EXHIBIT A.4
STATEMENT OF WORK – DIGITAL TERRAIN DATA
FOR
DIGITAL AERIAL DATA

1.1 GENERAL

1.1.1 INTRODUCTION

Contractor shall deliver under this Statement of Work Digital Terrain Data collected and Delivered in accordance with the USGS LiDAR Base Specification V1.0, 2012, but with two (2) different Quality Levels for Project Area 1 and Project Area 2.

1.1.2 DEFINITIONS

In addition to the terms defined in the Base Agreement, the following definitions shall apply throughout this Exhibit A.3 (Statement of Work – Building Representations): No additional definitions.

1. Digital Terrain Model (DTM)

   The terms "Digital Terrain Model" and "DTM" shall mean the bare earth terrain, LAS Class 2, from which elevated surface features, such as buildings and trees, have been reclassified as LAS Class 1, with the addition of breaklines as needed for hydro-flattening of water bodies.

2. Digital Elevation Model (DEM)

   The terms "Digital Elevation Model" and "DEM" shall mean the bare earth terrain (like the DTM), LAS Class 2, from which elevated surface features, such as buildings and trees, have been reclassified as LAS Class 1 – but is represented as a raster (regularly spaced GRID).

3. Digital Surface Model (DSM)

   The terms "Digital Surface Model" and "DSM" shall mean the top reflective surface and includes all objects on it (including buildings and trees). Sometimes referred to as "first return" data.

4. LiDAR Point Cloud

   The term "LiDAR Point Cloud" shall mean a large set of three dimensional points, collected from LiDAR. Points clouds are almost always 3D. Point clouds have an order of magnitude more features than point datasets. Individual features in point clouds do not typically possess individually meaningful attributes; the information value in a point cloud is derived from the relations among large numbers of features.

1.2 TASKS AND DELIVERABLES

TASK 1 – DEVELOP PROJECT WORK PLAN

Contractor shall review and analyze the Digital Terrain Data deliverable to be provided under this Agreement and develop a Project Work Plan, which shall be used to accomplish the following:

1. Guide project planning;

2. Document project planning assumptions and constraints;

3. Document project-planning decisions regarding alternatives chosen;

4. Facilitate communication between project stakeholders;

5. Define key management reviews as to content, extent and timing; and

6. Provide a baseline for progress measurement and project control.

DELIVERABLE 1 – PROJECT WORK PLAN

Contractor shall provide for County approval a Project Work Plan document in Word and Portable Document Format (PDF) developed in accordance with Task 1 (Develop Project Work Plan).

TASK 2 – PROVIDE DIGITAL TERRAIN DATASETS (DSM, DTM AND DEM) – PROJECT AREA 1

Contractor shall produce Digital Terrain Datasets for **Project Area 1** to support generation of ortho imagery, 3D visualization, change detection and 1 foot contour generation with breakline data. Digital Terrain Datasets should be produced using LiDAR technology with a combination of stereo compilation for breaklines specified in Acceptance Criterion C.8 for control of bridges, edge of pavement, hydrographic features, ridgelines, and retaining walls as needed for orthorectification and contouring.

The Digital Terrain Datasets shall comply with the following requirements:

1. The DTM nominal pulse spacing (NPS) shall be 0.707 meters or less per LiDAR swath to achieve a density of 2 points per square meter or better.

2. The DTM's vertical accuracy shall be suitable for 1 foot contouring, i.e., Accuracy (z) of 0.60 foot at the ninety-five percent (95%) confidence level.

3. The DTM's horizontal accuracy shall be suitable for 1:1200 mapping, i.e., Accuracy (r) of 3.80 foot at the ninety-five percent (95%) confidence level.

4. The DEM with cell size no greater than 0.7 meters or 2.5 feet, and no less than the design Nominal Pulse Spacing (NPS). Delivery should be in an industry-standard, GIS compatible, 32-bit floating point raster format (ERDAS .IMG preferred). Tiled delivery without overlap; and will show no edge artifacts or mismatch.

5. DEM 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).

6. The DSM is usually referred to as 'first return data'; requirements are the same as the DTM; with a different delivery format.

DELIVERABLE 2 – DIGITAL TERRAIN DATASETS – PROJECT AREA 1

Contractor shall provide the following Deliverables in accordance with Task 2 (Provide Digital Terrain Datasets (DSM), DTM and DEM) – Project Area 1):

2.1 Project documentation outlining procedures and data collected, and reports of accuracy evaluation.

2.2 First return data (DSM) in ArcGIS compatible format and CAD compatible format.

2.3 Bare-earth DTM incorporating the last return LiDAR data in ArcGIS raster format and CAD compatible format.

2.4   Raw point cloud data that includes the following:

 a) All swaths, returns, and collected points, fully calibrated and adjusted to ground, by swath.

 b) Fully compliant LAS v 1.2 or v1.3, point Data Record Format 1, 3, 4 or 5.

 c) LAS v1.3 deliverables with waveform data are to use external auxiliary files with the extension .wdp for the storage of waveform packet data.

 d) Correct and properly formatted georeferenced information must be included in all LAS file headers.

 e) GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each pulse.

 f) One file per swath per file, file size not to exceed 2 GB.

2.5   Classified point cloud includes the information in 2.3 above; but also includes a classification scheme. Minimum classified point cloud classification scheme should be as follows:

CODE	DESCRIPTION
1	Processed, but unclassified
2	Bare-earth ground
7*	Noise (low or high; manually identified; if needed)
9	Water
10*	Ignored Ground (Breakline proximity
11	Withheld (if the Withheld is not implemented in processing software)

 * *Class 7, Noise, is included as an adjunct to the Withheld bit. All noise points are to be identified using on of these two methods.*

 * Class 10, Ignored Ground, is for points previously classified as bare-earth but whose proximity to a subsequently added breakline requires that it be excluded during DEM generation.

2.6   FGDC compliant metadata.

TASK 3 – GENERATE CONTOURS WITH ONE FOOT INTERVAL – PROJECT AREA 1

Contractor shall generate contours with 1 foot intervals for **Project Area 1** using DTM prepared in Task 2 (Provide Digital Terrain Datasets (DSM, DTM and DEM) – Project Area 1). Contour lines should be seamless for the entire area as specified in the Statement of Work.

DELIVERABLE 3 – 1 FOOT CONTOURS – PROJECT AREA 1

Contractor shall provide the following Deliverables in accordance with Task 3A (Contours with One Foot Interval – Project Area 1):

3.1   ArcGIS shapefiles with contours tiled to LAR-IAC grid system.

3.2   AutoCAD drawing file with contours tiled to LAR-IAC grid system.

TASK 4 – PROVIDE DIGITAL TERRAIN DATASETS (DSM, DTM AND DEM) – PROJECT AREA 2

Contractor shall produce Digital Terrain Datasets for **Project Area 2** to support generation of ortho imagery, 3D visualization, change detection and 2 foot contour generation. DTM can be produced by using automatic stereo compilation (from ortho imagery) or can be produced by using LiDAR.

The Digital Terrain Datasets, if created by LIDAR, shall comply with the following requirements:

1. The DTM nominal pulse spacing (NPS) shall be 1.414 meters or less per LiDAR swath to achieve a density of 0.5 points per square meter or better.

2. The DTM's vertical accuracy shall be suitable for 2 foot contouring, i.e., Accuracy (z) of 1.19 feet at the ninety-five percent (95%) confidence level.

3. The DTM's horizontal accuracy shall be suitable for 1:2400 mapping, i.e., Accuracy (r) of 3.80 foot at the ninety-five percent (95%) confidence level.

4. The DEM with cell size no greater than 1 meters or 3.5 feet, and no less than the design Nominal Pulse Spacing (NPS). Delivery should be in an industry-standard, GIS compatible, 32-bit floating point raster format (ERDAS .IMG preferred). Tiled delivery without overlap; and will show no edge artifacts or mismatch.

5. DEM 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).

6. The DSM is usually referred to as 'first return data'; requirements are the same as the DTM; with a different delivery format.

DELIVERABLE 4 – DIGITAL TERRAIN DATASETS – PROJECT AREA 2

Contractor shall provide the following Deliverables in accordance with Task 4 (Provide Digital Terrain Datasets (DSM), DTM and DEM) – Project Area 2):

4.1 Project documentation outlining procedures and data collected, and reports of accuracy evaluation.

4.2 First return data (DSM) in ArcGIS compatible format and CAD compatible format.

4.3 Bare-earth DTM incorporating the last return LiDAR data in ArcGIS raster format and CAD compatible format.

4.4 **Raw point cloud data that includes the following:**

  a) All swaths, returns, and collected points, fully calibrated and adjusted to ground, by swath.

  b) Fully compliant LAS v 1.2 or v1.3, point Data Record Format 1, 3, 4 or 5.

  c) LAS v1.3 deliverables with waveform data are to use external auxiliary files with the extension .wdp for the storage of waveform packet data.

  d) Correct and properly formatted georeferenced information must be included in all LAS file headers.

e) GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each pulse.

f) One file per swath per file, file size not to exceed 2 GB.

4.5 Classified point cloud includes the information in 2.3 above; but also includes a classification scheme. Minimum classified point cloud classification scheme should be as follows:

CODE	DESCRIPTION
1	Processed, but unclassified
2	Bare-earth ground
7*	Noise (low or high; manually identified; if needed)
9	Water
10*	Ignored Ground (Breakline proximity
11	Withheld (if the Withheld is not implemented in processing software)

* *Class 7, Noise, is included as an adjunct to the Withheld bit. All noise points are to be identified using on of these two methods.*

* *Class 10, Ignored Ground, is for points previously classified as bare-earth but whose proximity to a subsequently added breakline requires that it be excluded during DEM generation.*

4.6 FGDC compliant metadata.

TASK 5– GENERATE CONTOURS WITH TWO FOOT INTERVAL – PROJECT AREA 2

Contractor shall generate contours with 2 foot intervals for **Project Area 2** using DTM prepared in Task 4 (Provide Digital Terrain Datasets (DSM, DTM and DEM) – Project Area 2). Contour lines should be seamless for the entire area as specified in the Statement of Work.

DELIVERABLE 5 – 2 FOOT CONTOURS – PROJECT AREA 2

Contractor shall provide the following Deliverables in accordance with Task 5A (Contours with Two Foot Interval – Project Area 2):

5.1 ArcGIS shapefiles with contours tiled to LAR-IAC grid system.

5.2 AutoCAD drawing file with contours tiled to LAR-IAC grid system.

TASK 6 – CORRECT DIGITAL TERRAIN DATA DEFICIENCIES

Contractor shall correct all Digital Terrain Data Deficiencies identified by County within the Warranty Period, as further described in the Base Agreement of Appendix A (Required Agreement) to the RFP.

DELIVERABLE 6 – FINAL ACCEPTANCE

Final Acceptance shall be reached when Contractor has corrected all Digital Terrain Data Deficiencies.

TASK 7 – PROVIDE OPTIONAL WORK

SUBTASK 7.1 – PROVIDE OPTIONAL PRODUCTS

If requested and approved by County, Contractor shall provide to County software, tools, data, and other products related to the Digital Terrain data. The Optional Products shall be provided in accordance with Paragraph 5.2 (Optional Work) and Paragraph 4 (Change Notices and Amendments)of the Base Agreement of Appendix A (Required Agreement) to the RFP.

SUBTASK 7.2 – PROVIDE OPTIONAL SERVICES

If requested and approved by County, Contractor shall provide to County on-site implementation support, additional training and other consulting services related to the Digital Terrain Data. The Optional Services shall be provided in accordance with Paragraph 5.2 (Optional Work) and Paragraph 4 (Change Notices and Amendments) of the Base Agreement of Appendix A (Required Agreement) to the RFP.

DELIVERABLE 7 – OPTIONAL WORK

Contractor shall successfully provide Optional Work, including Optional Products and Optional Services, in accordance with Task 7 (Provide Optional Work).

1.3   DIGITAL TERRAIN REQUIREMENTS

1.3.1   DATA REQUIREMENTS

Remote-sensed digital terrain data will be collected to provide source data for creation of the digital terrain model. Due to the County's desire to have a very high resolution digital terrain data, all data shall be collected to support a minimum 0.707 meter nominal pulse spacing (NPS) for urban areas (Project Area 1) and 1.414 meter NPS for national forest areas (Project Area 2).

1.3.2   EQUIPMENT REQUIREMENTS

Prior to commencing flyovers, Contractor shall clearly identify the equipment (aircraft, digital sensor, etc.) to be used to collect data.

1.3.3   CONTROL ESTABLISHMENT

If it is determined to be necessary by Contractor, additional ground control points, augmenting the county's control points as needed (approximately 200 to 300) to meet the accuracy requirements of this proposal, will be collected by Contractor All control used in the production of products for this effort shall conform to acceptable errors as set forth by the FGDC. If additional control points are generated as a result of this effort, Contractor will be required to provide these points as an attributed feature layer. The Project Work Plan shall contain a detailed explanation of control methodology and a listing of control data that will be provided under this effort. Collection of up to one hundred (100) additional ground control points may be considered Optional Work.

1.3.4   COLLECTION

Specifications and methodology for the LiDAR flight should include documentation of mission date(s), time, flight altitude, overlap, and airspeed. Flight plans shall be generated and should cover the proposed project areas. Proposal should address how various

environmental conditions will be handled and any special considerations for areas of dense coverage (e.g., locations containing dense foliage).

A complete survey control plan shall be submitted to include collection, processing and incorporation of survey control in the LiDAR processing. The plan should include a detailed description of survey control for quality control and validation checks of the LiDAR dataset.

Specifications for the data collection should include scan angle, along-track, and cross-track, pulse spacing, pulse width and density, and number of returns. LiDAR derived data will have the accuracy required to produce topographic maps including 1-foot elevation contours. Proposed data products shall be prepared to meet the accuracy requirements of ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data, Version 1, May 2004.

Proposer should describe the production process used for LAS classification of vegetation or structures in order to determine bare-earth representation. Proposer should describe the approach to definition and resolution of data voids and data artifacts resulting from the mission. Proposer should describe quality assurance and quality control (QA/QC) procedures to ensure the integrity of the LiDAR data. Proposer should describe acceptance test procedures to be used to ensure data conforms to the accuracy requirements.

1.3.5   ACCURACY

DTM accuracy testing will be performed by LAR-IAC consistent with ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data, Version 1, May 2004.

In Project Area 1, the Fundamental Vertical Accuracy (FVA) in open terrain shall be 18.13-cm or better at the 95% confidence level, based on RMSEz of 9.25-cm in open terrain. The Consolidated Vertical Accuracy (CVA) in all land cover categories combined shall be 27.2-cm at the 95th percentile.

In Project Area 2, the Fundamental Vertical Accuracy (FVA) in open terrain shall be 36.26-cm or better at the 95% confidence level, based on RMSEz of 18.5-cm in open terrain. The Consolidated Vertical Accuracy (CVA) in all land cover categories combined shall be 54.4-cm at the 95th percentile.

Proposer should describe the methodology for creating the Digital Terrain Datasets using stereo edited LiDAR data. To generate accurate contours at a 1 and 2 foot interval the LiDAR DTM points will be enhanced with photogrammetrically or lidargrammetrically compiled breaklines. Breaklines are defined as ridgelines, retaining walls, edges of pavements or hydrographic features. The LiDAR data points together with the breaklines will form a TIN (Triangular Irregular Network) from which the contours are generated.

Proposals should provide a detailed description of the input data, production process, quality assurance/quality control, and proposed acceptance test methodology for providing the digital terrain data required by this effort.

1.3.6   RE-FLIGHTS

If required, the Contractor will correct unacceptable digital terrain data at no additional cost to LA County. All re-flight coverage shall overlap the accepted LiDAR data by at least two swaths.

1.3.7 PROTOTYPE (TEST) AREA

Contractor will provide County with sample digital terrain data, which will be provided to the QA/QC vendor as well as to County. County will have an opportunity to review the samples, and will give written acceptance of the enhancements prior to the Contractor processing the remainder of the project.

1.3.8 METADATA

FGDC-compliant metadata will be provided for the deliverable digital terrain data and elevation contours data sets. These metadata will be completed using standard industry metadata tools and output in standard file formats for viewing in all widely available viewing utilities.

1.4 ACCEPTANCE CRITERIA

Contractor (and subcontractor) acknowledges that all finished products and final deliverables will be subject to systematic QA/QC, which will be done by an independent geospatial firm, whose services will be solicited by County in conjunction with this Agreement.

The Acceptance Criteria Table with "Tested Characteristics" and "Measure of Acceptability" will be finalized by Contractor and County's QA/QC vendor during the first month of the project. Contractor will provide in its subcontractor's Project Work Plan (which is Contractor's first project deliverable) and County's QA/QC vendor will provide in its Quality Plan document.

1.4.1 ACCEPTANCE CRITERIA: COMPLETENESS

	TESTED CHARACTERISTIC	MEASURE OF ACCEPTABILITY
A	**All Scales**	
A.1.	Information will be delivered by contractor to County, who will load data onto County Servers.	All files successfully copied to County servers, all files accessible, no files corrupted.
A.2.	File organization	Files written in tile sheet order
A.3.	File name	Conforms to required convention- based on CA SPCS Zone 5 L4_xxxx_yyyya (a-d).
A.4.	Files must open in correct location	Files must open with ESRI software
A.5.	Vertical Datum	NAVD88 (Feet to 2 decimal places)
A.6.	Projection	NAD 1983 State Plane – California Zone V
A.7.	Horizontal Datum	NAD 83 reference datum
A.8.	Units	U.S. Survey Feet (to 2 decimal places)
A.9	Conformance with tile index grid	Tile matches grid, no gaps between tiles at 1:1 view.
A.10.	Coverage	Full tiles; no data holidays. As indicated in County Data and Reference Maps. The basic rule is at least 500' buffer around County boundary (no partial tiles, no seams and no overlaps). Flying and image capture teams should be aware of this.

	TESTED CHARACTERISTIC	MEASURE OF ACCEPTABILITY
A	**All Scales**	
A.11.	Tile grid layout	Full tiles only with no gaps or seams between 4 inch and 1 ft. areas. Flying and image capture teams should be aware of this.
A.12.	Metadata	Complies with standard (to be determined by County; to match LAR-IAC4 metadata). Meets minimum FGDC Content Standard.

1.4.2 ACCEPTANCE CRITERIA B: GROUND CONTROL ACCEPTANCE – COUNTY AND CONTRACTOR RESPONSIBILITY

B	**Tested Characteristic**	**Measure of Acceptability**
B.1.	Report Format	Conforms to required convention
B.2.	Report Completeness	All information complete and readable
B.3.	Approval	CA Licensed Surveyor Signature and Seal
B.4.	Monument Record Form	Sufficient information to revisit point, description and picture
B.5.	Network	Meet NGS specifications for Order and Class
B.6.	Geodetic Survey: Horizontal Accuracy	Second Order Class 1 tied to NGS monuments.
B.7.	Geodetic Survey: Vertical Accuracy	Third Order.
B.8.	Coordinate System	California Coordinate System of 1983, Zone 5, US Feet
B.9	Epoch	Epoch date: 2004.0 unless otherwise determined.

1.4.3 ACCEPTANCE CRITERIA C: DIGITAL TERRAIN MODEL QA (SUITABLE ONLY FOR ORTHORECTIFICATION) – CONTRACTOR RESPONSIBILITY

C	**Tested Characteristic All Scales**	**Measure of Acceptability**
C.1.	Information will be delivered by contractor to County, who will load data onto County Servers.	All files successfully copied to County servers, all files accessible, no files corrupted.
C.2.	File organization	Files written one per ortho tile provided. Only updated tiles are provided.
C.3.	File name	Conforms to required convention
C.4.	Format	ArcGIS compatible format
C.5.	Format	CAD compatible format
C.6.	Georeferencing	Locates in proper tile grid cell

C	Tested Characteristic All Scales	Measure of Acceptability
C.7.	Mass point locations	Mass points updated as needed to accurately build terrain to support orthophotos;
C.8.	Breakline locations	Breaklines updated as needed to control bridges, edge of pavement, hydrographic features, ridgelines, retaining walls as needed for orthorectification and contouring, none in open water.
C.9.	Continuity	No spikes, holes or blunders; no gaps of sufficient size to affect orthorectification, regardless of perspective center.
C.10.	Breakline Format	Arc generated .lin and pnt files

1.5 SOFTWARE REQUIREMENTS

Digital Terrain Data from the project can be viewed using any software that can read and display standard digital terrain data file formats. The LAS format is widely used and software that supports this file format can generally be grouped into two categories; LiDAR viewers and GIS software.

1.6 COUNTY OBLIGATIONS – ORTHOGONAL IMAGES

1.6.1 SYSTEM REQUIREMENTS

County's system for use of the digital terrain data will have sufficient capabilities and capacity to view and manage digital images.

1.6.2 COUNTY RESPONSIBILITIES

1. County will make available the following countywide information to Contractor at the following URL: http://egis3.lacounty.gov/dataportal/lariac/lar-iac4/rfp-data/

    g) LAR-IAC Project Area Boundaries (shapefile format)

    h) Detailed County/City Boundaries (for orientation only - shapefile format)

    i) Grid for project tiles (shapefile format)

    j) Oblique Aerial Digital Imagery 1 sq. mile sector grid (for orientation only – shapefile format)

    k) Boundary of Urban Canyons "Downtown Areas" high-rise areas (shapefile format)

    l) Parcel vector database (for orientation only – shapefile format)

    m) Existing control cadastral monuments (shapefile format)

    n) Existing LAR-IAC deliverables in various formats as mutually agreed upon (ie. DTM and/or DSM, first generation 4" ortho imagery)

    o) Proposed Delivery Areas (shapefile format)

    p) Proposed Mosaic Tile Areas (shapefile format)

    q) Boundary of locations that could potentially have large changes in elevation (ie. Significant grading) that would affect ortho imagery rectification

    r) Other relevant GIS layers mutually determined by the Contractor and County.

EXHIBIT A.4 – STATEMENT OF WORK – DIGITAL TERRAIN DATA

2. Digital Terrain Data (from LiDAR and stereo compilation) provided by County for Contractor will be in ESRI raster format in California State Plane Coordinate System, Zone 5, NAD83, NAVD88.

3. All vector data sets provided by County for Contractor will be in ESRI shapefile format in California State Plane Coordinate System, Zone 5, NAD83, U.S. Survey Feet.

4. County will be responsible for:

   a) Assignment of all point numbers;

   b) Provision of blank monument record forms;

   c) Providing the County Survey Monuments digital files.

1.7   REFERENCE MAPS

1.7.1   PROJECT AREAS AND TILE GRID

INSET MAP: Catalina Island

PROJECT AREA 1

Legend

Area 1 - 4 inch

Area 2 - 1 foot

Ortho Imagery Grid

Los Angeles County Boundary

**Los Angeles Region -
Imagery Acquisition Consortium**

Project Areas and Tile Grid

*LOS ANGELES COUNTY
Department of Regional Planning
320 W. Temple St.
Los Angeles, CA 90012
March 5, 2009*