

Ground Control Survey Report

Duck Creek LiDAR Mapping Project

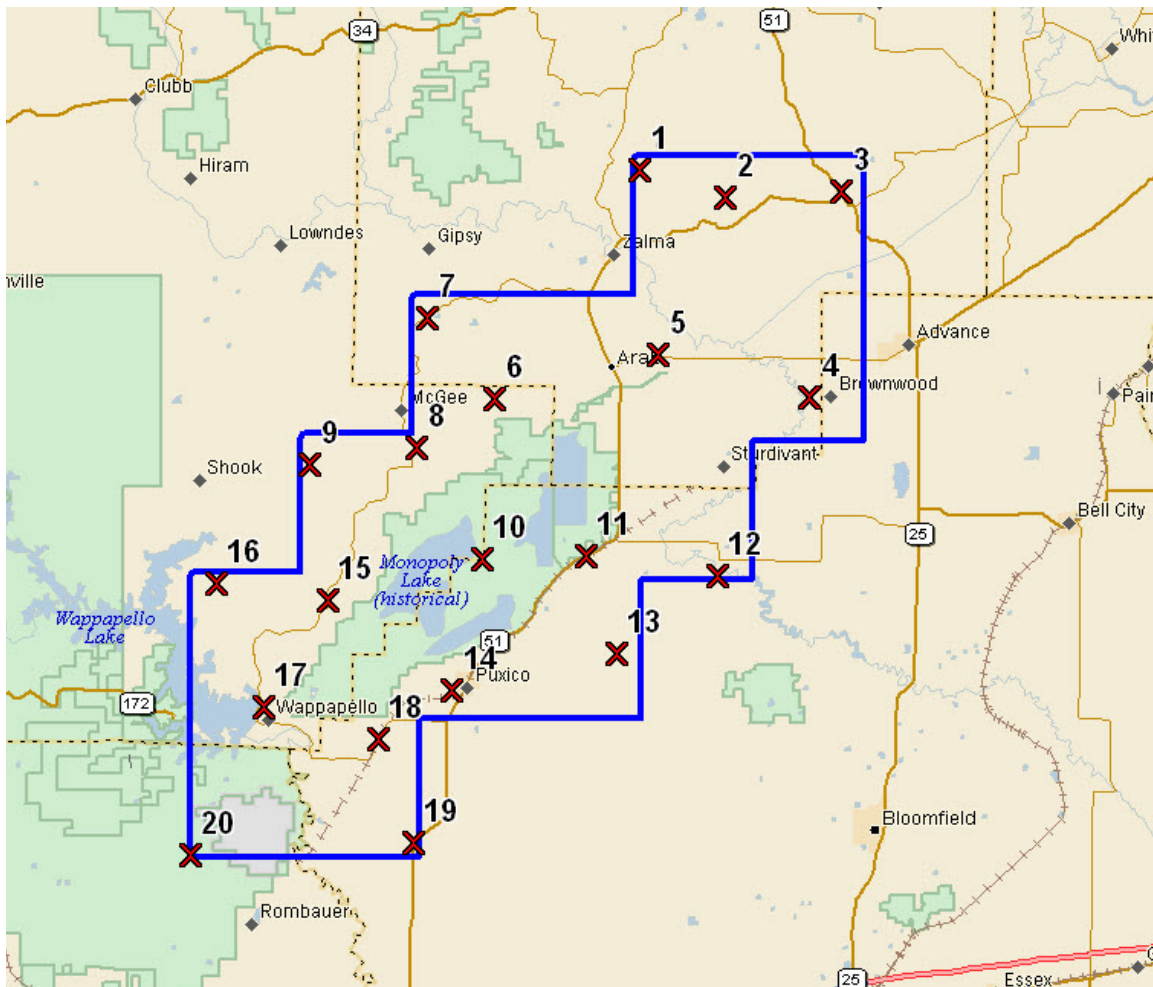
November 2, 2009

Prepared by Surdex Corporation

1.0 Project Overview

The Missouri Department of Conservation, U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey (USGS) required high-resolution digital elevation data be developed from an aerial LiDAR sensor to cover portions of Bollinger, Butler, Stoddard and Wayne counties in Missouri to the quarter-quad tile resolution. These data were then to be used to generate digital elevation models for use in hydrologic and wetland models for the purposes of conservation planning activities, environmental assessments and improved public use. To accomplish this mapping goal, Surdex was hired by the USACE to complete this mapping project under its task order contract with the St. Louis District in the spring of 2009.

The general project layout of the project area and the primary control is provided in the graphic below.



2.0 Survey Plan

The project required deliverables which were tested for and meet vertical and horizontal accuracy as stated in the NDEP guidelines for digital elevation data for NSSDA of 95%

confidence interval, for 2' contours (horizontal accuracy of 1.33 meters (4.39 feet) and vertical of 18.5 centimeters RMSE. In addition, the Contractor was to process the LiDAR data and produce a "bare earth" model with vertical accuracy on flat, bare ground of 15 centimeters or better and 40 centimeters or better in vegetation or on hillsides (overall accuracy meeting NDEP guidelines of 18.5 centimeters RMSE).

To accomplish this, Surdex designed a survey that would include 20 primary control points that were surveyed by rapid static GPS techniques and then a minimum of 60 LiDAR QC points that were surveyed by GPS RTK techniques from the primary control.

3.0 Field Data Collection

It was determined that 20 minute observations post processed through GrafNET and tied into existing monumentation in the area should provide adequate accuracy for this project. Dual frequency Trimble 5700 GPS receivers collecting data at a 0.5-second interval were used for all data collection. Field data observations were performed on July 23 and 24, 2009. The RTK check surveys were performed on July 28 and 29, 2009.

4.0 Post Processing

All field data was processed through a free-net adjustment in GrafNET. Once processed and validated, CORS data in the area were incorporated and utilized to compare against the final adjustments. The adjustments for each day and the final coordinates are provided at the end of this report.

5.0 Coordinate Systems

The final horizontal coordinates were derived in a modified NAD83(CORS96) projection as determined by point's m15, m302 and m303 as provided by the client. The orthometric heights were derived relative to NAVD88 with Geoid03 being utilized for the conversion from ellipsoid height. All coordinate transformations were performed with CORPSCON version 6.0.1. The control table presents values in UTM 15 meters and elevations as NAVD88 US survey feet.

Upon review of the field survey data it was determined that the control survey was sufficient to be utilized for the QC on the final products.

Respectfully submitted,

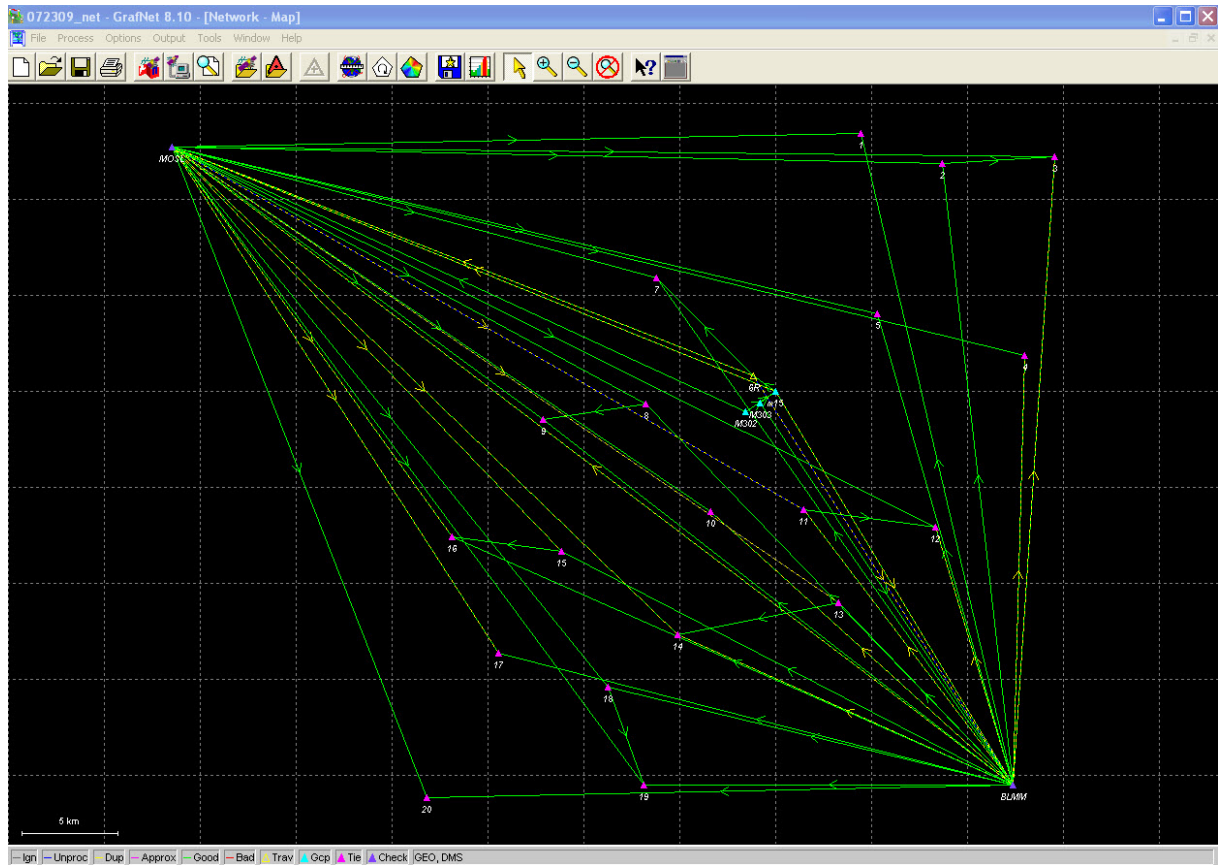


Steve Kasten CP, PLS
November 2, 2009

6.0 Network Reductions

The following section contains the network reductions for the Duck Creek survey.

The graphic below presents the general layout of the survey.



The survey was controlled against three provided control points M15, M302 and M303. These points were checked against CORS site BLMN and MOSL.

The network reduction is provided below:

```

*****
* NETWORK - WEIGHTED GPS NETWORK ADJUSTMENT *
* *
* (c) Copyright NovAtel Inc., (2008) *
* *
* Version: 8.10.2110 *
* *
* FILE: C:\gps data\1900316_duck Creek\07-23-09\1900316_
Survey\processed\072309_net.net
*****

```

DATE(m/d/y): Mon. 11/02/09 TIME: 12:23:36

```

*****
DATUM: 'NAD83'
SCALE FACTOR: 1.0000
CONFIDENCE LEVEL: 90.00 % (Scale factor is 2.1461)
*****

```

INPUT CONTROL/CHECK POINTS

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*****
STA ID TYPE -- LATITUDE -- -- LONGITUDE -- ELLHGT - HZ-SD V-SD
BLMM CHK-3D 36 52 47.19380 -89 58 21.07936 101.844
m15 GCP-3D 37 03 47.80460 -90 06 40.86196 77.461 0.00500 0.00500
M302 GCP-3D 37 03 14.00512 -90 07 43.70688 77.265 0.00500 0.00500
M303 GCP-3D 37 03 29.09037 -90 07 14.01469 77.280 0.00500 0.00500
MOSL CHK-3D 37 10 38.14561 -90 27 52.44338 97.295
*****

```

INPUT VECTORS

```

*****
SESSION NAME VECTOR(m) ----- Covariance (m) [unscaled] -----
DX/DY/DZ standard deviations in brackets
11 to 12 (1) 6842.7249 7.3368e-007 (0.0009)
-548.1110 1.3823e-006 6.9616e-006 (0.0026)
-700.0469 -1.8914e-006 -9.4717e-006 1.4506e-005 (0.0038)
13 to 14 (1) -8342.1281 1.1090e-006 (0.0011)
-996.1372 2.9226e-007 4.3711e-006 (0.0021)
-1335.3521 3.1761e-007 -1.6776e-006 1.3819e-006 (0.0012)
15 to 16 (1) -5673.3497 9.6380e-007 (0.0010)
412.4836 -4.9158e-010 1.4641e-006 (0.0012)
641.8310 3.6885e-007 -5.0067e-007 6.1139e-007 (0.0008)
18 to 19 (1) 1830.4111 2.4226e-007 (0.0005)
-3060.4252 4.6543e-008 3.7960e-007 (0.0006)
-4062.1751 7.0639e-008 -1.0295e-007 8.4498e-007 (0.0009)
2 to 3 (1) 5835.1102 4.5117e-007 (0.0007)
217.4318 4.0956e-007 1.3512e-006 (0.0012)
256.4155 -2.2442e-008 -1.6398e-007 2.3161e-007 (0.0005)
6R to BLMM (1) 13508.9532 3.5403e-005 (0.0060)
-12750.3334 -3.1274e-005 1.7524e-004 (0.0132)
-16888.4467 5.2737e-005 -1.3159e-004 1.7645e-004 (0.0133)
6R to 7 (1) -5044.0554 2.4782e-007 (0.0005)
3032.0025 -3.8943e-008 6.9683e-007 (0.0008)
4101.6219 -2.1578e-008 -1.2519e-007 2.3646e-007 (0.0005)
*****

```

The final primary control values are listed in the following file:

```

;*****
; Project:      072309_net
; Program:      GrafNet Version 8.10
; Source:       Network Adjustment
; CoordType:    Universal Transverse Mercator, Zone 15
; Units(h,v):   Metres, U.S. Survey Feet
;               Units for Convergence is degrees, Units for StDev is Metres
; Geoid:        Geoid03-ContUS.wpg
; Datum:        NAD83
;*****
;
;NAME          NORTHING      EASTING      HEIGHT ScaleFac Converg
1              4119267.093      760867.909   490.747 1.000439 1.7770      0.0101      0.0091      0.0542
10             4099490.747      753625.726   341.413 1.000393 1.7166      0.0084      0.0081      0.0435
11             4099713.202      758491.040   340.138 1.000423 1.7496      0.0129      0.0096      0.0998
12             4099040.133      765361.371   375.662 1.000468 1.7957      0.0129      0.0096      0.1013
13             4094959.163      760430.265   351.425 1.000436 1.7600      0.0079      0.0079      0.0431
14             4093030.567      752141.450   375.958 1.000383 1.7030      0.0077      0.0077      0.0406
15             4097188.648      745930.949   350.792 1.000345 1.6634      0.0083      0.0087      0.0486
16             4097770.504      740234.929   606.928 1.000311 1.6252      0.0083      0.0086      0.0488
17             4091824.688      742790.041   421.248 1.000326 1.6393      0.0080      0.0079      0.0420
18             4090249.840      748588.722   348.395 1.000362 1.6775      0.0091      0.0079      0.0411
19             4085222.137      750578.903   358.228 1.000374 1.6882      0.0092      0.0080      0.0413
2              4117879.507      765147.504   424.875 1.000466 1.8053      0.0128      0.0119      0.0559
20             4084267.129      739300.075   483.931 1.000306 1.6118      0.0105      0.0097      0.0579
3              4118399.955      770971.812   369.559 1.000505 1.8452      0.0129      0.0120      0.0562
4              4108040.406      769720.682   351.779 1.000496 1.8305      0.0118      0.0109      0.0820
5              4109962.120      762005.239   387.074 1.000446 1.7793      0.0099      0.0092      0.0572
6R             4106550.692      755656.960   365.902 1.000405 1.7344      0.0062      0.0062      0.0212
7              4111490.963      750452.504   582.646 1.000373 1.7019      0.0063      0.0063      0.0219
8              4104939.282      750097.230   584.351 1.000371 1.6958      0.0076      0.0075      0.0419
9              4103984.561      744761.936   623.355 1.000338 1.6592      0.0077      0.0075      0.0420
ELMM          4085816.696      769832.091   427.815 1.000497 1.8180      0.0067      0.0068      0.0285
m15           4105796.139      756837.580   348.681 1.000413 1.7419      0.0062      0.0062      0.0205
M302          4104707.221      755316.501   348.337 1.000403 1.7310      0.0062      0.0062      0.0208
M303          4105194.421      756036.042   348.112 1.000408 1.7362      0.0062      0.0062      0.0206
MOSL          4117547.996      725088.100   416.007 1.000224 1.5328      0.0066      0.0066      0.0275

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8.0 **Survey Photos**

The following section contains the field photos of the points contained in the Duck Creek survey.

Duck Creek

Primary Control