

**Scope of Work on Master Agreement # AV2406
Acquisition of Aerial Lidar Elevation Data
Northern, Central, and Southern Utah Areas**

The State of Utah, Department of Technology Services, Division of Integrated Technology, Automated Geographic Reference Center (AGRC) and partners are contracting with Aero-Graphics, Inc. (AGI) to acquire, process, and deliver aerial Lidar data and derivative products that meet the specifications described in this Scope of Work, and contracted under Master Agreement #AV2406.

This Scope of Work (SOW) identifies the specific acquisition requirements, production specifications and standards, deliverables, and schedule for Lidar data collection and deliverable data products that adhere to the U.S. Geological Survey (USGS) Quality Level 1 (QL1) and Quality Level 2 (QL2) Lidar specifications for the areas defined in this agreement. The Lidar data will be acquired in the spring, summer and fall of 2018 with leaf-off or leaf-on conditions, defined per area, and no snow on the ground. Pricing will be based on the cost submitted in the bid response to Solicitation #WS16020-Stage 2 for the Northern, Central, and Southern Utah project areas by Aero-Graphics, Inc.

1. Lidar Data Products

The lidar data products delivered to AGRC must adhere to U.S. Geological Survey (USGS) National Geospatial Program (NGP) *Lidar Base Specification Version 1.2* (2014) available at <http://pubs.usgs.gov/tm/11b4/>. These lidar specifications are the required minimum baseline specifications and project deliverables shall meet or exceed USGS Quality Level 1 (QL1) or Quality Level 2 (QL2), as specified per project area. For any item which is not specifically addressed, the referenced *Lidar Base Specification Version 1.2* will be the required specification authority.

2. Project Areas, Performance Period, and Acquisition Modifications

The State of Utah 2018 Lidar Acquisition Project ("Project") covers portions of Utah and one small area in Arizona as shown in AGI Project Areas.png, Figures 1, 2, 3 and are delineated in Utah_2018_Lidar_Acquisition_Areas shapefile Attachment 1. Please note the attributes in this shapefile for *Project* (project name), *Name* (acquisition area name), *QualityLev* (USGS Quality Level), and *Acquisitio* (Leaf-on, Leaf-off, or Anytime).

2.1. Project Areas

The Project acquisition areas total approximately 9,545 mi² in Utah and Arizona as shown in AGI Project Areas.png. Further details on the three areas: Northern Utah, Central Utah, and Southern Utah, are explained in Sections 2.1.1., 2.1.2., and 2.1.3. For the contracted areas, the delivered data products must cover at least the spatial extent (footprint) of the areas delineated in Attachment 1. Any acquisition footprints that extend

beyond the project areas are acceptable, and if data is acquired outside these footprints, at least the raw point cloud data shall be provided.

2.1.1. Northern Utah

The *Northern Utah* area totals 1,529 mi² and shall be collected and delivered according to a combination of USGS QL1 (555 mi²) and QL2 (986 mi²) lidar specifications as delineated in Attachment 1 and shown in Figure 1, 2 and 3. Acquisition may occur anytime between the contract award date and November 30, 2018.

There are no specific specifications for leaf-off/leaf-on requirements; however, the lidar acquisition shall be timed to ensure the ground surface is free of snow, ice, and standing water; rivers are free of ice and are at a stage of low flow; and preferably when lakes and reservoirs are close to the lowest levels of the year. In addition, lidar penetration to the ground must be adequate to produce a bare-earth surface digital elevation model (DEM) that meets or exceeds the requirements for vertical accuracy.

2.1.2. Central Utah

The *Central Utah* area totals 3,098 mi² and shall be collected and delivered according to a combination of USGS QL1 (1,724 mi²) and QL2 (1,375 mi²) lidar specifications as delineated in Attachment 1 and shown in Figure 1, 2 and 3. It is suggested the ski resorts within the project area be acquired in late July or August for a typical snow year. Acquisition may occur anytime between the contract award date and November 30, 2018.

Areas require leaf-off specifications with the exception of the Western San Rafael Swell Area that can be acquired any time (see Figure 2); however, the lidar acquisition shall be timed to ensure the ground surface is free of snow, ice, and standing water; rivers are free of ice and are at a stage of low flow; and lakes and preferably when reservoirs are close to the lowest levels of the year. Although there are no leaf-off/leaf-on requirements, lidar penetration to the ground must be adequate to produce a bare-earth surface DEM that meets or exceeds the requirements for vertical accuracy.

2.1.3. Southern Utah

The *Southern Utah* area totals 4,919 mi² and shall be collected and delivered according to a combination of USGS QL1 (744 mi²) and QL2 (4,175 mi²) lidar specifications as delineated in Attachment 1 and shown in Figure 1, 2 and 3. Acquisition may occur anytime between the contract award date and November 30, 2018.

There is a combination of leaf-off/leaf-on requirements and some areas that can be acquired anytime as defined for each portion of the area and shown in Figure 2; however, the lidar acquisition shall be timed to ensure the ground surface is free of snow, ice, and standing water; rivers are free of ice and are at a stage of low flow; and preferably when lakes and reservoirs are close to the lowest levels of the year. In addition, lidar penetration to the ground must be adequate to produce a bare-earth surface DEM that meets or exceeds the requirements for vertical accuracy.

The Bryce Canyon National Park portion of the area contains significant near-vertical walls and hoodoos, so we request minimal shadowing in the lidar data, but realize that some shadowing is unavoidable due to the terrain.

The 2017 Brian Head Fire and Moab portions of the area require leaf-on conditions.

2.1.4. Weber County Addition

The *Weber County Addition* area totals 239 mi² (consolidated into 2.1.1 square mileage) and shall be collected and delivered according to a combination of USGS QL1 lidar specifications as delineated in Attachment 1 and shown in Figure 4. Acquisition may occur anytime between the contract award date and November 30, 2018.

There are no specific specifications for leaf-off/leaf-on requirements; however, the lidar acquisition shall be timed to ensure the ground surface is free of snow, ice, and standing water; rivers are free of ice and are at a stage of low flow; and preferably when lakes and reservoirs are close to the lowest levels of the year. In addition, lidar penetration to the ground must be adequate to produce a bare-earth surface digital elevation model (DEM) that meets or exceeds the requirements for vertical accuracy.

Figure 1: Acquisition Areas

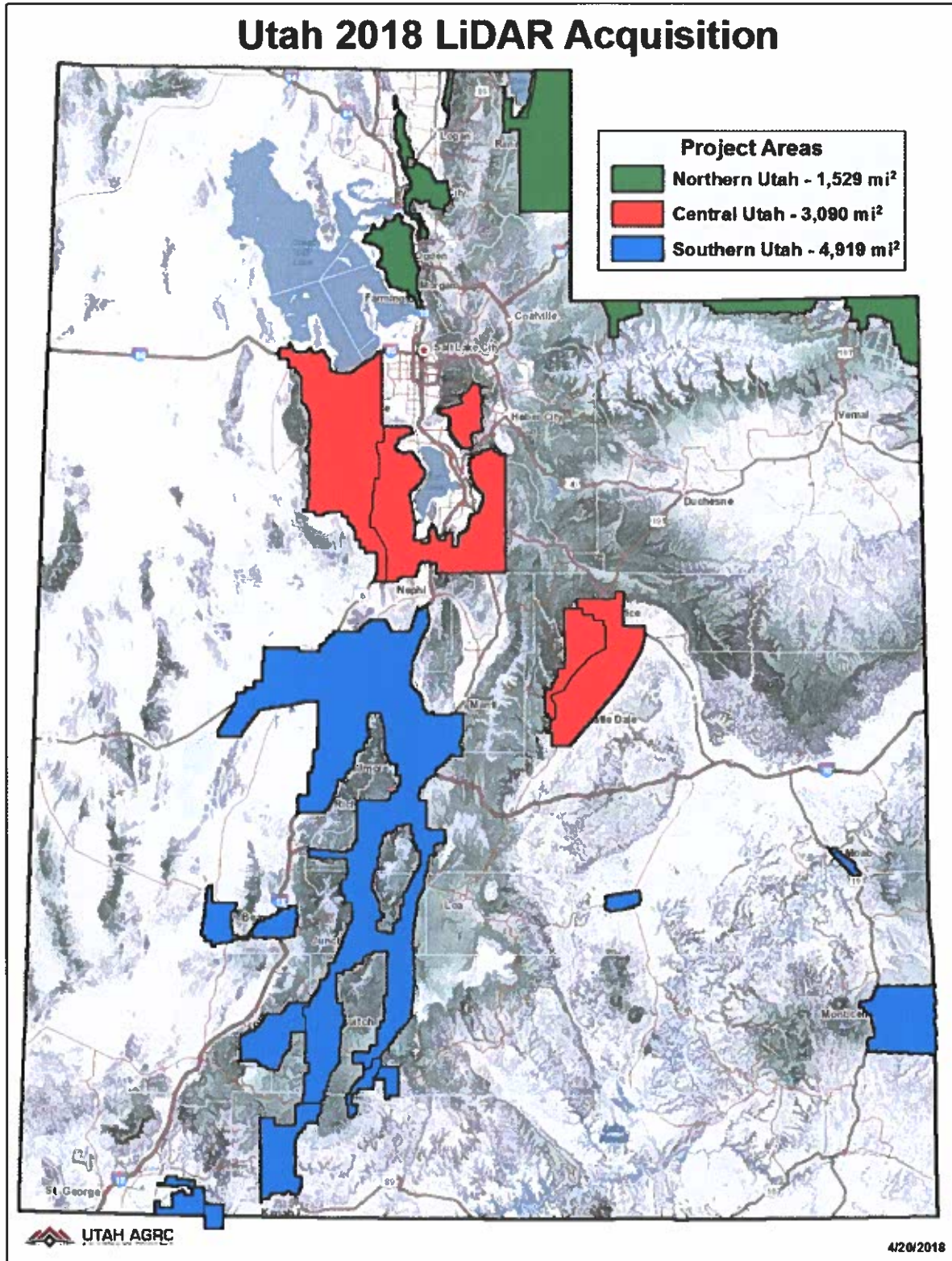


Figure 2: Acquisition Time

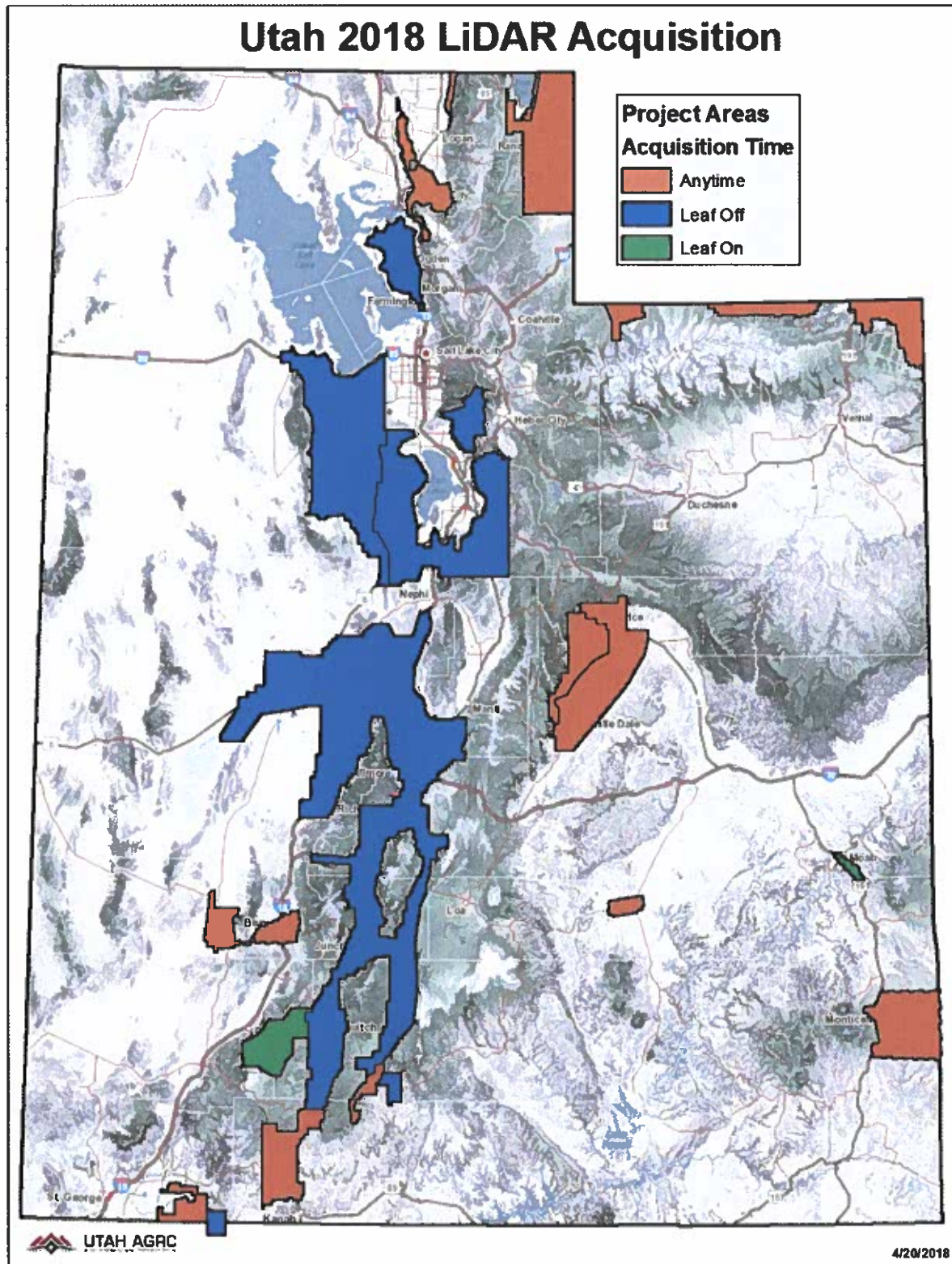


Figure 3: Acquisition Quality Level

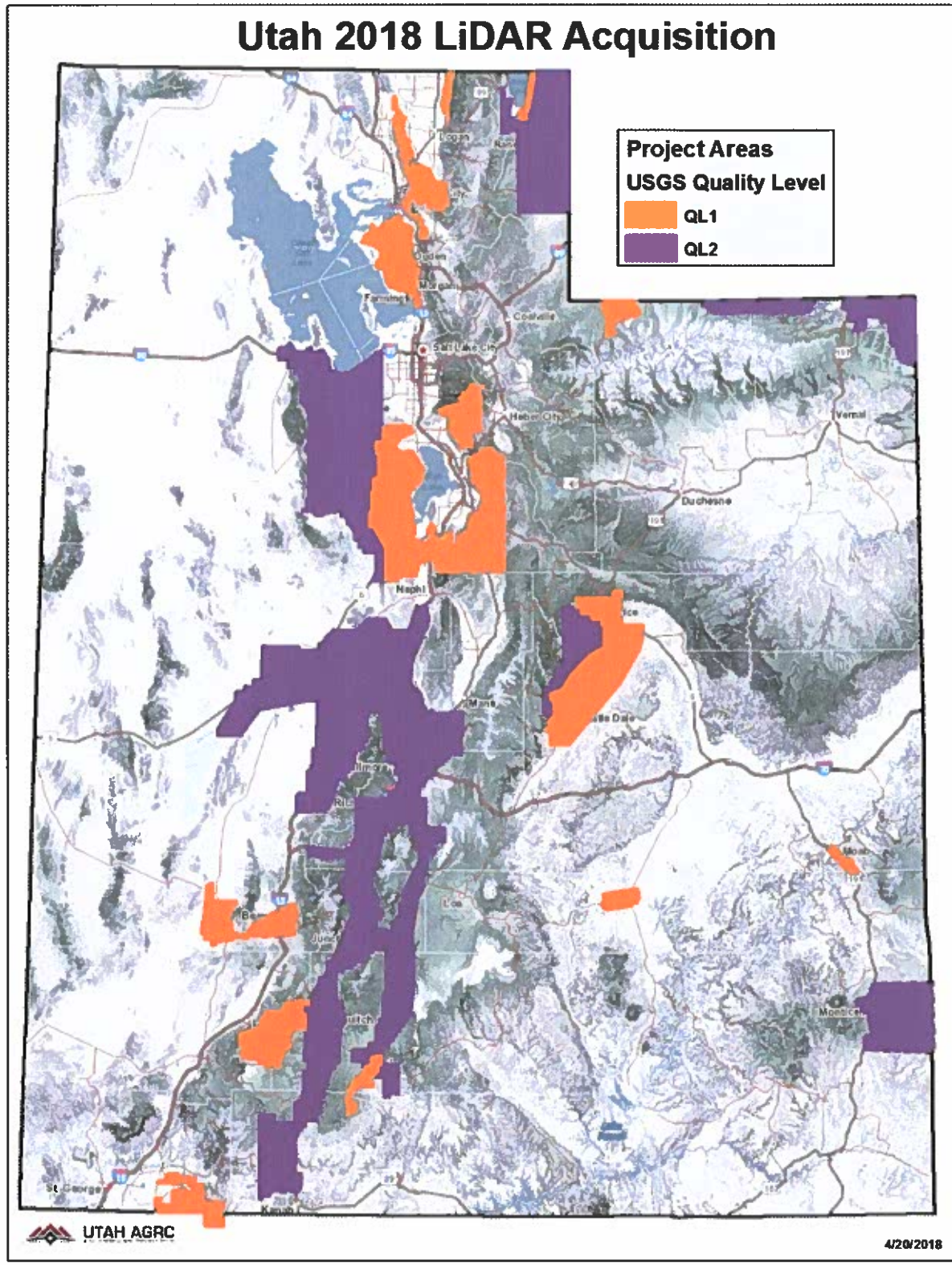
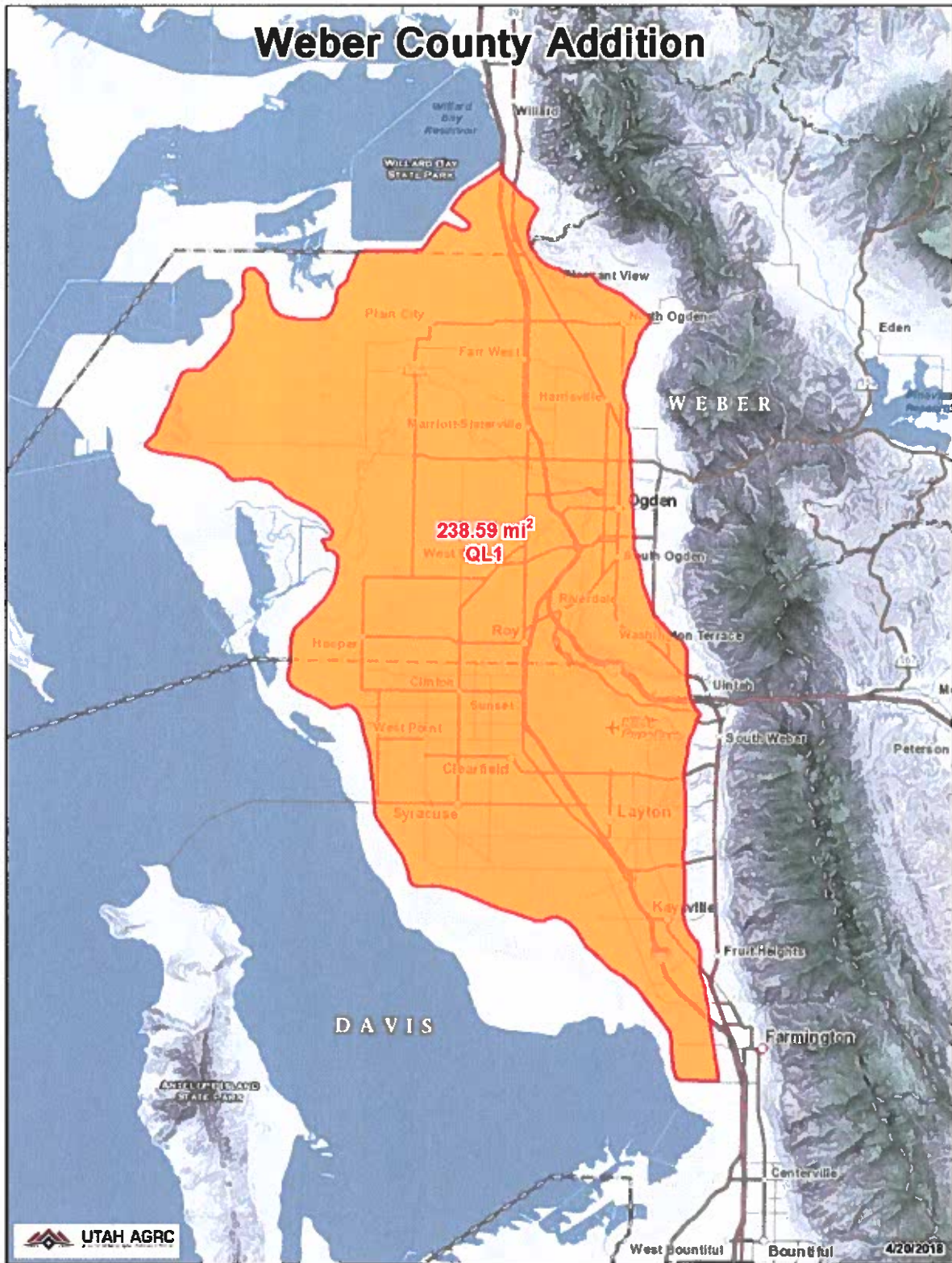


Figure 4: Weber County Addition



2.2. Performance Period

For the project areas described in Section 2.1, the acquisition shall be in the spring, summer, or fall of 2018, depending on specific leaf-off/leaf-on requirements, low water levels, and no snow on the ground (such as, may be encountered during October and later).

2.3. Acquisition Modifications

Any additions or modifications to the lidar areas, by either AGRC or the other cooperators, will adhere to the data deliverables, standards, specifications criteria, and inspection process described in this SOW. Any changes after initial contracts are negotiated will be made through the agreed upon contract amendment process between AGRC and the Vendor.

3. Delivery and Quality Assessment and Acceptance Schedule

The lidar data acquisition schedule will be agreed to by AGRC and the Vendor based on actual weather and on-the-ground conditions after the contract has been approved. This schedule may include a small, initial pilot delivery, selected from within the project areas, to ensure that the delivered data products meets the specifications and conditions of the contract.

A formal data product delivery schedule will be agreed to by AGRC and the Vendor after the contract has been approved and may be modified by changes in the acquisition schedule, such as unfavorable weather or other conditions out of the Vendor's control. Lidar acquisition shall be timed to ensure the ground is free of snow, ice, and standing water; rivers are free of ice and are at a stage of low flow; and preferably when lakes and reservoirs are close to the lowest levels of the year. Leaf-off vegetation conditions are preferred and lidar penetration to the ground must be adequate to produce a bare-earth surface DEM that meets or exceeds requirements for vertical accuracy.

The anticipated schedule of delivery and quality assurance is as follows:

- Flight of contracted area.
 - Length of acquisition time to be determined by the Vendor in collaboration with AGRC.
- Process and deliver all data products to AGRC for initial inspection and review.
 - AGRC and the USGS has 60 days to review and submit correction requests.
- Vendor addresses initial review comments and redelivers areas to AGRC for final inspection.
 - Vendor has 20 days to redeliver with corrections.
- AGRC final inspection and review.
 - AGRC and the USGS has 60 days to review and submit correction requests.
- Vendor addresses final review comments and delivers final and complete data products to AGRC.
 - Vendor has 20 days to redeliver final data product.

If it is not possible to rework the data to correct the error(s), a re-flight of that area may be required.

3.1. Inspection Schedule

An inspection schedule for quality assurance of all products will be developed between the Vendor and AGRC. The Vendor shall document its internal quality assurance work as described in Section 6. A review committee designated by AGRC will quality check the submitted lidar products. In addition, the USGS National Geospatial Technical Operations Center (NGTOC) will review the delivered data products to ensure they meet the requirements of the USGS NGP Lidar Base Specification Version 1.2 (2014) and The National Map: 3D Elevation Program (3DEP) requirements set forth in this SOW.

Deliverables will not be accepted by AGRC without acceptance by the USGS NGTOC. The inspection period for each initial data product delivery will be up to 60-calendar days; these inspection periods may be concurrent. Review of any redelivery of data with corrections will be completed within 20-calendar days of receipt. If collection conditions necessitate the need for a later acquisition, the Vendor can negotiate a time extension with AGRC through a contract amendment. Data deliveries will be made to AGRC at the address specified in the contract.

4. Access to Lands and Airspace

The Vendor is responsible for applying for and obtaining all required permits, clearances, permissions, etc. for access, over-flight, or intrusion to restricted or otherwise limited ground access and/or airspace, which may be included within the requirements of this project. AGRC can assist with expediting these processes where possible.

5. Data Product Deliverables

The products listed in Section 5 are required project deliverables. All deliverables will adhere to the USGS NGP *Lidar Base Specifications Version 1.2 (2014)*. See "Data Processing and Handling" section and Section 15 "Cited Specifications and Standards" for requirements on the processing and handling of the lidar data.

Once AGRC and the USGS NGTOC have approved and accepted data for a specific area, the vendor shall provide a complete copy of all the final deliverables, with any corrections incorporated, with raw swath and other (such as, classified) point cloud data delivered as lossless compressed LAZ files using LASzip (<https://www.laszip.org/>) v3.1 or later release, raster digital surface (DSM) and elevation (DEM) model data delivered as lossless compressed LZ77 or LZW ERDAS IMG files, and lidar intensity images as lossless compressed deflate GeoTIFF files. All files shall use lowercase extensions. **Raw swath and other point cloud data delivered before the final approval and acceptance must be in uncompressed LAS format, DSM and DEM data in uncompressed IMG format, and lidar intensity images in uncompressed GeoTIFF format for review.**

5.1. Metadata

Descriptive information about the project to include textual reports, graphics, supporting shapefiles or geodatabases, and Federal Geographic Data Committee (FGDC) compliant metadata files are required. See National Spatial Data Infrastructure (NSDI) Content Standards for Digital Geospatial Metadata (FGDC, 1998) and *Lidar Base Specifications Version 1.2 (USGS, 2014)* "Metadata" section for metadata requirements for this project.

A current Product Characterization Report on the lidar instrument(s) used shall be included in the Project History Report/Folder (Section 6) as a deliverable.

5.2 Raw Point Cloud

Raw point cloud deliverables shall include or conform to the following procedures and specifications:

- No classifications are required; however, Overage (overlap) and Withheld Flags will be properly set.
- All collected points, fully calibrated, georeferenced, and adjusted to ground, organized and delivered in their original swaths, one file per swath, one swath per file.
- If production processing requires segmentation of the swath files, the requirements listed in section "Swath Size and Segmentation," shall be met.
- Fully compliant LAS Specification version 1.4, Point Data Record Format 6, 7, 8, 9, or 10.
- If collected, waveform data in external auxiliary files with the extension .wdp. See the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011) for additional information.
- Correct and properly formatted georeference information as Open Geospatial Consortium (OGC) well known text (WKT) in all LAS file headers.
- GPS times recorded as Adjusted GPS Time at a precision sufficient to allow unique timestamps for each pulse.
- Intensity values, normalized to 16-bit. See the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011) for additional information.
- A report of the assessed relative vertical accuracy of the point cloud (smooth surface repeatability and overlap consistency). Relative vertical accuracy requirements are listed in table 2. Raw swath point cloud data shall meet the required accuracy levels before point cloud classification and derivative product generation.
- A report of the assessed absolute vertical accuracy (NVA only) of the unclassified lidar point data in accordance with the guidelines set forth in the Positional Accuracy Standards for Digital Geospatial Data (American Society for Photogrammetry and Remote Sensing, 2014). Absolute vertical accuracy requirements using the ASPRS methodology for the raw point cloud are listed in table 4. Raw swath point cloud data shall meet the required accuracy levels

before point cloud classification and derivative product generation.

5.3 Classified Point Cloud

Classified point cloud deliverables shall include or conform to the following procedures and specifications:

- All project area swaths, returns, and collected points, fully calibrated, adjusted to ground, and classified, by tiles. Project swaths exclude calibration swaths, cross-ties, and other swaths not used and not intended to be used, in product generation.
- Fully compliant LAS Specification version 1.4 Point Data Record Format 6, 7, 8, 9, or 10.
- If collected, waveform data in external auxiliary files with the extension .wdp. See the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011) for additional information.
- Correct and properly formatted georeferenced information as OGC WKT included in all LAS file headers.
- GPS times recorded as Adjusted GPS Time at a precision sufficient to allow unique timestamps for each pulse.
- Intensity values, normalized to 16-bit. See the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011) for additional information.
- Tiled delivery, without overlap, using the project tiling scheme.
- Classification, as defined below.

Code/Class	Description
1	Processed, but unclassified
2	Bare earth
7	Low noise
9	Water
10	Ignored ground (near a breakline)
17	Bridge decks
18	High noise

5.4 Bare-Earth Surface (Raster DTM), Hydro-Flattening, and Breaklines

Bare-earth deliverables include the following:

- Bare-earth DEM with hydro-flattening (see section 5.4.1 Hydro-Flattening).
- Cell size no greater than 0.5 meters (QL1) and 1.0 meters (QL2) and no less than the design Nominal Pulse Spacing (NPS).
- Delivery in 32-bit floating point ERDAS .img format.
- Georeference information shall be included in each raster file.
- Tiled delivery, without overlap, using Project Tiling Scheme (section 7).
- 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 deliverable.
- Void areas shall be coded using a unique 'NODATA' value. This value shall be identified in the appropriate location within the raster file header or external support files (for example, .aux).
- A report on the assessed absolute vertical accuracy (NVA and VVA) of the bare-earth surface in accordance with the guidelines set forth in the "Positional Accuracy Standards for Digital Geospatial Data" (American Society for Photogrammetry and Remote Sensing, 2014).
- The following thresholds represent the minimum vertical accuracy requirements using the NDEP/ASPRS methodology:
 - NVA \leq 19.6 cm, 95% Confidence Level (\leq 10 cm RMSE_z)
 - VVA \leq 29.4 cm, 95% Confidence Level (\leq 10 cm RMSE_z)
 - All Quality Assurance/Quality Control (QA/QC) analysis materials and results are to be delivered.
- Depressions (sinks), natural or man-made, are not to be filled (as in hydro-conditioning and hydro-enforcement).
- Permanent islands 1 acre or larger shall be delineated within all water bodies.

5.4.1. Hydro-Flattening

- Hydro-flattening shall be applied to all water within the main channels of rivers and streams, along with all water bodies or impoundments, natural or man-made, that are larger than 2 acres in area (approximately equal to a round pond 350 feet in diameter), and to all streams that are nominally wider than 100 feet, and to all non-tidal boundary waters bordering the project area regardless of size are to be hydro-flattened within the delivered DEMs. Refer to *Lidar Base Specifications Version 1.2* (USGS, 2014) "Hydro-Flattening" section for further explanation.
- Hydro-flattened water bodies (lake and ponds) are leveled at a single elevation and streams and rivers are conditioned for continuous downhill flow.
- Hydro-flattened/bare-earth surface must cover the entire water body and leave no holes in the center. This can be done with interpolation and does not require lidar collection over the entire water body.
- All hydro-flattened areas should have pleasing aesthetic appearance.
- The methodology used for hydro-flattening is at the discretion of the Vendor. Refer to the "Digital Elevation Model Hydro-Flattening" section and "Appendix 2. Hydro-Flattening Reference" in the Lidar Base

Specifications Version 1.2 for detailed discussions concerning hydro-flattening.

- The bare-earth DEM data should keep intact all road culverts and similar features, regardless of size, defined as having earth between the road surface and the top of the structure.
- Bridges are required to be removed from the bare-earth DEM. Streams and rivers should be continuous at bridge locations.

5.4.2. Breaklines

All breaklines used for hydro-flattening are to be delivered in a shapefile and/or geodatabase format as PolylineZ or PolygonZ feature classes. See Lidar Base Specifications Version 1.2 (USGS, 2014) "Breaklines" section for breakline requirements.

5.5 First Return Surface (Raster DSM)

First-return deliverables include the following:

- First return DEM (for example, highest hit).
- Cell size no greater than 0.5 meters (QL1) and 1.0 meters (QL2) and no less than the design Nominal Pulse Spacing (NPS).
- Delivery in 32-bit floating point ERDAS .img format.
- Georeference information shall be included in each raster file.
- Tiled delivery, without overlap, using Project Tiling Scheme (Section 7).
- 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 deliverable.

Void areas shall be coded using a unique 'NODATA' value. This value shall be identified in the appropriate location within the raster file header or external support files (for example, .aux).

5.6 Intensity Images

Intensity Images deliverable include the following:

- 0.5 meter resolution intensity images in 8-bit grayscale GeoTIFF format with lossless deflate compression and accompanying TFW world files for QL1 collections.
- 1 meter resolution intensity images in 8-bit grayscale GeoTIFF Format with lossless deflate compression and accompanying TFW world files for QL2 collections.

6. Contractor's Project History Report/Folder

The Vendor will compile and provide a project history report/folder upon conclusion of the lidar acquisition for each project area. This folder will be used by AGRC in the inspection process for the lidar data products. The report/folder, will contain, at a minimum, the following:

- **Methods**
 - A record of field work procedures.
 - Data derivation and adjustments.
 - Processing report detailing calibration, classification, and product generation procedures including the methodology used for breakline collection and hydro-flattening.
 - Any problems encountered and solutions used in resolving such problems.
- **Correspondence and records**
 - The Statement of Work (SOW) between AGRC and the Vendor
 - All production guidance received from AGRC to include all written guidance from telephone conferences, emails, or contractual modifications, or any other source.
 - Lidar acquisition methods and equipment used; results; Vendor accuracy assessments, including internal reproducibility and absolute accuracy; file formats; file-naming schemes; and tiling schemes.
- **Flight information**
 - Aircraft trajectory log
 - SBET files (smooth, best, estimated trajectory) detailing aircraft position (easting, northing, elevation), angle, rotation (heading, pitch, and roll), and GPS time, recorded at regular intervals of ≤ 1 second. May include additional attributes (ASCII text or shapefile and .dbf format).
 - Statistical report summarizing the results of the airborne GPS adjustment and the overall accuracy of the adjusted IMU data.
 - Collection report detailing mission planning and flight logs.
- **Control**
 - Survey Report detailing the collection of control and reference points used for calibration and QA/QC.
 - The documentation for the identity, published position, and measured position of all existing National Geodetic Survey (NGS) marks used for reference stations.
- **Quality Assurance/Quality Control (QA/QC)**
 - 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
 - Quality control procedures and results.
 - All internal quality control checklists.
 - Internal quality control error calls and the corrective actions taken to correct the error(s).
 - All Vendor QA validation reports/error reports and accuracy reports, generated from internal software QA programs demonstrating that the data meets requirements as stated in the SOW.

7. Tiling Scheme

A single non-overlapped tiling scheme for both data products will be established and agreed upon by AGRC and the Vendor before each collection. This scheme will be used for ALL tiled deliverables.

Tiling for the Lidar deliverables will be based on the U.S. National Grid and should be named according to the U.S. National Grid System based on the SW corner (ex. 12TVK060160). Tiles will be 2,000-meter x 2,000-meter tiles with the exception of tiles around the periphery of the project area that are better suited for 1,000-meter x 1,000-meter tiles. 1,000-meter x 1,000-meter tiles will be used for the .las point cloud files.

- Tile size is required to be an integer multiple of 0.5 meters for raster deliverables.
- Tiles are required to be sized using the same units as the coordinate system of the data.
- Tiles are required to be indexed in X and Y to an integer multiple of the tile's X-Y dimensions.
- All tiled deliverables will conform to the project tiling scheme, without added overlap.
- Tiled deliverables will edge-match seamlessly and without gaps.

7.1. Void Areas

The extent of lidar coverage over the project areas shall be sufficient to ensure void areas do not exist within the project areas. Void areas within delivered tiles and within the project areas are not acceptable.

8. Delivery Medium and Format

Deliverables shall be delivered on USB3 compatible portable hard drives using an uncompressed and unencrypted NTFS file system. Delivery tiles shall be accompanied by an index shapefile, of the tiles delivered, suitable for loading into ArcMap.

All data and products associated with contract deliverables will meet or exceed relevant National Standard for Spatial Data Accuracy (NSSDA) standards. See *NSDI Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy* (FGDC, 1998).

At the completion of the project, after all deliverables have been accepted by AGRC, the Vendor will deliver hard drives containing all the finalized deliverables for the project as described in Section 5, and become the property of the State of Utah.

9. Data Acquisition Requirements and Collection Conditions

Refer to *Lidar Base Specification Version 1.2* (2014) for the following specifications:

- Acquisition requirements
- Collection conditions

9.1. Additional Data Acquisition Requirements

- Instrument calibrated for every mission.
- Flight plans are parallel flight lines with a cross-tie at/and or near the end of each project flightline.
- Flight plan considers requirements for point density, terrain, PDOP (positional dilution of position), and Geomagnetic K_p Index (see <https://www.gfz-potsdam.de/en/kp-index/>).
- The intensity values (signal strength) of each return pulse will be recorded in the LAS, in their files native radiometric resolution.
- In order to prevent clustering effects and ensure uniform densities throughout the data set, a regular 1 x 1 meter grid will be laid over the data. At least 90% of the cells in the grid shall contain the requisite number of points per square meter (ppsm).

10. Standards, Specifications, and Requirements

Refer to *Lidar Base Specification Version 1.2* (2014) for the following specifications:

- Quality Level 1 and Quality Level 2 Specifications
- Vertical Accuracy Requirements
- Positional Accuracy Validation
- Relative Accuracy Requirements
- Completeness of Coverage

10.1. Projection and Mapping Units

- Projection (Coordinate System): Universal Transverse Mercator (UTM) Zone 12, NAD 83, Meters; NAVD88, Meters (NAD_1983_2011_UTM_Zone_12N).
- Mapping Units: Meters (UTM).
- Vertical Reference: Orthometric Heights, Meters.
- WKID: 6341 Authority: EPSG

10.2. Datums

All data collected must be tied to the datums listed below:

- Horizontal Datum:
 - North American Datum of 1983 / High Accuracy Resolution Network adjustment (NAD 83 [2011] / HARN) required.
- Vertical Datum:
 - North American Vertical Datum 1988 (NAVD88), using latest geoid model available from the NGS (for example, GEOID12B). All vertical units will be measured in meters.
- Geoid Model:

- o The most recent NGS approved geoid model is required to perform conversions from ellipsoidal heights to orthometric heights.

10.3. Usability

- Files shall have consistent internal formats.
- Vendor shall propose all details of file names and file formats that are not specified here. Proposed names and formats must be approved by AGRC.
- All file extensions shall be lowercase.
- Files may be gzip or zip compressed. Use of compression shall be lossless and uniform across a given data layer.
- GIS data (.tif, .img, shapefiles, etc.) shall have complete and correct associated projection, metadata, and sidecar files.
- All files must be readable and free of malicious code.

10.4. GPS Procedures

10.4.1. GPS Measurements

All GPS measurements shall be made with multi-frequency Global Navigation Satellite System (GNSS) receivers with GLONASS. All GPS measurements shall be made during periods with PDOP ≤ 3.0 and with at least six satellites in common view of both a stationary reference receiver and the roving receiver.

10.4.2. Stationary Reference Receivers

Stationary reference receivers shall be located at existing NGS marks or at new marks. In the case of an existing mark, its location shall be verified by processing one GPS session of at least two hours duration and comparing the computed position with the position published by NGS. Each new mark shall be located by tying to one or more NGS Continuously Operating Reference Stations (CORS) by static GPS methods. If the distance to the nearest CORS is less than 80 km, use at least two independent GPS sessions, each at least two hours long. If the distance to the nearest CORS is greater than 80 km, use at least two sessions each at least four hours long.

10.4.3. GPS Reference Receivers

At least two GPS reference receivers shall be in operation during all lidar missions, sampling positions at ≥ 1 Hz. The roving GPS receiver in the aircraft shall sample positions at ≥ 2 Hz. Differential GPS baseline lengths shall be no longer than 30 km. Check Points, Ground Control Points (GCPs), or ground survey points used for both survey calibration and assessment of absolute vertical accuracy, shall be established using GPS and (or) other techniques that are expected to result in accuracies of 1.5 cm (RMSE_v) or better. Strongly clustered GCPs are useful, perhaps even desirable, for calibration. Vertical

accuracy shall be assessed by calculating and averaging the distances between a subset of at least 30 GCPs that are not clustered and a surface interpolated from lidar first returns. At least 20% of flight line swaths should contain points in this subset and the maximum distance between these GCPs should be no less than one-half the maximum distance across the survey area.

10.4.4. Project History Report/Folder

The Vendor Project History Report/Folder (Section 6) shall document the identity, published position, and measured position of all existing NGS marks used for reference stations. The locations of new marks shall be described, along with their measured positions and the identity and published positions of CORS to which their locations were tied. The report shall describe the technique(s) used to establish GCPs and document the positions and residuals of all GCPs used to evaluate survey accuracy.

10.5. Ground Control

Two types of vertical accuracy GCP (or ground surveyed points) will be collected by the Vendor for this project: Control Points and Check Points. Refer to NSSDA guidelines, Lidar Base Specifications Version 1.2 (USGS, 2014) "Collection" section, and ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data (ASPRS, 2004) "2.3 Selecting and Collecting Check Points" section for Check Point placement in land cover classes and guidelines on Check Points.

- The above two types of ground control will be clearly labeled and delivered as separate shapefiles.

10.6. Supplemental Ground Control

Differentially corrected or real time GNSS network, real-time kinematic (RTK) GPS ground control used to supplement the airborne GPS positional adjustment shall be stored on portable media, in a non-proprietary format mutually agreeable to AGRC and the Vendor. Ground control is the responsibility of the Vendor.

10.6.1. Utah Reference Network

AGRC maintains *The Utah Reference Network* (<http://gis.utah.gov/#gps>) of over 90 GNSS/GPS virtual reference (VRS) RTK stations and will facilitate use of this network upon request of the Vendor.

11. Data Release, Data Use and Distribution Rights

11.1. Data Release

The Vendor will not release data produced as part of this project plan, to any other party or entity without approval by AGRC, prior to AGRC's final acceptance of data products.

11.2. Data Use and Distribution Rights

After final acceptance has been made, all deliverable data and documentation will be free from restrictions regarding use and distribution (the State of Utah and partners require unrestricted rights to all delivered data and reports that are placed in the public domain). Data and documentation provided under this project plan shall be in the public domain and freely distributable by Federal, State, and local government agencies.

12. Contact List

Agency	Contact Person	Phone Number	Email
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ADMINISTRATIVE

Utah AGRC	Matt Peters <i>Director</i>	385-202-3297	mpeters@utah.gov
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TECHNICAL

Utah AGRC	Rick Kelson <i>Project Manager</i>	801-538-3237	rkelson@utah.gov
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13. Project Communication

13.1. Production Status Reports

The Vendor shall provide weekly status reports for all work on projects to AGRC's Project Manager. Reports will include detailed information regarding the work accomplished for each production phase. An online website may be used to provide status information.

13.2. Acquisition Reports

The Vendor shall provide regular progress updates to AGRC's Project Manager throughout the data acquisition process.

- Update frequency shall be based upon the collection period, but no less than once a week.
- Reports shall include shapefiles representing the geographic extent of the acquired data.
- Updates shall commence at acquisition onset and shall continue until acquisition is complete.

13.3. Initial Project Meeting

An initial project meeting between AGRC and the Vendor will be scheduled after each project request. This meeting will ensure that both AGRC and the Vendor 1) understand the requirements necessary to produce the deliverables, 2) review source data, and 3) make any final adjustments to technical guidance.

13.4. Teleconference

The Vendor will teleconference regularly (weekly or as needed) with AGRC to discuss status, production, and technical issues during a project.

14. Delivery Date and Timely Completion

14.1. Delivery Date

AGRC and the Vendor will agree in writing to a delivery schedule for lidar products. Delivery for all final lidar products, including any redeliveries because of quality assurance rejection, is no later than June 30, 2019. The Vendor shall not exceed this date without agreement to a new date from AGRC. Any request for modifications of the final delivery date must be received 30 days prior to the expiration of the original date. Requests will only be considered for reasons outside of the Vendor's control, such as unforeseen weather changes.

14.2. Timely Completion

The payment schedule shall include penalties for late delivery of products. The payment schedule will be based on 40% of the total project cost after completion of the lidar acquisition flights. After the completion of processing and corrections based on the quality assurance review by AGRC, and delivery of the final product(s) to AGRC, payment will be made as follows. If delivered on time as specified in the contract, another 30% of the total project cost will be paid. There will be a 30% holdback that will be paid after that final delivery of all data and required reports and metadata deliveries are accepted by the USGS NGTOC and confirmed by AGRC. If the final product(s) is not

delivered on the schedule specified, there will be a 3% (of the total bid) penalty for each week the product delivery is delayed.

15. List of Cited Specifications and Standards

Specifications for the acquisition of lidar and deliverables not explicitly outlined above must adhere to the required specifications in the following documents:

Proponent Agency/ Organization	Name	Published Date	Website
American Society for Photogrammetry and Remote Sensing (ASPRS)	LAS Specification Version 1.4	July 2011	http://www.asprs.org/a/society/committees/standards/LAS_1_4_r13.pdf
U.S. Geological Survey, National Geospatial Program (USGS NGP)	Lidar Base Specifications Version 1.2	2014	http://pubs.usgs.gov/tm/11b4/
Federal Geographic Data Committee (FGDC)	National Spatial Data Infrastructure (NSDI) Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy	1998	http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3
National Digital Elevation Program (NDEP)	NDEP Guidelines for Digital Elevation Data	May 2004	http://www.ndep.gov/NDEP_Elevation_Guidelines_Ver1_10May2004.pdf
FGDC	NSDI Content Standard for Digital Geospatial Metadata	1998	http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/base-metadata/v2_0698.pdf
Federal Emergency Management Agency (FEMA)	Guidance for Flood Risk Analysis and Mapping: Elevation Guidance	May 2016	https://www.fema.gov/media-library-data/1469794589266-f404b39e73fa7a1c5ffe4447636634d4/Elevation_Guidance_May_2016.pdf
FGDC	United States National Grid	December 2001	http://www.fgdc.gov/standards/projects/FGDC-standards-projects/usng/fgdc_std_011_2001_usng.pdf

16. Pricing

16.1. Northern Utah

Pricing is based on the cost of **\$184,835.30 for the 1,290 mi² project area**, submitted in the Utah Lidar Proposal 2018 Price Matrix in the bid response to solicitation #WS16020-Stage 2 (see attached).

16.2. Central Utah

Pricing is based on the cost of \$511,602.30 for the 3,334 mi² project area, submitted in the Utah Lidar Proposal 2018 Price Matrix in the bid response to solicitation #WS16020-Stage 2 (see attached). With adjustments to the project area the final cost is **\$526,860.58 for the 3,098 mi² project area**.

16.3. Southern Utah

Pricing is based on the cost of \$637,967.99 for the 4,912 mi² project area, submitted in the Utah Lidar Proposal 2018 Price Matrix in the bid response to solicitation #WS16020-Stage 2 (see attached). With adjustments to the project area the final cost is **\$639,810.66 for the 4,919 mi² project area and quality level changes**.

16.4. Weber County Addition

Pricing is based on the cost of \$2,754.17 for the 12 mi² project area, submitted in the Utah Lidar Proposal 2018 Price Matrix in the bid response to solicitation #WS16020-Stage 2 (see attached). With adjustments to the project area the final cost is **\$65,929.57 for the 239 mi² project area**.

16.5. Project Area Adjustment

Adjustment to existing project areas, including the expansion of project boundaries or changes to USGS Quality Level specification, **will not exceed \$334,289.00 of the original bid total**.

17. Contract Payments

- I. For purchases and service pursuant to this contract, invoices shall be sent electronically to Matt Peters and Rick Kelson at the Utah Department of Technology Services:
mpeters@utah.gov
rkelson@utah.gov
- II. Invoices approved for payment shall be sent electronically to:
dtsaccountspayable@utah.gov
rkelson@utah.gov

Payments will be processed in accordance with the State of Utah Cooperative Contract Standard Terms and Conditions for Services, as included in Master Agreement # AV2406.

IN WITNESS WHEREOF, the parties sign Scope of Work on Master Agreement # AV2406

CONTRACTOR

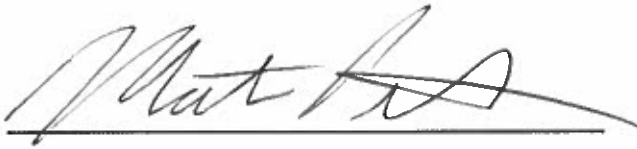


Contractor's Signature

CASEY C. FRANCIS, VICE-PRESIDENT

Type or Print Name and Title

AGRC



Agency's Signature

MATT PETERS, Director

Type or Print Name and Title

State of Utah Department of Technology Services



Agency's Signature

Daniel Frei, Executive, DTS

Utah Lidar Proposal 2018 Price Matrix

RFP # WS16020 - Stage 2

Pricing: USGS Quality Level 1 (QL1) and Quality Level 2 (QL2) lidar and associated derivative data products. Vendors may submit project plans and pricing for one, some, or all areas identified in this stage of the RFP process. Area plans and pricing will be evaluated separately for each project area.

Offeror (Vendor) Name: Aero-Graphics, Inc.

Project Areas include portions of: Northern Utah, Central Utah, Southern Utah (see Attachment 1).

Products: USGS Quality Level 1 and Quality Level 2 lidar standards and deliverables (see sections 5 – 7 of RFP) will apply to all projects/deliverables identified in this stage of the RFP process.

Project area awards will be awarded based on “Best Value” or highest total score (technical + cost). Cost points will be determined using the following standard formula:

The Offeror with the lowest cost per project area will receive 30 points, or 100% of the total cost points. All other Offerors will receive a portion of the total cost points based on what percentage higher their total cost is than the total lowest cost. An Offeror whose total cost is more than double (200%) the Lowest Proposed Price will receive no points. The formula to compute the points is: Cost Points x (2- Proposed Price/Lowest Proposed Price).

Acquisition Area (RFP section)	Project Cost (\$)
Northern Utah (2.1.1)	\$184,835.30
Central Utah (2.1.2)	\$511,602.30
Southern Utah (2.1.3)	\$637,967.99
Weber County Addition (2.1.1)*	\$2,754.17