Ground Control Survey Report

UNITED STATES GEOLOGICAL SURVEY
MT STILLWATER COMPLEX QL2 LIDAR

TASK ORDER NUMBER: G15PD00899

Contractor: Woolpert, Inc.
Woolpert Project # 76827

November 2016

Ground Control Survey Report

UNITED STATES GEOLOGICAL SURVEY MT STILLWATER COMPLEX QL2 LIDAR

Task Order G15PD00899

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Section 1: Survey Report

TASK ORDER NAME: UNITED STATES GEOLOGICAL SURVEY MT STILLWATER COMPLEX QL2 LIDAR

Task Order: #G15PD00899

This report contains a comprehensive outline of the Ground Control Survey that supported the Stillwater, MT airborne LiDAR collection. All surveys were performed in such a way as to achieve ground control accuracies that meet or exceed the National Mapping Accuracy Standards.

Project Area

The project area consists of approximately 162 square miles over South Central Montana.

Purpose

The purpose of this survey was to establish three-dimensional coordinates for 27 LiDAR primary control points and 33 ground classification check points. The points were collected per the flight layout and were uniformly dispersed over the project area.

Date of Survey

Multiple ground control field missions took place August 6th through August 12th, 2016.

Monumentation

Prior to aerial acquisition, Woolpert field crews performed a field reconnaissance to verify the existence and suitability of pre-selected existing National Geodetic Survey (NGS) control stations. No NSRS monumentation was recovered within the project limits. The Woolpert field crew established coordinates on 6 TSMs (Temporary Survey Marks) dispersed across the area of acquisition. The TSM marks were observed using GPS static methods. Multiple GPS observations were collected over several days. The raw GPS data was then processed in coincidence with CORS data from the three nearest NSRS continuously operating reference stations. The three CORS stations MTSU, P722, and MAWY were constrained 3D in the final adjustment and the TSM coordinates are a result of that adjustment. The newly established TSMs were utilized as checks to ensure that quality x, y, and z coordinate values were computed for each of the newly established photogrammetric control stations. Recovery information sheets for the existing NGS continuously operating reference stations can be found in Section 4 of this report. A control diagram showing the ground control stations used to support this mapping project can be found in Section 5 of this report.

Accuracy Standards

The relative accuracy of the LiDAR data will be ≤ 8 cm RMSEZ between adjacent swaths with a maximum difference of ± 16 cm.

GPS Equipment

Woolpert utilized 3 Trimble Navigation R8 Model 3 GNSS dual-frequency GPS receivers, 1 Trimble Navigation R10 Model GNSS dual-frequency GPS receiver and 1 TSC3 data collector for this project.

Methodology

Real-Time Kinematic (RTK) GPS

The field crew utilized Real-Time Kinematic (RTK) and GPS Rapid Static methods throughout the ground control data collection process. Using these techniques, observations were performed on a total of 37 LiDAR control points and 33 ground classification check points. The survey was conducted using a 1-second epoch rate, in a fixed solution RTK mode, with each observation lasting between 60 to 180 seconds. Each station was occupied twice to insure the necessary horizontal and vertical accuracies were being met for this LiDAR / photogrammetric project.

GPS Data Analysis and Processing

The field crew chief processed all session baselines each day using Trimble Navigation's Trimble Business Center (TBC) Version 3.80 baseline processor with the accompanying broadcast ephemeris. Daily processing ensured the integrity of the network as it was constructed, and allowed the field crews to immediately reschedule observations of poor baselines.

Datum Reference and Final Coordinates

The spatial reference system for this project is will be UTM Zone 12 North. The datum shall be NAD83 (2011) meters to 2 decimal places horizontal and NAVD88 Meters vertical using the latest geoid model (GEOID12B) Units for both the horizontal and vertical datum will be expressed in meters to two (2) decimal places.

Quality Assurance

Existing NSRS published continuously operating reference stations were utilized to assure that there were no discrepancies in the field observation data. Close examinations of the residuals showed no distortions in orientation or scale. The ground control data meets positional accuracies necessary to support 1.0 point per 0.3 meters squared (1' GSD) data at 95% confidence level as outlined in the Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA), published by the Federal Geographic Data Committee (FGDC-STD-007.3-1998).

Section 2: Ground Control / Geodetic Control Coordinate Listings

- Coordinate System: Grid
- Horizontal Datum: NAD83 2011 UTM12 North
- Vertical Datum: NAVD88
- Geoid Model: GEOID 12B
- Units: Meter

Point No.	UTM Zone 12 North		Ortho Height (NAVD88) (m)	Description
	UTM Northing (m)	UTM Easting (m)		
1	5030445.177	589098.982	1604.979	Primary Control
2	5022528.824	585885.243	1582.175	Primary Control
2A	5022488.550	585925.803	1583.729	Primary Control
3	5031140.268	591116.930	1473.463	Primary Control
4	5027519.397	595067.500	1958.243	Primary Control
5	5023780.145	596919.473	2302.517	Primary Control
6	5027302.285	597402.098	1766.599	Primary Control
7	5025480.363	596346.766	2157.421	Primary Control
7A	5025517.114	596344.603	2154.500	Primary Control
8	5022426.834	594252.147	2587.581	Primary Control
9	5030285.175	563692.407	1677.540	Primary Control
9A	5030251.595	563693.074	1680.376	Primary Control
10	5043052.859	561474.279	1573.108	Primary Control
10A	5043028.458	561496.518	1572.813	Primary Control
11	5038938.253	560385.742	1588.468	Primary Control
11A	5038969.386	560376.253	1588.575	Primary Control
12	5025692.888	595478.361	2230.323	Primary Control
13	5024590.102	594427.315	2455.449	Primary Control
14	5027945.444	573084.087	3018.423	Primary Control
15	5030455.541	573962.895	2815.346	Primary Control
16	5032682.441	574756.678	2860.283	Primary Control
17	5032244.649	578000.090	2358.349	Primary Control
17A	5032271.514	577981.560	2362.083	Primary Control
18	5040713.369	569185.578	1832.212	Primary Control

Point No.	UTM Zone 12 North		Ortho Height (NAVD88) (m)	Description
	UTM Northing (m)	UTM Easting (m)		
18A	5040724.350	569157.822	1830.534	Primary Control
19	5028857.612	593835.305	1788.814	Primary Control
19A	5028855.806	593867.064	1787.313	Primary Control
20	5039052.363	569940.295	2125.553	Primary Control
20A	5039072.646	569918.441	2126.112	Primary Control
21	5038561.550	569137.328	2264.757	Primary Control
22	5031010.593	568126.700	2928.477	Primary Control
23	5032318.439	584247.699	1766.404	Primary Control
23A	5032347.704	584249.419	1764.130	Primary Control
24	5030698.038	590411.081	1487.018	Primary Control
25	5026560.799	587398.197	1664.905	Primary Control
26	5027065.819	585964.088	2116.731	Primary Control
27	5028955.853	593026.168	1725.647	Primary Control
2001	5037661.428	561074.985	1599.698	NVA
2002	5041299.277	560531.027	1592.108	NVA
2003	5035086.636	562790.000	1621.479	NVA
2004	5040144.515	570543.090	1917.522	NVA
2005	5033754.251	562767.617	1636.392	NVA
2006	5031835.730	563406.593	1657.734	NVA
2007	5041254.538	567812.716	1804.533	NVA
2008	5038760.012	573413.631	1991.159	NVA
2009	5031252.713	583383.307	1864.157	NVA
2010	5031566.530	580747.464	2055.070	NVA
2011	5031208.135	579479.590	2148.791	NVA
2012	5032095.193	567219.763	3062.152	NVA
2012A	5032049.665	567177.477	3068.036	NVA
2013	5032051.711	568560.763	2910.552	NVA
2013A	5032038.300	568525.523	2911.661	NVA
2014	5030303.963	570728.468	2683.568	NVA
2015	5029287.443	572138.154	2803.572	NVA
2015A	5029374.942	571993.197	2800.485	NVA
2016	5023920.200	586398.596	1555.181	NVA
2016A	5023948.697	586419.933	1554.272	NVA
2017	5024832.118	587144.202	1529.719	NVA
2018	5025861.637	588184.140	1526.805	NVA

Point No.	UTM Zone 12 North		Ortho Height (NAVD88) (m)	Description
	UTM Northing (m)	UTM Easting (m)		
2019	5026763.452	596556.751	1845.935	NVA
2020	5024135.126	593440.485	2584.484	NVA
2020A	5024165.311	593448.243	2584.655	NVA
2021	5023321.343	593632.945	2570.784	NVA
2022	5024885.782	597792.385	2151.762	NVA
2022A	5024898.924	597710.138	2155.646	NVA
2023	5029342.139	589660.370	1480.115	NVA
2023A	5029360.660	589622.892	1479.928	NVA
2024	5029655.409	586679.402	1869.613	NVA
2024A	5029634.060	586717.419	1869.718	NVA
2025	5028028.183	589065.370	1487.782	NVA
3001	5040083.827	560341.798	1589.052	VVA
3002	5038742.025	560420.306	1598.568	VVA
3003	5033518.131	562787.416	1639.548	VVA
3004A	5031989.258	563417.052	1669.889	VVA
3005	5040378.932	570179.321	1865.856	VVA
3006	5039033.665	569959.152	2125.264	VVA
3007	5029365.207	589262.208	1498.586	VVA
3008	5027109.489	596452.886	1826.622	VVA
3009	5022395.971	594230.958	2590.842	VVA
3010	5022968.072	586093.570	1578.634	VVA

- Coordinate System: Geodetic
- Horizontal Datum: NAD83 (2011) Epoch 2010.00
- Vertical Datum: NAVD88
- Units: Meter

Point No.	Geodetic Coordinates NAD-83 (2011) Epoch 2010.00		Ellipsoid Height (m)	Description
	Latitude (N)	Longitude (W)		
1	45°25'18.66215"	-109°51'40.07796"	1596.009	Primary Control
2	45°21'03.62969"	-109°54'12.89348"	1573.811	Primary Control
2A	45°21'02.30696"	-109°54'11.05498"	1575.365	Primary Control
3	45°25'40.24533"	-109°50'06.77728"	1464.330	Primary Control
4	45°23'41.04494"	-109°47'07.52681"	1949.250	Primary Control
5	45°21'38.98912"	-109°45'45.01175"	2293.771	Primary Control
6	45°23'32.85547"	-109°45'20.33035"	1757.475	Primary Control
7	45°22'34.35605"	-109°46'10.13627"	2148.552	Primary Control
7A	45°22'35.54775"	-109°46'10.20986"	2145.627	Primary Control
8	45°20'56.45488"	-109°47'48.51950"	2579.093	Primary Control
9	45°25'23.47228"	-110°11'09.10283"	1669.149	Primary Control
9A	45°25'22.38403"	-110°11'09.08780"	1671.986	Primary Control
10	45°32'17.87460"	-110°12'45.40659"	1563.902	Primary Control
10A	45°32'17.07694"	-110°12'44.39227"	1563.609	Primary Control
11	45°30'04.90009"	-110°13'37.42075"	1579.604	Primary Control
11A	45°30'05.91179"	-110°13'37.84415"	1579.708	Primary Control
12	45°22'41.66946"	-109°46'49.90695"	2221.501	Primary Control
13	45°22'06.45493"	-109°47'38.98261"	2446.800	Primary Control
14	45°24'04.35714"	-110°03'58.23498"	3010.340	Primary Control
15	45°25'25.35226"	-110°03'16.45976"	2807.178	Primary Control
16	45°26'37.19977"	-110°02'38.71946"	2851.998	Primary Control
17	45°26'21.73902"	-110°00'09.68741"	2349.952	Primary Control
17A	45°26'22.61686"	-110°00'10.52490"	2353.686	Primary Control
18	45°30'59.47056"	-110°06'51.06726"	1823.282	Primary Control
18A	45°30'59.83626"	-110°06'52.34091"	1821.603	Primary Control
19	45°24'24.99852"	-109°48'03.26994"	1779.753	Primary Control
19A	45°24'24.92466"	-109°48'01.81047"	1778.250	Primary Control
20	45°30'05.38263"	-110°06'17.13809"	2116.792	Primary Control
20A	45°30'06.04769"	-110°06'18.13460"	2117.350	Primary Control

Point No.	Geodetic Coordinates NAD-83 (2011) Epoch 2010.00		Ellipsoid Height (m)	Description
	Latitude (N)	Longitude (W)		
21	45°29'49.76849"	-110°06'54.38359"	2256.071	Primary Control
22	45°25'45.47147"	-110°07'44.71402"	2920.276	Primary Control
23	45°26'21.51851"	-109°55'22.11627"	1757.605	Primary Control
23A	45°26'22.46591"	-109°55'22.01905"	1755.329	Primary Control
24	45°25'26.24796"	-109°50'39.54636"	1477.952	Primary Control
25	45°23'13.58708"	-109°53'00.80502"	1656.299	Primary Control
26	45°23'30.58840"	-109°54'06.42646"	2108.207	Primary Control
27	45°24'28.57034"	-109°48'40.41799"	1716.617	Primary Control
2001	45°29'23.31343"	-110°13'06.23575"	1590.935	NVA
2002	45°31'21.35439"	-110°13'29.67668"	1583.057	NVA
2003	45°27'59.33935"	-110°11'48.41721"	1612.906	NVA
2004	45°30'40.54976"	-110°05'48.79881"	1908.629	NVA
2005	45°27'16.17582"	-110°11'50.06061"	1627.873	NVA
2006	45°26'13.80572"	-110°11'21.53449"	1649.295	NVA
2007	45°31'17.49038"	-110°07'54.06877"	1795.559	NVA
2008	45°29'54.62513"	-110°03'37.26487"	1982.346	NVA
2009	45°25'47.36350"	-109°56'02.54703"	1855.483	NVA
2010	45°25'58.64499"	-109°58'03.64789"	2046.556	NVA
2011	45°25'47.55642"	-109°59'02.20006"	2140.374	NVA
2012	45°26'20.92949"	-110°08'25.91436"	3053.893	NVA
2012A	45°26'19.46899"	-110°08'27.88292"	3059.777	NVA
2013	45°26'19.05160"	-110°07'24.21793"	2902.316	NVA
2013A	45°26'18.62951"	-110°07'25.84655"	2903.425	NVA
2014	45°25'21.64599"	-110°05'45.35725"	2675.403	NVA
2015	45°24'48.19186"	-110°04'41.03355"	2795.447	NVA
2015A	45°24'51.08066"	-110°04'47.65590"	2792.356	NVA
2016	45°21'48.48161"	-109°53'48.42928"	1546.741	NVA
2016A	45°21'49.39541"	-109°53'47.43068"	1545.830	NVA
2017	45°22'17.69412"	-109°53'13.58235"	1521.215	NVA
2018	45°22'50.58043"	-109°52'25.11865"	1518.211	NVA
2019	45°23'15.82048"	-109°45'59.57984"	1836.921	NVA
2020	45°21'52.19109"	-109°48'24.64921"	2575.932	NVA
2020A	45°21'53.16528"	-109°48'24.27210"	2576.101	NVA
2021	45°21'25.73380"	-109°48'16.35929"	2562.277	NVA
2022	45°22'14.37198"	-109°45'04.10891"	2142.864	NVA

Point No.	Geodetic Coordinates NAD-83 (2011) Epoch 2010.00		Ellipsoid Height (m)	Description
	Latitude (N)	Longitude (W)		
2022A	45°22'14.83905"	-109°45'07.87988"	2146.753	NVA
2023	45°24'42.66750"	-109°51'14.97359"	1471.190	NVA
2023A	45°24'43.28483"	-109°51'16.68537"	1471.003	NVA
2024	45°24'54.16982"	-109°53'31.89502"	1860.858	NVA
2024A	45°24'53.46118"	-109°53'30.15972"	1860.962	NVA
2025	45°24'00.37133"	-109°51'43.19741"	1478.990	NVA
3001	45°30'42.03162"	-110°13'38.93780"	1580.097	VVA
3002	45°29'58.53128"	-110°13'35.91521"	1589.719	VVA
3003	45°27'08.51884"	-110°11'49.25770"	1631.039	VVA
3004A	45°26'18.77681"	-110°11'20.98186"	1661.445	VVA
3005	45°30'48.27707"	-110°06'05.44129"	1856.944	VVA
3006	45°30'04.77001"	-110°06'16.27886"	2116.505	VVA
3007	45°24'43.59820"	-109°51'33.27323"	1489.680	VVA
3008	45°23'27.08266"	-109°46'04.11159"	1817.580	VVA
3009	45°20'55.46524"	-109°47'49.51422"	2582.357	VVA
3010	45°21'17.76887"	-109°54'03.04549"	1570.244	VVA

Section 3: Ground / Geodetic Control Photos

This section contains the station recovery information sheets and photographs regarding the ground control positions established for the project. The stations appear as they are ordered in the final coordinate listing of Section 2.

The data is assembled on the following pages.

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	1	File Name	76827_LGC_080716_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 25 18.6
Longitude	109 51 40.0
Ellipsoidal Height	1596.009

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 1

1 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	2	File Name	76827_LGC_080716_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 21 03.6
Longitude	109 54 12.9
Ellipsoidal Height	1573.811

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 2

2 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	3	File Name	76827_LGC_080716_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 25 40.2
Longitude	109 50 06.8
Ellipsoidal Height	1464.33

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 3

3 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	4	File Name	76827_LGC_080816_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 23 41.0
Longitude 109 47 07.5
Ellipsoidal Height 1949.25

Type of Mark
Mark Stamping

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 4

4 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	5	File Name	76827_LGC_080816_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 21 38.9
Longitude	109 45 45.0
Ellipsoidal Height	2293.771

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 5

5 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	6	File Name	76827_LGC_080816_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 23 32.8
Longitude	109 45 20.3
Ellipsoidal Height	1757.475

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 6

6 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	7	File Name	76827_LGC_080816_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 22 34.3
Longitude	109 46 10.1
Ellipsoidal Height	2148.552

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 7

7 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	8	File Name	76827_LGC_080816_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 20 56.5
Longitude	109 47 48.5
Ellipsoidal Height	2579.093

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 16.562 USFT / 5.040 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 8

8 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	11-Aug-16
Station Name	9	File Name	76827_LGC_081116_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 25 23.5
Longitude 110 11 09.1
Ellipsoidal Height 1669.149

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark
Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 9

9 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	11-Aug-16
Station Name	10	File Name	76827_LGC_081116_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 32 17.8
Longitude	110 12 45.4
Ellipsoidal Height	1563.902

Receiver :

R10	x
R8	
Other, specify	

Type of Mark: _____

Mark Stamping: _____

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : _____ Stop Time : _____
PDOP Begin : _____ PDOP End : _____
Start Time : _____ Stop Time : _____
PDOP Begin : _____ PDOP End : _____

Weather Conditions: _____

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 10

10 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	11-Aug-16
Station Name	11	File Name	76827_LGC_081116_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 30 04.9
Longitude 110 13 37.4
Ellipsoidal Height 1579.604

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark
Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 11

11 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	12	File Name	76827_LGC_080816_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 22 41.7
Longitude 109 46 49.9
Ellipsoidal Height 2221.501

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark
Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

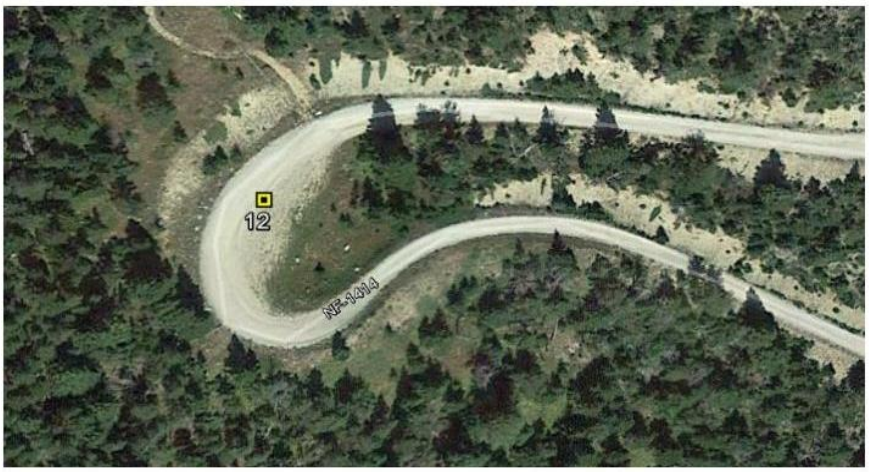
To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH



Station: 12

12 EAST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	13	File Name	76827_LGC_080816_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 22 06.4
Longitude	109 47 38.9
Ellipsoidal Height	2446.8

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 13

13 EAST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	10-Aug-16
Station Name	14	File Name	76827_LGC_081016_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 24 04.3
Longitude 110 03 58.2
Ellipsoidal Height 3010.34

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark
Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 14

14 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	10-Aug-16
Station Name	15	File Name	76827_LGC_081016_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 25 25.3
Longitude	110 03 16.4
Ellipsoidal Height	2807.178

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 15

15 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	09-Aug-16
Station Name	16	File Name	76827_LGC_080916_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 26 37.2
Longitude	110 02 38.7
Ellipsoidal Height	2851.997

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 16

16 EAST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	09-Aug-16
Station Name	17	File Name	76827_LGC_080916_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session #

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15					
16	17	18	19	20					

WGS 84 COORDINATES:

Latitude	45 26 21.7
Longitude	110 00 09.7
Ellipsoidal Height	2349.952

Receiver :

R10	x
R8	
Other, specify	

Type of Mark _____

Mark Stamping _____

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : _____ Stop Time : _____

PDOP Begin : _____ PDOP End : _____

Start Time : _____ Stop Time : _____

PDOP Begin : _____ PDOP End : _____

Weather Conditions _____

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 17

17 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	12-Aug-16
Station Name	18	File Name	76827_LGC_081216_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session #

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15					
16	17	18	19	20					

WGS 84 COORDINATES:

Latitude	45 30 59.5
Longitude	110 06 51.0
Ellipsoidal Height	1823.282

Receiver :

R10	x
R8	
Other, specify	

Type of Mark _____

Mark Stamping _____

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : _____ Stop Time : _____

PDOP Begin : _____ PDOP End : _____

Start Time : _____ Stop Time : _____

PDOP Begin : _____ PDOP End : _____

Weather Conditions _____

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 18

18 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	19	File Name	76827_LGC_080716_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 24 24.9
Longitude	109 48 03.3
Ellipsoidal Height	1779.753

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 19

19 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	12-Aug-16
Station Name	20	File Name	76827_LGC_081216_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session #: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 30 05.4
Longitude	110 06 17.1
Ellipsoidal Height	2116.792

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark: _____

Mark Stamping: _____

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : _____ Stop Time : _____
PDOP Begin : _____ PDOP End : _____
Start Time : _____ Stop Time : _____
PDOP Begin : _____ PDOP End : _____

Weather Conditions: _____

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 20

20 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	12-Aug-16
Station Name	21	File Name	76827_LGC_081216_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 29 49.8
Longitude	110 06 54.4
Ellipsoidal Height	2256.071

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 21

21 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	10-Aug-16
Station Name	22	File Name	76827_LGC_081016_EN

Methodology				
	RTK base	x	Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	x
	Rapid Static		LiDAR QC Point (LQC)	
			Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 25 45.5
Longitude	110 07 44.7
Ellipsoidal Height	2920.276

Type of Mark	
Mark Stamping	

Receiver :	
R10	x
R8	
Other, specify	

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 22

22 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	09-Aug-16
Station Name	23	File Name	76827_LGC_080916_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 26 21.5
Longitude 109 55 22.1
Ellipsoidal Height 1757.605

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark
Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 23

23 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	24	File Name	76827_LGC_080716_EN

Methodology: RTK base [x], RTK VRS [ ], Rapid Static [ ]

Photo Control Point (PCP) [ ]
LiDAR Control Point (LCP) [x]
LiDAR QC Point (LQC) [ ]
Control Station [ ]

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude 45 25 26.2
Longitude 109 50 39.5
Ellipsoidal Height 1477.952

Receiver :
R10 [x]
R8 [ ]
Other, specify [ ]

Type of Mark
Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 24

24 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	25	File Name	76827_LGC_080716_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 23 13.6
Longitude	109 53 00.8
Ellipsoidal Height	1656.299

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 25

25 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	10-Aug-16
Station Name	26	File Name	76827_LGC_081016_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	x
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	
			Session #	1

WGS 84 COORDINATES:

Latitude	45 23 30.6
Longitude	109 54 06.4
Ellipsoidal Height	2108.207

Receiver :		
R10	x	
R8		
Other, specify		

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 26

26 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	07-Aug-16
Station Name	27	File Name	76827_LGC_080716_EN

Methodology

RTK base	x	Photo Control Point (PCP)	
RTK VRS		LiDAR Control Point (LCP)	x
Rapid Static		LiDAR QC Point (LQC)	
		Control Station	

Session # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WGS 84 COORDINATES:

Latitude	45 24 28.6
Longitude	109 48 40.4
Ellipsoidal Height	1716.617

Receiver :

R10	x
R8	
Other, specify	

Type of Mark

Mark Stamping

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time : Stop Time :
PDOP Begin : PDOP End :
Start Time : Stop Time :
PDOP Begin : PDOP End :

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 27

27 SOUTH

Section 4: Survey Control Stations

This section contains control stations that were used to establish 3-dimensional coordinates for the LiDAR ground control survey points for the project.

```
PROGRAM = datasheet95, VERSION = 8.10
1         National Geodetic Survey,   Retrieval Date = NOVEMBER 21, 2016
 DK7547 ***********************************************************************
 DK7547  CORS         -  This is a GPS Continuously Operating Reference Station.
 DK7547  DESIGNATION -  BOZEMAN CORS ARP
 DK7547  CORS_ID      -  MTSU
 DK7547  PID          -  DK7547
 DK7547  STATE/COUNTY-  MT/GALLATIN
 DK7547  COUNTRY      -  US
 DK7547  USGS QUAD    -  BOZEMAN (1987)
 DK7547
 DK7547                        *CURRENT SURVEY CONTROL
 DK7547  ______________________________________________________________________
 DK7547* NAD 83(2011) POSITION- 45 39 40.37689(N) 111 02 42.00898(W)   ADJUSTED
 DK7547* NAD 83(2011) ELLIP HT-  1495.496 (meters)        (08/??/11)   ADJUSTED
 DK7547* NAD 83(2011) EPOCH   -  2010.00
 DK7547* NAVD 88 ORTHO HEIGHT -          **(meters)           **(feet)
 DK7547  ______________________________________________________________________
 DK7547  GEOID HEIGHT    -        -10.891 (meters)                     GEOID12B
 DK7547  NAD 83(2011) X  - -1,603,880.119 (meters)                     COMP
 DK7547  NAD 83(2011) Y  - -4,168,461.522 (meters)                     COMP
 DK7547  NAD 83(2011) Z  -  4,540,079.729 (meters)                     COMP
 DK7547
 DK7547  Network accuracy estimates per FGDC Geospatial Positioning Accuracy
 DK7547  Standards:
 DK7547         FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
 DK7547            Horiz  Ellip           SD_N   SD_E   SD_h      (unitless)
 DK7547  ------------------------------------------------------------------
 DK7547  NETWORK    1.76   5.34           0.82   0.56   2.73      0.00503500
 DK7547  ------------------------------------------------------------------
 DK7547
 DK7547
 DK7547.The coordinates were established by GPS observations
 DK7547.and adjusted by the National Geodetic Survey in August 2011.
 DK7547
 DK7547.NAD 83(2011) refers to NAD 83 coordinates where the reference frame has
 DK7547.been affixed to the stable North American Tectonic Plate.
 DK7547
 DK7547.The coordinates are valid at the epoch date displayed above
 DK7547.which is a decimal equivalence of Year/Month/Day.
 DK7547
 DK7547.Significant digits in the geoid height do not necessarily reflect accuracy.
 DK7547.GEOID12B height accuracy estimate available here.
 DK7547
 DK7547.The PID for the CORS L1 Phase Center is DO1573.
 DK7547
```

```
 DK7547.The XYZ, and position/ellipsoidal ht. are equivalent.
 DK7547
 DK7547.The ellipsoidal height was determined by GPS observations
 DK7547.and is referenced to NAD 83.
 DK7547
 DK7547. The following values were computed from the NAD 83(2011) position.
 DK7547
 DK7547;                    North         East     Units Scale Factor Converg.
 DK7547;SPC MT       -   158,024.855   479,638.532   MT  0.99966751   -1 07 48.6
 DK7547;SPC MT       -   518,454.25  1,573,617.23   iFT  0.99966751   -1 07 48.6
 DK7547;UTM  12      - 5,056,408.350   496,494.147   MT  0.99960015   -0 01 55.9
 DK7547
 DK7547!             -  Elev Factor  x  Scale Factor =   Combined Factor
 DK7547!SPC MT       -   0.99976560  x   0.99966751  =   0.99943319
 DK7547!UTM  12      -   0.99976560  x   0.99960015  =   0.99936584
 DK7547
 DK7547_U.S. NATIONAL GRID SPATIAL ADDRESS: 12TVR9649456408(NAD 83)
 DK7547
 DK7547                           SUPERSEDED SURVEY CONTROL
 DK7547
 DK7547  NAD 83(CORS)-  45 39 40.37669(N)    111 02 42.01023(W) AD(2002.00) c
 DK7547  ELLIP H (12/??/08) 1495.512  (m)                       GP(2002.00) c c
 DK7547
 DK7547.Superseded values are not recommended for survey control.
 DK7547
 DK7547.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 DK7547.See file dsdata.txt to determine how the superseded data were derived.
 DK7547
 DK7547_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 DK7547
 DK7547                           STATION DESCRIPTION
 DK7547
 DK7547'DESCRIBED BY NATIONAL GEODETIC SURVEY 2011
 DK7547'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
 DK7547'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
 DK7547'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
 DK7547'   ftp://cors.ngs.noaa.gov/cors/README.txt
 DK7547'   ftp://cors.ngs.noaa.gov/cors/coord/coord_08
 DK7547'   ftp://cors.ngs.noaa.gov/cors/station_log
 DK7547'   http://geodesy.noaa.gov/CORS
1        National Geodetic Survey,   Retrieval Date = NOVEMBER 21, 2016
 AI5647 ***********************************************************************
 AI5647  CORS        -  This is a GPS Continuously Operating Reference Station.
 AI5647  DESIGNATION -  MAMMOTH WYOMING CORS ARP
 AI5647  CORS_ID     -  MAWY
 AI5647  PID         -  AI5647
 AI5647  STATE/COUNTY-  WY/PARK
 AI5647  COUNTRY     -  US
 AI5647  USGS QUAD   -  MAMMOTH (1986)
 AI5647
 AI5647                        *CURRENT SURVEY CONTROL
 AI5647  ______________________________________________________________________
 AI5647* NAD 83(2011) POSITION- 44 58 24.31920(N) 110 41 21.43310(W)   ADJUSTED
 AI5647* NAD 83(2011) ELLIP HT-  1824.912 (meters)        (08/??/11)   ADJUSTED
 AI5647* NAD 83(2011) EPOCH   -  2010.00
```

```
AI5647* NAVD 88 ORTHO HEIGHT -          **(meters)           **(feet)
AI5647  ____________________________________________________________________
AI5647  GEOID HEIGHT    -         -8.629 (meters)                    GEOID12B
AI5647  NAD 83(2011) X  - -1,597,258.369 (meters)                    COMP
AI5647  NAD 83(2011) Y  - -4,229,413.078 (meters)                    COMP
AI5647  NAD 83(2011) Z  -  4,486,549.185 (meters)                    COMP
AI5647
AI5647  Network accuracy estimates per FGDC Geospatial Positioning Accuracy
AI5647  Standards:
AI5647         FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
AI5647            Horiz  Ellip           SD_N   SD_E   SD_h      (unitless)
AI5647  ------------------------------------------------------------------
AI5647  NETWORK    1.24   3.93           0.57   0.41   2.01      0.03479700
AI5647  ------------------------------------------------------------------
AI5647
AI5647
AI5647.The coordinates were established by GPS observations
AI5647.and adjusted by the National Geodetic Survey in August 2011.
AI5647
AI5647.NAD 83(2011) refers to NAD 83 coordinates where the reference frame has
AI5647.been affixed to the stable North American Tectonic Plate.
AI5647
AI5647.The coordinates are valid at the epoch date displayed above
AI5647.which is a decimal equivalence of Year/Month/Day.
AI5647
AI5647.Significant digits in the geoid height do not necessarily reflect accuracy.
AI5647.GEOID12B height accuracy estimate available here.
AI5647
AI5647.The PID for the CORS L1 Phase Center is DH8010.
AI5647
AI5647.The XYZ, and position/ellipsoidal ht. are equivalent.
AI5647
AI5647.The ellipsoidal height was determined by GPS observations
AI5647.and is referenced to NAD 83.
AI5647
AI5647. The following values were computed from the NAD 83(2011) position.
AI5647
AI5647;                    North         East     Units Scale Factor Converg.
AI5647;SPC WYWC     -   498,740.937   447,032.175   MT  1.00022513   -1 22 15.3
AI5647;SPC WYWC     - 1,636,285.89  1,466,638.06   sFT  1.00022513   -1 22 15.3
AI5647;UTM  12      - 4,980,044.881   524,500.259   MT  0.99960738   +0 13 10.6
AI5647
AI5647!             -  Elev Factor  x  Scale Factor =   Combined Factor
AI5647!SPC WYWC     -   0.99971396  x   1.00022513  =   0.99993902
AI5647!UTM  12      -   0.99971396  x   0.99960738  =   0.99932145
AI5647
AI5647_U.S. NATIONAL GRID SPATIAL ADDRESS: 12TWQ2450080044(NAD 83)
AI5647
AI5647                          SUPERSEDED SURVEY CONTROL
AI5647
AI5647  ELLIP H (06/27/12) 1824.849  (m)                        GP(2010.00) 0 0
AI5647  NAD 83(2011)-  44 58 24.31946(N)    110 41 21.43283(W) AD(2010.00) c
AI5647  NAD 83(CORS)-  44 58 24.31911(N)    110 41 21.43443(W) AD(2002.00) c
AI5647  ELLIP H (03/??/08) 1824.887  (m)                        GP(2002.00) c c
AI5647  ELLIP H (02/10/07) 1824.890  (m)                        GP(2002.00)
```

```
 AI5647  NAD 83(2007)-  44 58 24.31899(N)    110 41 21.43403(W) AD(2002.00) c
 AI5647  NAD 83(CORS)-  44 58 24.31899(N)    110 41 21.43403(W) AD(2002.00) c
 AI5647  ELLIP H (03/??/02) 1824.890  (m)                       GP(2002.00) c c
 AI5647  NAD 83(CORS)-  44 58 24.31845(N)    110 41 21.43411(W) AD(1997.00) c
 AI5647  ELLIP H (06/??/00) 1824.872  (m)                       GP(1997.00) c c
 AI5647
 AI5647.Superseded values are not recommended for survey control.
 AI5647
 AI5647.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 AI5647.See file dsdata.txt to determine how the superseded data were derived.
 AI5647
 AI5647_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 AI5647
 AI5647                          STATION DESCRIPTION
 AI5647
 AI5647'DESCRIBED BY NATIONAL GEODETIC SURVEY 2011
 AI5647'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
 AI5647'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
 AI5647'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
 AI5647'   ftp://cors.ngs.noaa.gov/cors/README.txt
 AI5647'   ftp://cors.ngs.noaa.gov/cors/coord/coord_08
 AI5647'   ftp://cors.ngs.noaa.gov/cors/station_log
 AI5647'   http://geodesy.noaa.gov/CORS
1        National Geodetic Survey,   Retrieval Date = NOVEMBER 21, 2016
 DL7758 ***********************************************************************
 DL7758  CORS         -  This is a GPS Continuously Operating Reference Station.
 DL7758  DESIGNATION -  YNPBASSRCHMT2005 CORS ARP
 DL7758  CORS_ID      -  P722
 DL7758  PID          -  DL7758
 DL7758  STATE/COUNTY-  MT/STILLWATER
 DL7758  COUNTRY      -  US
 DL7758  USGS QUAD    -  FISHTAIL (1956)
 DL7758
 DL7758                         *CURRENT SURVEY CONTROL
 DL7758  ______________________________________________________________________
 DL7758* NAD 83(2011) POSITION- 45 27 25.98579(N) 109 34 15.58670(W)   ADJUSTED
 DL7758* NAD 83(2011) ELLIP HT-  1453.444 (meters)        (08/??/11)   ADJUSTED
 DL7758* NAD 83(2011) EPOCH   -  2010.00
 DL7758* NAVD 88 ORTHO HEIGHT -          **(meters)           **(feet)
 DL7758  ______________________________________________________________________
 DL7758  GEOID HEIGHT    -        -10.465 (meters)                    GEOID12B
 DL7758  NAD 83(2011) X  - -1,501,536.192 (meters)                    COMP
 DL7758  NAD 83(2011) Y  - -4,223,567.849 (meters)                    COMP
 DL7758  NAD 83(2011) Z  -  4,524,171.159 (meters)                    COMP
 DL7758
 DL7758.Formal positional accuracy estimates are not available for this CORS
 DL7758.because its coordinates were determined in part using modeled
 DL7758.velocities. Approximate one-sigma accuracies for latitude, longitude,
 DL7758.and ellipsoid height can be obtained from the short-term time series.
 DL7758.Additional information regarding modeled velocities is available on
 DL7758.the CORS Coordinates and Multi-Year CORS Solution FAQ web pages.
 DL7758
 DL7758.The coordinates were established by GPS observations
 DL7758.and adjusted by the National Geodetic Survey in August 2011.
 DL7758
```

```
DL7758.NAD 83(2011) refers to NAD 83 coordinates where the reference frame has
DL7758.been affixed to the stable North American Tectonic Plate.
DL7758
DL7758.The coordinates are valid at the epoch date displayed above
DL7758.which is a decimal equivalence of Year/Month/Day.
DL7758
DL7758.Significant digits in the geoid height do not necessarily reflect accuracy.
DL7758.GEOID12B height accuracy estimate available here.
DL7758
DL7758.The PID for the CORS L1 Phase Center is DL7759.
DL7758
DL7758.The XYZ, and position/ellipsoidal ht. are equivalent.
DL7758
DL7758.The ellipsoidal height was determined by GPS observations
DL7758.and is referenced to NAD 83.
DL7758
DL7758. The following values were computed from the NAD 83(2011) position.
DL7758
DL7758;                    North         East     Units Scale Factor Converg.
DL7758;SPC MT       -   134,173.968   594,448.219   MT  0.99975633   -0 03 07.0
DL7758;SPC MT       -   440,203.31  1,950,289.43   iFT  0.99975633   -0 03 07.0
DL7758;UTM  12      - 5,034,736.736   611,727.838   MT  0.99975348   +1 01 06.9
DL7758
DL7758!             -  Elev Factor  x  Scale Factor =   Combined Factor
DL7758!SPC MT       -   0.99977218  x   0.99975633  =   0.99952857
DL7758!UTM  12      -   0.99977218  x   0.99975348  =   0.99952572
DL7758
DL7758_U.S. NATIONAL GRID SPATIAL ADDRESS: 12TXR1172734736(NAD 83)
DL7758
DL7758                           SUPERSEDED SURVEY CONTROL
DL7758
DL7758  NAD 83(CORS)-  45 27 25.98558(N)    109 34 15.58722(W) AD(2002.00) c
DL7758  ELLIP H (05/??/10) 1453.442  (m)                       GP(2002.00) c c
DL7758
DL7758.Superseded values are not recommended for survey control.
DL7758
DL7758.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
DL7758.See file dsdata.txt to determine how the superseded data were derived.
DL7758
DL7758_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
DL7758
DL7758                           STATION DESCRIPTION
DL7758
DL7758'DESCRIBED BY NATIONAL GEODETIC SURVEY 2011
DL7758'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
DL7758'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
DL7758'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DL7758'   ftp://cors.ngs.noaa.gov/cors/README.txt
DL7758'   ftp://cors.ngs.noaa.gov/cors/coord/coord_08
DL7758'   ftp://cors.ngs.noaa.gov/cors/station_log
DL7758'   http://geodesy.noaa.gov/CORS
```

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	06-Aug-16
Station Name	10000	File Name	76827_LGC_080616_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	x
			Session #	1

WGS 84 COORDINATES:

Latitude	45 26 07.9
Longitude	109 48 29.3
Ellipsoidal Height	1466.535

Type of Mark	Rebar and Cap
Mark Stamping	None

Receiver :	
R10	x
R8	
Other, specify	

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :	7:19	Stop Time :	12:07
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 10000

10000 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	08-Aug-16
Station Name	10001	File Name	76827_LGC_080816_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	x
			Session #	1

WGS 84 COORDINATES:

Latitude	45 23 33.2
Longitude	109 45 10.5
Ellipsoidal Height	1756.297

Receiver :	
R10	
R8	x
Other, specify	

Type of Mark	Rebar and Cap
Mark Stamping	None

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :	6:28	Stop Time :	4:00
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

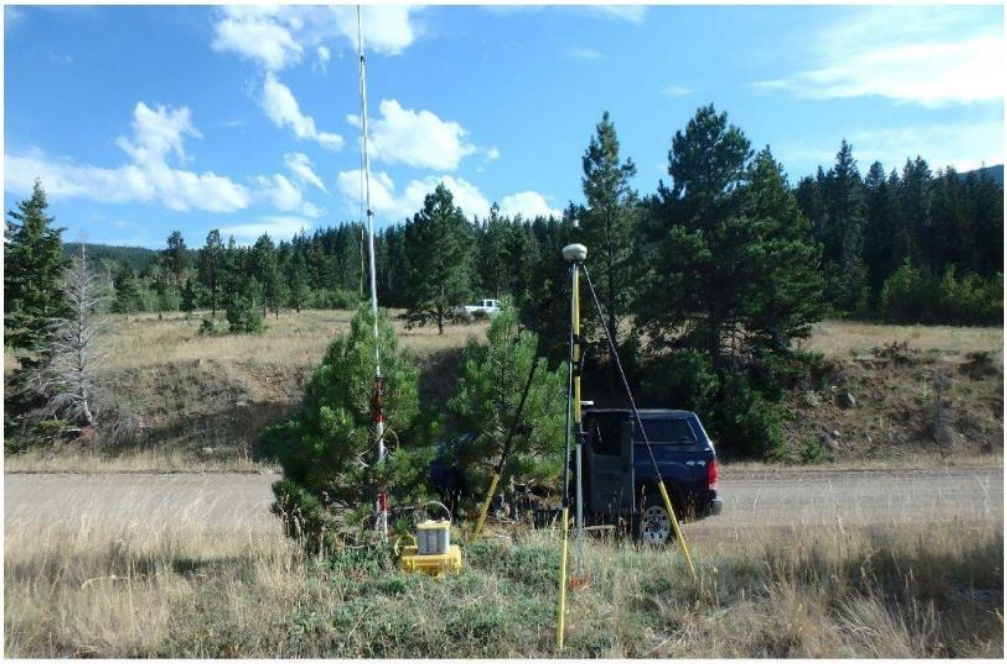
Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 10001



10001 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	09-Aug-16
Station Name	10002	File Name	76827_LGC_080916_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	x
			Session #	1

WGS 84 COORDINATES:

Latitude	45 26 01.9
Longitude	109 56 41.0
Ellipsoidal Height	1944.998

Type of Mark	Rebar and Cap
Mark Stamping	None

Receiver :	
R10	
R8	x
Other, specify	

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :	11:20	Stop Time :	1:35
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

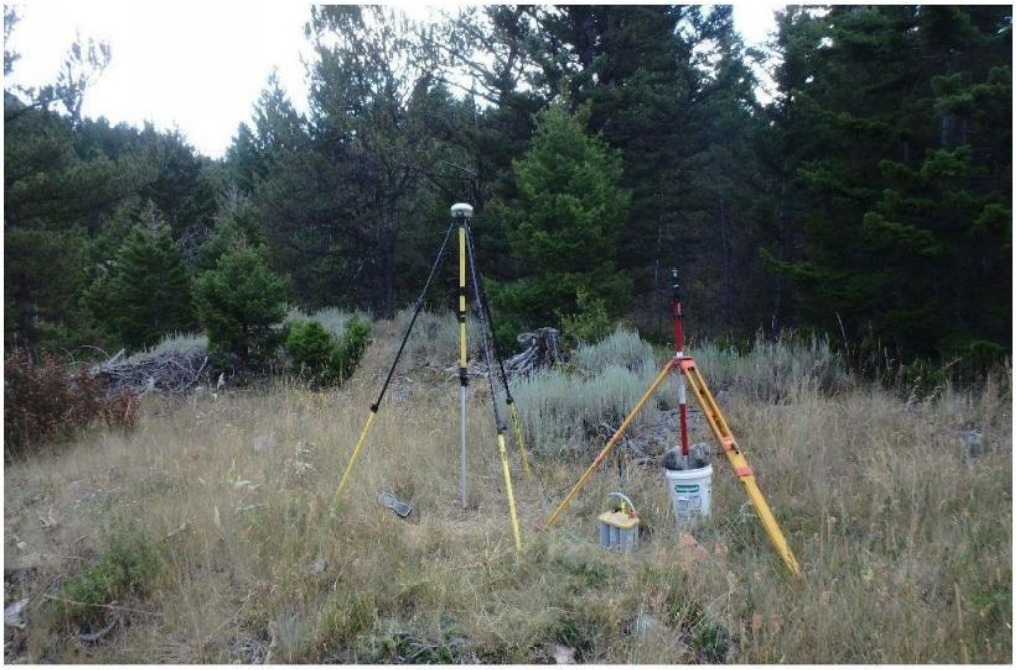
Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 10002



10002 WEST

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	10-Aug-16
Station Name	10003	File Name	76827_LGC_081016_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	x
			Session #	1

WGS 84 COORDINATES:

Latitude	45 24 44.5
Longitude	110 03 56.9
Ellipsoidal Height	2916.549

Type of Mark	Rebar and Cap
Mark Stamping	None

Receiver :	
R10	
R8	x
Other, specify	

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :	2:23	Stop Time :	6:00
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

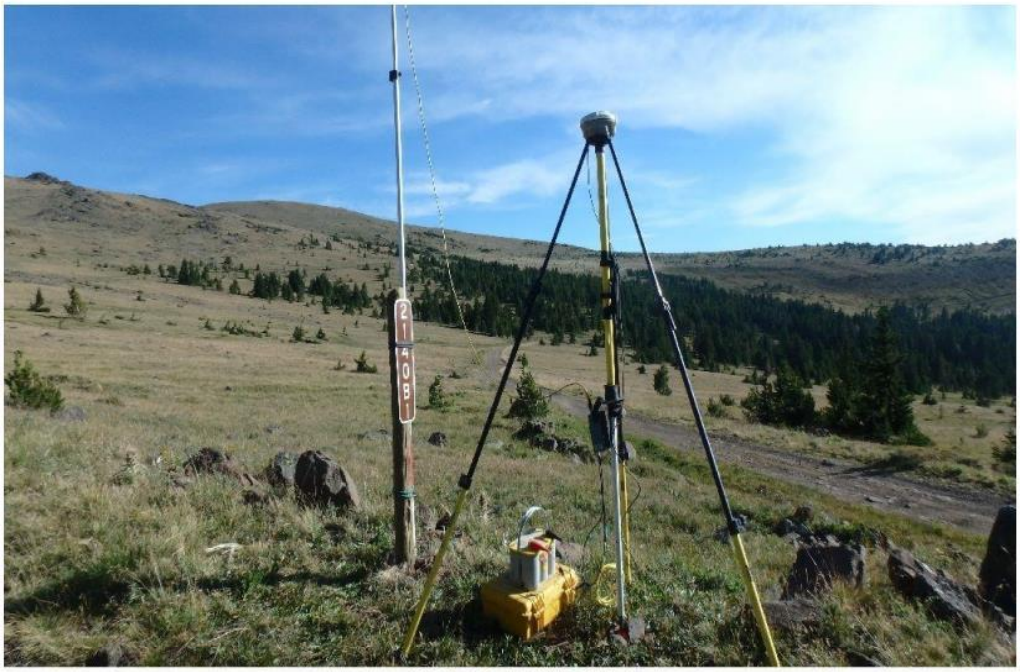
Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 10003



10003 SOUTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	11-Aug-16
Station Name	10004	File Name	76827_LGC_081116_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	x
			Session #	1

WGS 84 COORDINATES:

Latitude	45 28 41.6
Longitude	110 12 26.1
Ellipsoidal Height	1630.405

Type of Mark	Rebar and Cap
Mark Stamping	Federal HWY Admin 2014

Receiver :	
R10	
R8	x
Other, specify	

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :	1:26	Stop Time :	4:44
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

Station: 10004

10004 NORTH

GPS STATION RECOVERY - GPS LOG SHEET

Project Name	Stillwater Complex LiDAR	Operator Name	Eric Noyer
Project Number	76827	Date of Survey	12-Aug-16
Station Name	10005	File Name	76827_LGC_081216_EN

Methodology				
	RTK base		Photo Control Point (PCP)	
	RTK VRS		LiDAR Control Point (LCP)	
	Rapid Static	x	LiDAR QC Point (LQC)	
			Control Station	x
			Session #	1

WGS 84 COORDINATES:

Latitude	45 30 47.4
Longitude	110 06 03.2
Ellipsoidal Height	1862.736

Type of Mark	Rebar and Cap
Mark Stamping	None

Receiver :	
R10	x
R8	
Other, specify	

Antenna Height: 6.562 USFT / 2.000 METERS

Start Time :	9:18	Stop Time :	12:22
PDOP Begin :		PDOP End :	
Start Time :		Stop Time :	
PDOP Begin :		PDOP End :	

Weather Conditions

To Reach Description :

Witness Ties :

Reference Object	Distance	N-E-S-W

Sketch

NORTH

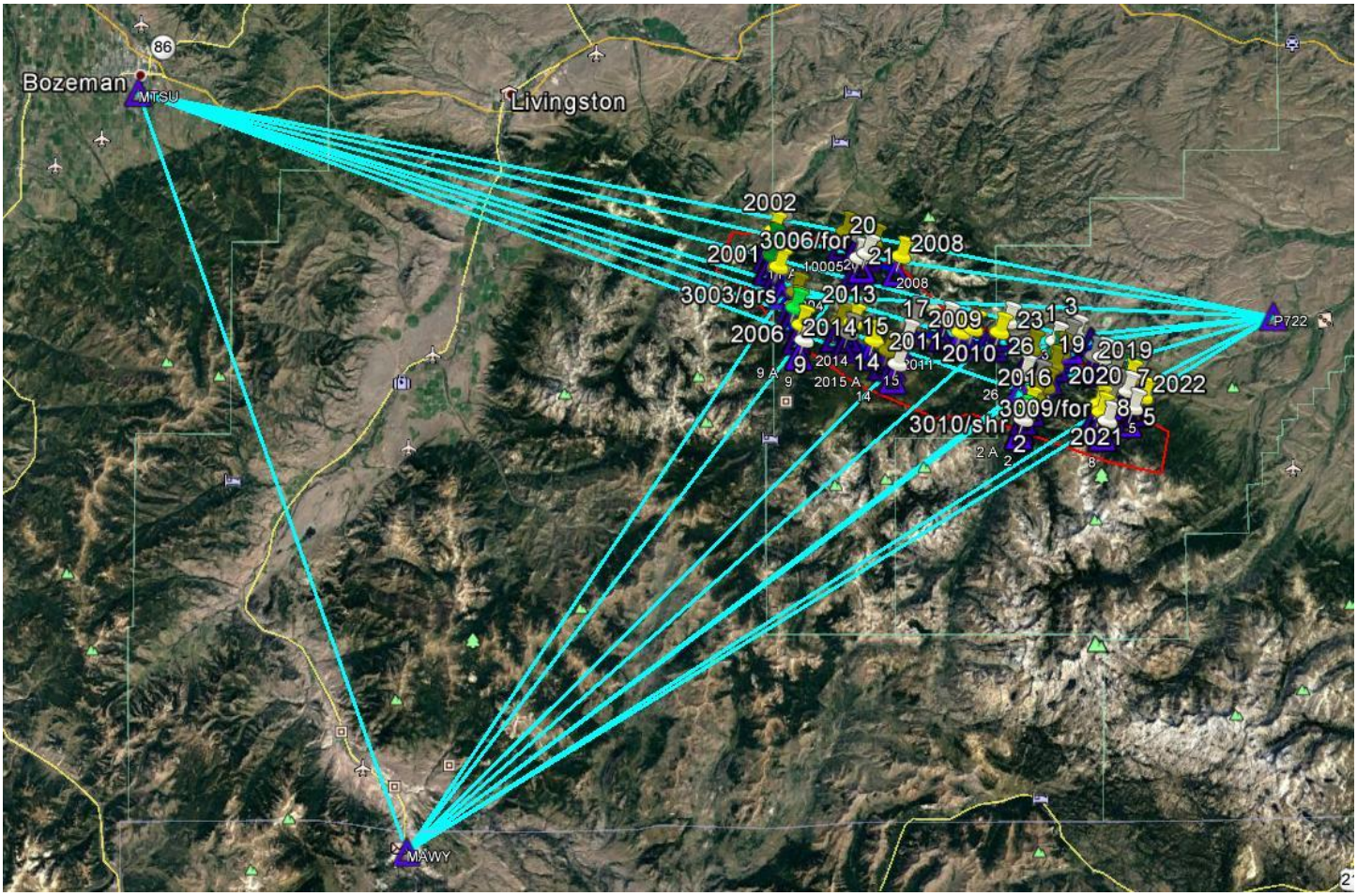
Station: 10005

10005 WEST

Section 5: GPS Control Diagram

This section contains a graphical representation of the new and existing control stations used for the project.

Overview of Control Network



N

Not to Scale