Multiple GPS receivers and redundant baselines are used to create a network. In performing an adjustment to the network the highest coordinate accuracy is obtained.

Lab 3: Static GPS Network

Cyr,Samantha

1. Project Description

After tackling static collections in labs 1 and 2, this lab sought to generate a higher accuracy in the collected GPS coordinates. A static network is created from a collection of location points and a series of loops that collect redundant baselines between these points. These loops are defined by their need to start at one location and create baselines connecting two more locations; then returning to the origin point. Therefore the coordinates of the starting point need to match the same point at the end of the loop. The redundant baselines resulting from loops are used to measure the distance between the location points so that an average distance can be computed. Therefore once all the loops in the network are collected an adjustment can be made in order to "massage" the location points into place. Specifically the adjustment uses baselines that are computed between the multiple points, with control locations used as reference for the rest. This process will not only obtain a higher accuracy but highlights when errors occur in the collection, such as a wrongly inputted antenna height and other anomalies.

2. Procedures

The six locations for the GPS receivers were chosen by the instructor and represent two High Precision Network (HPN) monuments for reference points and four Nova Scotia survey control monuments (CM). Each one was given a monument number in reference to this project and is observable in appendix 5.2. Their correspondences to geographical locations in Annapolis County, in order from one to six, are: Tupperville, Lawrencetown, Kingston, Hampton, Outram, and Mosher's Corner. Each monument was visited prior to collection in order to locate their exact position and more accurately time driving distances between each. For each monument's location survey sketches are provided in appendix 5.8

In planning the execution of this project decisions were made which would result in a static network with an AA standard. This required that all stations are observed 3 or more times totaling 80%, HPN controls are observed 2 or more times for 100%, survey monuments are observed 2 or more times at 100% and baselines duplicate 2 or more times totaling 25%. This goal was met with all stations being observed 3 or more times, providing 100% coverage for all station related criteria. The baseline criteria exceeded 25% with 6 of the seven baselines repeating, totaling 85% of the network.

Out of each loop only two baselines would be used in the adjustment (independent lines) and one line is designated as a dependent (trivial) line. Those lines chosen as independent are based on a number of criteria: including the shortest distance, utilizing a particular station multiple times and redundancy across sessions. The

trivial line is not used in the processing of the network. To see which baselines are created and designated for each session (aka loop) please see appendix 5.2.

The second half of planning for this project was focused on collection logistics; a task that was broken down into two days. The first day focused on loop sessions 3,4,6 and 7, representing the east portion of the network extents. The second day completed the network with loops 1,2,5, and 9. On each day gear was collected and inventoried so that all three team collectors had complete sets of receiver equipment with charged batteries and data storage cards. Some other necessities needed were warm clothing, safety vests and cell phones for communication.

Timing for collection was a huge component. Despite most team members having cell phones these could not be relied on to convey start and stop times; little to no cell reception was available on the North Mountain. Thus the schedule for the entire day was calculated before all collectors were dropped off to their respective locations. In the case of delay or other happenings cell phones could be tried, with one member designated as driver and visiting collection points as needed.

To calculate the schedule the first student and receiver were dropped off with all members remaining till the GPS receiver was set-up over the monument. As soon as collection began the time was recorded. Travel to the next point and set-up time was added so that the next receiver was to be collecting by a particular time. From this another set of travel and setup time was added so that the last receiver had a time to be collecting by. This last time is the point that actual collection could start from. By adding the appropriate collection interval a known point where all receivers could stop the recording and start a new session is provided to all collectors, circumventing immediate communications. This procedure of adding travel, set-up and collection intervals was repeated for each session of the day and is available in detail in appendix 5.4. As a general rule these times were rounded up in order to provide some buffer in the schedule.

At the end of each collection day the equipment was retuned, with data being extracted from each storage card. This data comprised of each receiver recording 4 collection periods for each day, totaling 24. The associated field base logs for each GPS recording are available in appendix 5.9.

In regards to processing the network results the 24 recorded intervals were brought into the Leica GeoOffice software. The two HPN monuments were set as control points with official coordinates added. Next the baselines were measured for each loop session. A receiver location was set to reference whereas another was set to rover (both from the same session loop), thus computing the baseline between the two points. Three

baselines in each session added to a total of 24 baselines. During this process if a monument location was already used it had to be referred to its first instance. This enabled the program to register that the receiver location was the same point between all sessions, continually updating the location of the receiver as each baseline was made.

Once all baselines were made an adjustment pre-analysis and a loops and misclosures report were generated. In the event that anything was wrong during collection these reports could indicate an issue with outlying data. Therefore these issues were resolved before the final adjustment, the outcomes of which are discussed in the following section.

3. Results

As mentioned before the goal of the planned network was to reach an AA standard, which was exceeded. A least-squares adjustment was performed, providing results that would deem the network as successful by reaching sub-centimeter accuracy. The highest standard deviation for a corrected coordinate was 35mm (M#26831) whereas the lowest was 28mm (M#14427). From within the network adjustment report (appendix 5.6) a variety of testing was provided to assess the return values. For instance the T-test was done in a 2 dimensional and 3 dimensional framework to look for manual errors in the receiver stations, which returned 2.42 and 1.89 respectively. Those intervals that were on the higher end and flagged by the report were reviewed and deemed acceptable. One of the more important assessments was the F-test whose value was at 0.14, falling well below the F-test limit of 0.96. This indicates the model test for the adjustment succeeded.

While Leica Geo Office successfully performed the network adjustment on the receiver stations, externally the returned coordinates were compared to the established coordinates documented for each survey monument. Appendix 5.5 contains an excel sheet that displays the collected results and the official coordinates while measuring the difference between the two. Collection of the receiver points was in WGS 84 and transformed to UTM 20 NAD83 CSRS with ellipsoidal heights converted to orthometric heights via a HT 2.0 model. The UTM coordinates are presented in geographic and projected coordinates. The official coordinates are in ATS 77, also displayed as geographic and projected, as well as a transformed projected version (UTM 20 NAD83 CSRS) to more easily compare the results. Of these the most accurate Easting for a survey monument was M#14427 at 72mm, the furthest was M#26831 at 6cm. Northing was best at M#214393 with 4.8cm difference and worst at M#26831 with 13cm. Lastly for the elevation the smallest difference was at M#27012 with 1.3cm and farthest at M#14393 with 4.1cm. Despite the two HPN monuments being used as control points in the network and their

official coordinate inputted for use, they show differences in this table. Therefore these results are suspect, possibly due to the transformation of ATS77 to NAD83.

4. Discussion

Overall the precision and accuracy of the network were quite satisfactory. The collection for the network could be replicated without much difficulty, given the documentation created during the planning phase. This would include the collection times, network map and sessions break down. Some items could be addressed, such as naming and storage conventions. As it was discovered during the network processing in Leica Geo Office one of the collection days at a single receiver was stored in a single job, whereas all other receivers and their sessions were stored as separate jobs with a single point in each. Likewise one collector lost a sheet with the planned session numbers, leaving 2 sessions at that receiver location to be renamed in order to correlate with everything else. These issues are certainly symptomatic to the isolated nature of collection, not being able to confirm procedure as problems arose. This could be curtailed with a short review on collection standards before heading to the field. As well, having a safe location to store pertinent information or making duplicates would help safeguard key instructions. While it did not cause any major issues, other than the ability to automatically sort the recording intervals by name, there was the shortening of the monument numbers in storage name and/or base log forms. This could lead to problems in a larger area with more points with similar identifiers. By the second day of collection base log forms were partially filled out in order to maintain the naming convention and imply a schedule to session collection.

One of the benefits of creating a network is that errors in collection are detected. This was the case for S7M27012 which was missing its measurement for antenna height. Without this information the elevation for M#21012 would have been skewed unless this collection interval was removed from the network. Luckily by reviewing the base log form the antenna height was documented and was able to be added to the interval to correct the omission.

5. Conclusion

In retrospect the static network collection would be deemed a success; the collected data met the AA standard and the adjustment reached sub-centimeter accuracy. This outcome was attainable primarily due to extensive planning before entering the field. Despite some of this planning some issues would arise during collection, such naming conventions and missing data. While these did occur they were easily solvable in the Leica Geo Office

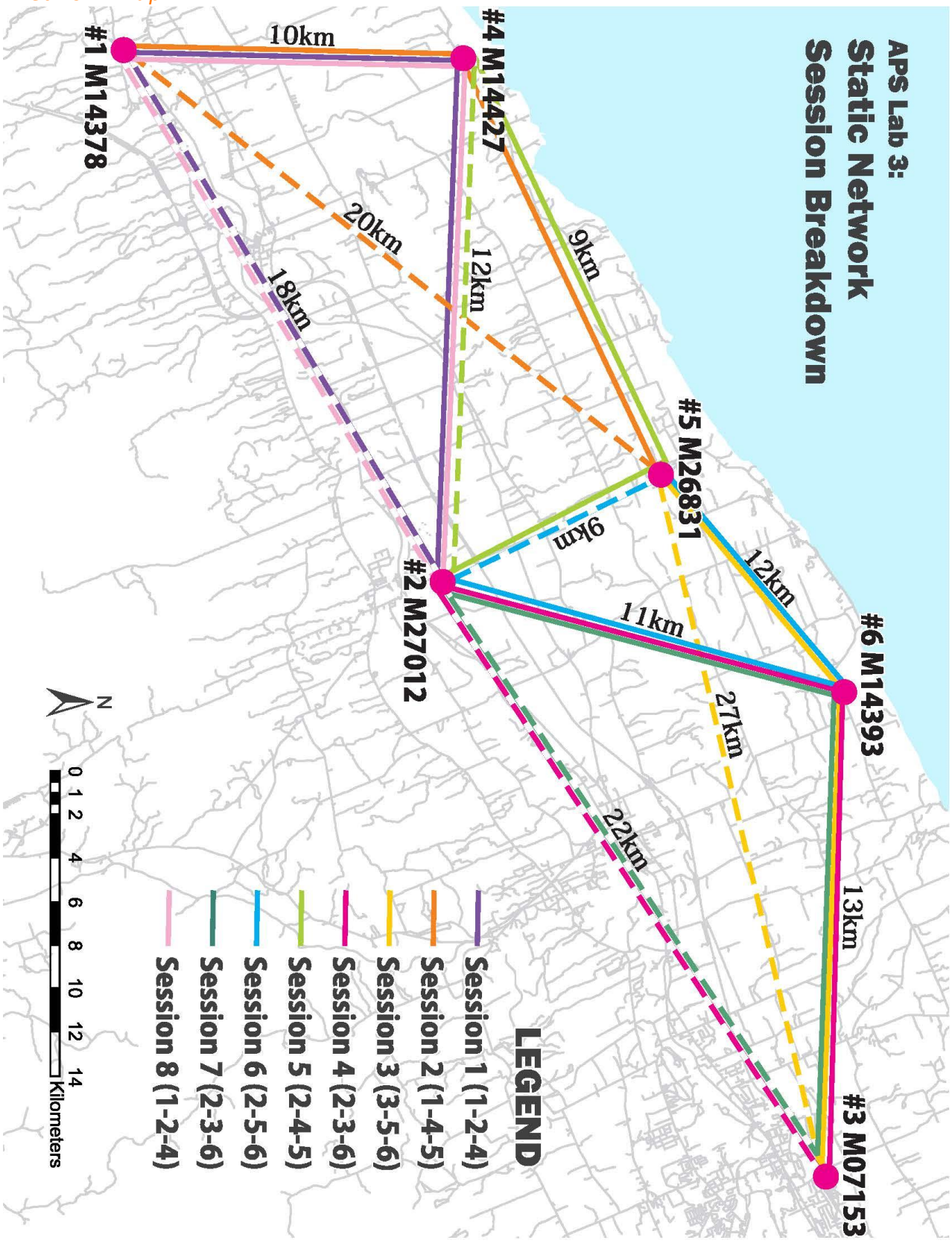
software accompanied by planning notes and base logs, demonstrating one of the chief benefits of working in a network.

5. Appendices

5.1 Configuration Parameters

Processing Parameters	
GPS Unit	Leica 1200 + GNSS
Antenna Type	AX1203 + GNSS Tripod
Observation Type	Fast Static, every 1 second
Cut-off Angle	15°
Ephemeris type (GPS)	Broadcast
Satellite Frequency	L1/E1 and L2
Fix ambiguities up to	80 km
Tropospheric model	Hopfield
Ionospheric model	Automatic (Computed)
Local Time Zone	-3.00 hours/-4.00 hours
Coordinate System	WGS84
Observation Date	23-Oct-12/ 06-Nov-12
Julian Day	297/311
GPS Week/Day	1713:2/ 1711:2

5.2 Network Map



5.3 Timing Collection

Bold typeface minutes are the minimum length of time to collect for each session. Times are based on 10 minutes plus one minute for every km, under 15km.

Session and Baselines	Distance (Km)	Recording Time (minutes)	Adjustment for 15km+
Session 1 & 8			
M1 - M4	10	20	
M2 - M4	12	22	
(M1 - M2)	18	28	**45**
Session 2			
M1 - M4	10	20	
M4 - M5	9	19	
(M1 - M5)	20	30	**45**
Session 3			
M3 - M6	13	23	
M5 - M6	12	22	
(M3 - M5)	27	37	**45**
Session 4 & 7			
M2 - M6	11	21	
M3 - M6	13	23	
(M2 - M3)	22	32	**45**
Session 5			
M2 - M5	9	19	
M4 - M5	9	19	
(M2 - M4)	12	**22**	
Session 6			
M2 - M5	9	19	
M2 - M6	11	21	
(M5 - M6)	12	**22**	

5.4 Collection Schedule

Day One, October 23, 2012

Session 4
Each receiver, when it reaches its destination, is set-up and recording begins.

M2 start time (a) 11:15am

M3 (a) 11:15am + 21 min Travel + 20 min Set-up = (b) 11:56am

M6 (b) 11:56am + 26 min Travel + 20 min Set-up = (c) 12:42am

+ 23 min = record Session 1 till (d) 1:05pm

Session 7
All receivers remain at their locations, but are turned off and back on for the next recording session.

Start at (d) 1:05pm + 45 min = record Session 8 till (e) 1:50pm

Session 3
Move M2 to M5

(e) 1:50pm + 26 min Travel + 20 min Set-up = M5 must start by (f) 2:36pm

Restart M1 and M4 at (f) 2:36pm + 37 min = record Session 2 till (g) 3:15pm

Session 6
Move M3 to M2

(g) 3:15pm + 21 min Travel + 20 min Set-up = M2 must start by (h) 3:56pm

Restart M5 and M4 at (h) 3:56pm + 22 min = record Session 5 till (i) 4:18pm

Day Two, November 6, 2012

Session 1
Each receiver, when it reaches its destination, is set-up and recording begins.

M2 start time (a) 10:30am

M1 (a) 10:30am + 20 min Travel + 20 min Set-up = (b) 11:10am

M4 (b) 11:10am + 32 min Travel + 20 min Set-up = (c) 11:10am

+ 45 min = record Session 1 till (d) 12:50pm

Session 8
All receivers remain at their locations, but are turned off and back on for the next recording session.

Start at (d) 12:50pm + 45 min = record Session 8 till (e) 1:35pm

Session 2
Move M2 to M5

(e) 1:35pm + 26 min Travel + 20 min Set-up = M5 must start by (f) 2:20pm

Restart M1 and M4 at (f) 1:35pm + 45 min = record Session 2 till (g) 3:05pm

Session 5
Move M1 to M2

(g) 3:05pm + 20min Travel + 20 min Set-up = M2 must start by (h) 3:45pm

Restart M5 and M4 at (h) 3:05pm + 22 min = record Session 5 till (i) 4:07pm

5.5 Coordinate Comparison Table

Some survey monument id numbers were shortened when inputted to the receivers. For this table these instances have their full identification number corresponding to the GeoNova Data Locator.

Lab 3	Monument One (M #1)	Monument Two (M #2)	Monument Three (M #3)	Monument Four (M #4)	Monument Five (M #5)	Monument Six (M #6)
	NSHPN 214378	CM 227012	NSHPN 207153	CM 214427	CM 226831	CM 214393
UTM NAD 83 Zone 20						
Easting	313047.7692	328880.2892	346589.1558	313291.5368	325693.449	332163.8017
Northing	4963666.098	4973164.578	4984573.545	4973777.568	4979668.111	4985121.236
Latitude	44°48'06.94826" N	44°53'28.83576"N	44°59'52.88026"N	44°53'34.58928"N	44°56'56.65968"N	44°56'58.86318"N
Longitude	65°21'50.01814"W	65°10'01.39382"W	64°56'47.01389"W	65°21'52.32318"W	65°12'34.64790"W	65°07'46.11071"W
Ellip. Hgt.	-16.5529	7.5887	14.823	59.8758	148.5267	63.6614
Ortho Height	4.9771	28.8547	35.792	81.2798	169.7317	84.7694
Geoid Seperation	-21.53	-21.266	-20.969	-21.404	-21.205	-21.108
Position + Hgt Qlty	0	0.0054	0	0.0049	0.0061	0.0055
Official Coordinate						
ATS 77 Easting	5431654.477	5447308.098	5464802.729	5431711.459	5444001.658	5450369.786
ATS 77 Northing	4962794.864	4972583.727	4984318.244	4972908.314	4979027.038	4984598.766
UTM Easting Transformation	313047.771	328880.315	346589.141	313291.544	325693.515	332163.846
UTM Northing Transformation	4963666.085	4973164.686	4984573.583	4973777.479	4979668.249	4985121.284
ATS 77 Latitude	44 48 6.84227	44 53 28.7327	44 59 52.77485	44 53 34.48106	44 56 56.55719	44 59 58.75824
ATS 77 Longitude	65 21 50.14324	65 10 1.51958	64 56 47.14711	65 21 52.44776	65 12 34.77306	65 7 46.23701
Elevation	5.172	28.841	35.744	81.315	169.765	84.728
Difference						
Easting	0.0018	0.0258	-0.0148	0.0072	0.066	0.0443
Northing	-0.0129	0.108299999	0.038199999	-0.089199999	0.1379	0.0482
Elevation	0.1949	-0.0137	-0.048	0.0352	0.0333	-0.0414

5.6 LGO processing reports

- when it has to be right

Network Adjustment

www.MOVE3.com

Created: 11/13/2012 13:28:38

Project Information

Project name:	Lab3_Try2 (2)
Date created:	11/13/2012 12:22:09
Time zone:	-3h 00' Coordinate system name: WGS 1984
Application software:	LEICA Geo Office 8.2
Processing kernel:	MOVE3 4.0.5

General Information

Adjustment

Type:	Constrained Dimension:	3D Coordinate system:	WGS 1984
Height mode:	Ellipsoidal		
Number of iterations:	1		
Maximum coord correction in last iteration:	0.0000 m	✔	(tolerance is met)

Stations

Number of (partly) known stations:	2
Number of unknown stations:	4
Total:	6

Observations

GPS coordinate differences:	57
(19 baselines) Known coordinates:	6
Total:	63

Unknowns

Coordinates:	18
Total:	18

Degrees of freedom: 45

Testing

Alfa (multi dimensional):	0.5393		
Alfa 0 (one dimensional):	5.0 % Beta:	80.0 % Sigma a-priori (GPS):	10.0
Critical value W-test:	1.96		
Critical value T-test (2-dimensional):	2.42		
Critical value T-test (3-dimensional):	1.89		
Critical value F-test:	0.96		
F-test:	0.14	✔	

(accepted) Results based on a-posteriori variance factor

Adjustment Results

Coordinates

Station		Coordinate	Corr	Sd	
M14378	Latitude	44° 48' 06.94829" N	0.0000 m	-	fixed
	Longitude	65° 21' 50.01813" W	0.0000 m	-	fixed
	Height	-16.5530 m	0.0000 m	-	fixed
M14393	Latitude	44° 59' 58.86318" N	0.0016 m	0.0032 m	
	Longitude	65° 07' 46.11072" W	-0.0015 m	0.0032 m	
	Height	63.6613 m	-0.0007 m	0.0032 m	
M14427	Latitude	44° 53' 34.58929" N	-0.0020 m	0.0028 m	
	Longitude	65° 21' 52.32318" W	-0.0013 m	0.0028 m	
	Height	59.8758 m	-0.0041 m	0.0028 m	
M26831	Latitude	44° 56' 56.65969" N	-0.0028 m	0.0035 m	
	Longitude	65° 12' 34.64790" W	-0.0009 m	0.0035 m	
	Height	148.5267 m	-0.0035 m	0.0035 m	
M27012	Latitude	44° 53' 28.83575" N	0.0000 m	0.0031 m	
	Longitude	65° 10' 01.39381" W	-0.0006 m	0.0031 m	
	Height	7.5886 m	0.0010 m	0.0031 m	
M7153	Latitude	44° 59' 52.88030" N	0.0000 m	-	fixed
	Longitude	64° 56' 47.01385" W	0.0000 m	-	fixed
	Height	14.8229 m	0.0000 m	-	fixed

Observations and Residuals

	Station	Target	Adj obs	Resid	Resid (ENH)	Sd
DX	M14378	M27012	11209.1014 m	0.0019 m	0.0021 m	0.0031 m
DY			12859.9906 m	0.0009 m	-0.0004 m	0.0031 m
DZ			7061.8810 m	-0.0006 m	-0.0004 m	0.0031 m
DX	M14427	M27012	14205.7491 m	-0.0056 m	-0.0044 m	0.0032 m
DY			6446.9630 m	0.0017 m	-0.0010 m	0.0032 m
DZ			-162.7275 m	-0.0052 m	-0.0064 m	0.0032 m
DX	M26831	M14393	4043.3038 m	0.0001 m	-0.0003 m	0.0032 m
DY			6317.4467 m	-0.0011 m	0.0049 m	0.0032 m
DZ			3919.0445 m	0.0080 m	0.0063 m	0.0032 m
DX	M27012	M14427	-14205.7491 m	-0.0019 m	-0.0040 m	0.0032 m
DY			-6446.9630 m	-0.0053 m	0.0013 m	0.0032 m
DZ			162.7275 m	0.0058 m	0.0070 m	0.0032 m
DX	M27012	M26831	-4910.1088 m	-0.0055 m	-0.0094 m	0.0027 m
DY			2610.8658 m	-0.0106 m	-0.0104 m	0.0027 m
DZ			4642.2765 m	-0.0074 m	0.0000 m	0.0027 m
DX	M27012	M26831	-4910.1088 m	0.0028 m	0.0048 m	0.0027 m
DY			2610.8658 m	0.0054 m	0.0081 m	0.0027 m
DZ			4642.2765 m	0.0078 m	0.0028 m	0.0027 m
DX	M14427	M26831	9295.6403 m	0.0032 m	0.0039 m	0.0034 m
DY			9057.8288 m	0.0023 m	0.0050 m	0.0034 m
DZ			4479.5490 m	0.0062 m	0.0038 m	0.0034 m
DX	M14427	M26831	9295.6403 m	0.0032 m	0.0062 m	0.0034 m
DY			9057.8288 m	0.0077 m	0.0098 m	0.0034 m
DZ			4479.5490 m	0.0082 m	0.0018 m	0.0034 m
DX	M7153	M27012	-12261.0874 m	0.0032 m	0.0030 m	0.0031 m
DY			-14933.4134 m	0.0001 m	-0.0046 m	0.0031 m
DZ			-8396.1880 m	-0.0051 m	-0.0027 m	0.0031 m
DX	M7153	M27012	-12261.0874 m	0.0052 m	0.0043 m	0.0031 m
DY			-14933.4134 m	-0.0010 m	0.0021 m	0.0031 m
DZ			-8396.1880 m	0.0061 m	0.0065 m	0.0031 m
DX	M27012	M14393	-866.8051 m	0.0005 m	0.0050 m	0.0028 m
DY			8928.3125 m	0.0108 m	0.0013 m	0.0028 m

DZ			8561.3210 m	-0.0077 m	-0.0123 m	0.0028 m
DX	M27012	M14393	-866.8051 m	-0.0004 m	0.0047 m	0.0028 m
DY			8928.3125 m	0.0120 m	0.0117 m	0.0028 m
DZ			8561.3210 m	0.0054 m	-0.0040 m	0.0028 m
DX	M27012	M14393	-866.8051 m	0.0075 m	0.0037 m	0.0028 m
DY			8928.3125 m	-0.0073 m	-0.0114 m	0.0028 m
DZ			8561.3210 m	-0.0063 m	0.0025 m	0.0028 m
DX	M7153	M14393	-13127.8925 m	0.0008 m	-0.0023 m	0.0032 m
DY			-6005.1010 m	-0.0071 m	-0.0032 m	0.0032 m
DZ			165.1331 m	0.0021 m	0.0063 m	0.0032 m
DX	M7153	M14393	-13127.8925 m	-0.0137 m	-0.0168 m	0.0032 m
DY			-6005.1010 m	-0.0102 m	-0.0030 m	0.0032 m
DZ			165.1331 m	-0.0008 m	0.0019 m	0.0032 m
DX	M7153	M14393	-13127.8925 m	0.0033 m	0.0030 m	0.0032 m
DY			-6005.1010 m	0.0001 m	-0.0060 m	0.0032 m
DZ			165.1331 m	-0.0072 m	-0.0042 m	0.0032 m
DX	M14378	M14427	-2996.6477 m	0.0018 m	0.0013 m	0.0028 m
DY			6413.0275 m	-0.0008 m	0.0020 m	0.0028 m
DZ			7224.6085 m	0.0043 m	0.0041 m	0.0028 m
DX	M14378	M14427	-2996.6477 m	-0.0005 m	0.0011 m	0.0028 m
DY			6413.0275 m	0.0037 m	0.0017 m	0.0028 m
DZ			7224.6085 m	-0.0012 m	-0.0034 m	0.0028 m
DX	M14378	M14427	-2996.6477 m	0.0010 m	0.0040 m	0.0028 m
DY			6413.0275 m	0.0075 m	0.0048 m	0.0028 m
DZ			7224.6085 m	0.0004 m	-0.0043 m	0.0028 m

GPS Baseline Vector Residuals

	Station	Target	Adj vector [m]	Resid [m]	Resid [ppm]
DV	M14378	M27012	18463.3008	0.0021	0.1
DV	M14427	M27012	15601.0615	0.0078	0.5
DV	M26831	M14393	8462.7033	0.0080	0.9
DV	M27012	M14427	15601.0615	0.0081	0.5
DV	M27012	M26831	7244.0679	0.0140	1.9
DV	M27012	M26831	7244.0679	0.0099	1.4
DV	M14427	M26831	13730.2422	0.0074	0.5
DV	M14427	M26831	13730.2422	0.0117	0.9
DV	M7153	M27012	21067.4411	0.0061	0.3
DV	M7153	M27012	21067.4411	0.0081	0.4
DV	M27012	M14393	12400.0941	0.0133	1.1
DV	M27012	M14393	12400.0941	0.0132	1.1
DV	M27012	M14393	12400.0941	0.0122	1.0
DV	M7153	M14393	14437.1073	0.0074	0.5
DV	M7153	M14393	14437.1073	0.0171	1.2
DV	M7153	M14393	14437.1073	0.0080	0.6
DV	M14378	M14427	10114.4346	0.0047	0.5
DV	M14378	M14427	10114.4346	0.0039	0.4
DV	M14378	M14427	10114.4346	0.0075	0.7

Absolute Error Ellipses (2D - 39.4% 1D - 68.3%)

Station	A [m]	B [m]	A/B	Phi	Sd Hgt [m]
M14378	0.0000	0.0000	1.0	90°	0.0000
M14393	0.0032	0.0032	1.0	-6°	0.0032
M14427	0.0028	0.0028	1.0	90°	0.0028
M26831	0.0035	0.0035	1.0	90°	0.0035
M27012	0.0031	0.0031	1.0	-4°	0.0031
M7153	0.0000	0.0000	1.0	90°	0.0000

Testing and Estimated Errors

Coordinate Tests

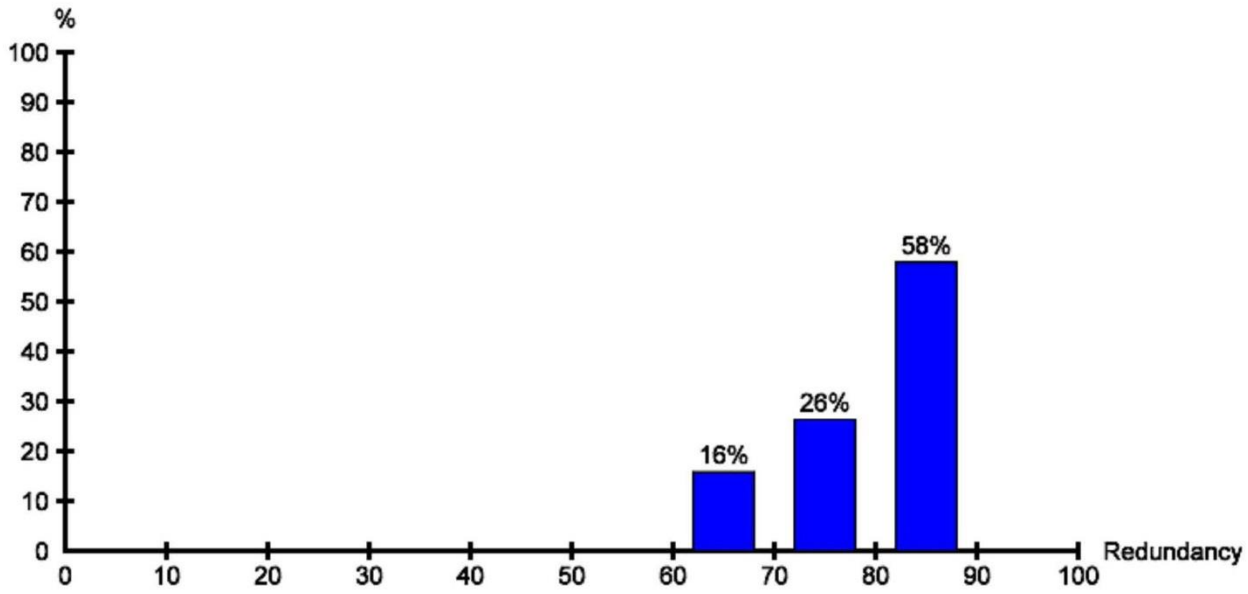
Station		MDB	BNR	W-Test	T-Test
M14378	Latitude	0.0170 m	999.9	0.00	0.00
	Longitude	0.0170 m	999.9	0.00	
	Height	0.0170 m	999.9	0.00	
M7153	Latitude	0.0170 m	999.9	0.00	0.00
	Longitude	0.0170 m	999.9	0.00	
	Height	0.0170 m	999.9	0.00	

Observation Tests

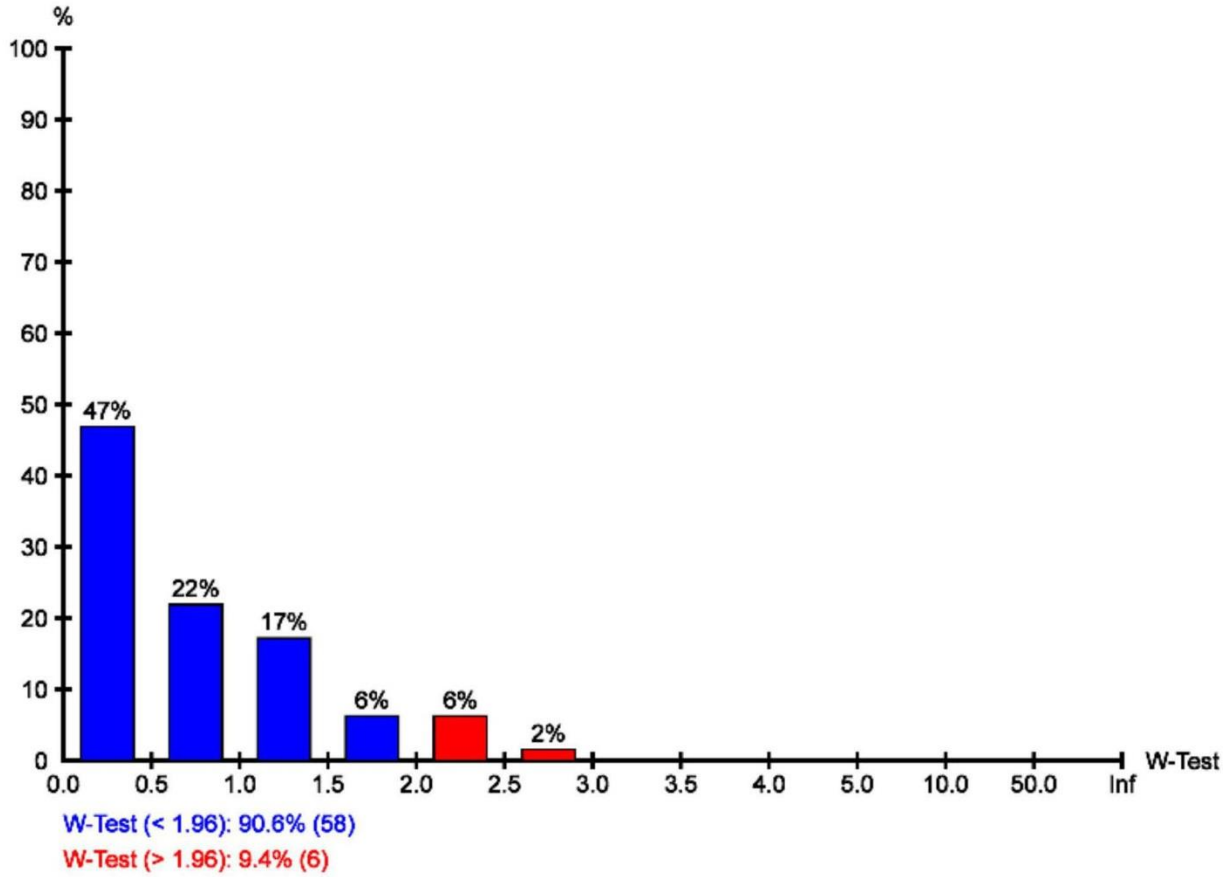
	Station	Target	MDB	Red	BNR	W-Test	T-Test
DX	M14378	M27012	0.0266 m	87	1.1	0.22	0.02
DY			0.0266 m	87	1.1	0.10	
DZ			0.0266 m	87	1.1	-0.07	
DX	M14427	M27012	0.0240 m	83	1.3	-0.78	0.40
DY			0.0240 m	83	1.3	0.24	
DZ			0.0240 m	83	1.3	-0.73	
DX	M26831	M14393	0.0184 m	60	2.3	0.03	1.36
DY			0.0184 m	60	2.3	-0.26	
DZ			0.0184 m	60	2.3	2.00	
DX	M27012	M14427	0.0240 m	83	1.3	-0.27	0.43
DY			0.0240 m	83	1.3	-0.75	
DZ			0.0240 m	83	1.3	0.81	
DX	M27012	M26831	0.0159 m	67	2.0	-1.44	4.52
DY			0.0159 m	67	2.0	-2.78	
DZ			0.0159 m	67	2.0	-1.94	
DX	M27012	M26831	0.0159 m	67	2.0	0.74	2.26
DY			0.0159 m	67	2.0	1.43	
DZ			0.0159 m	67	2.0	2.05	
DX	M14427	M26831	0.0226 m	77	1.5	0.51	0.46
DY			0.0226 m	77	1.5	0.37	
DZ			0.0226 m	77	1.5	0.99	
DX	M14427	M26831	0.0226 m	77	1.5	0.52	1.17
DY			0.0226 m	77	1.5	1.24	
DZ			0.0226 m	77	1.5	1.31	
DX	M7153	M27012	0.0292 m	89	0.9	0.34	0.14
DY			0.0292 m	89	0.9	0.01	
DZ			0.0292 m	89	0.9	-0.55	
DX	M7153	M27012	0.0292 m	89	0.9	0.56	0.25
DY			0.0292 m	89	0.9	-0.11	
DZ			0.0292 m	89	0.9	0.65	
DX	M27012	M14393	0.0205 m	81	1.3	0.08	1.66
DY			0.0205 m	81	1.3	1.82	
DZ			0.0205 m	81	1.3	-1.29	
DX	M27012	M14393	0.0205 m	81	1.3	-0.07	1.63
DY			0.0205 m	81	1.3	2.01	
DZ			0.0205 m	81	1.3	0.91	
DX	M27012	M14393	0.0205 m	81	1.3	1.26	1.40

DY			0.0205 m	81	1.3	-1.23	
DZ			0.0205 m	81	1.3	-1.06	
DX	M7153	M14393	0.0229 m	81	1.3	0.12	0.42
DY			0.0229 m	81	1.3	-1.06	
DZ			0.0229 m	81	1.3	0.32	
DX	M7153	M14393	0.0229 m	81	1.3	-2.06	2.21
DY			0.0229 m	81	1.3	-1.54	
DZ			0.0229 m	81	1.3	-0.12	
DX	M7153	M14393	0.0229 m	81	1.3	0.49	0.48
DY			0.0229 m	81	1.3	0.02	
DZ			0.0229 m	81	1.3	-1.09	
DX	M14378	M14427	0.0184 m	75	1.6	0.36	0.30
DY			0.0184 m	75	1.6	-0.17	
DZ			0.0184 m	75	1.6	0.86	
DX	M14378	M14427	0.0184 m	75	1.6	-0.11	0.21
DY			0.0184 m	75	1.6	0.74	
DZ			0.0184 m	75	1.6	-0.24	
DX	M14378	M14427	0.0184 m	75	1.6	0.20	0.76
DY			0.0184 m	75	1.6	1.49	
DZ			0.0184 m	75	1.6	0.07	

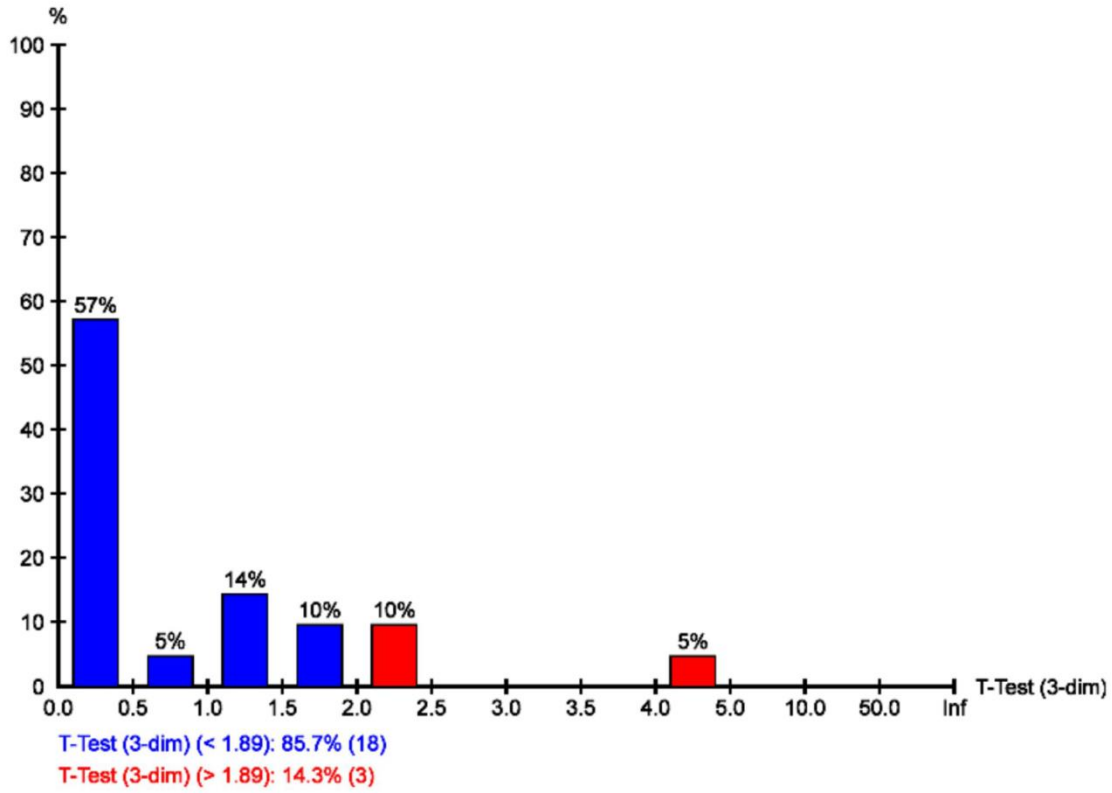
Redundancy:



W-Test:



T-Test (3-dimensional):



Estimated Errors (Observations)

Estimated Errors For Observations With Rejected W-Tests (max 10)

	Station	Target	W-Test	Fact	Est err
DY	M27012	M26831	-2.78	1.4	-0.0158 m
DX	M7153	M14393	-2.06	1.1	-0.0168 m
DZ	M27012	M26831	2.05	1.0	0.0116 m
DY	M27012	M14393	2.01	1.0	0.0147 m
DZ	M26831	M14393	2.00	1.0	0.0131 m

Estimated Errors For Observations With Rejected Antenna Hgt W-Tests (max 10)

Station	Target	W-Test	Fact	MDB [m]	Est ant err [m]
M27012	M14393	-2.06	1.0	0.0205	-0.0150

Estimated Errors For Observations With Rejected T-Tests (max 10)

	Station	Target	T-Test	Fact	Est err
DX	M27012	M26831	4.52	1.5	-0.0082 m
DY					-0.0158 m
DZ					-0.0110 m
DX	M27012	M26831	2.26	1.1	0.0042 m
DY					0.0081 m
DZ					0.0116 m
DX	M7153	M14393	2.21	1.1	-0.0168 m
DY					-0.0126 m
DZ					-0.0010 m

5.7 Weather Reports

This data is courtesy of Environment Canada and accessed November 17, 2012. All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed. Twelve hours of activity were selected out to be concise. Data was last modified by Environment Canada 2012-05-29, http://www.climate.weatheroffice.gc.ca/climateData/canada_e.html

Hourly Data Report for October 23, 2012

GREENWOOD A
NOVA SCOTIA

Latitude: 44°59'00.000" N **Longitude:** 64°55'00.000" W **Elevation:** 28.00 m
Climate ID: 8202000 **WMO ID:** 71397 **TC ID:** YZX

Hourly Data Report for October 23, 2012										
Time	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10s deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
08:00	6.5	0.6	66	29	17	24.1	100.86			Mostly Cloudy
09:00	6.7	1.1	67	30	17	24.1	100.89			Mostly Cloudy
10:00	7.2	1.2	66	29	19	24.1	100.89			Mostly Cloudy
11:00	7.4	1.5	66	27	20	24.1	100.89			Mostly Cloudy
12:00	7.5	1.1	64	29	15	24.1	100.86			Mostly Cloudy
13:00	9.0	1.4	59	26	28	24.1	100.83			Mostly Cloudy
14:00	8.7	1.3	60	27	17	24.1	100.84			Mostly Cloudy
15:00	9.9	1.0	54	27	20	24.1	100.82			Mainly Clear
16:00	10.2	1.4	54	28	17	24.1	100.87			Mainly Clear
17:00	9.8	0.6	53	27	13	24.1	100.92			Mainly Clear
18:00	9.4	0.3	53	27	11	24.1	101.01			Mainly Clear
19:00	9.1	0.7	56	30	6	24.1	101.08			Mainly Clear
20:00	8.2	0.3	57	35	6	24.1	101.14			Mainly Clear

Hourly Data Report for November 06, 2012

GREENWOOD A
NOVA SCOTIA

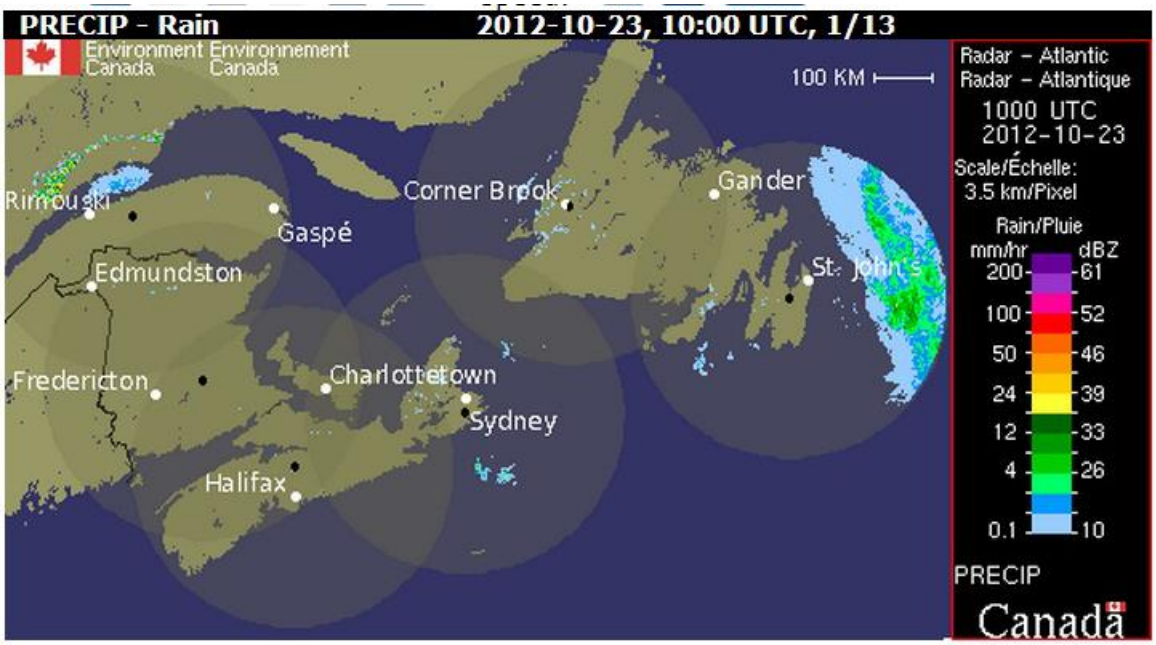
Latitude: 44°59'00.000" N **Longitude:** 64°55'00.000" W **Elevation:** 28.00 m
Climate ID: 8202000 **WMO ID:** 71397 **TC ID:** YZX

Hourly Data Report for November 6, 2012

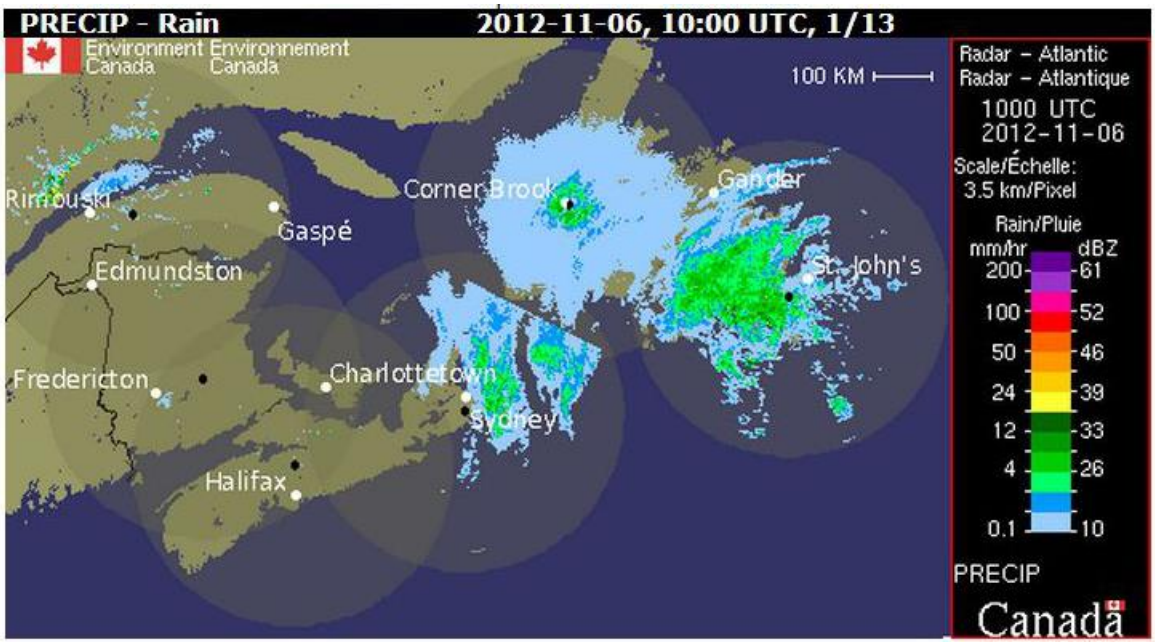
Time	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10s deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
08:00	1.1	-4.7	65	29	17	24.1	101.51			Mostly Cloudy
09:00	1.6	-4.6	63	29	15	24.1	101.52			Mostly Cloudy
10:00	1.7	-2.7	73	27	13	24.1	101.57			Cloudy
11:00	2.0	-1.2	79	27	20	24.1	101.62			Cloudy
12:00	2.6	-0.8	78	24	26	24.1	101.65			Mostly Cloudy
13:00	2.9	-3.7	62	27	30	24.1	101.67			Mainly Clear
14:00	3.1	-4.7	57	26	22	24.1	101.70			Mainly Clear
15:00	2.7	-3.6	63	24	22	24.1	101.73			Mostly Cloudy
16:00	2.6	-1.9	72	25	22	24.1	101.80			Mostly Cloudy
17:00	2.4	-2.2	72	22	15	24.1	101.81			Cloudy
18:00	2.3	-1.4	77	23	11	24.1	101.86			Cloudy
19:00	2.3	-1.7	75	22	9	24.1	101.92			Cloudy
20:00	2.3	-0.4	82	26	9	24.1	101.99			Mostly Cloudy

Radar Images for collection days

Oct 23, 2012



Nov 6, 2012

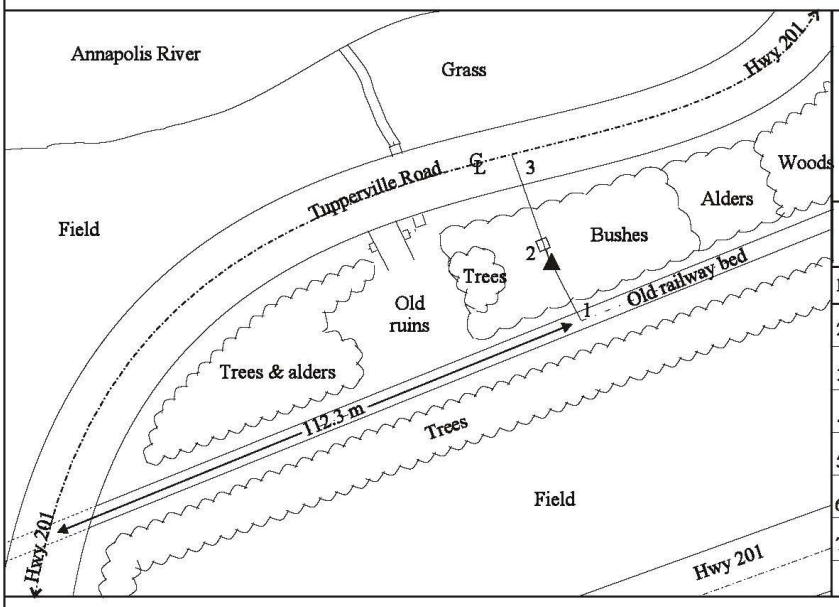


5.8 Survey Monument Sketch Data (GeoNova Data Locator)

Monument #1

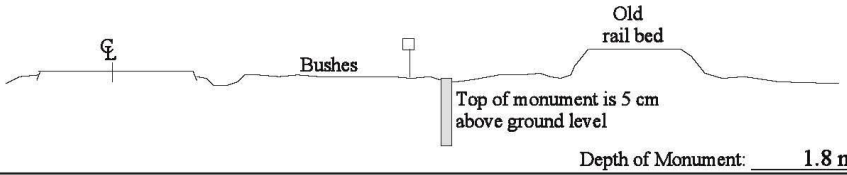
NSHPN CONTROL POINT SKETCH

Reconnaissance Date:	December, 1974	Station Number:	214378
Reconnaissance By:	D. A. J.	Station Name:	Tupperville
Construction Date:	December, 1974	Map Number:	159
Construction Inspector:	G. E. B.	District Office:	Lawrencetown



Inspected October 24, 2001

	Distance (m.)	Magnetic Azimuth(deg)
1.	10.20	157
2.	1.32	340
3.	17.85	340
4.		
5.		
6.		
7.		



Depth of Monument: 1.8 m

At or near Tupperville, Annapolis County, Nova Scotia.

From the junction of Hwy 201 and South Rd to Bridgetown and Carleton Corner, travel 0.85 kilometres west on Hwy 201 to a connector road to Hwy 101. Continue on Hwy 201 towards Tupperville 5.9 kilometres to the old Tupperville Road and a yellow house, # 165. Turn right on the old Tupperville Rd and travel 0.55 kilometre to the monument on the right.

From the junction of Hwy 8 and Hwy 201, travel east on Hwy 201 for 3.9 kilometres to a creosote bridge over Sawmill Creek. Continue travelling for 10.0 kilometres to the old Tupperville Rd on the left. Take this road, past houses # 11 and # 21 on the left, and past the old railway bed 0.3 kilometre to the monument on the right.

NSHPNv2.0

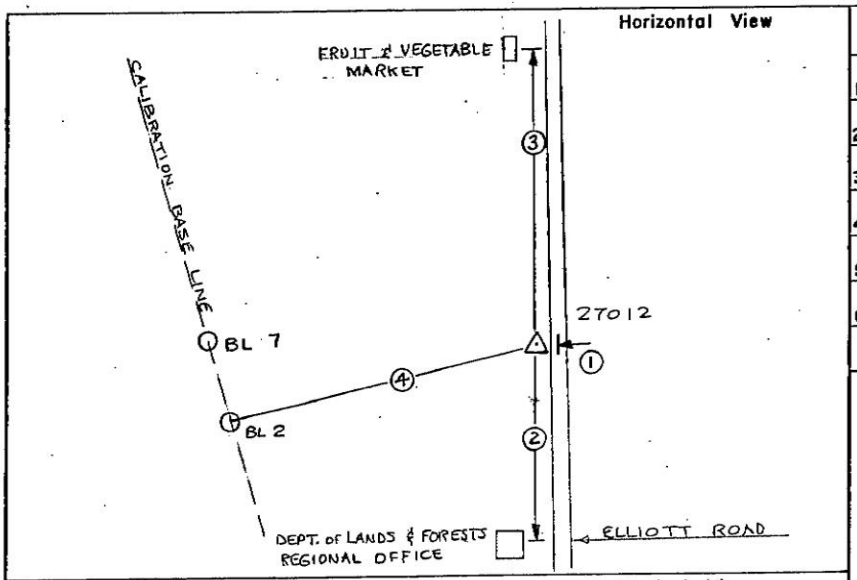
NOVASCOTIA GEOMATICS CENTRE AMHERST, NOVA SCOTIA

Monument #2

Map No. 159
Photo No.
Date of Inspection

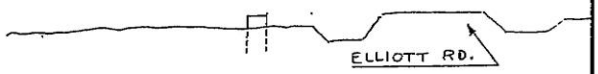
Control Monument No. 27012
District Office
Date of Reconnaissance
Date of Construction

Horizontal View



	Dist.(m)	Azimuth(Mag)
1	15.1	
2	400 ±	
3	500 ±	
4		254.5°
5		
6		

Vertical View



J. Kaulbach
Sketched By

Top of Monument Flush ____ Below ____ Above √(0.3m)

SIGHT LINES

Monument No.	Clear	Blocked	Remarks

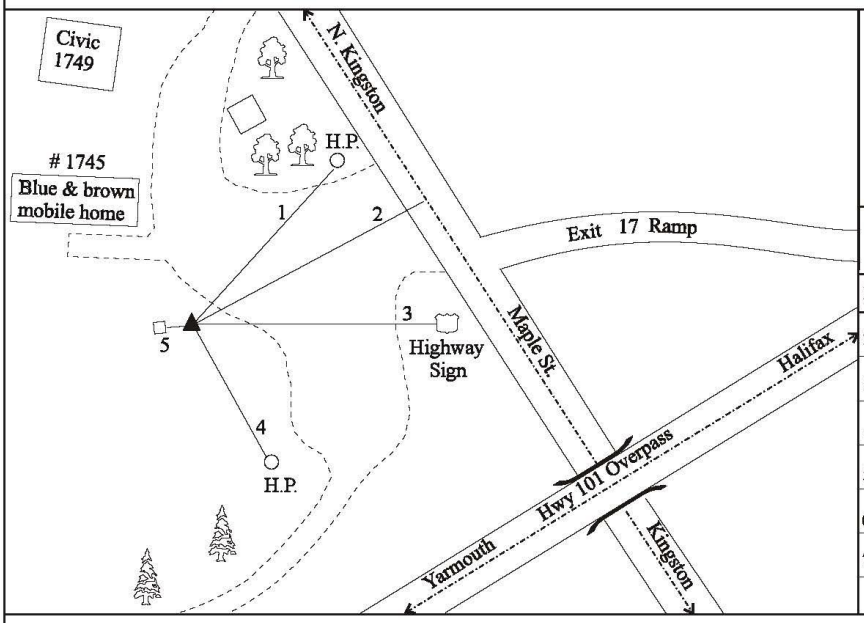
Type of Monument STD (√) Rock Plug ( ) Replug ( ) Iron Bar ( ) Other ____
Depth of Monument ____ Posted (√) Not Posted ( )
Reconnaissance by ____ Construction Inspector ____

Remarks:

Monument #3

NSHPN CONTROL POINT SKETCH

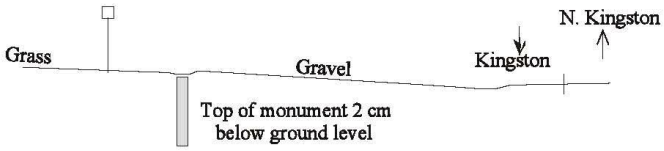
Reconnaissance Date:	1972	Station Number:	207153
Reconnaissance By:		Station Name:	Kingston
Construction Date:	September, 1972	Map Number:	160
Construction Inspector:		District Office:	Lawrencetown



Magnetic

Inspected October 24, 2001

	Distance (m.)	Magnetic Azimuth(deg)
1.	27.50	45
2.	38.13	86
3.	29.97	102
4.	11.13	157
5.	1.50	264
6.		
7.		



Depth of Monument: _____

At or near Kingston, Kings County, Nova Scotia.

Travelling west on Hwy 101, from Kentville, take Exit 17 (Kingston, Greenwood, Bishop Mtn. Rd.). The monument is located opposite the Exit 17 ramp road where it connects with Maple St. into Kingston and Hwy 221.

From intersection of Hwy # 1 and Maple St. (Best Western Aurora Inn and Esso Station) travel in a northwesterly direction (towards Hwy 101) for 0.90 km to the monument on the left hand side of the road (just past the Hwy 101 overpass).

NSHPNv2.0

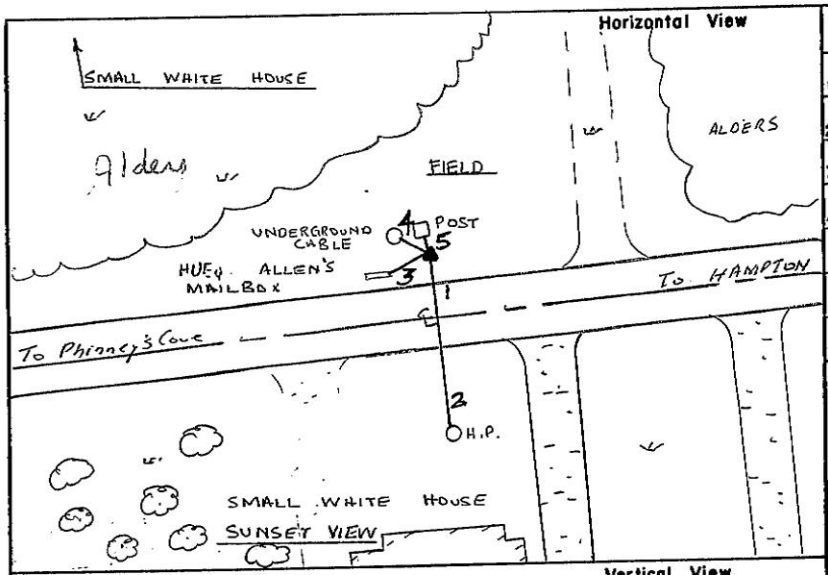
NOVASCOTIA GEOMATICS CENTRE AMHERST, NOVA SCOTIA

Monument #4

Map No. 159
Photo No. —
Date of Inspection JULY 28/81

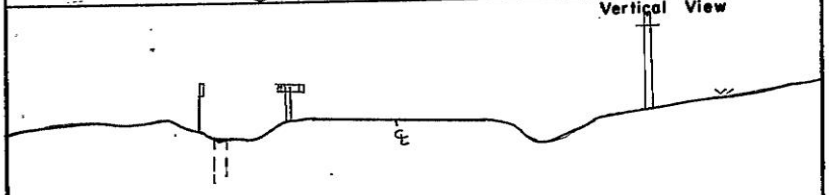
Control Monument No. N.S. 14427
District Office BRIDGETOWN
Date of Reconnaissance OCT 174
Date of Construction OCT 174

Horizontal View



	Dist.(m)	Azimuth(Mag)
1	6.24	170°
2	17.88	170°
3	3.95	228°
4	1.80	301°
5	1.33	349°
6		

Vertical View



B. WENTZELL
Sketched By

Top of Monument Flush ____ Below ____ Above ____

SIGHT LINES

Monument No.	Clear	Blocked	Remarks
14426	✓		
14428	✓		

Type of Monument STD (✓) Rock Plug ( ) Replug ( ) Iron Bar ( ) Other ____
Depth of Monument 1.83 Posted (✓) Not Posted ( )
Reconnaissance by D.A.S. Construction Inspector G.E.B.

L 6

Remarks:

Monument #5

159

Map No. _____

Photo No. _____

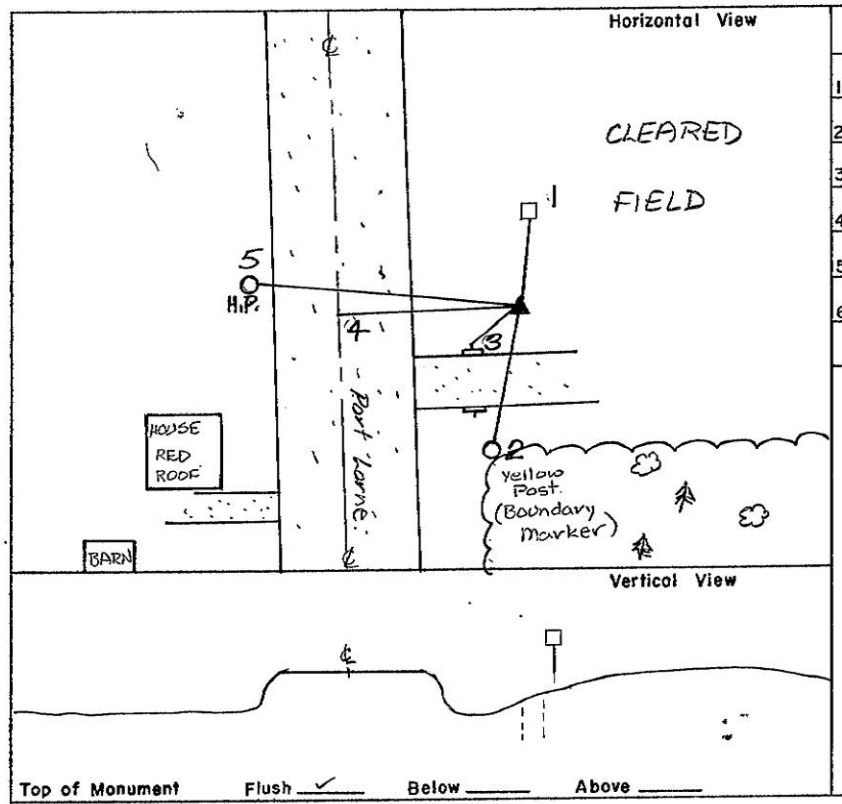
Date of Inspection AUG. 20/81

Control Monument No. NS. 26831

District Office BRIDGETOWN

Date of Reconnaissance AUG. 19/81

Date of Construction OCT. 15/81



	Dist.(m)	Azimuth(Mag)
1	0.98	360°
2	8.75	178°
3	2.15	238°
4	9.20	268°
5	19.27	282°
6		

G. WRIGHT.
Sketched By

Top of Monument Flush ✓ Below _____ Above _____

SIGHT LINES

Monument No.	Clear	Blocked	Remarks
14409	✓		
26830	✓		

Type of Monument STD (✓) Rock Plug ( ) Replug ( ) Iron Bar ( ) Other _____

Depth of Monument 1.85 m. Posted (✓) Not Posted ( )

Reconnaissance by P. GAUL. Construction Inspector P. GAUL

G 12

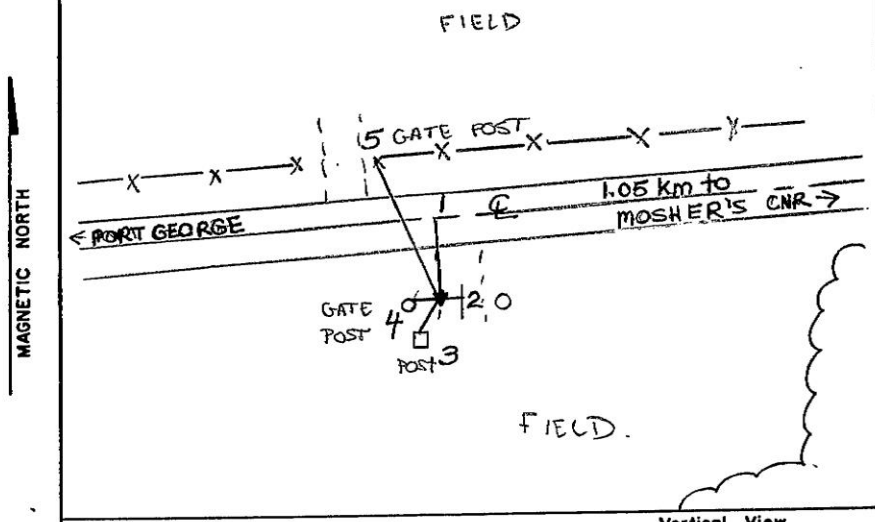
Remarks:

Monument #6

Map No. 159
Photo No.
Date of Inspection AUGUST 11, 1981

Control Monument No. NS14393
District Office BRIDGETOWN
Date of Reconnaissance Oct. 1974
Date of Construction Oct. 1974

Horizontal View

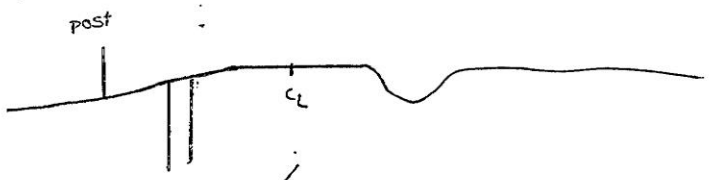


MAGNETIC NORTH

	Dist.(m)	Azimuth(Mag)
1	7.00	2°
2	2.6	92°
3	1.72	225°
4	1.35	283°
5	21.30	339°
6		

G. Gosbrecht
Sketched By

Vertical View



Top of Monument Flush ✓ Below ____ Above ____

SIGHT LINES

Monument No.	Clear	Blocked	Remarks
14392	✓		
14394		✓	TREES

Type of Monument STD (✓) Rock Plug ( ) Replug ( ) Iron Bar ( ) Other ____
Depth of Monument 1.8 Posted (✓) Not Posted ( )
Reconnaissance by D.A.J. Construction Inspector G.E.B.
K 1

Remarks:

5.9 GPS Baseline Logs.

The following pages are the GPS baseline logs that were collected during the recording of baselines within the network. Each one represents a single receiver and session. The last one is page 52 of this report.