	99.52709295	Pass
Granite_MT_082	11541879	1565001	1559721	99.66262002	
Granite_MT_083	13043877	1565001	1562470	99.83827486	
Granite_MT_084	10981896	1565001	1547286	98.86805184	

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_085	11405583	1565001	1561455	99.77341868	
Granite_MT_086	10850084	1565001	1558957	99.61380216	
Granite_MT_087	3704254	1565001	634701	40.55594853	
Granite_MT_088	9544584	1565001	1493877	95.45533837	
Granite_MT_089	11285661	1565001	1548004	98.91393041	Pass
Granite_MT_090	10644692	1565001	1562057	99.8118851	
Granite_MT_091	4810008				
Granite_MT_092	7683237				
Granite_MT_093	2462572	1565001	461232	29.47167446	
Granite_MT_094	11173535	1565001	1556348	99.44709301	
Granite_MT_095	11484515	1565001	1559666	99.65910565	Pass
Granite_MT_096	8679952	1565001	1398959	89.39029432	
Granite_MT_097	5509413	1565001	950254	60.71906663	
Granite_MT_098	11350713	1565001	1559872	99.67226858	Pass
Granite_MT_099	11467347	1565001	1562290	99.82677327	
Granite_MT_100	5393024	1565001	890101	56.87542692	
Granite_MT_101	8548009	1565001	1413194	90.2998784	
Granite_MT_102	11038173	1565001	1557007	99.4892016	Pass
Granite_MT_103	11151515	1565001	1562070	99.81271577	
Granite_MT_104	2355971				
Granite_MT_105	1960378				
Granite_MT_106	10566616	1565001	1553125	99.24115064	

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_107	11409825	1565001	1559022	99.61795552	Pass
Granite_MT_108	9232003	1565001	1456058	93.03879039	
Granite_MT_109	5289763	1565001	910633	58.18737496	
Granite_MT_110	11189736	1565001	1549995	99.04115077	
Granite_MT_111	11542851	1565001	1553068	99.23750847	Pass
Granite_MT_112	6520148	1565001	986610	63.04213224	
Granite_MT_113	10880935	1565001	1542105	98.53699774	
Granite_MT_114	11385632	1565001	1549791	99.02811564	Pass
Granite_MT_115	10959494	1565001	1546716	98.83163014	Pass
Granite_MT_116	9662687	1565001	1482729	94.74300655	
Granite_MT_117	10176254	1565001	1472181	94.06901337	
Granite_MT_118	10810160	1565001	1547056	98.85335537	
Granite_MT_119	11711378	1565001	1541852	98.52083162	Pass
Granite_MT_120	10857417	1565001	1538359	98.29763687	
Granite_MT_121	8978118	1565001	1394091	89.0792402	
Granite_MT_122	8229047	1565001	1304387	83.34735888	
Granite_MT_123	11485546	1565001	1556610	99.46383421	
Granite_MT_124	11213643	1565001	1545950	98.78268448	Pass
Granite_MT_125	11035486	1565001	1544864	98.71329156	Pass
Granite_MT_126	10482736	1565001	1498733	95.76562571	
Granite_MT_127	6667326				
Granite_MT_128	10705496	1565001	1553994	99.29667777	

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_129	10914659	1565001	1552018	99.17041587	Pass
Granite_MT_130	11364586	1565001	1550481	99.07220507	
Granite_MT_131	10807985	1565001	1541824	98.51904248	
Granite_MT_132	3372268	1565001	567788	36.2803602	
Granite_MT_133	10300291	1565001	1550882	99.09782805	
Granite_MT_134	10761583	1565001	1554832	99.35022406	
Granite_MT_135	11189301	1565001	1552900	99.22677366	
Granite_MT_136	10636499	1565001	1546152	98.79559182	
Granite_MT_137	5618043				
Granite_MT_138	14064924	1565001	1561923	99.80332281	
Granite_MT_139	13856740	1565001	1561285	99.76255606	Pass
Granite_MT_140	12442313	1565001	1494227	95.47770257	
Granite_MT_141	8154902	1565001	596331	38.1041929	
Granite_MT_142	25955581	1565001	1562273	99.82568701	
Granite_MT_143	26299705	1565001	1556964	99.486454	Pass
Granite_MT_144	22130301	1565001	1460872	93.34639403	
Granite_MT_145	12918026	1565001	921138	58.85862054	
Granite_MT_146	25125181	1565001	1561185	99.75616629	Pass
Granite_MT_147	25843237	1565001	1560896	99.73769985	Pass
Granite_MT_148	24727701	1565001	1561743	99.79182122	
Granite_MT_149	24229519	1565001	1561479	99.77495222	
Granite_MT_150	25712212	1565001	1558445	99.58108653	Pass

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_151	25053297	1565001	1535781	98.13290854	Pass
Granite_MT_152	27332231	1565001	1562468	99.83814707	
Granite_MT_153	18666080	1565001	1304938	83.38256653	
Granite_MT_154	24034663	1565001	1561398	99.7697765	
Granite_MT_155	26291395	1565001	1560502	99.71252415	Pass
Granite_MT_156	25755457	1565001	1562466	99.83801927	Pass
Granite_MT_157	26396281	1565001	1562381	99.83258797	Pass
Granite_MT_158	17425670	1565001	1253461	80.09330345	
Granite_MT_159	24213205	1565001	1561651	99.78594263	
Granite_MT_160	27444392	1565001	1559269	99.63373825	Pass
Granite_MT_161	25208809	1565001	1560170	99.6913101	Pass
Granite_MT_162	25710614	1565001	1555814	99.41297162	Pass
Granite_MT_163	17330489	1565001	1140607	72.88218985	
Granite_MT_164	10074810	1565001	668097	42.68987688	
Granite_MT_165	24923170	1565001	1559325	99.63731653	
Granite_MT_166	26143544	1565001	1560197	99.69303534	
Granite_MT_167	25457180	1565001	1562527	99.84191703	
Granite_MT_168	25059686	1565001	1539554	98.37399465	
Granite_MT_169	16468625	1565001	1091940	69.77247938	
Granite_MT_170	10576731	1565001	701217	44.80616945	
Granite_MT_171	25656050	1565001	1553004	99.23341902	Pass
Granite_MT_172	24317330	1565001	1538401	98.30032057	

LASFILE	NO OF POINTS	NO OF GRIDS/TILE	NO OF GRIDS MEETING THE SPEC	PERCENT OF GRIDS MEETING THE SPEC	STATUS
Granite_MT_173	16207470	1565001	1105372	70.63075359	
Granite_MT_174	26963835	1565001	1560367	99.70389795	Pass
Granite_MT_175	19448880	1565001	1331041	85.05048879	
Granite_MT_176	18476663	1565001	1280388	81.81387744	
Granite_MT_177	27483006	1565001	1559645	99.6577638	Pass
Granite_MT_178	18669077	1565001	1258536	80.4175844	
Granite_MT_179	20228972	1565001	1341916	85.74537652	
Granite_MT_180	26406027	1565001	1560877	99.73648579	Pass
Granite_MT_181	22960200	1565001	1516148	96.87840455	
Granite_MT_182	8406744	1565001	591903	37.82125379	
Granite_MT_183	21774158	1565001	1417383	90.56754596	
Granite_MT_184	25126454	1565001	1561433	99.77201293	
Granite_MT_185	23726660	1565001	1526627	97.54798879	
Granite_MT_186	24671879	1565001	1560451	99.70926536	
Granite_MT_187	11832119				
Granite_MT_188	11286280				
Granite_MT_189	5455876				

The tiles that were failed were visually checked and it was observed that the issue is due to water bodies present (as LiDAR is absorbed and not reflected) and it is acceptable. The data void check is pass 100%.