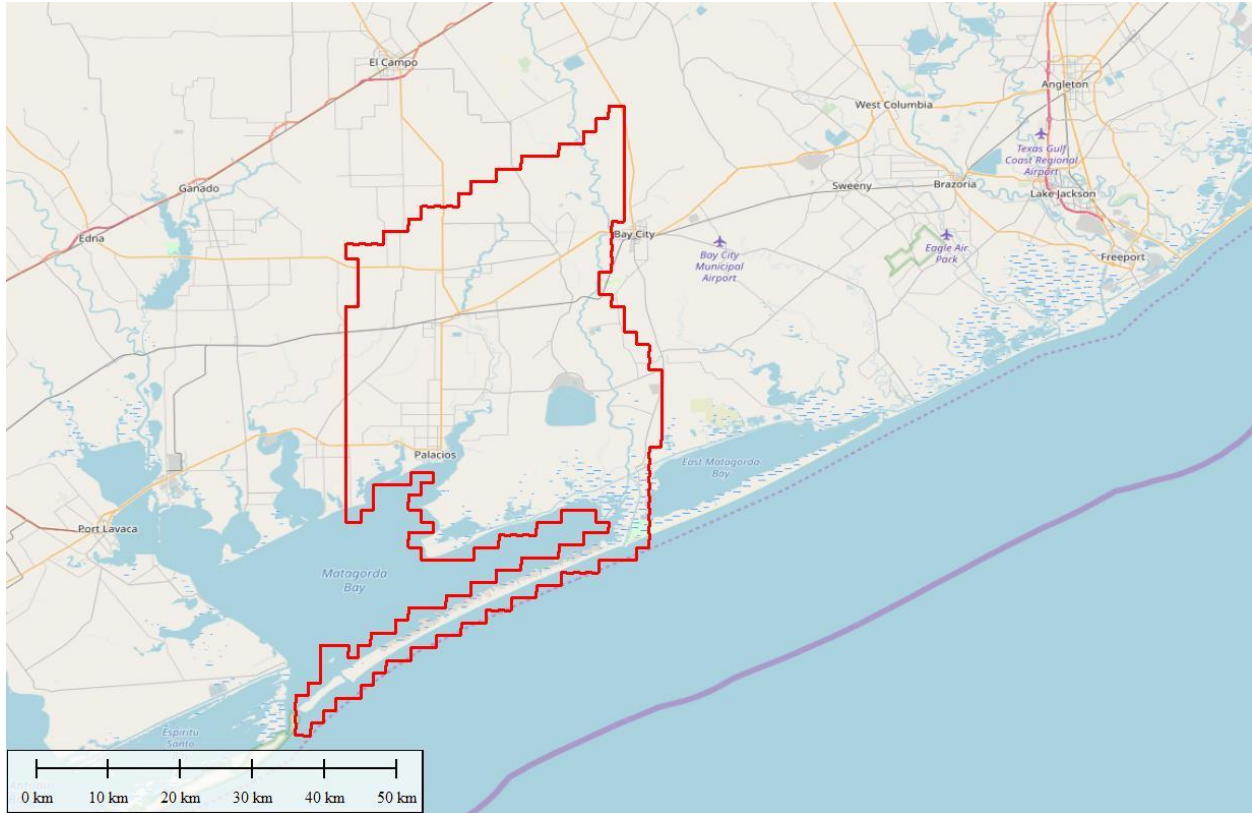


REPORT OF SURVEY
United States Geological Survey
MATAGORDA, TX
Ground Control Report



Performed by:



For:

Fugro Geospatial

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REPORT OF SURVEY

USGS MATAGORDA TEXAS

INTRODUCTION

Terrasurv, Inc of Pittsburgh, PA was tasked by Fugro Geospatial with performing a control survey in support of LiDAR data collection covering the western half of Matagorda County in eastern Texas. The project consisted of two parts: ground control (GCP, 12 points) and quality control (VVA/NVA, 80 points). The map below in figure 1 shows the location of the project with the county boundaries in black.

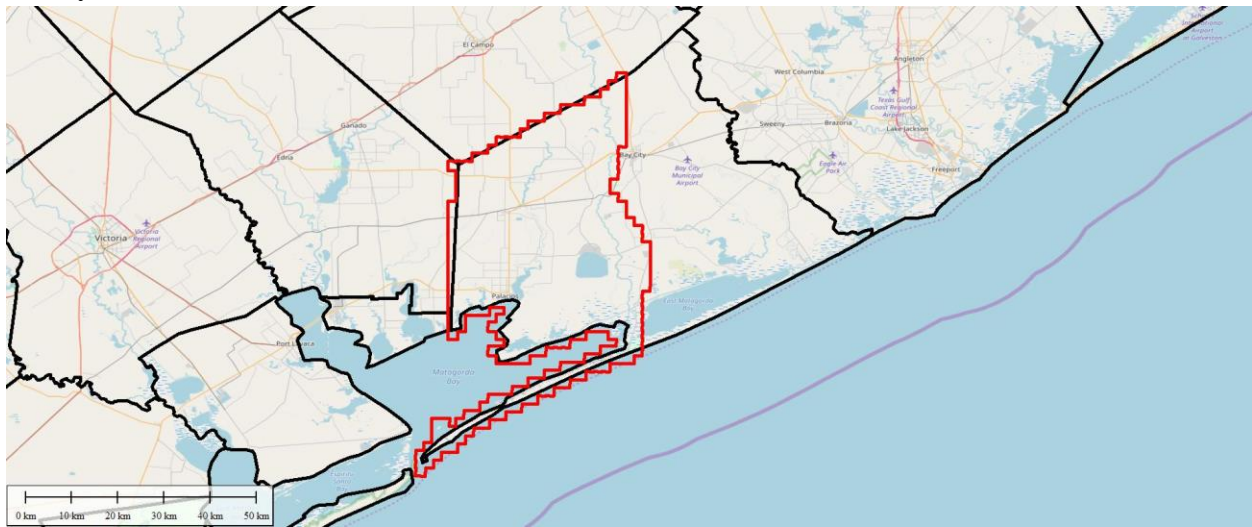


Figure 1 – Project Location

CONTROL

The horizontal datum was the North American Datum of 1983 – NAD83 (2011), epoch 2010.0. The vertical datum was the North American Vertical Datum of 1988 (NAVD88), realized with GEOID12B.

The [RTKNet](#) Virtual Reference System (VRS) was used (GCP, NVA, and VVA stations) along with the [Trimble Centerpoint RTX](#) service (VVA-F stations) to position the stations.

STATIONS

There were 12 GCP stations requested, which are shown in figure 2 along with the RTKNET Continuously Operating Reference Stations (CORS).

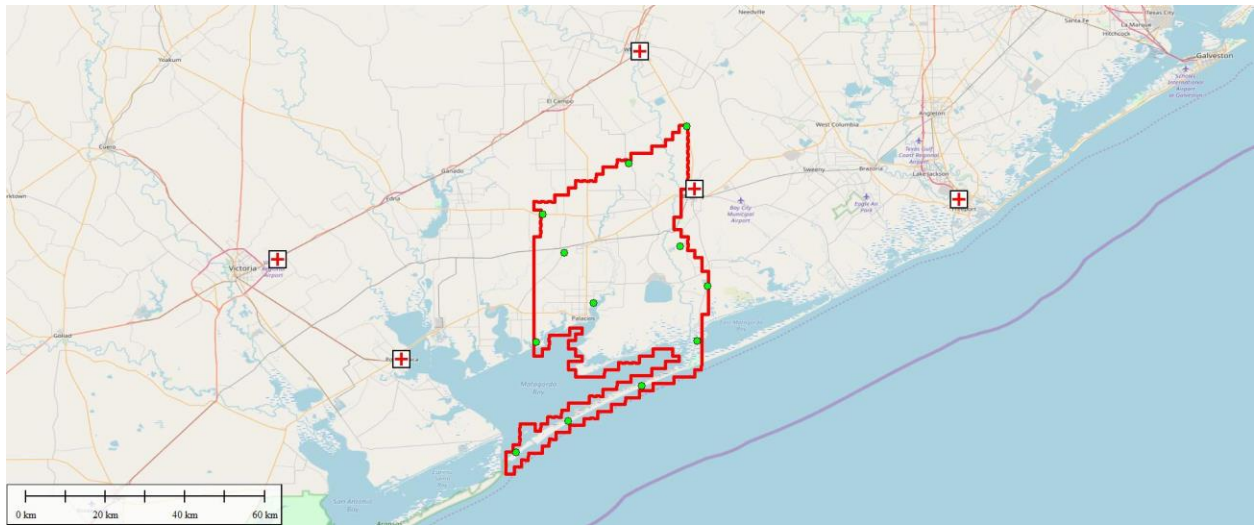


Figure 2 - GCP and CORS Stations

A total of 80 QA/QC checkpoints were requested, summarized in table 1.

Table 1 - QA/QC points summary

QC/QA Type	Quantity	Map Symbol
NVA	41	Red dot
NVA-HV	4	Red X
VVA	22	Yellow dot
VVA-F	13	Green tree

These points are shown in figure 3.

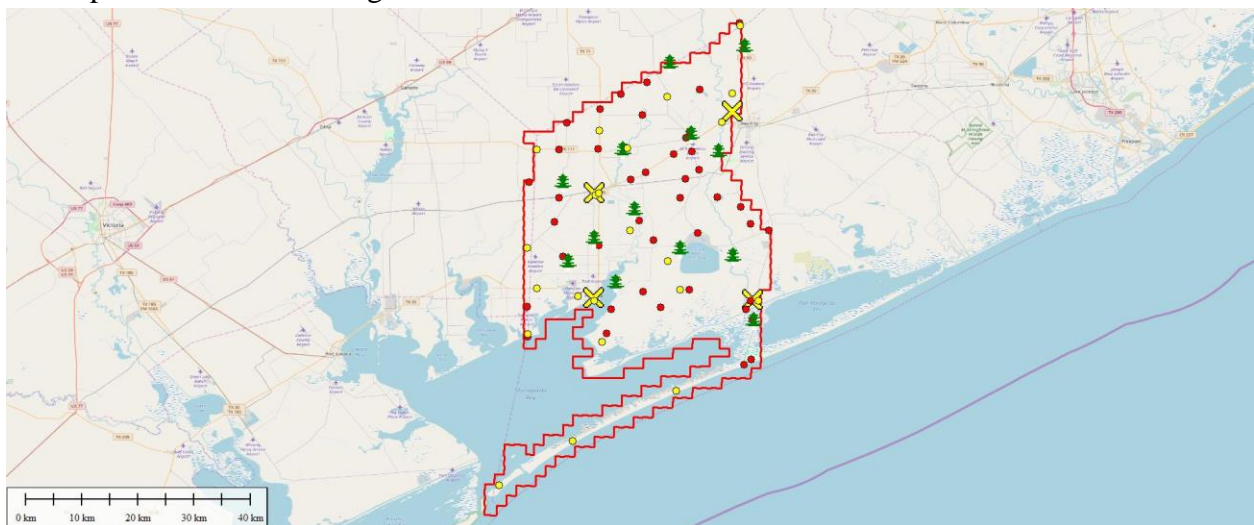


Figure 3 - QA/QC points

Table 2 lists the stations established in this survey, including traverse stations that were set to enable survey of VVA-Forest points and VRS Continuously Operating Reference Stations (CORS).

Table 2 – Station Summary

Station Name	GPSID	USGS Quadrangle	Description
	PRS224568262	WHARTON	RTKNET CORS
	PRS180861903	VICTORIA EAST	RTKNET CORS
	PRS853977558	FREEPORT	RTKNET CORS

Station Name	GPSID	USGS Quadrangle	Description
	PRS801241861	PORT LAVACA WEST	RTKNET CORS
	PRS108339458	BAY CITY	RTKNET CORS
100 RTX	100 RTX	FRANCITAS NE	Traverse station for woods point
101 RTX	101 RTX	FRANCITAS NE	Traverse station for woods point
102 RTX	102 RTX	BLESSING	Traverse station for woods point
103 RTX	103 RTX	BLESSING	Traverse station for woods point
104 RTX	104 RTX	FRANCITAS	Traverse station for woods point
105 RTX	105 RTX	FRANCITAS	Traverse station for woods point
106 RTX	106 RTX	MARKHAM	Traverse station for woods point
107 RTX	107 RTX	MARKHAM	Traverse station for woods point
108 RTX	108 RTX	BLESSING	Traverse station for woods point
109 RTX	109 RTX	BLESSING	Traverse station for woods point
110 RTX	110 RTX	LANE CITY SE	Traverse station for woods point
111 RTX	111 RTX	LANE CITY SE	Traverse station for woods point
112 RTX	112 RTX	VAN VLECK	Traverse station for woods point
113 RTX	113 RTX	VAN VLECK	Traverse station for woods point
114 RTY	114 RTY	WADSWORTH	Traverse station for woods point
115 RTX	115 RTX	WADSWORTH	Traverse station for woods point
877 2936 B	DP0701	WADSWORTH	Hgt Mod station
877 3156 90034 H	DP0708	PALACIOS	Hgt Mod station
GCP01	19012IA	DECROS POINT	sparse mowed grass on east side of cottages
GCP02	19012AB	TURTLE BAY	Center of dirt field access road on west side of Hwy 3280
GCP03	19012AC	PALACIOS	pavement at intersection of Bayshore Road and connector to Hwy 2853. Point is in turn radius from Bayshore Road southbound turning west
GCP04	19012AD	FRANCITAS	dirt road surface at intersection of Hwy 1862 and Co Rd 474. Point is in turn radius from Hwy 1862 southbound turning west
GCP05	19012IC	DECROS POINT	bare ground
GCP06	19012AF	PLEDGER	center of dirt drive on east side of Hwy 60
GCP07	19012IE	PALACIOS SE	center of trail with sparse grass
GCP08	19012AH	LANE CITY SE	center of a dirt road on west side of Hwy 1162 leading west to Aquaculture ponds
GCP09	19012AI	WADSWORTH	center of gravel access road to railroad on north side of Hwy 3057
GCP10	19012AJ	FRANCITAS NE	center of gravel drive on north side of Hwy 111
GCP11	19012AK	MATAGORDA	pavement on west shoulder of Hwy 2031
GCP12	19012AL	WADSWORTH	gravel/rough pavement on field access road on east side of Hwy 60
J 1256	AM0123	WADSWORTH	Benchmark (posted)
NVA01	19012AM	FRANCITAS NE	center of dirt road intersection with dirt drive to the north
NVA02	19012AN	TURTLE BAY	center of graveled field entrance road on east side of Hwy 3280
NVA03	19012AO	TURTLE BAY	pavement near south end of Hwy 3280
NVA04	19012AP	FRANCITAS	dirt road surface for field access road on east side of Hwy 1862
NVA05	19012AQ	FRANCITAS NE	northbound dirt travel lane of CO Rd 470 just south of Hwy 111
NVA06	19012AR	FRANCITAS	paved northeast bound travel lane of CO Rd 436 south of Hwy 616
NVA07	19012AS	FRANCITAS	dirt road surface in on south side of CO Rd 324 at intersection with dirt roads
NVA08	19012AT	FRANCITAS NE	dirt road surface at T intersection
NVA09HV	19012AU	BLESSING	ID/Lidar: NW corner of concrete parking lot on north side of Dollar General Store on north side of Avenue B
NVA10	19012AV	MIDFIELD	old asphalt pavement at north end of Cornelius Avenue

Station Name	GPSID	USGS Quadrangle	Description
NVA11	19012AW	DANEVANG	pavement on westbound lane of Iezak Road on the east side of Hwy 71
NVA12	19012AX	BLESSING	dirt/gravel on east side of Hwy 35 and south side of drive
NVA13HV	19012AY	PALACIOS	ID/LIDAR: NE corner of basketball court in park in SW quadrant of intersection of 6th Street and Lucas Avenue
NVA14	19012AZ	PALACIOS	dirt road surface at west end of Cockburn Road
NVA15	19012BA	DANEVANG	dirt road surface in T intersection of Farm Road 403 and CO Rd 424
NVA16	19012BB	MIDFIELD	sand/dirt/gravel at entrance to stockpiles on south side of Hwy 35
NVA17	19012BC	MIDFIELD	dirt access road to gas well on north side of Hwy 1468
NVA18	19012BD	PALACIOS	C/L dirt road surface on CO Rd 365. Note: original location not accessible due to locked gates and impassable roads
NVA19	19012BE	DANEVANG	center of dirt road on levee around fishponds. Point is at SE corner of SE'ly pond and in NW quadrant of intersection of Jurek Road and John Fella Road
NVA20	19012BF	BLESSING	dirt road surface on west side of Hwy 2853 and westbound lane of CO Rd 351. Note: point moved from original location due to controlled access gate on Live Oak Boulevard
NVA21	19012BG	MIDFIELD	dirt/gravel road surface on CO Rd 428 south of Hwy 35
NVA22	19012BH	PALACIOS	dirt/gravel/broken asphalt surface in intersection of CO Rd 378 and CO Rd 371
NVA23	19012BI	BLESSING SE	dirt road surface on turn radius from Hwy 1095 NB to driveway to the east
NVA24	19012BJ	MARKHAM	center of dirt/gravel road to the SE off of Hwy 35
NVA25	19012BK	BLESSING SE	intersection of dirt roads
NVA26	19012BL	MARKHAM	center of dirt/gravel drive on west side of Avenue L opposite Canal Street
NVA27	19012BM	MARKHAM	center of dirt road on south side of Buckeye El Maton Road
NVA28	19012BN	MARKHAM	gravel surface at intersection of Avenue A and 10th Street
NVA29	19012BO	MARKHAM	dirt road surface of Private Road 819 on east side of Hwy 1468
NVA30	19012BP	BLESSING SE	asphalt road surface on north side of gate for power plant about 165 meters south of Hwy 521
NVA31	19012BQ	MARKHAM	dirt/gravel road surface for driveway on SW side of Hwy 1468
NVA32	19012BR	PALACIOS NE	center of dirt road (Gillette Road) just west of gate. Original location is inaccessible due to locked gates. See also NVA99
NVA33	19012BS	LANE CITY SE	pavement of CO Rd 403 at gated entrance to Spread Oaks Ranch. Original location is inside ranch which was not accessible
NVA34	19012BT	BLESSING SE	pavement on road to the SW on south side of Farm to Market 3057
NVA35HV	19012BU	VAN VLECK	ID/LIDAR: NE corner of concrete parking pad on south side of Timberline Drive
NVA36	19012BV	PLEDGER	center of dirt field road on west side of Hwy 60
NVA37	19012BW	WADSWORTH	pavement on south lane of Gilmore Road on east side of Hwy 2668
NVA38	19012BX	MATAGORDA SW	paved area on south side of beach parking lot at south end of Hwy 2031 just
NVA39	19012BY	MATAGORDA	pavement in Y road intersection at west end of Matagorda Street west of Orleans Street
NVA40	19012BZ	WADSWORTH	pavement of north travel lane of Farm to Market 2078 east of Hwy 2668

Station Name	GPSID	USGS Quadrangle	Description
NVA41	19012CA	MATAGORDA	sparse grass/gravel at south tip of grass island between CO Rd 521 and Magnolia Street
NVA42	19012CB	MATAGORDA	pavement in boat ramp parking area between Beach Road and river
NVA43	19012CC	MATAGORDA SW	pavement on north lane of Beach Road
NVA44HV	19012CD	MATAGORDA	ID/LIDAR=SW corner of concrete drive to RV park at east edge of CO Rd 253
NVA45	19012CE	WADSWORTH	center of gravel/dirt access road to cell tower on south side of Hwy 521
NVA99	19012EA	PALACIOS NE	center of dirt road just west of gate to WMA (location of NVA32 which was not accessible). See also NVA32
VVA01	19012IB	DECROS POINT	high grass/weeds on east side of cottages
VVA02	19012CG	FRANCITAS	high weeds/fallow field in south quadrant of intersection of Hwy 1862 and CO Rd 464
VVA03	19012CH	TURTLE BAY	high grass on west side of Hwy 3280
VVA04	19012CI	FRANCITAS NE	high grass on pipeline R-O-W on south side of Hwy 111
VVA05	19012CJ	TURTLE BAY	high weeds on north side of Hwy 35 and west side of CO Rd 306 Buffalo road
VVA06	19012ID	DECROS POINT	marsh grass
VVA07	19012CL	PALACIOS	unmowed grass in SE quadrant of intersection of Hwy 35 and CO Rd 300
VVA08	19012CM	BLESSING	unmowed grass on south side of Avenue C opposite park entrance
VVA09	19012CN	PALACIOS	grass in triangle formed by 5th Street and S Bay Boulevard
VVA10	19012CO	MIDFIELD	high grass/weeds in SW quadrant of intersection of Hwy 71 and CO Rd 451
VVA11	19012CP	BLESSING	high grass in island formed by Hwy 35 and Avenue B
VVA12	19012CQ	PALACIOS	fallow field on west side of Oyster Lake Road and north side of gated field road to the west
VVA13	19012CR	MIDFIELD	fallow field on south side of Hwy 2431 opposite CO Rd 440 on east side of power line R-O-W
VVA14	19012CS	BLESSING	high weeds on north side of Laslie Road at SE corner of fallow field
VVA15	19012CT	LANE CITY SE	high weeds on west side of Hwy 1162 at SE corner of fallow field and on north side of field road
VVA16	19012CU	BLESSING SE	low brush on NE side of CO Rd 383 at 90° bend
VVA17	19012IF	PALACIOS SE	marsh grass
VVA18	19012CW	PALACIOS NE	overgrown field in SW quadrant of CO Rd 389 and CR Rd 390
VVA19	19012CX	MARKHAM	high grass on north side of Hwy 35 and west side of gated dirt road to the north
VVA20	19012CY	VAN VLECK	fallow field on south side of Ohio Road
VVA21	19012CZ	PLEDGER	high grass on east side of Hwy 60
VVA22	19012DA	MATAGORDA	high weeds on south side of S Gulf Road
VVAF01	VVA-F-01	FRANCITAS NE	woods
VVAF02	VVA-F-02	FRANCITAS	Woods
VVAF03	VVA-F-03	BLESSING	Woods
VVAF04	VVA-F-04 RTX	PALACIOS	Woods
VVAF05	VVA-F-05 RTX	MIDFIELD	Woods
VVAF06	VVA-F-06	BLESSING	Woods
VVAF07	VVA-F-07	LANE CITY SE	Woods
VVAF08	VVA-F-08 RTX	BLESSING SE	Woods
VVAF09	VVA-F-09 RTX	MARKHAM	Woods
VVAF10	VVA-F-10	MARKHAM	Woods
VVAF11	VVA-F-11	VAN VLECK	Woods
VVAF12	VVA-F-12	WADSWORTH	Woods
VVAF13	VVA-F-13 RTX	MATAGORDA	Woods
Z 755	AM0143	MATAGORDA	Benchmark (posted)

METHODOLOGY

The field survey was done by using Trimble R10 dual frequency, multi-constellation GNSS receivers in a real time mode. Two methods were used: RTK/VRS and RTX. In the RTK method a network of Continuously Operating Reference Stations (CORS) send real time observations to a server. The server computes corrections for a nearby “virtual” CORS and transmits this data over the cellular system to the rover, and the corrections are applied at the rover to obtain cm level positions. The data is stored as vectors from the nearest physical CORS. The RTKNet VRS was used for the GCP, NVA, and VVA points. Stations were observed once, then re-initialized and observed a second time a few minutes later. In the RTX method, corrections are obtained using the Trimble Centerpoint RTX service ([RTX](#)), with real-time satellite orbit and clock corrections as well as atmospheric modeling parameters received over a geosynchronous communications link. These corrections are applied in real time and used by the rover to converge to a solution. Once the convergence criteria (0.03 m H/0.05 m V) was met, one or more short occupations of the station are obtained, and the ITRF 2008 epoch 2005.0 position stored along with quality data. The RTX method was used for the VVA-F (woods) stations.

Table 3 summarizes the VRS occupations (precisions in meters):

Table 3 - VRS Occupations

GPSID	UTC Start	UTC End	Horz Prec	Vert Prec	# of SV's	PDOP	Reject
19012BU	02/27/2019 14:31:49	14:34:48	0.005	0.009	17	1.3	
19012BU	02/27/2019 14:36:02	14:39:01	0.007	0.012	17	1.4	
19012CY	02/27/2019 14:53:02	14:56:01	0.009	0.014	15	1.4	
19012CY	02/27/2019 14:57:57	15:00:56	0.010	0.017	16	1.3	
19012CZ	02/27/2019 15:15:37	15:18:36	0.006	0.009	15	1.5	
19012CZ	02/27/2019 15:19:03	15:22:02	0.010	0.016	15	1.5	
19012AF	02/27/2019 15:24:24	15:27:23	0.008	0.014	15	1.6	
19012AF	02/27/2019 15:28:07	15:31:06	0.007	0.013	15	1.5	
19012BV	02/27/2019 15:34:08	15:37:07	0.005	0.009	15	1.6	
19012BV	02/27/2019 15:38:00	15:40:59	0.012	0.021	13	1.8	
19012CX	02/27/2019 16:02:24	16:05:23	0.007	0.014	12	1.8	
19012CX	02/27/2019 16:06:17	16:09:16	0.005	0.011	14	1.5	
19012BS	02/27/2019 16:22:15	16:25:14	0.007	0.014	14	1.4	
19012BS	02/27/2019 16:27:22	16:30:21	0.005	0.010	14	1.4	
19012BS	02/27/2019 16:30:48	16:33:47	0.009	0.020	13	1.5	X
19012BL	02/27/2019 16:47:45	16:50:44	0.006	0.010	13	1.5	
19012BL	02/27/2019 16:51:08	16:54:07	0.006	0.011	12	1.8	
19012BN	02/27/2019 17:02:00	17:04:59	0.008	0.014	12	1.8	
19012BN	02/27/2019 17:05:38	17:08:37	0.011	0.019	12	1.8	
19012CT	02/27/2019 17:17:54	17:20:53	0.007	0.012	12	1.6	
19012CT	02/27/2019 17:21:12	17:24:11	0.008	0.014	11	1.8	
19012AH	02/27/2019 17:29:28	17:32:37	0.010	0.017	11	1.9	

GPSID	UTC Start	UTC End	Horz Prec	Vert Prec	# of SV's	PDOP	Reject
19012AH	02/27/2019 17:32:58	17:35:57	0.009	0.016	10	2.3	
19012BE	02/27/2019 17:45:38	17:48:37	0.006	0.010	12	1.7	
19012BE	02/27/2019 17:49:43	17:52:42	0.006	0.010	11	1.5	
19012BA	02/27/2019 18:02:00	18:04:59	0.007	0.011	13	1.4	
19012BA	02/27/2019 18:06:43	18:09:42	0.008	0.013	13	1.5	
19012AW	02/27/2019 18:20:04	18:23:04	0.006	0.010	13	1.4	
19012AW	02/27/2019 18:23:29	18:26:28	0.015	0.026	13	1.6	
19012AW	02/27/2019 18:26:59	18:29:58	0.013	0.023	13	1.6	
19012BC	02/27/2019 18:36:39	18:39:38	0.009	0.017	13	1.7	
19012BC	02/27/2019 18:39:55	18:42:54	0.010	0.017	9	2.2	
19012CO	02/27/2019 18:51:46	18:54:45	0.010	0.018	13	1.7	
19012CO	02/27/2019 18:55:45	18:58:44	0.006	0.011	13	1.7	
19012AV	02/27/2019 19:03:23	19:06:22	0.008	0.013	13	1.6	
19012AV	02/27/2019 19:07:43	19:10:42	0.015	0.027	12	1.7	
19012CR	02/27/2019 19:17:09	19:20:08	0.007	0.012	12	1.7	
19012CR	02/27/2019 19:20:44	19:23:43	0.009	0.016	13	1.5	
19012AT	02/27/2019 19:37:15	19:40:14	0.009	0.015	14	1.4	
19012AT	02/27/2019 19:41:01	19:44:00	0.008	0.014	14	1.4	
19012AT	02/27/2019 19:44:24	19:47:23	0.011	0.019	13	1.6	
19012AQ	02/27/2019 19:57:23	20:00:25	0.010	0.020	13	2.1	
19012AQ	02/27/2019 20:00:49	20:03:48	0.017	0.036	13	2.1	X
19012AQ	02/27/2019 20:04:18	20:07:17	0.016	0.033	13	2.1	
19012AQ	02/27/2019 20:08:01	20:11:01	0.014	0.030	14	1.6	
19012AJ	02/27/2019 20:15:40	20:18:39	0.011	0.023	13	1.7	
19012AJ	02/27/2019 20:20:03	20:23:02	0.013	0.025	15	1.4	
19012CI	02/27/2019 20:25:44	20:28:43	0.011	0.019	14	1.6	
19012CI	02/27/2019 20:29:28	20:32:27	0.007	0.012	6	3.4	
19012AM	02/27/2019 20:46:48	20:49:47	0.008	0.017	15	1.6	
19012AM	02/27/2019 20:50:06	20:53:06	0.008	0.015	13	2.1	
19012AR	02/27/2019 21:08:37	21:11:36	0.014	0.033	14	2.2	X
19012AR	02/27/2019 21:12:06	21:15:05	0.010	0.027	15	1.8	
19012AR	02/27/2019 21:15:27	21:18:26	0.007	0.016	14	1.8	
19012AP	02/27/2019 21:25:33	21:28:32	0.005	0.013	15	1.8	
19012AP	02/27/2019 21:29:40	21:32:39	0.008	0.018	14	1.8	
19012AP	02/27/2019 21:33:04	21:36:03	0.006	0.014	15	1.8	
19012AD	02/27/2019 21:40:38	21:43:38	0.016	0.026	17	1.4	
19012AD	02/27/2019 21:44:02	21:47:03	0.011	0.027	11	1.9	
19012CG	02/27/2019 21:54:45	21:57:44	0.005	0.011	18	1.4	
19012CG	02/27/2019 21:58:33	22:01:32	0.005	0.011	16	1.8	
19012AS	02/27/2019 22:09:47	22:12:46	0.017	0.028	14	1.9	X
19012AS	02/27/2019 22:13:28	22:16:27	0.020	0.028	17	1.5	
19012AS	02/27/2019 22:17:01	22:20:02	0.018	0.027	16	1.7	
19012AS	02/27/2019 22:20:52	22:23:51	0.010	0.019	17	1.5	
19012AY	02/27/2019 22:42:30	22:45:29	0.009	0.016	17	1.3	
19012AY	02/27/2019 22:45:50	22:48:49	0.019	0.030	9	2.0	X
19012AY	02/27/2019 22:49:12	22:52:11	0.008	0.014	9	2.0	
19012CN	02/27/2019 22:55:48	22:58:47	0.012	0.021	16	1.3	
19012CN	02/27/2019 22:59:21	23:02:20	0.007	0.013	14	1.4	
19012AO	02/27/2019 23:16:54	23:19:53	0.007	0.014	14	1.7	
19012AO	02/27/2019 23:20:15	23:23:18	0.021	0.032	13	1.8	X
19012AO	02/27/2019 23:23:44	23:26:43	0.008	0.016	14	1.7	
19012CH	02/27/2019 23:29:08	23:32:07	0.006	0.011	14	1.8	
19012CH	02/27/2019 23:32:27	23:35:26	0.005	0.010	13	1.9	
19012AB	02/27/2019 23:37:55	23:40:54	0.006	0.012	14	1.8	
19012AB	02/27/2019 23:41:18	23:44:17	0.005	0.010	14	1.8	
19012AN	02/27/2019 23:48:27	23:51:26	0.006	0.011	14	1.8	
19012AN	02/27/2019 23:52:15	23:55:14	0.009	0.017	13	2.2	
19012CJ	02/28/2019 00:00:40	00:05:18	0.005	0.009	13	1.8	
19012CJ	02/28/2019 00:05:41	00:08:40	0.007	0.014	13	1.9	
19012CL	02/28/2019 00:14:55	00:17:54	0.009	0.018	16	1.3	
19012CL	02/28/2019 00:18:17	00:21:16	0.006	0.011	11	2.5	
19012BO	02/28/2019 13:47:23	13:50:22	0.008	0.016	14	1.6	
19012BO	02/28/2019 13:51:18	13:54:17	0.006	0.010	12	1.6	
19012BQ	02/28/2019 13:58:35	14:01:34	0.007	0.013	17	1.4	

GPSID	UTC Start	UTC End	Horz Prec	Vert Prec	# of SV's	PDOP	Reject
19012BQ	02/28/2019 14:02:02	14:05:01	0.008	0.014	14	1.6	
19012BQ	02/28/2019 14:05:25	14:08:26	0.011	0.020	14	1.6	
19012BM	02/28/2019 14:14:14	14:17:13	0.010	0.019	15	1.5	
19012BM	02/28/2019 14:17:39	14:20:38	0.007	0.013	16	1.5	
19012BK	02/28/2019 14:33:35	14:36:34	0.013	0.020	16	1.4	
19012BK	02/28/2019 14:36:54	14:39:56	0.023	0.030	12	1.6	
19012BP	02/28/2019 14:48:50	14:51:49	0.015	0.017	14	1.6	
19012BP	02/28/2019 14:52:12	14:55:11	0.011	0.019	9	2.0	
19012BZ	02/28/2019 15:04:50	15:08:17	0.010	0.017	13	1.8	
19012BZ	02/28/2019 15:09:11	15:12:10	0.010	0.016	14	1.6	
19012CE	02/28/2019 15:17:31	15:20:30	0.011	0.020	15	1.6	
19012CE	02/28/2019 15:21:46	15:24:45	0.013	0.025	15	1.6	
19012AL	02/28/2019 15:29:37	15:32:40	0.006	0.012	14	1.8	
19012AL	02/28/2019 15:33:53	15:36:52	0.008	0.018	12	1.9	
19012CD	02/28/2019 15:45:20	15:48:19	0.006	0.013	14	2.1	
19012CD	02/28/2019 15:49:36	15:52:35	0.008	0.019	14	2.0	
19012CA	02/28/2019 15:56:02	15:59:01	0.006	0.014	12	2.2	
19012CA	02/28/2019 15:59:26	16:02:25	0.006	0.015	12	2.1	
19012CA	02/28/2019 16:02:47	16:05:46	0.005	0.014	11	2.1	
19012BY	02/28/2019 16:15:19	16:18:18	0.005	0.012	15	1.4	
19012BY	02/28/2019 16:19:26	16:22:25	0.006	0.015	14	1.5	
19012DA	02/28/2019 16:27:42	16:30:41	0.006	0.015	13	1.5	X
19012DA	02/28/2019 16:31:57	16:34:56	0.006	0.013	12	1.6	
19012DA	02/28/2019 16:36:17	16:39:16	0.007	0.016	12	1.6	
19012CB	02/28/2019 17:10:24	17:13:26	0.013	0.025	12	1.6	
19012CB	02/28/2019 17:14:33	17:17:32	0.010	0.018	13	1.5	
19012CB	02/28/2019 17:18:23	17:21:22	0.011	0.020	12	1.6	
19012AK	02/28/2019 17:24:47	17:27:46	0.007	0.012	11	1.8	
19012AK	02/28/2019 17:28:05	17:31:05	0.010	0.021	7	2.2	
19012CC	02/28/2019 17:41:42	17:44:53	0.011	0.020	11	1.9	X
19012CC	02/28/2019 17:47:36	17:50:35	0.006	0.012	13	1.5	
19012CC	02/28/2019 17:50:59	17:53:58	0.008	0.016	10	2.2	
19012CC	02/28/2019 17:55:22	17:58:21	0.008	0.015	13	1.4	
19012BX	02/28/2019 18:03:08	18:06:07	0.008	0.017	13	1.5	X
19012BX	02/28/2019 18:07:44	18:10:43	0.008	0.016	14	1.4	
19012BX	02/28/2019 18:11:13	18:14:12	0.009	0.017	14	1.4	
19012CU	02/28/2019 18:52:19	18:55:18	0.010	0.018	14	1.8	
19012CU	02/28/2019 18:55:53	18:58:52	0.007	0.014	8	2.3	
19012CW	02/28/2019 19:10:00	19:12:59	0.009	0.016	13	1.7	
19012CW	02/28/2019 19:14:13	19:17:12	0.008	0.015	14	1.5	
19012BR	02/28/2019 19:29:15	19:32:14	0.013	0.024	14	1.5	
19012BR	02/28/2019 19:32:52	19:35:51	0.014	0.026	15	1.4	
19012BH	02/28/2019 19:50:18	19:53:17	0.007	0.014	13	2.2	
19012BH	02/28/2019 19:56:18	19:59:17	0.012	0.025	14	2.1	
19012BH	02/28/2019 20:00:19	20:03:18	0.014	0.029	15	1.6	
19012AZ	02/28/2019 20:19:27	20:22:26	0.015	0.031	15	1.6	
19012AZ	02/28/2019 20:22:49	20:25:50	0.013	0.026	13	2.3	
19012CQ	02/28/2019 20:37:08	20:40:07	0.006	0.011	17	1.4	
19012CQ	02/28/2019 20:40:34	20:43:35	0.008	0.014	15	1.6	
19012BD	02/28/2019 20:52:09	20:55:08	0.005	0.011	15	1.8	
19012BD	02/28/2019 20:55:39	20:58:38	0.005	0.011	15	1.8	
19012EA	02/28/2019 21:12:24	21:15:23	0.009	0.025	14	2.2	
19012EA	02/28/2019 21:15:51	21:18:50	0.005	0.012	14	2.2	
19012BI	02/28/2019 21:32:17	21:35:16	0.007	0.017	16	1.6	
19012BI	02/28/2019 21:35:56	21:38:55	0.006	0.014	13	1.8	
19012AC	02/28/2019 21:50:24	21:53:23	0.005	0.012	17	1.7	
19012AC	02/28/2019 21:53:44	21:56:43	0.007	0.017	16	1.7	
19012AX	02/28/2019 22:03:27	22:06:27	0.006	0.013	15	1.8	
19012AX	02/28/2019 22:06:55	22:09:54	0.013	0.026	15	1.7	
19012CS	02/28/2019 22:18:13	22:21:39	0.010	0.018	16	1.5	
19012CS	02/28/2019 22:22:05	22:25:04	0.005	0.010	16	1.5	
19012BF	02/28/2019 22:30:37	22:33:37	0.009	0.016	16	1.4	
19012BF	02/28/2019 22:34:19	22:35:03	0.009	0.016	16	1.4	
19012AI	03/01/2019 15:00:29	15:03:28	0.014	0.023	15	1.3	

GPSID	UTC Start	UTC End	Horz Prec	Vert Prec	# of SV's	PDOP	Reject
19012AI	03/01/2019 15:03:50	15:06:49	0.011	0.018	13	1.7	
19012BT	03/01/2019 15:17:17	15:20:18	0.009	0.016	14	1.6	
19012BT	03/01/2019 15:20:43	15:23:42	0.010	0.013	14	1.6	
19012BW	03/01/2019 15:38:48	15:41:47	0.011	0.022	13	2.2	
19012BW	03/01/2019 15:42:12	15:44:15	0.016	0.034	13	2.3	
19012BJ	03/01/2019 16:27:12	16:30:11	0.010	0.020	14	1.5	
19012BJ	03/01/2019 16:31:09	16:34:08	0.011	0.021	14	1.5	
19012BG	03/01/2019 16:39:26	16:42:25	0.006	0.011	13	1.8	
19012BG	03/01/2019 16:44:30	16:47:29	0.013	0.024	13	1.8	
19012BG	03/01/2019 16:48:53	16:51:52	0.007	0.012	13	1.8	
19012BB	03/01/2019 16:58:21	17:01:20	0.009	0.016	13	1.6	
19012BB	03/01/2019 17:01:43	17:04:42	0.009	0.017	13	1.6	
19012CP	03/01/2019 17:10:06	17:13:05	0.012	0.021	13	1.5	
19012CP	03/01/2019 17:13:37	17:16:37	0.012	0.021	13	1.6	
19012CM	03/01/2019 17:19:22	17:22:21	0.015	0.028	12	1.8	
19012CM	03/01/2019 17:22:43	17:25:42	0.007	0.013	12	1.8	
19012AU	03/01/2019 17:29:56	17:32:55	0.011	0.020	12	1.8	
19012AU	03/01/2019 17:33:19	17:35:23	0.012	0.022	12	1.8	
19012IA	04/16/2019 15:10:42	15:13:41	0.008	0.015	11	1.7	
19012IA	04/16/2019 15:14:11	15:17:10	0.019	0.018	12	1.8	
19012IB	04/16/2019 15:18:09	15:21:08	0.008	0.013	13	1.7	
19012IB	04/16/2019 15:21:37	15:24:36	0.009	0.017	13	1.7	
19012IC	04/16/2019 15:44:42	15:47:41	0.017	0.030	12	1.9	
19012IC	04/16/2019 15:48:01	15:51:00	0.012	0.020	8	2.2	
19012ID	04/16/2019 15:52:11	15:55:10	0.009	0.015	12	1.7	
19012ID	04/16/2019 15:55:57	15:58:56	0.006	0.010	12	1.7	
19012IE	04/16/2019 16:21:13	16:24:12	0.006	0.011	12	1.8	
19012IE	04/16/2019 16:24:37	16:27:36	0.007	0.013	13	1.7	
19012IF	04/16/2019 16:29:04	16:32:03	0.006	0.012	12	2.0	
19012IF	04/16/2019 16:32:55	16:35:54	0.007	0.014	12	2.0	

The differences in Earth Centered Earth Fixed (ECEF) vector components between occupations were transformed to a local horizon system (N-E-Up) for analysis, as shown in table 4. Station names in red had one of the two lines disabled after analysis.

Table 4 - Repeat Baseline Analysis

GPSID	Delta N	Delta E	Horiz	Delta U	Length
19012AB	-0.003	0.001	0.004	-0.009	60690
19012AC	0.008	-0.010	0.012	0.024	63514
19012AD	0.015	0.007	0.017	-0.026	52950
19012AF	0.000	0.011	0.011	0.011	21335
19012AH	0.010	0.001	0.010	0.006	28004
19012AI	-0.002	0.005	0.006	-0.011	49360
19012AJ	0.007	0.010	0.012	0.028	45949
19012AK	0.002	-0.012	0.012	0.003	67562
19012AL	0.006	-0.003	0.007	0.018	59387
19012AM	0.016	0.014	0.022	0.021	51599
19012AN	-0.005	0.009	0.010	0.017	59345
19012AO	0.019	0.035	0.040	0.022	61140
19012AO	-0.015	-0.002	0.015	-0.033	61140
19012AO	-0.034	-0.038	0.051	-0.055	61140
19012AP	0.007	0.011	0.013	-0.036	56629
19012AP	0.015	0.013	0.020	-0.030	56629
19012AP	0.008	0.001	0.008	0.007	56629
19012AQ	-0.013	-0.004	0.014	-0.063	44471
19012AQ	-0.012	-0.001	0.012	-0.039	44471
19012AQ	-0.007	-0.009	0.011	-0.045	44471

GPSID	Delta N	Delta E	Horiz	Delta U	Length
19012AQ	0.001	0.003	0.003	0.023	44471
19012AQ	0.007	-0.005	0.009	0.018	44471
19012AQ	0.005	-0.008	0.010	-0.005	44471
19012AR	0.001	0.006	0.006	0.032	52371
19012AR	0.001	0.009	0.009	0.040	52371
19012AR	0.001	0.003	0.003	0.008	52371
19012AS	0.007	0.037	0.038	-0.089	62047
19012AS	0.018	0.034	0.038	-0.055	62047
19012AS	0.020	0.052	0.055	-0.061	62047
19012AS	0.011	-0.003	0.012	0.033	62047
19012AS	0.013	0.015	0.020	0.027	62047
19012AS	0.002	0.018	0.018	-0.006	62047
19012AT	-0.009	0.010	0.013	-0.040	39647
19012AT	-0.003	0.004	0.005	-0.038	39647
19012AT	0.006	-0.006	0.009	0.002	39647
19012AU	-0.012	-0.018	0.022	0.008	49929
19012AV	0.005	0.005	0.007	-0.008	42312
19012AW	-0.004	-0.003	0.005	0.031	35499
19012AW	0.000	-0.001	0.001	0.017	35499
19012AW	0.004	0.002	0.004	-0.014	35499
19012AX	-0.013	-0.008	0.016	-0.007	58843
19012AY	-0.004	0.022	0.022	0.052	68091
19012AY	-0.001	-0.004	0.004	0.026	68091
19012AY	0.003	-0.026	0.026	-0.026	68091
19012AZ	-0.009	-0.016	0.018	0.015	69686
19012BA	-0.004	0.002	0.004	-0.015	32029
19012BB	0.005	0.000	0.005	-0.006	46520
19012BC	-0.008	-0.005	0.009	-0.026	34974
19012BD	-0.014	-0.003	0.015	0.030	72507
19012BE	-0.003	0.011	0.012	-0.020	29194
19012BF	-0.001	0.006	0.006	-0.023	53614
19012BG	-0.006	-0.010	0.011	-0.035	45017
19012BG	-0.007	0.005	0.009	-0.027	45017
19012BG	-0.001	0.015	0.015	0.009	45017
19012BH	0.005	-0.040	0.041	-0.027	66073
19012BH	0.021	-0.025	0.032	-0.016	66073
19012BH	0.016	0.016	0.022	0.010	66073
19012BI	0.018	0.000	0.018	0.005	56805
19012BJ	0.002	-0.004	0.004	0.026	41512
19012BK	0.005	0.008	0.009	-0.005	49317
19012BL	0.005	-0.009	0.010	-0.025	38743
19012BM	0.002	0.011	0.011	-0.010	45941
19012BN	0.003	0.002	0.004	-0.002	37727
19012BO	0.003	-0.004	0.004	-0.014	41134
19012BP	-0.003	0.000	0.003	0.017	55641
19012BQ	0.002	0.000	0.002	-0.033	44439
19012BQ	-0.004	-0.001	0.004	-0.031	44439
19012BQ	-0.006	-0.001	0.006	0.001	44439
19012BR	-0.012	-0.008	0.015	0.009	65527
19012BS	-0.011	0.007	0.013	-0.032	30358
19012BS	-0.003	0.022	0.022	0.021	30358
19012BS	0.008	0.015	0.017	0.053	30358
19012BT	0.014	-0.003	0.014	-0.001	49561
19012BU	-0.011	0.000	0.011	-0.001	35106
19012BV	0.003	-0.003	0.004	-0.007	21019

GPSID	Delta N	Delta E	Horiz	Delta U	Length
19012BW	-0.003	0.000	0.003	0.023	51981
19012BX	0.011	0.013	0.017	-0.057	72607
19012BX	0.019	-0.004	0.019	-0.034	72607
19012BX	0.008	-0.017	0.018	0.022	72607
19012BY	-0.002	-0.001	0.002	0.001	67063
19012BZ	0.008	0.007	0.010	-0.002	55237
19012CA	0.002	0.000	0.002	-0.035	65747
19012CA	0.000	-0.001	0.001	-0.036	65747
19012CA	-0.002	-0.001	0.002	-0.001	65747
19012CB	0.040	0.013	0.042	0.000	67074
19012CB	0.026	0.027	0.038	-0.012	67074
19012CB	-0.013	0.014	0.019	-0.012	67074
19012CC	0.002	-0.013	0.013	-0.062	71083
19012CC	-0.016	-0.001	0.016	-0.035	71083
19012CC	-0.015	-0.003	0.015	-0.053	71083
19012CC	-0.018	0.012	0.022	0.028	71083
19012CC	-0.017	0.010	0.019	0.009	71083
19012CC	0.001	-0.002	0.003	-0.019	71083
19012CD	-0.004	-0.007	0.008	0.026	65399
19012CE	0.011	-0.011	0.016	0.003	56960
19012CG	0.004	0.000	0.004	0.020	57252
19012CH	0.002	-0.003	0.004	0.015	60947
19012CI	-0.008	-0.011	0.013	0.007	45971
19012CJ	0.001	0.000	0.001	0.023	59986
19012CL	0.000	0.007	0.007	-0.017	66494
19012CM	0.005	-0.005	0.007	-0.003	50243
19012CN	0.000	-0.008	0.008	-0.021	68644
19012CO	-0.004	-0.008	0.009	0.017	39161
19012CP	-0.006	0.003	0.007	0.006	49798
19012CQ	-0.005	-0.004	0.006	-0.014	72333
19012CR	-0.002	-0.004	0.004	-0.023	41150
19012CS	-0.007	-0.008	0.010	0.012	55427
19012CT	-0.002	0.013	0.013	0.022	31378
19012CU	0.011	0.013	0.017	-0.001	60413
19012CW	0.018	0.018	0.026	0.005	65529
19012CX	0.009	-0.004	0.010	0.009	36641
19012CY	-0.008	-0.003	0.009	-0.007	32105
19012CZ	0.006	0.003	0.007	0.005	21493
19012DA	0.014	-0.009	0.017	-0.092	64623
19012DA	0.010	-0.012	0.015	-0.114	64623
19012DA	-0.005	-0.003	0.005	-0.022	64623
19012EA	-0.006	-0.001	0.006	-0.018	68711
19012IA	0.013	0.015	0.020	-0.010	34397
19012IB	0.004	-0.007	0.008	-0.004	34402
19012IC	-0.002	-0.026	0.026	-0.027	39903
19012ID	0.001	-0.008	0.008	0.005	39899
19012IE	-0.002	0.000	0.002	0.001	50495
19012IF	-0.003	-0.007	0.008	-0.017	50500

Table 5 is a summary of the RTX observations.

Table 5 - RTX Summary

GPSID	Horz Prec	Vert Prec	# of SV's	UTC Start	# of Positions	PDOP
AM0123	0.005	0.026	13	05/05/2019 13:11	300	1.6
AM0143	0.009	0.031	14	05/05/2019 13:54	300	1.4
VVA-F-13_RTX1	0.008	0.036	13	05/05/2019 14:37	300	1.6
VVA-F-13_RTX1	0.009	0.036	13	05/05/2019 14:44	300	1.6
VVA-F-05_RTX1	0.005	0.026	12	05/05/2019 16:43	470	2.1
VVA-F-05_RTX1	0.006	0.035	13	05/05/2019 16:55	300	1.9
100_RTX	0.008	0.029	18	05/05/2019 17:58	300	1.3
101_RTX	0.007	0.022	17	05/05/2019 18:09	300	1.3
102_RTX	0.005	0.024	13	05/05/2019 19:26	300	1.9
103_RTX	0.007	0.033	15	05/05/2019 19:33	300	1.3
104_RTX	0.005	0.024	13	05/05/2019 20:11	300	1.6
105_RTX	0.008	0.035	14	05/05/2019 20:18	300	1.4
DP0707	0.006	0.044	13	05/05/2019 21:14	300	1.4
VVA-F-04_RTX1	0.009	0.035	11	05/05/2019 22:06	300	1.8
VVA-F-04_RTX1	0.006	0.033	6	05/05/2019 22:13	300	2.9
VVA-F-08_RTX1	0.008	0.030	13	05/05/2019 22:58	300	1.6
VVA-F-08_RTX1	0.006	0.028	11	05/05/2019 23:06	300	1.8
106_RTX	0.010	0.029	14	05/06/2019 15:14	300	1.5
107_RTX	0.008	0.027	14	05/06/2019 15:22	300	1.5
108_RTX	0.005	0.029	13	05/06/2019 16:08	300	1.8
109_RTX	0.004	0.027	12	05/06/2019 16:16	300	2.2
VVA-F-09_RTX1	0.006	0.035	14	05/06/2019 17:35	300	1.7
VVA-F-09_RTX1	0.007	0.033	12	05/06/2019 17:42	300	2.0
110_RTX	0.008	0.033	14	05/06/2019 18:39	300	1.6
111_RTX	0.006	0.025	13	05/06/2019 18:47	300	1.6
112_RTX	0.006	0.028	12	05/06/2019 20:12	300	1.7
113_RTX	0.006	0.038	13	05/06/2019 20:36	300	1.3
114_RTY	0.011	0.026	11	05/06/2019 22:33	300	2.0
115_RTX	0.013	0.029	12	05/06/2019 22:41	300	1.9
DP0701	0.007	0.028	15	05/06/2019 23:14	300	1.6

The Trimble Centerpoint RTX real time solutions are stored as ITRF2008 epoch 2005.0 positions. The NGS utility Horizontal Time Dependent Positioning ([HTDP](#)) was used to transform the ITRF 2008 epoch 2005.0 positions to NAD83 (2011) epoch 2010.0 positions.

WOODS VVA CHECK POINTS

Of the 13 woods checkpoints, 5 were surveyed by direct occupation (VRS or RTX), and 8 were surveyed by establishing a pair of intervisible stations nearby in an open area using a Trimble R10 GNSS receiver (RTX Real Time). A Trimble S6 total station was then used to traverse to the woods point. Table 6 lists the conventional observations (mark-to-mark, grads and meters).

Table 6 - Conventional Total Station Observations to VVA-F points

Stand point	Back sight	Fore point	HI	HT	Direction	M-to-M Zenith Distance	M-to-M Distance
100_RTX	101_RTX	101_RTX	1.751	2.137	0.0000	99.9073	85.149
100_RTX	101_RTX	101_RTX	1.751	2.137	0.0000	99.9058	85.150
100_RTX	101_RTX	VVA-F-01	1.751	2.137	134.0628	100.7346	60.675
102_RTX	103_RTX	103_RTX	1.745	2.137	0.0000	99.7119	74.194
102_RTX	103_RTX	VVA-F-03	1.745	2.137	252.3758	101.1905	22.394

Stand point	Back sight	Fore point	HI	HT	Direction	M-to-M Zenith Distance	M-to-M Distance
104_RTX	105_RTX	105_RTX	1.771	2.137	0.0000	99.9481	98.131
104_RTX	105_RTX	VVA-F-02	1.771	2.137	136.7673	101.4869	22.346
106_RTX	107_RTX	107_RTX	1.658	2.137	0.0000	100.3123	46.957
106_RTX	107_RTX	VVA-F-10	1.658	2.137	230.9449	99.7377	53.844
108_RTX	109_RTX	109_RTX	1.722	2.137	0.0000	100.3406	52.804
108_RTX	109_RTX	VVA-F-06	1.722	2.137	113.3666	100.2209	20.597
110_RTX	111_RTX	111_RTX	1.743	2.137	0.0000	100.0490	107.482
110_RTX	111_RTX	VVA-F-07	1.743	2.137	198.2603	100.6137	24.226
112_RTX	113_RTX	113_RTX	1.677	2.137	0.0000	99.8257	56.779
112_RTX	113_RTX	VVA-F-11	1.677	2.137	305.5086	100.5141	26.216
114_RTY	115_RTX	115_RTX	1.771	2.137	0.0000	99.9170	108.991
114_RTY	115_RTX	VVA-F-12	1.771	2.137	293.3035	101.4387	33.495

LEAST SQUARES ADJUSTMENTS

Geolab was used to adjust the VRS vectors, RTX positions, and conventional observations. No scaling of the apriori GPS statistics was done. Station errors (centering, HI and HT) of 0.005 m were input. The GEOID12B model was used.

The VRS derived vectors for the GCP, NVA, and VVA points were adjusted by holding fixed the broadcast positions of the RTKNET CORS. The adjustment had an estimated variance factor of 0.52. A separate adjustment was performed for the VVA forested checkpoints surveyed by RTX, which had an estimated variance factor of 2.37. Table 7 lists the station confidence regions (error ellipses) at the 95% level (in meters) for these adjustments.

Table 7 - Station Confidence Regions (95% meters)

Station Name	Major Semi-Axis	Azimuth	Minor Semi-Axis	Vertical
100_RTX	0.020	74	0.015	0.053
101_RTX	0.019	85	0.015	0.053
102_RTX	0.013	115	0.011	0.059
103_RTX	0.020	100	0.012	0.060
104_RTX	0.015	101	0.011	0.060
105_RTX	0.022	90	0.013	0.060
106_RTX	0.026	57	0.015	0.060
107_RTX	0.022	41	0.012	0.060
108_RTX	0.014	64	0.010	0.059
109_RTX	0.011	90	0.008	0.059
110_RTX	0.021	180	0.013	0.061
111_RTX	0.015	179	0.012	0.061
112_RTX	0.016	153	0.011	0.068
113_RTX	0.016	157	0.011	0.068
114_RTY	0.034	143	0.013	0.058
115_RTX	0.038	152	0.009	0.058
19012AB	0.011	162	0.010	0.013
19012AC	0.011	40	0.010	0.015
19012AD	0.015	14	0.013	0.026
19012AF	0.011	1	0.011	0.015
19012AH	0.013	164	0.011	0.018

Station Name	Major Semi-Axis	Azimuth	Minor Semi-Axis	Vertical
19012AI	0.014	177	0.013	0.022
19012AJ	0.015	25	0.012	0.025
19012AK	0.012	172	0.011	0.017
19012AL	0.011	16	0.011	0.016
19012AM	0.011	51	0.011	0.017
19012AN	0.011	153	0.010	0.015
19012AO	0.012	169	0.011	0.016
19012AP	0.009	72	0.008	0.013
19012AQ	0.013	33	0.010	0.022
19012AR	0.012	89	0.011	0.021
19012AS	0.014	25	0.011	0.019
19012AT	0.010	41	0.009	0.014
19012AU	0.014	154	0.013	0.022
19012AV	0.013	55	0.012	0.019
19012AW	0.011	103	0.010	0.014
19012AX	0.012	32	0.011	0.018
19012AY	0.012	31	0.011	0.016
19012AZ	0.016	31	0.013	0.029
19012BA	0.011	120	0.010	0.014
19012BB	0.013	14	0.011	0.018
19012BC	0.013	68	0.012	0.019
19012BD	0.010	58	0.010	0.013
19012BE	0.010	140	0.010	0.012
19012BF	0.013	18	0.011	0.018
19012BG	0.010	15	0.009	0.013
19012BH	0.012	29	0.009	0.017
19012BI	0.011	43	0.010	0.017
19012BJ	0.013	19	0.012	0.021
19012BK	0.019	79	0.011	0.023
19012BL	0.011	13	0.010	0.013
19012BM	0.012	23	0.011	0.017
19012BN	0.013	11	0.011	0.018
19012BO	0.011	32	0.010	0.014
19012BP	0.015	7	0.012	0.019
19012BQ	0.010	33	0.009	0.013
19012BR	0.018	36	0.011	0.026
19012BS	0.011	13	0.010	0.013
19012BT	0.013	11	0.011	0.015
19012BU	0.011	26	0.010	0.012
19012BV	0.011	5	0.011	0.014
19012BW	0.015	6	0.014	0.027
19012BX	0.012	110	0.011	0.018
19012BY	0.010	14	0.010	0.015
19012BZ	0.012	159	0.012	0.018
19012CA	0.008	17	0.008	0.013
19012CB	0.012	4	0.010	0.018
19012CC	0.009	129	0.009	0.013
19012CD	0.011	18	0.010	0.017
19012CE	0.014	14	0.013	0.023
19012CG	0.010	35	0.010	0.013
19012CH	0.010	161	0.010	0.013
19012CI	0.012	49	0.011	0.016
19012CJ	0.011	149	0.010	0.013
19012CL	0.011	140	0.011	0.015

Station Name	Major Semi-Axis	Azimuth	Minor Semi-Axis	Vertical
19012CM	0.013	177	0.012	0.019
19012CN	0.012	9	0.011	0.017
19012CO	0.012	59	0.011	0.016
19012CP	0.015	7	0.012	0.022
19012CQ	0.011	65	0.010	0.014
19012CR	0.012	49	0.011	0.016
19012CS	0.011	21	0.011	0.015
19012CT	0.012	2	0.010	0.015
19012CU	0.012	68	0.011	0.017
19012CW	0.012	53	0.011	0.017
19012CX	0.011	11	0.010	0.014
19012CY	0.013	36	0.012	0.017
19012CZ	0.011	178	0.011	0.014
19012DA	0.011	7	0.010	0.016
19012EA	0.011	50	0.010	0.017
19012IA	0.013	12	0.011	0.014
19012IB	0.012	74	0.011	0.017
19012IC	0.016	49	0.015	0.025
19012ID	0.011	55	0.010	0.014
19012IE	0.011	43	0.010	0.014
19012IF	0.011	39	0.010	0.015
DP0701	0.022	141	0.015	0.086
DP0707	0.018	65	0.011	0.134
AM0123	0.016	118	0.013	0.080
VVA-F-01	0.034	51	0.017	0.054
VVA-F-02	0.019	75	0.015	0.061
VVA-F-03	0.019	122	0.014	0.060
VVA-F-04_RTX	0.014	148	0.012	0.071
VVA-F-05_RTX	0.011	95	0.009	0.063
VVA-F-06	0.019	31	0.013	0.060
VVA-F-07	0.027	179	0.016	0.061
VVA-F-08_RTX	0.014	164	0.009	0.060
VVA-F-09_RTX	0.014	24	0.010	0.073
VVA-F-10	0.051	95	0.022	0.061
VVA-F-11	0.020	14	0.015	0.068
VVA-F-12	0.038	160	0.014	0.058
VVA-F-13_RTX	0.018	63	0.014	0.076
AM0143	0.026	118	0.021	0.094

SUMMARY

A LiDAR ground control network consisting of 12 ground control points (GCP) and 80 QA/QC check points was established in coastal Texas. The estimated accuracy of the control network is ± 0.05 m with respect to the NAD83 (2011) epoch 2010.0 reference frame and the NAVD88 vertical datum.

Adjusted Coordinates

Horizontal Datum: NAD83 (2011) epoch 2010.0

Vertical Datum: NAVD88=Ellipsoidal Height-GEOID12B

Units: meters

Table 8 - Geodetic Coordinates

Station Name	Latitude	Longitude	NAVD88	Ellip Hgt
GCP01	28°24'19.77971" N	96°22'08.30534" W	1.035	-25.814
GCP02	28°39'11.87721" N	96°19'23.16390" W	1.761	-25.177
GCP03	28°44'33.86766" N	96°11'39.74627" W	4.600	-22.261
GCP04	28°51'17.62999" N	96°15'40.23050" W	9.015	-17.949
GCP05	28°28'35.89311" N	96°15'06.00050" W	0.565	-26.237
GCP06	29°08'22.90019" N	95°59'05.13967" W	21.800	-5.199
GCP07	28°33'20.86977" N	96°05'08.99934" W	1.889	-24.798
GCP08	29°03'24.09767" N	96°06'53.14245" W	21.206	-5.806
GCP09	28°52'13.34685" N	95°59'56.63277" W	9.311	-17.424
GCP10	28°56'27.96426" N	96°18'33.02351" W	13.392	-13.719
GCP11	28°39'25.75772" N	95°57'40.88750" W	1.137	-25.507
GCP12	28°46'47.83079" N	95°56'16.61421" W	5.006	-21.666
NVA01	28°53'21.19355" N	96°19'14.95747" W	10.869	-16.199
NVA02	28°41'24.21850" N	96°19'25.72170" W	3.512	-23.421
NVA03	28°38'33.36021" N	96°19'21.92217" W	2.818	-24.122
NVA04	28°49'32.04253" N	96°16'49.38847" W	8.310	-18.646
NVA05	28°56'27.45665" N	96°16'25.58730" W	13.938	-13.133
NVA06	28°51'50.93073" N	96°16'24.29606" W	8.582	-18.404
NVA07	28°46'13.99673" N	96°16'00.72422" W	5.051	-21.858
NVA08	28°59'01.50518" N	96°15'40.65801" W	17.701	-9.395
NVA09HV	28°52'19.26514" N	96°13'02.73869" W	11.698	-15.238
NVA10	28°56'29.64242" N	96°12'37.82335" W	14.578	-12.425
NVA11	29°00'18.64208" N	96°12'27.63852" W	17.901	-9.158
NVA12	28°47'16.94782" N	96°12'35.65120" W	7.462	-19.413
NVA13HV	28°42'16.37175" N	96°13'07.26631" W	4.168	-22.707
NVA14	28°41'09.28489" N	96°11'26.19185" W	4.517	-22.344
NVA15	29°01'44.68487" N	96°10'28.26837" W	18.231	-8.813
NVA16	28°53'34.91467" N	96°09'31.05777" W	10.482	-16.419
NVA17	28°59'45.48053" N	96°08'25.28472" W	17.774	-9.208
NVA18	28°38'49.84617" N	96°11'52.28119" W	3.496	-23.364
NVA19	29°02'52.00225" N	96°08'00.26381" W	21.333	-5.688
NVA20	28°49'37.81630" N	96°08'44.37806" W	7.714	-19.124
NVA21	28°54'15.17425" N	96°08'07.37447" W	11.613	-15.276
NVA22	28°42'49.92151" N	96°08'21.66396" W	5.115	-21.718
NVA23	28°47'48.18452" N	96°07'21.89829" W	6.996	-19.817
NVA24	28°56'02.08370" N	96°05'24.75811" W	12.988	-13.880
NVA25	28°51'48.90643" N	96°04'46.98243" W	10.936	-15.865
NVA26	28°57'33.52201" N	96°04'14.97494" W	16.011	-10.859
NVA27	28°53'39.36926" N	96°04'18.53525" W	11.009	-15.806
NVA28	28°58'07.79263" N	96°03'51.23446" W	16.416	-10.456
NVA29	28°56'17.60741" N	96°03'38.97865" W	13.816	-13.024
NVA30	28°48'27.13401" N	96°03'08.38718" W	10.160	-16.605
NVA31	28°54'32.85382" N	96°02'57.31927" W	12.284	-14.520
NVA32	28°43'03.56671" N	96°03'53.62288" W	3.941	-22.846
NVA33	29°02'12.96449" N	96°02'57.12522" W	18.602	-8.329
NVA34	28°51'55.60821" N	96°01'15.75508" W	10.484	-16.267
NVA35HV	29°00'09.23566" N	95°59'48.02838" W	17.248	-9.593
NVA36	29°08'32.97602" N	95°59'08.49609" W	21.663	-5.340

NVA37	28°50'56.27528" N	95°59'00.02122" W	10.028	-16.687
NVA38	28°35'50.41017" N	95°58'41.81695" W	3.129	-23.466
NVA39	28°41'10.81418" N	95°58'28.94628" W	2.186	-24.500
NVA40	28°49'18.73303" N	95°58'03.45955" W	8.525	-18.175
NVA41	28°41'57.53407" N	95°58'02.44932" W	3.013	-23.673
NVA42	28°40'12.06269" N	95°57'51.57033" W	1.933	-24.727
NVA43	28°36'22.62807" N	95°57'58.94394" W	1.378	-25.211
NVA44HV	28°42'05.74789" N	95°57'52.87396" W	2.598	-24.085
NVA45	28°48'44.12117" N	95°56'16.94994" W	7.871	-18.804
NVA99	28°41'19.55772" N	96°06'39.14082" W	3.272	-23.545
VVA01	28°24'19.67536" N	96°22'08.16139" W	1.034	-25.816
VVA02	28°47'01.52113" N	96°19'26.57792" W	7.409	-19.556
VVA03	28°38'49.58720" N	96°19'22.49454" W	2.344	-24.595
VVA04	28°56'26.96212" N	96°18'32.59458" W	12.730	-14.379
VVA05	28°43'10.77786" N	96°18'29.46499" W	4.356	-22.566
VVA06	28°28'35.62438" N	96°15'06.28815" W	0.926	-25.877
VVA07	28°42'23.52981" N	96°14'35.74260" W	3.068	-23.817
VVA08	28°52'06.92602" N	96°12'54.55364" W	10.452	-16.479
VVA09	28°41'57.11450" N	96°13'01.09009" W	3.506	-23.368
VVA10	28°58'14.83324" N	96°12'31.75756" W	14.440	-12.592
VVA11	28°52'17.85810" N	96°12'36.19241" W	10.535	-16.394
VVA12	28°38'01.82664" N	96°12'16.69298" W	3.250	-23.612
VVA13	28°56'34.54669" N	96°09'52.06772" W	11.850	-15.108
VVA14	28°48'43.70859" N	96°09'36.56347" W	6.990	-19.855
VVA15	29°01'31.73243" N	96°06'01.01422" W	18.590	-8.377
VVA16	28°45'48.39215" N	96°06'00.53227" W	6.877	-19.926
VVA17	28°33'20.79728" N	96°05'09.52340" W	2.006	-24.682
VVA18	28°43'02.20214" N	96°04'48.53102" W	4.143	-22.656
VVA19	28°59'05.33386" N	96°00'48.50332" W	17.568	-9.269
VVA20	29°01'50.32336" N	95°59'48.69558" W	16.909	-9.966
VVA21	29°08'17.54714" N	95°59'04.07974" W	21.830	-5.166
VVA22	28°42'00.41768" N	95°57'17.24815" W	1.741	-24.930
VVAF01	28°53'24.87285" N	96°16'03.83373" W	10.678	-16.329
VVAF02	28°45'48.22776" N	96°15'35.52055" W	3.016	-23.886
VVAF03	28°48'00.50958" N	96°13'04.84030" W	7.916	-18.969
VVAF04	28°43'46.63811" N	96°11'02.95251" W	3.240	-23.617
VVAF05	28°56'32.92075" N	96°10'19.45991" W	11.080	-15.886
VVAF06	28°50'47.02721" N	96°09'13.48633" W	8.873	-17.982
VVAF07	29°04'49.90670" N	96°05'52.50375" W	21.918	-5.105
VVAF08	28°47'03.44071" N	96°04'52.74499" W	8.112	-18.673
VVAF09	28°58'01.96804" N	96°03'47.89908" W	16.094	-10.775
VVAF10	28°56'21.12935" N	96°01'12.17226" W	13.974	-12.825
VVAF11	29°06'21.07502" N	95°58'39.40227" W	20.797	-6.155
VVAF12	28°46'20.56320" N	95°59'48.22469" W	6.100	-20.627
VVAF13	28°40'10.43980" N	95°57'48.48203" W	1.060	-25.599

Horizontal Datum: NAD83 (2011) epoch 2010.0
 Vertical Datum: NAVD88=Ellipsoidal Height-GEOID12B
 Units: meters

UTM Zone 14 & 15

State Plane Coordinates TX SC (4204)

Table 9 - UTM and State Plane Coordinates

Station Name	SPC Northing	SPC Easting	UTM 14 Northing	UTM 14 Easting	UTM 15 Northing	UTM 15 Easting
GCP01	4066313.299	857794.073	3144939.038	757764.257	3146742.552	169897.399
GCP02	4093870.788	861659.461	3172507.333	761646.826	3174095.495	175156.970
GCP03	4104075.025	874002.055	3182711.721	774000.946	3183669.040	188013.448
GCP04	4116346.362	867188.298	3194992.984	767187.807	3196282.517	181826.743
GCP05	4074459.832	869100.741	3153082.315	769081.386	3154314.420	181611.863
GCP06	4148561.205	893334.759	3227223.719	793360.033	3227148.010	209606.671
GCP07	4083623.037	885116.362	3162241.208	785111.871	3162662.178	198084.266
GCP08	4139046.564	880917.283	3217704.071	780931.692	3218273.202	196708.631
GCP09	4118688.451	892709.326	3197327.839	792726.769	3197323.220	207455.796
GCP10	4125788.444	862286.857	3204441.958	762286.416	3205971.383	177408.181
GCP11	4095161.961	897000.298	3173781.576	797010.617	3173591.621	210547.247
GCP12	4108825.748	898931.554	3187455.020	798949.957	3187149.157	213172.173
NVA01	4120014.348	861283.344	3198664.940	761280.687	3200250.182	176110.568
NVA02	4097942.133	861496.807	3176580.848	761485.962	3178173.813	175201.063
NVA03	4092686.160	861720.312	3171322.070	761707.142	3172908.157	175157.685
NVA04	4113053.111	865390.115	3191698.462	765387.451	3193081.952	179861.468
NVA05	4125852.734	865737.093	3204505.350	765738.648	3205859.653	180860.605
NVA06	4117343.308	865970.492	3195990.913	765969.627	3197341.159	180660.136
NVA07	4106988.901	866851.462	3185630.262	766847.345	3186945.446	181013.736
NVA08	4130622.083	866842.345	3209277.233	766845.780	3210571.008	182208.868
NVA09HV	4118343.941	871410.205	3196990.354	771412.904	3198064.287	186148.891
NVA10	4126065.427	871901.316	3204716.477	771906.661	3205757.816	187033.493
NVA11	4133119.522	872008.729	3211774.987	772015.933	3212803.761	187500.921
NVA12	4109057.564	872365.985	3187697.964	772365.922	3188732.809	186631.459
NVA13HV	4099786.839	871728.892	3178421.967	771724.532	3179498.108	185523.239
NVA14	4097787.795	874520.964	3176420.443	774517.344	3177358.029	188212.624
NVA15	4135845.073	875174.178	3214501.593	775184.031	3215366.558	190804.355
NVA16	4120809.943	877087.851	3199456.081	777094.949	3200239.943	191949.951
NVA17	4132257.444	878590.294	3210910.789	778601.607	3211605.934	194035.807
NVA18	4093479.548	873915.790	3172109.916	773909.718	3173082.307	187388.934
NVA19	4138014.192	879126.535	3216671.342	779139.497	3217332.810	194865.904
NVA20	4113544.092	878530.208	3192184.973	778535.747	3192903.715	193021.508
NVA21	4122104.218	879323.910	3200750.509	779332.900	3201419.667	194251.036
NVA22	4101006.282	879452.879	3179638.643	779453.824	3180324.523	193305.931
NVA23	4110225.002	880848.470	3188862.800	780854.269	3189468.081	195169.767
NVA24	4125503.030	883645.698	3204150.349	783658.697	3204596.527	198744.209
NVA25	4117737.165	884862.957	3196378.615	784874.314	3196772.284	199564.947
NVA26	4128364.150	885464.381	3207012.992	785479.492	3207363.492	200708.016
NVA27	4121155.851	885548.476	3199799.494	785561.475	3200154.381	200424.383
NVA28	4129434.919	886080.444	3208084.368	786096.294	3208402.299	201378.434
NVA29	4126052.384	886497.357	3204699.259	786512.558	3205000.137	201622.527
NVA30	4111594.815	887690.488	3190230.845	787701.560	3190488.946	202078.228
NVA31	4122857.086	887706.462	3201501.264	787721.569	3201744.746	202668.052
NVA32	4101606.430	886714.321	3180235.837	786720.394	3180555.274	200594.399
NVA33	4137016.755	887354.381	3215671.466	787373.009	3215915.362	203038.967
NVA34	4118087.756	890579.938	3196727.446	790595.564	3196831.367	205296.924
NVA35HV	4133339.346	892566.238	3211990.053	792587.972	3211973.581	208060.284

Station Name	SPC Northing	SPC Easting	UTM 14 Northing	UTM 14 Easting	UTM 15 Northing	UTM 15 Easting
NVA36	4148868.941	893236.084	3227531.713	793261.322	3227460.632	209523.800
NVA37	4116356.137	894304.027	3194993.161	794321.846	3194910.911	208930.775
NVA38	4088492.025	895517.678	3167107.495	795523.204	3167000.882	208726.834
NVA39	4098361.115	895612.129	3176983.860	795623.057	3176859.447	209322.438
NVA40	4113394.055	895914.346	3192028.168	795932.274	3191868.450	210389.304
NVA41	4099817.485	896293.875	3178440.989	796306.046	3178280.325	210077.814
NVA42	4096579.404	896673.325	3175200.262	796684.140	3175024.844	210292.479
NVA43	4089513.645	896656.386	3168129.216	796663.337	3167964.106	209916.721
NVA44HV	4100076.995	896547.123	3178700.572	796559.615	3178526.812	210344.107
NVA45	4112404.156	898828.736	3191036.319	798848.562	3190730.696	213251.603
NVA99	4098293.760	882303.069	3176923.019	782304.592	3177468.422	196016.957
VVA01	4066310.175	857798.063	3144935.910	757768.247	3146739.228	169901.229
VVA02	4108322.397	861236.007	3186966.675	761229.319	3188564.139	175467.938
VVA03	4093185.207	861693.338	3171821.384	761680.394	3173408.413	175156.044
VVA04	4125757.870	862299.179	3204411.363	762298.736	3205940.189	177418.939
VVA05	4101256.631	862947.981	3179896.451	762939.350	3181413.540	176820.149
VVA06	4074451.377	869093.113	3153073.861	769073.749	3154306.355	181603.811
VVA07	4099950.281	869323.046	3178586.588	769317.364	3179783.725	183126.620
VVA08	4117969.481	871640.975	3196615.588	771643.692	3197678.211	186360.494
VVA09	4099198.179	871910.578	3177832.879	771906.057	3178900.449	185674.945
VVA10	4129306.614	871988.246	3207959.676	771994.510	3208993.341	187285.779
VVA11	4118317.774	872130.353	3196963.935	772133.488	3198001.436	186867.432
VVA12	4091985.869	873288.383	3170615.676	773281.190	3171621.092	186685.975
VVA13	4126324.285	876384.773	3204974.250	776393.064	3205787.843	191528.381
VVA14	4111844.500	877156.395	3190484.793	777160.404	3191274.801	191561.754
VVA15	4135623.434	882412.583	3214278.220	782427.324	3214775.203	198028.327
VVA16	4106592.945	883145.598	3185227.359	783151.447	3185720.826	197281.012
VVA17	4083620.451	885102.178	3162238.629	785097.677	3162660.313	198069.958
VVA18	4101527.141	885225.770	3180157.185	785230.781	3180551.697	199102.563
VVA19	4131330.927	890980.404	3209980.491	791000.406	3210047.203	206372.721
VVA20	4136449.745	892468.288	3215102.894	792490.680	3215087.331	208121.280
VVA21	4148397.208	893367.644	3227059.588	793392.921	3226982.418	209631.144
VVA22	4099938.100	897518.012	3178561.089	797531.178	3178338.642	211307.368
VVAF01	4120247.365	866457.291	3198896.498	766457.635	3200219.434	181294.749
VVAF02	4106211.843	867553.471	3184852.481	767549.443	3186132.957	181675.978
VVAF03	4110379.331	871542.737	3189020.850	771542.687	3190095.957	185875.790
VVAF04	4102645.522	875035.015	3181280.895	775033.919	3182187.611	188973.307
VVAF05	4126256.289	875644.471	3204906.417	775652.258	3205757.643	190784.913
VVAF06	4115654.814	877689.510	3194297.380	777695.265	3195056.342	192288.670
VVAF07	4141727.886	882491.406	3220386.988	782507.432	3220872.836	198419.127
VVAF08	4108948.251	884926.135	3187583.534	784934.188	3187984.404	199180.532
VVAF09	4129257.938	886175.211	3207907.233	786191.082	3208220.567	201464.121
VVAF10	4126261.360	890468.748	3204907.218	790486.951	3205006.385	205602.579
VVAF11	4144830.110	894127.024	3223489.539	794152.361	3223378.392	210207.587
VVAF12	4107837.817	893215.940	3186468.801	793229.506	3186452.681	207409.533
VVAF13	4096531.638	896758.441	3175152.416	796769.296	3174972.782	210375.118