Ground Control Survey Report for the U.S. Geological Survey

Contractor: Woolpert
Date: December 2021
Contract : 140G0221D0013
Task Order: 140G0221F0299
Project Name: Arizona Blackrock Goodwin 2021 D21

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1. Survey Report

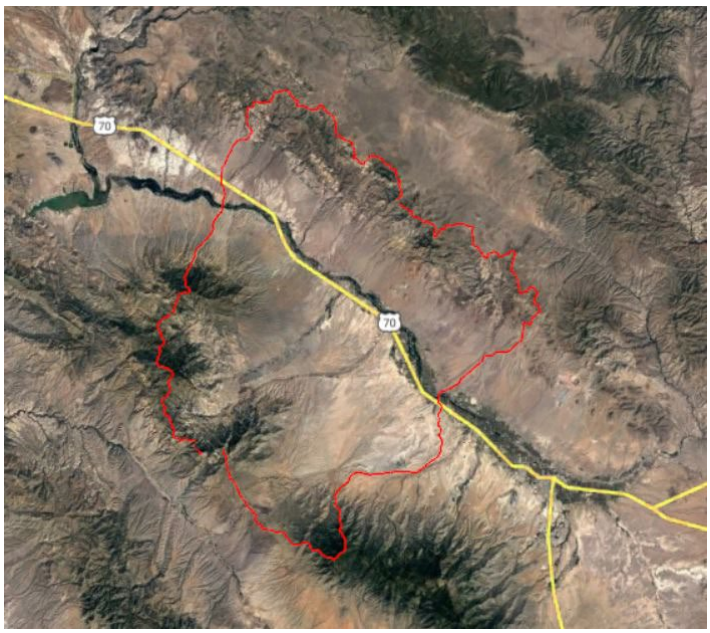
1.1. Introduction

This report contains a comprehensive outline of the Ground Control Survey that supported the lidar data collected for the task order. All survey activity was performed to achieve ground control accuracies that meet or exceed the National Mapping Accuracy Standards (NMAS).

1.2. Project Area

The project area consists of approximately 2035 square kilometers within Graham County, AZ.

Figure 1.2.1 – Defined Project Area



1.3. Purpose

The purpose of this survey was to establish three-dimensional coordinates for 19 lidar control points, 55 non-vegetated checkpoints, and 46 vegetated check points. The points were collected per the flight layout and were uniformly dispersed over the project area.

1.4. Date of Survey

Ground control field operations were conducted from October 7, 2021 to December 12, 2021.

1.5. Monumentation

Prior to aerial imagery acquisition, Woolpert field crews performed a field reconnaissance to verify the existence and suitability of pre-selected existing National Geodetic Survey (NGS) control stations. Existing NSRS control stations were utilized as checks to ensure that quality x, y, z coordinate values were computed for each of the newly established photogrammetric control stations. Recovery information sheets for the

existing NGS control stations can be found in Section 5 of this report. A control diagram can be found in Section 3 of this report.

1.6. Accuracy Standards

The relative vertical accuracy of the LiDAR data will be 10-cm RMSEz with swath overlap (between adjacent swaths) and an absolutevertical accuracy of 15-cm RMSE.

1.7. GPS Equipment

Woolpert survey crews used the following GPS equipment:

- Two (2) Trimble Navigation R8 model 4 dual-frequency GPS receivers
- Two (2) R10 Model GNSS dual- frequency GPS receivers
- Two (2) TSC7 data collectors

1.8. Methodology

1.8.1. Static GPS

The field crew utilized Static GPS surveying throughout the ground control data collection process. The survey was conducted using a 5-second epoch rate with each observation lasting at least 20 minutes. Each station was occupied twice to ensure the required horizontal and vertical accuracies were met.

1.8.2. Real-time Kinematic (RTK) GPS

The field crew utilized Real-Time Kinematic (RTK) GPS surveying throughout the ground control data collection process. The survey was conducted using a 1-second epoch rate, in a fixed solution RTK mode, with each observation lasting between 60 and 180 seconds. Each station was occupied twice to insure the required horizontal and vertical accuracies were met.

1.8.3. GPS Data Analysis and Processing

The field crew chief processed all session baselines each day using Trimble Navigation's Trimble Business Center (TBC) software, version 5.60 baseline processor, with the accompanying broadcast ephemeris. Daily processing ensured the integrity of the network as it was constructed and allowing the field crews to immediately reschedule observations of any poor baselines.

1.8.4. Datum Reference and Final Coordinates

The spatial reference system for the project is NAD83 2011 (2010.00 epoch). Orthometric heights are based on NAVD88 vertical datum. Geoid18 was used to determine the orthometric heights from the ellipsoid heights. The projected coordinates are displayed in Universal Transverse Mercator, Zone 12 North (UTM12N). Units for both the horizontal and vertical datums are expressed in meters to three (3) decimal places.

1.8.5. Quality Assurance

Existing NGS published benchmarks were surveyed to assure that there were no discrepancies in the field observation data. Close examinations of the residuals showed no distortions in orientation or scale. Ground control data meets positional accuracies necessary to support 1.0-point per 0.3-meters squared (1-foot Ground Sampling Distance (GSD)) data at 95% confidence level as outlined in the Federal Geographic Data Committee *"Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA)", (FGDC-STD-007.3-1998)*.

2. Ground Control/Geodetic Control Coordinates

2.1. Geodetic Control – Worldwide UTM

- Horizontal Datum: NAD 1983 (Conus) 2011
- Horizontal Projection: UTM 12 North
- Vertical Datum: NAVD88
- Geoid Model: Geoid18 (Conus)
- Units: Meters

Table 2.1 Geodetic Control -Worldwide UTM

Point Number	UTM 12N Northing (M)	UTM 12N Easting (M)	Orthometric Height (M)	Description
BLACK	3651294.771	598398.039	863.030	NA
Q 438	3670994.685	580079.89	785.207	DU1114
VS 6	3635660.143	585388.791	1250.358	CZ2447

2.2. Ground Control- Worldwide UTM

- Horizontal Datum: NAD 1983 (Conus)
- Vertical Datum: NAVD88
- Units: Meters

Table 2.2 Ground Control -Worldwide UTM

Point Number	UTM 12N Northing (M)	UTM 12N Easting (M)	Orthometric Height (M)	Description
1001_2021_AZ	3676762.692	571489.847	861.764	LCP
1002_2021_AZ	3673471.877	576152.758	813.449	LCP
1003_2021_AZ	3669292.722	580189.325	796.576	LCP
1004_2021_AZ	3666101.737	582185.980	801.745	LCP
1005_2021_AZ	3661809.531	587103.931	808.248	LCP
1006_2021_AZ	3659672.872	591494.771	819.976	LCP
1007_2021_AZ	3656388.548	595444.628	823.704	LCP
1008_2021_AZ	3652378.170	598443.875	830.778	LCP
1009_2021_AZ	3647450.179	600985.738	839.986	LCP
1010_2021_AZ	3643539.591	604908.101	852.917	LCP
1011_2021_AZ	3636767.976	604643.264	945.700	LCP
1012_2021_AZ	3629723.658	575688.139	1486.830	LCP
1013_2021_AZ	3631764.313	577646.368	1490.588	LCP
1014_2021_AZ	3632971.855	580234.035	1419.543	LCP
1015_2021_Az	3633863.403	582402.859	1353.103	LCP
1016_2021_AZ	3635092.335	583298.344	1322.336	LCP
1017_2021_AZ	3635898.152	585634.289	1234.155	LCP
1018_2021_AZ	3636233.137	587907.063	1152.429	LCP
1019_2021_AZ	3637200.813	589938.350	1077.992	LCP

Point Number	UTM 12N Northing (M)	UTM 12N Easting (M)	Orthometric Height (M)	Description
2001_2021_AZ	3645696.373	604327.035	848.699	NVA
2002_2021_AZ	3658154.156	604346.006	1044.796	NVA
2003_2021_AZ	3668115.794	601924.562	1433.637	NVA
2004_2021_AZ	3670298.685	594431.225	1264.511	NVA
2005_2021_AZ	3675914.301	572707.263	867.330	NVA
2006_2021_AZ	3671394.936	573142.290	787.672	NVA
2006A_2021_AZ	3663643.698	575538.310	1206.465	NVA
2007_2021_AZ	3648563.992	576554.446	1026.396	NVA
2008_2021_AZ	3646610.743	575160.095	1148.211	NVA
2009_2021_AZ	3627849.622	579756.014	1415.788	NVA
2010_2021_AZ	3625355.235	587187.967	1899.526	NVA
2011_2021_AZ	3629765.980	588862.124	1359.299	NVA
2012_2021_AZ	3648224.176	585422.346	975.053	NVA
2013_2021_AZ	3669859.225	579085.934	791.659	NVA
2013A_2021_AZ	3660637.772	580789.269	997.067	NVA
2014_2021_AZ	3674815.462	591293.090	1213.717	NVA
2015_2021_AZ	3635140.264	583303.202	1322.980	NVA
2016_2021_AZ	3631315.715	576481.644	1547.547	NVA
2017_2021_AZ	3635005.872	587779.046	1162.160	NVA
2018_2021_AZ	3639839.569	593090.343	1004.122	NVA
2019_2021_AZ	3643324.075	596801.796	928.491	NVA
2020_2021_AZ	3653373.458	604579.660	899.209	NVA
2021_2021_AZ	3650083.041	599653.119	836.129	NVA
2022_2021_AZ	3655545.992	597166.116	827.547	NVA
2023_2021_AZ	3657981.642	593516.850	820.767	NVA
2024_2021_AZ	3660566.830	589431.065	822.640	NVA
2025_2021_AZ	3663884.171	584633.899	806.904	NVA
2026_2021_AZ	3668411.510	581349.458	788.271	NVA
2027_2021_AZ	3671993.136	578452.052	787.302	NVA
2028_2021_AZ	3674750.233	574197.521	831.709	NVA
2029_2021_AZ	3656237.325	602677.813	953.769	NVA
2030_2021_AZ	3654624.749	601973.580	887.272	NVA
2031_2021_AZ	3649165.881	603010.245	840.616	NVA
2032_2021_AZ	3667323.179	598720.503	1240.054	NVA
2033_2021_AZ	3664492.311	597548.888	1147.788	NVA
2034_2021_AZ	3662092.828	596527.417	1018.641	NVA
2035_2021_AZ	3659296.976	596734.756	891.284	NVA
2036_2021_AZ	3668707.203	593650.942	1158.754	NVA
2037_2021_AZ	3666570.040	592791.201	1045.927	NVA
2038_2021_AZ	3665374.105	591609.245	969.801	NVA
2039_2021_AZ	3663873.652	590994.898	901.682	NVA
2040_2021_AZ	3672937.936	589723.596	1185.627	NVA

Point Number	UTM 12N Northing (M)	UTM 12N Easting (M)	Orthometric Height (M)	Description
2041_2021_AZ	3672060.228	589152.229	1156.839	NVA
2042_2021_AZ	3671228.526	589166.448	1148.226	NVA
2043_2021_AZ	3671457.452	574857.406	782.416	NVA
2043A_2021_AZ	3664533.254	576983.841	1117.215	NVA
2044_2021_AZ	3670982.627	577507.283	793.623	NVA
2044A_2021_AZ	3665844.048	579417.015	929.806	NVA
2045_2021_AZ	3670995.549	580061.065	785.059	NVA
2045A_2021_AZ	3662585.689	582713.514	878.131	NVA
2046_2021_AZ	3652835.920	591407.902	919.374	NVA
2047_2021_AZ	3674091.661	590687.033	1193.283	NVA
2048_2021_AZ	3650721.958	588875.385	958.056	NVA
2049_2021_AZ	3652316.856	601368.244	836.342	NVA
2050_2021_AZ	3649102.621	600155.899	836.774	NVA
3001_2021_AZ	3650332.222	602978.784	850.492	VVA
3002_2021_AZ	3655538.527	597107.777	828.304	VVA
3003_2021_AZ	3650743.566	599234.445	834.571	VVA
3004_2021_AZ	3668146.859	601923.239	1432.623	VVA
3004A_2021_AZ	3625156.773	587589.857	1971.537	VVA
3005_2021_AZ	3624572.662	588619.165	2081.404	VVA
3006_2021_AZ	3626655.839	587698.852	1634.119	VVA
3007_2021_AZ	3666943.980	603942.137	1652.778	VVA
3008_2021_AZ	3667339.078	598743.030	1241.741	VVA
3009_2021_AZ	3675498.412	573320.490	840.423	VVA
3010_2021_AZ	3646621.678	575207.841	1146.207	VVA
3011_2021_AZ	3671387.895	573118.689	787.928	VVA
3011A_2021_AZ	3672696.176	589547.867	1206.336	VVA
3011A_2021_AZ	3663639.865	575538.675	1206.416	VVA
3012_2021_AZ	3669885.091	579077.550	791.050	VVA
3012A_2021_AZ	3660826.179	580873.860	992.323	VVA
3013_2021_AZ	3658146.973	604315.056	1043.566	VVA
3014_2021_AZ	3650712.813	588892.107	957.944	VVA
3015_2021_AZ	3663870.916	591015.170	902.109	VVA
3016_2021_AZ	3635163.938	583331.328	1322.872	VVA
3017_2021_AZ	3631357.887	576488.937	1546.348	VVA
3018_2021_AZ	3639816.862	593086.201	1004.786	VVA
3019_2021_AZ	3668496.574	581340.913	786.857	VVA
3020_2021_AZ	3635012.674	587800.725	1162.587	VVA
3021_2021_AZ	3627848.067	579780.626	1417.294	VVA
3022_2021_AZ	3643298.369	596806.222	928.477	VVA
3023_2021_AZ	3653369.760	604561.359	899.349	VVA
3024_2021_AZ	3656233.225	602653.979	953.504	VVA
3025_2021_AZ	3666556.379	592794.836	1045.024	VVA

Point Number	UTM 12N Northing (M)	UTM 12N Easting (M)	Orthometric Height (M)	Description
3026_2021_AZ	3671470.025	574843.582	781.959	VVA
3026A_2021_AZ	3664539.125	576980.980	1117.522	VVA
3027_2021_AZ	3671007.741	577501.509	793.285	VVA
3027A_2021_AZ	3665836.035	579402.694	930.082	VVA
3028_2021_AZ	3670316.793	594425.654	1264.730	VVA
3029_2021_AZ	3668620.584	593581.984	1163.300	VVA
3030_2021_AZ	3662157.027	596497.167	1021.192	VVA
3031_2021_AZ	3672003.669	578439.482	788.291	VVA
3032_2021_AZ	3660510.214	589477.558	823.462	VVA
3033_2021_AZ	3663371.050	585378.880	814.712	VVA
3034_2021_AZ	3656886.895	596467.724	817.519	VVA
3035_2021_AZ	3648230.346	585434.177	974.769	VVA
3036_2021_AZ	3648546.462	576550.122	1025.861	VVA
3037_2021_AZ	3655646.653	596414.011	831.565	VVA
3038_2021_AZ	3652346.584	601361.667	836.216	VVA
3039_2021_AZ	3644101.480	603998.358	848.858	VVA
3040_2021_AZ	3671570.936	575611.312	778.817	VVA

2.3. Geodetic Control- Geodetic Coordinate System NAD83

- Horizontal Datum: NAD 1983 (Conus) 2011
- Horizontal Projection: 12N
- Vertical Datum: NAVD88
- Geoid Model: Geoid18 (Conus)
- Units: Meters

Table 2.3 Ground Control - Geodetic Coordinate System NAD83

Point Number	NAD83 (Conus) Latitude (N)	NAD83 (Conus) Longitude (W)	Ellipsoid Height (M)	Description
BLACK	32°59'44.25921"	-109°56'48.27354"	835.875	NA
Q 438	33°10'29.30142"	-110°08'27.86692"	758.157	DU1114
VS 6	32°51'20.55845"	-110°05'14.73576"	1223.571	CZ2447

2.4. Ground Control-Geodetic Coordinate System NAD83

- Horizontal Datum: NAD 1983 (Conus)
- Vertical Datum: NAVD88
- Units: Meters

Table 2.4 Ground Control -Geodetic Coordinate System NAD83

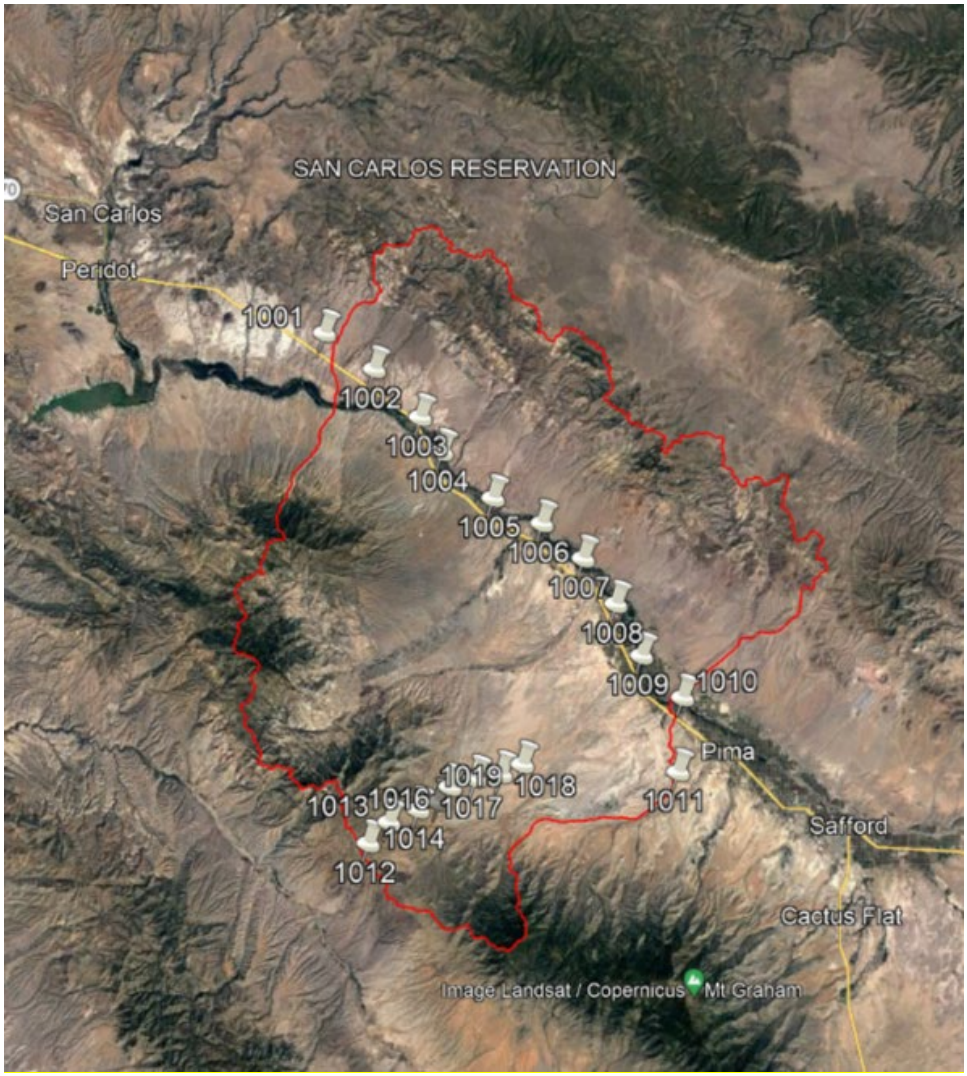
Point Number	NAD83 (Conus) Latitude (N)	NAD83 (Conus) Longitude (W)	Ellipsoid Height (M)	Description
1001_2021_AZ	33°13'38.75050"	-110°13'57.89466"	834.685	LCP
1002_2021_AZ	33°11'50.75396"	-110°10'58.74535"	786.379	LCP
1003_2021_AZ	33°09'34.01155"	-110°08'24.18132"	769.515	LCP
1004_2021_AZ	33°07'49.86535"	-110°07'08.14129"	774.694	LCP
1005_2021_AZ	33°05'29.12174"	-110°03'59.83483"	781.173	LCP
1006_2021_AZ	33°04'18.44826"	-110°01'11.24222"	792.909	LCP
1007_2021_AZ	33°02'30.59005"	-109°58'40.15792"	796.629	LCP
1008_2021_AZ	33°00'19.41994"	-109°56'46.08933"	803.651	LCP
1009_2021_AZ	32°57'38.58201"	-109°55'10.09358"	812.811	LCP
1010_2021_AZ	32°55'30.28315"	-109°52'40.63538"	825.773	LCP
1011_2021_AZ	32°51'50.51582"	-109°52'53.59502"	918.587	LCP
1012_2021_AZ	32°48'10.36224"	-110°11'29.67333"	1460.056	LCP
1013_2021_AZ	32°49'16.13181"	-110°10'13.76755"	1463.871	LCP
1014_2021_AZ	32°49'54.67107"	-110°08'33.88025"	1392.842	LCP
1015_2021_Az	32°50'23.04094"	-110°07'10.18131"	1326.383	LCP
1016_2021_AZ	32°51'02.70101"	-110°06'35.33962"	1295.593	LCP
1017_2021_AZ	32°51'28.21759"	-110°05'05.21211"	1207.359	LCP
1018_2021_AZ	32°51'38.44637"	-110°03'37.66226"	1125.574	LCP
1019_2021_AZ	32°52'09.27262"	-110°02'19.17629"	1051.054	LCP
2001_2021_AZ	32°56'40.50879"	-109°53'02.12552"	821.575	NVA
2002_2021_AZ	33°03'24.97120"	-109°52'56.29769"	1018.139	NVA
2003_2021_AZ	33°08'49.22172"	-109°54'25.65510"	1407.394	NVA
2004_2021_AZ	33°10'02.53907"	-109°59'14.04672"	1238.033	NVA
2005_2021_AZ	33°13'10.91140"	-110°13'11.10647"	840.254	NVA
2006_2021_AZ	33°10'44.06524"	-110°12'55.61052"	760.534	NVA
2006A_2021_AZ	33°06'31.79497"	-110°11'25.40847"	1179.571	NVA
2007_2021_AZ	32°58'21.90333"	-110°10'50.74098"	999.553	NVA
2008_2021_AZ	32°57'18.82981"	-110°11'45.02834"	1121.396	NVA
2009_2021_AZ	32°47'08.47387"	-110°08'53.85194"	1389.113	NVA
2010_2021_AZ	32°45'45.44738"	-110°04'09.01171"	1873.148	NVA
2011_2021_AZ	32°48'08.18183"	-110°03'03.15413"	1332.721	NVA
2012_2021_AZ	32°58'08.49912"	-110°05'09.25464"	948.038	NVA
2013_2021_AZ	33°09'52.69741"	-110°09'06.59805"	764.590	NVA
2013A_2021_AZ	33°04'52.83331"	-110°08'03.78014"	970.108	NVA
2014_2021_AZ	33°12'30.15708"	-110°01'13.56127"	1187.271	NVA
2015_2021_AZ	32°51'04.25593"	-110°06'35.13720"	1296.235	NVA
2016_2021_AZ	32°49'01.85998"	-110°10'58.69150"	1520.809	NVA
2017_2021_AZ	32°50'58.63432"	-110°03'43.00670"	1135.345	NVA
2018_2021_AZ	32°53'34.00221"	-110°00'16.94574"	977.020	NVA

Point Number	NAD83 (Conus) Latitude (N)	NAD83 (Conus) Longitude (W)	Ellipsoid Height (M)	Description
2019_2021_AZ	32°55'25.97935"	-109°57'52.79480"	901.273	NVA
2020_2021_AZ	33°00'49.67567"	-109°52'49.25305"	872.328	NVA
2021_2021_AZ	32°59'04.50645"	-109°56'00.39004"	808.972	NVA
2022_2021_AZ	33°02'02.68545"	-109°57'34.11743"	800.488	NVA
2023_2021_AZ	33°03'22.91758"	-109°59'53.88733"	793.695	NVA
2024_2021_AZ	33°04'48.09221"	-110°02'30.51052"	795.563	NVA
2025_2021_AZ	33°06'37.18598"	-110°05'34.41756"	779.842	NVA
2026_2021_AZ	33°09'05.08816"	-110°07'39.68052"	761.219	NVA
2027_2021_AZ	33°11'02.14924"	-110°09'30.40694"	760.241	NVA
2028_2021_AZ	33°12'32.75043"	-110°12'13.88054"	804.632	NVA
2029_2021_AZ	33°02'23.30901"	-109°54'01.38836"	926.942	NVA
2030_2021_AZ	33°01'31.19152"	-109°54'29.18072"	860.341	NVA
2031_2021_AZ	32°58'33.60529"	-109°53'51.43133"	813.529	NVA
2032_2021_AZ	33°08'24.55589"	-109°56'29.62395"	1213.632	NVA
2033_2021_AZ	33°06'53.02725"	-109°57'15.92856"	1121.171	NVA
2034_2021_AZ	33°05'35.45094"	-109°57'56.25083"	991.857	NVA
2035_2021_AZ	33°04'04.60988"	-109°57'49.31819"	864.371	NVA
2036_2021_AZ	33°09'11.11158"	-109°59'44.75815"	1132.162	NVA
2037_2021_AZ	33°08'01.98917"	-110°00'18.72586"	1019.188	NVA
2038_2021_AZ	33°07'23.52159"	-110°01'04.76988"	942.952	NVA
2039_2021_AZ	33°06'34.99104"	-110°01'29.01322"	874.744	NVA
2040_2021_AZ	33°11'29.67118"	-110°02'14.84676"	1159.028	NVA
2041_2021_AZ	33°11'01.34400"	-110°02'37.22017"	1130.172	NVA
2042_2021_AZ	33°10'34.33618"	-110°02'36.96451"	1121.524	NVA
2043_2021_AZ	33°10'45.67287"	-110°11'49.36840"	755.301	NVA
2043A_2021_AZ	33°07'00.31254"	-110°10'29.36864"	1090.269	NVA
2044_2021_AZ	33°10'29.58417"	-110°10'07.19772"	766.539	NVA
2044A_2021_AZ	33°07'42.24136"	-110°08'55.07617"	902.791	NVA
2045_2021_AZ	33°10'29.33450"	-110°08'28.59346"	758.009	NVA
2045A_2021_AZ	33°05'55.55884"	-110°06'48.93081"	851.101	NVA
2046_2021_AZ	33°00'36.48975"	-110°01'17.04768"	892.208	NVA
2047_2021_AZ	33°12'06.84068"	-110°01'37.22888"	1166.777	NVA
2048_2021_AZ	32°59'28.60638"	-110°02'55.37832"	930.930	NVA
2049_2021_AZ	33°00'16.46371"	-109°54'53.42922"	809.296	NVA
2050_2021_AZ	32°58'32.50854"	-109°55'41.40565"	809.609	NVA
3001_2021_AZ	32°59'11.48409"	-109°53'52.17266"	823.437	VVA
3002_2021_AZ	33°02'02.46182"	-109°57'36.36899"	801.244	VVA
3003_2021_AZ	32°59'26.08975"	-109°56'16.26218"	807.420	VVA
3004_2021_AZ	33°08'50.23077"	-109°54'25.69363"	1406.382	VVA
3004A_2021_AZ	32°45'38.88828"	-110°03'53.63460"	1945.181	VVA
3005_2021_AZ	32°45'19.62516"	-110°03'14.28010"	2055.113	VVA

Point Number	NAD83 (Conus) Latitude (N)	NAD83 (Conus) Longitude (W)	Ellipsoid Height (M)	Description
3006_2021_AZ	32°46'27.53199"	-110°03'48.93643"	1607.704	VVA
3007_2021_AZ	33°08'10.48706"	-109°53'08.26919"	1626.561	VVA
3008_2021_AZ	33°08'25.06470"	-109°56'28.74840"	1215.320	VVA
3009_2021_AZ	33°12'57.25865"	-110°12'47.53855"	813.349	VVA
3010_2021_AZ	32°57'19.17304"	-110°11'43.18622"	1119.392	VVA
3011_2021_AZ	33°10'43.84234"	-110°12'56.52386"	760.789	VVA
3011A_2021_AZ	33°11'21.87421"	-110°02'21.71836"	1179.718	VVA
3011A_2021_AZ	33°06'31.67042"	-110°11'25.39554"	1179.522	VVA
3012_2021_AZ	33°09'53.53945"	-110°09'06.91363"	763.981	VVA
3012A_2021_AZ	33°04'58.92809"	-110°08'00.45760"	965.360	VVA
3013_2021_AZ	33°03'24.74868"	-109°52'57.49390"	1016.907	VVA
3014_2021_AZ	32°59'28.30454"	-110°02'54.73727"	930.818	VVA
3015_2021_AZ	33°06'34.89606"	-110°01'28.23213"	875.172	VVA
3016_2021_AZ	32°51'05.01692"	-110°06'34.04756"	1296.127	VVA
3017_2021_AZ	32°49'03.22750"	-110°10'58.39851"	1519.611	VVA
3018_2021_AZ	32°53'33.26621"	-110°00'17.11340"	977.685	VVA
3019_2021_AZ	33°09'07.85240"	-110°07'39.98302"	759.805	VVA
3020_2021_AZ	32°50'58.84893"	-110°03'42.17046"	1135.771	VVA
3021_2021_AZ	32°47'08.41692"	-110°08'52.90631"	1390.619	VVA
3022_2021_AZ	32°55'25.14332"	-109°57'52.63413"	901.260	VVA
3023_2021_AZ	33°00'49.56192"	-109°52'49.95982"	872.466	VVA
3024_2021_AZ	33°02'23.18400"	-109°54'02.30878"	926.677	VVA
3025_2021_AZ	33°08'01.54452"	-110°00'18.59059"	1018.284	VVA
3026_2021_AZ	33°10'46.08453"	-110°11'49.89846"	754.843	VVA
3026A_2021_AZ	33°07'00.50389"	-110°10'29.47723"	1090.576	VVA
3027_2021_AZ	33°10'30.40109"	-110°10'07.41294"	766.201	VVA
3027A_2021_AZ	33°07'41.98498"	-110°08'55.63130"	903.067	VVA
3028_2021_AZ	33°10'03.12873"	-109°59'14.25500"	1238.253	VVA
3029_2021_AZ	33°09'08.32072"	-109°59'47.45184"	1136.701	VVA
3030_2021_AZ	33°05'37.54503"	-109°57'57.39324"	994.409	VVA
3031_2021_AZ	33°11'02.49451"	-110°09'30.88905"	761.230	VVA
3032_2021_AZ	33°04'46.24019"	-110°02'28.73737"	796.385	VVA
3033_2021_AZ	33°06'20.31551"	-110°05'05.84849"	787.648	VVA
3034_2021_AZ	33°02'46.44538"	-109°58'00.52932"	790.490	VVA
3035_2021_AZ	32°58'08.69611"	-110°05'08.79684"	947.755	VVA
3036_2021_AZ	32°58'21.33523"	-110°10'50.91279"	999.019	VVA
3037_2021_AZ	33°02'06.19454"	-109°58'03.06984"	804.491	VVA
3038_2021_AZ	33°00'17.43110"	-109°54'53.67083"	809.172	VVA
3039_2021_AZ	32°55'48.83943"	-109°53'15.42995"	821.703	VVA
3040_2021_AZ	33°10'49.16888"	-110°11'20.22474"	751.710	VVA

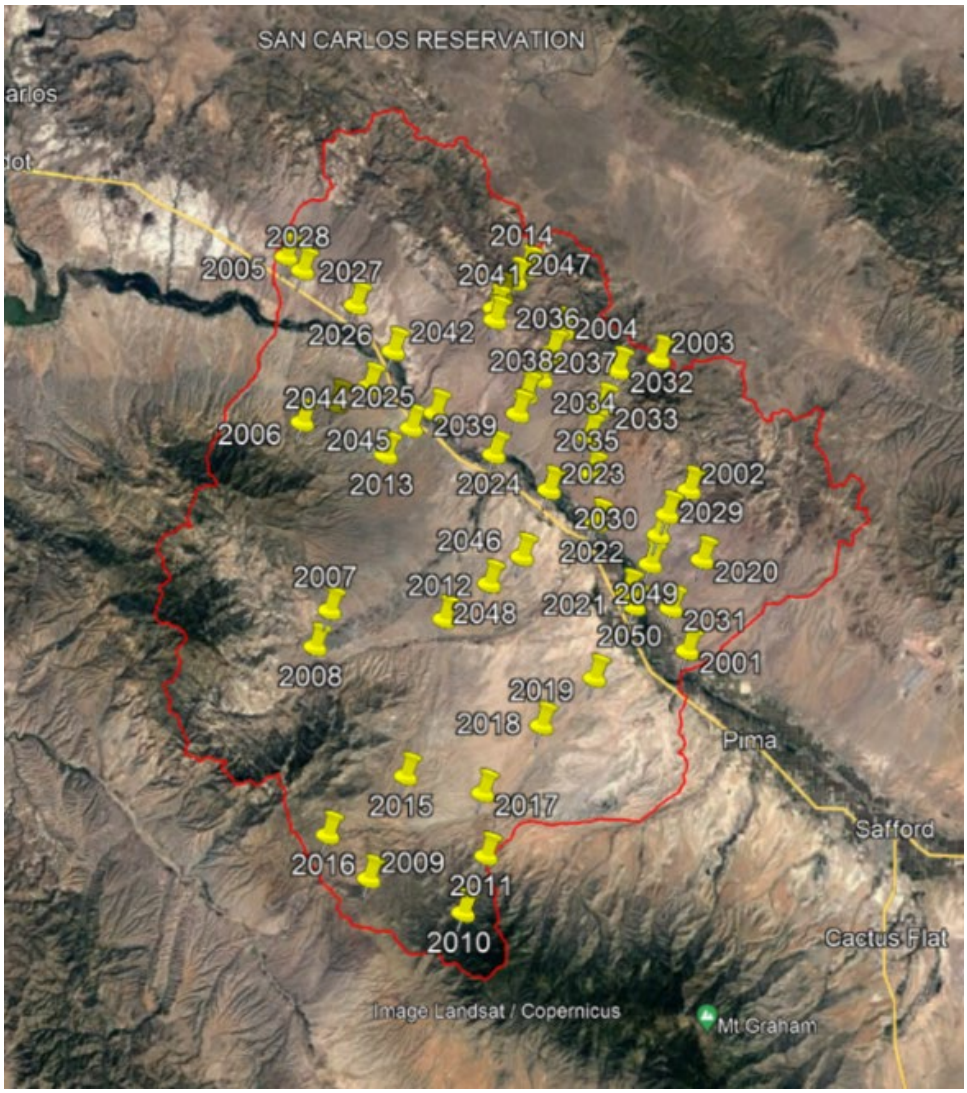
3. GPS Control Diagram

Image 3.1 Overview of the Lidar Control Network



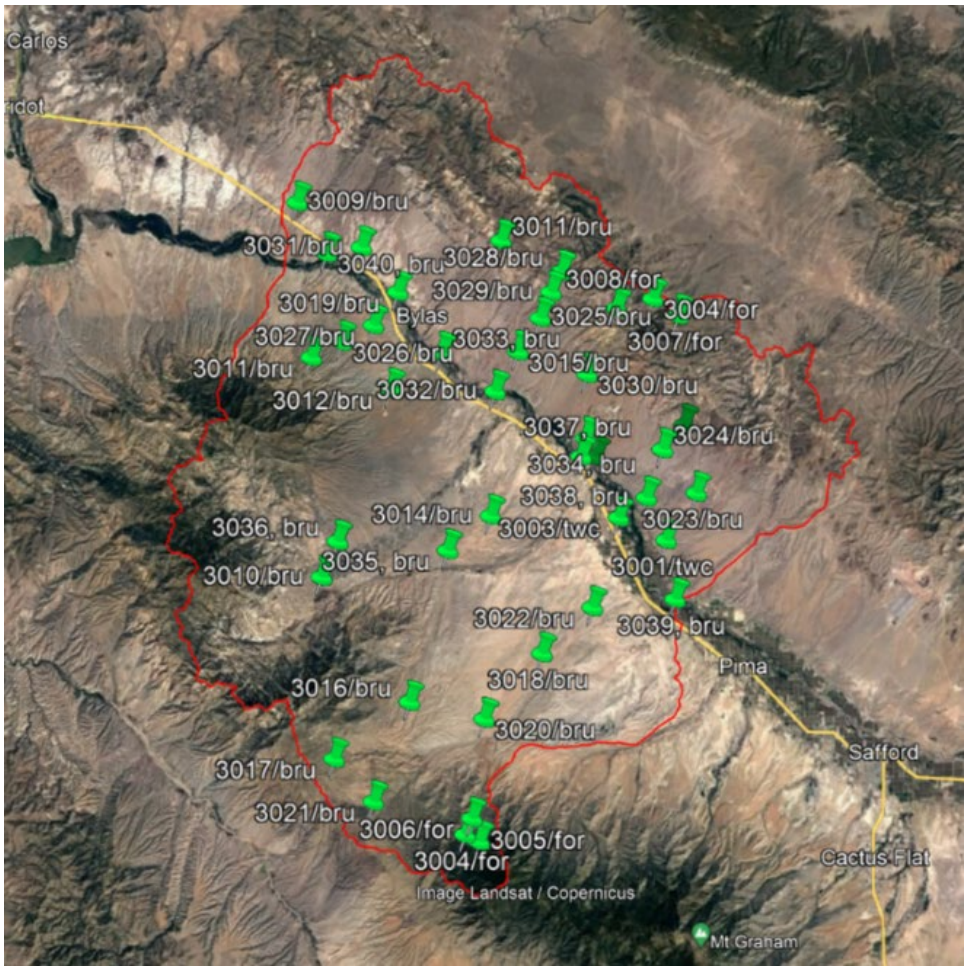
N
Not to Scale

Image 3.2 Overview of the Lidar NVA Network



N
Not to Scale

Image 3.3 Overview of the Lidar VVA Network



N
Not to Scale

4. NGS Datasheets

Below are the published National Geodetic Survey (NGS) datasheets for those existing monumented control stations used to establish 3-dimensional coordinates for each of the newly established project ground control survey points.

4.1. NGS Data Sheet for Black

```
**********************************************************************
 DESIGNATION -BLACK
 PID         -CY0744
 STATE/COUNTY-AZ/GRAHAM
 COUNTRY     -US
 USGS QUAD   -EDEN (2018)

                        *CURRENT SURVEY CONTROL

 ______________________________________________________________________
  NAD 83(1992) POSITION- 32 59 44.25758(N) 109 56 48.27164(W)   ADJUSTED
  NAVD 88 ORTHO HEIGHT -   863.025 (meters)     2831.44  (feet) ADJUSTED
 ______________________________________________________________________
 GEOID HEIGHT    -        -27.155 (meters)                     GEOID18
 LAPLACE CORR    -          2.05  (seconds)                    DEFLEC18
 DYNAMIC HEIGHT  -        861.836 (meters)     2827.54  (feet) COMP
 MODELED GRAVITY -    979,233.1   (mgal)                       NAVD 88

 HORZ ORDER      -  FIRST
 VERT ORDER      -  FIRST     CLASS II

 The horizontal coordinates were established by classical geodetic methods
 and adjusted by the National Geodetic Survey in August 1993.

 The orthometric height was determined by differential leveling and
 adjusted by the NATIONAL GEODETIC SURVEY
 in June 1991.

 Significant digits in the geoid height do not necessarily reflect accuracy.
 GEOID18 height accuracy estimate available here.

 Click photographs - Photos may exist for this station.

 The Laplace correction was computed from DEFLEC18 derived deflections.

 The dynamic height is computed by dividing the NAVD 88
 geopotential number by the normal gravity value computed on the
 Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 degrees latitude (g = 980.6199 gals.).

 The modeled gravity was interpolated from observed gravity values.

  The following values were computed from the NAD 83(1992) position.
```

```
                     North          East      Units Scale Factor Converg.
SPC AZ E      -   221,288.097   233,911.635   MT  0.99990521   +0 07 11.2
SPC AZ E      -   726,010.82    767,426.62   iFT  0.99990521   +0 07 11.2
UTM  12       - 3,651,294.721   598,398.089   MT  0.99971938   +0 34 25.0

              -  Elev Factor  x  Scale Factor =   Combined Factor
SPC AZ E      -   0.99986878  x   0.99990521  =   0.99977401
UTM  12       -   0.99986878  x   0.99971938  =   0.99958820

                 Primary Azimuth Mark                     Grid Az
SPC AZ E      -  DIAMOND                                  339 04 44.7
UTM  12       -  DIAMOND                                  338 37 30.9

U.S. NATIONAL GRID SPATIAL ADDRESS: 12SWB9839851294(NAD 83)

|-----------------------------------------------------------------------|
PID    Reference Object                     Distance      Geod. Az  |
                                                          dddmmss.s |
DT0780 PEAK TARGET 5 1/2 MI NW SEEP       APPROX.15.0 KM 0174310.9 |
CC5934 HIGHWAY 70 STA 3381+13                            0591009.7 |
CY0568 J 15                                              0601356.4 |
CY1245 HOT SPRINGS HOTEL BELFRY           APPROX. 4.4 KM 0861657.8 |
CY0745 BLACK RM 1                          10.024 METERS 16124     |
CZ1759 WEST PEAK LOOKOUT TOWER            APPROX.29.9 KM 1964433.4 |
CY0746 BLACK RM 2                          11.202 METERS 24755     |
DU1949 DIAMOND                            APPROX.22.4 KM 3391155.9 |
DT0781 FORT THOMAS SCHOOLHOUSE BELFRY     APPROX. 4.7 KM 3391442.3 |
DT0785 GILA PEAK TARGET                   APPROX.22.0 KM 3584322.1 |
|-----------------------------------------------------------------------|

                        SUPERSEDED SURVEY CONTROL

NAD 83(1986)-  32 59 44.25343(N)    109 56 48.27262(W) AD(       ) 1
NAD 27      -  32 59 44.03400(N)    109 56 45.97100(W) AD(       ) 1
NGVD 29             862.33   (m)          2829.2    (f) LEVELING    3
NGVD 29 (07/19/86)  862.7    (m)          2830.     (f) VERT ANG

Superseded values are not recommended for survey control.

NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
See file dsdata.pdf to determine how the superseded data were derived.

MARKER: DS = TRIANGULATION STATION DISK
SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
STAMPING: BLACK 1945
MARK LOGO: CGS
PROJECTION: PROJECTING 10 CENTIMETERS
STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
STABILITY: SURFACE MOTION
SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
SATELLITE: SATELLITE OBSERVATIONS - January 24, 2016
```

HISTORY	- Date	Condition	Report By
HISTORY	- 1945	MONUMENTED	CGS
HISTORY	- 1960	GOOD	CGS
HISTORY	- 1968	GOOD	AMS
HISTORY	- 1979	GOOD	NGS
HISTORY	- 1985	GOOD	AZDT
HISTORY	- 20081009	GOOD	GEOCAC
HISTORY	- 20160124	GOOD	AZDT

STATION DESCRIPTION

DESCRIBED BY COAST AND GEODETIC SURVEY 1945 (RAM)
STATION IS 3 MILES (AIR LINE) SSE OF FT. THOMAS AND IS 10 MILES (AIR LINE) NW OF PIMA. THE STATION IS ON THE N END OF A LOW RIDGE ABOUT 1/2 MILE S OF U.S. HIGHWAY 70.

TO REACH STATION FROM THE FIRE DEPARTMENT IN PIMA, GO W ON U.S. HIGHWAY 70 FOR 10.2 MILES TO A STONE HOUSE ON THE RIGHT AND A GRAVEL ROAD LEFT. (THIS POINT IS 3.0 MILES E OF FT. THOMAS ON U.S. HIGHWAY 70.) THE AZIMUTH MARK IS JUST TO THE LEFT OF THE ROAD AT THIS POINT. TURN LEFT ON THE GRAVEL ROAD AND GO ACROSS THE RAILROAD TRACKS FOR 0.3 MILE TO A T-INTERSECTION. HERE TURN RIGHT AND GO 0.1 MILE TO A FORK. TAKE THE LEFT FORK AND GO 0.3 MILE TO A FORK. TAKE THE LEFT FORK AND GO 0.2 MILE TO A FORK ON TOP OF THE RIDGE WITH A SMALL CEMETERY TO THE LEFT. TAKE THE LEFT FORK AND GO 0.2 MILE ALONG THE TOP OF THE RIDGE TO THE WITNESS POST AND THE END OF TRUCK TRAVEL.

STATION IS 15 FEET SSW OF THE EDGE OF THE MESA AND 19 FEET ESE OF THE WITNESS POST. IT IS MARKED BY A BRONZE STATION DISK SET IN A SQUARE CONCRETE POST PROJECTING ABOUT 3 INCHES ABOVE THE GROUND AND IS STAMPED BLACK 1945. UNDERGROUND MARK IS A BRONZE STATION DISK SET IN CONCRETE.

REFERENCE MARK 1 IS A BRONZE REFERENCE DISK SET IN A SQUARE CONCRETE POST PROJECTING ABOUT 2 INCHES AND IS ABOUT 6 INCHES BELOW THE STATION. THE MARK IS SE OF THE STATION AND IS STAMPED BLACK NO 1 1945.

REFERENCE MARK 2 IS A BRONZE REFERENCE DISK SET IN A SQUARE CONCRETE POST WHICH IS FLUSH WITH THE GROUND AND IS ABOUT 6 INCHES BELOW THE STATION. THE MARK IS WSW OF THE STATION AND IS STAMPED BLACK NO 2 1945.

AZIMUTH MARK IS A BRONZE BENCH-MARK DISK SET IN A SQUARE CONCRETE POST PROJECTING ABOUT 8 INCHES ABOVE THE GROUND AND IS STAMPED J 15 1933. THE MARK IS 3.5 FEET WSW OF THE WITNESS POST, 35.5 FEET WSW OF THE CENTER LINE OF U.S. HIGHWAY 70, 23 FEET ENE OF THE CENTER OF THE SOUTHERN PACIFIC CO. RAILROAD TRACKS, AND

33 FEET SSE OF THE CENTER OF THE GRADED ROAD TO STATION.
THE MARK IS ENE OF THE STATION.

HEIGHT OF LIGHT ABOVE STATION MARK - 1.0 METER.

STATION RECOVERY (1960)

RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1960 (NES)
THE STATION MARK, REFERENCE MARK NO. 1 AND REFERENCE MARK NO. 2 WERE RECOVERED AND FOUND IN GOOD CONDITION. IT IS BELIEVED THE AZIMUTH MARK WAS DESTROYED WHEN THE HIGHWAY WAS IMPROVED. ANOTHER MARK WAS USED FOR THE AZIMUTH MARK. A DIFFERENT ROUTE TO THE STATION WAS USED. A NEW AND COMPLETE DESCRIPTION FOLLOWS.

THE STATION IS ABOUT 10 MILES NORTHWEST OF PIMA, ABOUT 3 MILES SOUTH OF FT. THOMAS 0.35 MILE WEST OF U.S. HIGHWAY 70 AND 0.15 MILE NORTH OF A SMALL CEMETERY.

TO REACH THE STATION FROM THE POST OFFICE AT FT. THOMAS GO SOUTHEAST ON U.S. HIGHWAY 70 FOR 2.9 MILES TO THE ARIZONA HIGHWAY DEPT. ELEV. DISK ON THE RIGHT, JUST BEFORE REACHING A SIDE ROAD RIGHT. TURN RIGHT ON THE SIDE ROAD AND GO WEST FOR 0.25 MILE TO A ROAD LEFT, JUST AFTER CROSSING AN IRRIGATION DITCH, CONTINUE AHEAD BEARING TO THE RIGHT ON THE MAIN TRAVELED ROAD FOR 0.15 MILE TO A FORK, KEEP LEFT FORK, SOUTHERLY, FOR 0.3 MILE TO A FORK. HERE TAKE LEFT FORK FOR 0.25 MILE TO A T ROAD INTERSECTION AT THE TOP OF THE RIDGE, TURN LEFT, NORTH, 0.1 MILE TO A SMALL CEMETERY, PASS THRU THE CEMETERY AND CONTINUE NORTH ON THE TRACK ROAD FOR 0.15 MILE TO THE STATION.

THE STATION MARK, STAMPED BLACK 1945, IS A STANDARD DISK SET IN THE TOP OF A 12-INCH SQUARE CONCRETE POST THAT PROJECTS 3 INCHES. IT IS 19 FEET EAST OF THE WITNESS POST

REFERENCE MARK NO. 1, STAMPED BLACK NO 1 1945, IS A STANDARD DISK SET IN THE TOP OF A 12-INCH SQUARE CONCRETE POST THAT PROJECTS 3 INCHES. IT IS 46 FEET SOUTHEAST OF THE WITNESS POST.

REFERENCE MARK NO. 2, STAMPED BLACK NO 2 1945, IS A STANDARD DISK SET IN THE TOP OF A 12-INCH SQUARE CONCRETE POST THAT PROJECTS 2 INCHES. IT IS 25 FEET SOUTHWEST OF THE WITNESS POST.

THE ARIZONA HIGHWAY DEPT. ELEV. DISK, WHICH WAS USED FOR THE AZIMUTH MARK, IS STAMPED 2726.68 3381+13 1959. THE DISK IS CEMENTED IN A DRILL HOLE IN THE WEST HEADWALL OF A CONCRETE CULVERT. IT IS 37 FEET SOUTHWEST OF THE CENTER OF U.S. HIGHWAY 70, 26 FEET NORTHEAST OF THE NORTHEAST RAIL OF THE RAILROAD TRACKS AND 23 FEET NORTHWEST OF THE CENTER OF A GRAVELED ROAD.

STATION RECOVERY (1968)

RECOVERY NOTE BY US ARMY MAP SERVICE (NOW DMA) 1968
STATION IS LOCATED ABOUT 10.2 AIRMILES (NW) OF PIMA AND 3.1 AIRMILES (SE) OF FORT THOMAS.

TO REACH STATION FROM UNION HIGH SCHOOL IN FT. THOMAS GO (E) ON U.S. HWY 70 FOR 3.4 MILES TO A ROAD RIGHT, TURN RIGHT (SSW) CROSS R.R. TRACKS AND GO 0.3 MILE TO THE BASE OF A HILL AND A ROAD RIGHT AND A HOUSE ON THE LEFT, PROCEED STRAIGHT TO THE TOP OF THE HILL AND A Y INTERSECTION, TAKE THE RIGHT FORK (NNW) AND TRAVEL ALONG THE TOP OF THE HILL PASSING THROUGH A CEMETERY AND ON TO THE STATION LOCATED ON THE RIGHT SIDE (N) OF THE ROAD IMMEDIATELY BEFORE A LEFT CURVE. STATION IS LOCATED 24 FT FROM THE (N) EDGE OF THE HILL AND 19 FT AT 270 DEG (MAG AZ) TO A WITNESS POST.

REFERENCE MARK 1 IS (SE) ON A MAG AZ OF 135 DEG AT A DISTANCE OF 32.90 FT AND A DE OF +0.9 FEET.

REFERENCE MARK 2 IS (SW) ON A MAG AZ OF 220 DEG AT A DISTANCE OF 36.75 FT AND A DE OF +0.8 FEET.

AZIMUTH MARK WAS NOT RECOVERED.

CONDITION OF ALL MARKS IS EXCELLENT. VIEW FROM STATION IS GOOD IN ALL DIRECTIONS FOR APPROXIMATELY 10 MILES.

STATION RECOVERY (1979)

RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1979
4.3 MI SE FROM FT THOMAS.
3.5 MILES SOUTHEAST ALONG U. S. HIGHWAY 70 FROM THE POST OFFICE IN FT. THOMAS, THENCE 0.5 MILE WEST ALONG A GRAVEL ROAD TO THE TOP OF A MESA, THENCE 0.3 MILE NORTH ALONG A GRAVEL ROAD THROUGH THE ASHURST CEMETERY AND PAST A MICROWAVE TOWER, 23 FEET WEST OF THE EAST EDGE OF THE MESA, 37 FEET NORTHEAST OF RM 2 AND 33 FEET NORTHWEST OF RM 1.
THE MARK IS 3 FT SE FROM A WITNESS POST.
THE MARK IS 100 FT ABOVE THE HIGHWAY.

STATION RECOVERY (1985)

RECOVERY NOTE BY ARIZONA DEPARTMENT OF TRANSPORTATION 1985 (BK)
THE STATION MARK AND REFERENCE MARKS WERE RECOVERED AS DESCRIBED IN 1945. A NEW ROUTE TO THE STATION FOLLOWS.

TO REACH THE STATION FROM THE POST OFFICE IN PIMA TRAVEL NORTHWEST ALONG U.S. HIGHWAY 70 FOR 10.0 MILES TO MILE POST 310.15 AND A BLADED ROAD ON THE LEFT. TURN LEFT AND TRAVEL SOUTH FOR 0.6 MILE TO THE GATE OF A CEMETERY. PASS THROUGH GATE FOR 0.1 MILE TO THE WEST GATE OF THE CEMETERY. PASS THROUGH THE GATE AND TRAVEL 0.1 MILE TO THE NORTH EDGE

OF THE MESA AND THE STATION.

STATION RECOVERY (2008)

RECOVERY NOTE BY GEOCACHING 2008 (ACM)
RECOVERED AS DESCRIBED, IN GOOD CONDITION. APPROACHED USING THE 1945 TO-REACH. THE 1985 TO-REACH IS INCORRECT IN THAT AFTER TURNING OFF HIGHWAY 70 ONE MUST TRAVEL 0.6 MILE WEST (NOT SOUTH) TO THE GATE OF THE CEMETERY.

STATION RECOVERY (2016)

RECOVERY NOTE BY ARIZONA DEPARTMENT OF TRANSPORTATION 2016 (DLR)
RECOVERED IN GOOD CONDITION.

4.2. NGS Data Sheet for Q 438

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**********************************************************************
 DESIGNATION -  Q 438
 PID         -  DU1114
 STATE/COUNTY-  AZ/GRAHAM
 COUNTRY     -  US
 USGS QUAD   -  CALVA (2018)

                      *CURRENT SURVEY CONTROL
 ______________________________________________________________________
 NAD 83(1986) POSITION- 33 10 29.2    (N) 110 08 27.7    (W)   HD_HELD2
 NAVD 88 ORTHO HEIGHT -   785.221 (meters)     2576.18  (feet) ADJUSTED
 ______________________________________________________________________
 GEOID HEIGHT    -        -27.049 (meters)                     GEOID18
 DYNAMIC HEIGHT  -        784.156 (meters)     2572.69  (feet) COMP
 MODELED GRAVITY -    979,257.0   (mgal)                       NAVD 88

 VERT ORDER      -  FIRST     CLASS II
The horizontal coordinates were established by autonomous hand held GPS
observations and have an estimated accuracy of +/- 10 meters.

The orthometric height was determined by differential leveling and
adjusted by the NATIONAL GEODETIC SURVEY
in June 1991.

Significant digits in the geoid height do not necessarily reflect accuracy.
GEOID18 height accuracy estimate available here.

Click photographs - Photos may exist for this station.

The dynamic height is computed by dividing the NAVD 88
geopotential number by the normal gravity value computed on the
Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
degrees latitude (g = 980.6199 gals.).

The modeled gravity was interpolated from observed gravity values.

                   North         East     Units  Estimated Accuracy
SPC AZ E     -   241,134.      215,751.      MT  (+/- 10 meters HH2 GPS)
```

U.S. NATIONAL GRID SPATIAL ADDRESS: 12SWB8008470991(NAD 83)

SUPERSEDED SURVEY CONTROL

No superseded survey control is available for this station.

MARKER: DV = VERTICAL CONTROL DISK
SETTING: 49 = STAINLESS STEEL ROD W/O SLEEVE (10 FT.+)
STAMPING: Q 438 1979
MARK LOGO: NGS
PROJECTION: FLUSH
MAGNETIC: N = NO MAGNETIC MATERIAL
STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
SATELLITE: SATELLITE OBSERVATIONS - October 08, 2008
ROD/PIPE-DEPTH: 9 meters

HISTORY	- Date	Condition	Report By
HISTORY	- 1979	MONUMENTED	NGS
HISTORY	- 20031015	GOOD	NGS
HISTORY	- 20081008	GOOD	GEOCAC

STATION DESCRIPTION

DESCRIBED BY NATIONAL GEODETIC SURVEY 1979
6.8 KM NW FROM BYLAS.
6.8 KILOMETERS (4.25 MILES) NORTHWEST ALONG U. S. HIGHWAY 70 FROM THE POST OFFICE IN BYLAS, 0.1 KILOMETER (0.05 MILE) NORTHWEST OF HIGHWAY MILE POST 292, AT THE SOUTHEAST END OF A TURNOUT AREA, 30.2 METERS (99 FEET) NORTHEAST OF THE CENTERLINE OF THE HIGHWAY, 9.0 METERS (29.5 FEET) NORTHWEST OF THE CENTERLINE OF A DIRT ROAD LEADING NORTHEAST THEN SOUTHEAST AND 0.3 METER (1 FOOT) SOUTHWEST OF THE RIGHT-OF-WAY FENCE.
THE MARK IS 1 METERS SE FROM A WITNESS POST.
THE MARK IS ABOVE LEVEL WITH THE HIGHWAY.

STATION RECOVERY (2003)

RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2003 (DW)
RECOVERED IN GOOD CONDITION.

STATION RECOVERY (2008)

RECOVERY NOTE BY GEOCACHING 2008 (ACM)
RECOVERED IN GOOD CONDITION

5. Station Recovery Sheets

Station recovery information sheet images are contained in a separate zip file, and are labeled/ordered as the control points are ordered in Section 2. Photographs of the ground control positions are also contained in a separate zip file.