Geodetic Survey Division
Earth Sciences Sector

Vernon Calibration Baseline
1997 Adopted Values

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Baseline Site

The Vernon baseline is along the right of way of Highway #97, about 6 km SW of Vernon.

This linear baseline consists of 6 concrete piers whose tops are about 1.5 meters above ground level. Piers 1, 2, 3 and 4 are located approximately 30 meters east of the highway and pier 6 is 10 meters west of the highway.

There are three major difficulties with the profile of this baseline. First, there are six lines where the recommended maximum slope of 3% is exceeded -- a steep slope angle can increase pointing errors during measurements. The second is that there are seven lines where the line of sight passes high above ground level while the meteorological conditions are being sampled near ground level. Such elevated lines can cause poor internal data consistency due to the inability to model the meteorological conditions. Third, the lines of sight from pier 3 to piers 5 and 6 are blocked.

See Appendix A for a plan and profile view of the baseline.

Measurements

The 1997 measurements of this baseline were made by Coffey from July 14-16, using the Mekometer ME5000 (serial number 357061). The 1997 meteorological measurements were made with an automated system with 5 temperature sensors at various heights (to a maximum of 8 metres above ground level) to better model the conditions along the lines of sight. See Table 1 for the measurement history of this baseline.

Currently, each baseline measurement for a year consists of at least three double (forward and backward) distance measurements between all intervisible piers using either the Geomensor CR204 or Mekometer ME5000 EDM instruments.

Table 1: Measurement history

Date	Observer	Instrument	Serial Number
Aug. 14-18/1990	Lafrance	Mekometer ME5000	357061
Sept. 02-05/1991	Lafrance	Mekometer ME5000	357061
July 03-04/1996	Hennessey	Mekometer ME5000	357061
July 14-16/1997	Coffey	Mekometer ME5000	357061

NGBL Calibration

The scale bias for the Mekometer ME5000 was determined from calibration surveys on the National Geodetic Baseline (NGBL). The constant bias from the NGBL was used as a gross check on the value determined from the Vernon baseline adjustment. The average scale bias from the two NGBL calibrations was applied to all distance observations. See Table 2 for the 1997 NGBL biases.

Table 2: Mekometer ME5000 biases derived from 1997 NGBL measurements

Date	Measurement Sets	Constant Bias Value ± Std.Dev. (mm)	Scale Bias Value ± Std.Dev. (ppm)
April 23-29	3	-0.4 ± 0.1	+0.1 ± 0.1
October 6-10	3	-0.3 ± 0.1	+0.7 ± 0.1
Average		-0.4 ± 0.1	+0.4 ± 0.1

Baseline Adjustment

The 1997 Vernon baseline measurements were processed with the new baseline adjustment program CALIB (version 1.1, May 95). Interpier distances and a constant instrument bias were estimated. A minimally constrained adjustment was made with pier 1 fixed. An a priori standard deviation of 0.1 mm + 0.5 ppm was used for all Mekometer distances, and 0.1 mm for the centering errors. The results of the adjustments back to 1990 are summarized in Appendix B.

The constant bias from the CALIB adjustment was -0.4 ± 0.1 mm, which agrees with the estimate obtained from the NGBL calibration (see Table 2). The variance factor for the 1997 adjustment was 0.594, which fails the Chi-square test. There was one residual outlier on line 6-5 in the 1997 adjustment using all the observations. This outlier was kept since it did not appear to be a blunder and its inclusion had little effect on the results. All residuals passed the Chi-square goodness-of-fit test for normal distribution. All tests were performed at the 95% confidence level.

Comparison with Previous Epochs

The results of the 1990, 1991, 1996 and 1997 adjustments were compared to check for any scale differences and pier movements between epochs. The analyses were performed with the new baseline comparison program LINCOMP (version 1.3, May 95). For the adjustments and analyses of the measurements prior to 1997, the reader is referred to the reports issued for those years.

Pier Movement Analysis

The pier movement analysis performed by program LINCOMP uses the "least absolute sum" (L1-norm) solution. Piers that are identified as having statistically significant coordinate differences are removed from the analysis by renaming them. The process is iterated until no "outliers" remain. For the comparisons between the 1990, 1991, and 1996 epochs, the piers in Table 3 were found to have moved. The coordinate difference is estimated from a combined CALIB adjustment of the two applicable epochs. A positive sign for the movement implies that the pier has moved away from the first pier (the distance has lengthened over time).

There were no pier movements between the 1996 and 1997 epochs.

Table 3: Pier movements on the Vernon baseline

Comparison		Pier	Coordinate Differences	
From	To		Value ± Std.Dev. (mm)	95% Confidence Interval (mm)
1990	1991	2	+1.2 ± 0.1	+1.0 to +1.4
1991	1996	1	+2.7 ± 0.2	+2.3 to +3.1
1991	1996	2	+0.5 ± 0.2	+0.2 to +0.8

Scale Difference Analysis

Any scale difference between epochs is estimated with program LINCOMP using the least squares (L2-norm) solution with suspected pier movements removed. The estimated scale differences between the epochs are given in Table 4.

Table 4: Scale difference between epochs

Comparison		Piers Used	Scale Change	
From	To		Value ± Std.Dev. (ppm)	95% Confidence Interval (ppm)
1990	1991	1,3,4,5,6	+0.75 ± 0.73	-0.69 to +2.19
1991	1996	3,4,5,6	-1.36 ± 0.61	-2.55 to -0.17
1996	1997	1,2,3,4,5,6	+0.44 ± 0.29	-0.12 to +1.00

The estimated scale difference from 1991 to 1996 is statistically significant at the 95% confidence level. The large standard deviation and confidence interval reflect the fact that the scale difference estimation is primarily based on the longer (less precise) distances.

Adopted Distances

The Adopted Distances for the Vernon baseline are given in Appendix C and are based on the 1997 measurements. This appendix gives the adjusted interpier slope distances, estimated standard deviations and elevation differences.

Recommendations

The six piers on the Vernon baseline have stabilized from 1996 to 1997. A remeasurement should only be done at the request of the controlling agency.

Any future remeasurement should use the scheme of elevated sensors employed in 1996 and 1997 to better model temperatures at the heights of the lines-of-sight.

Hennessey/Bresee
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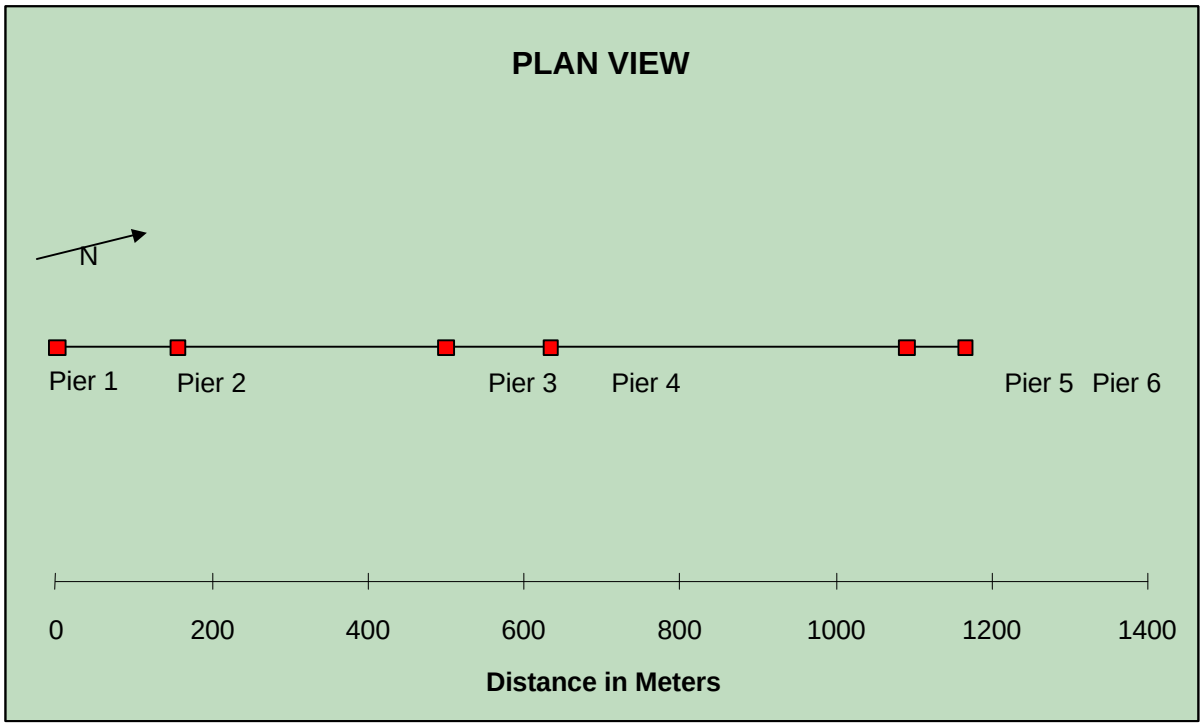
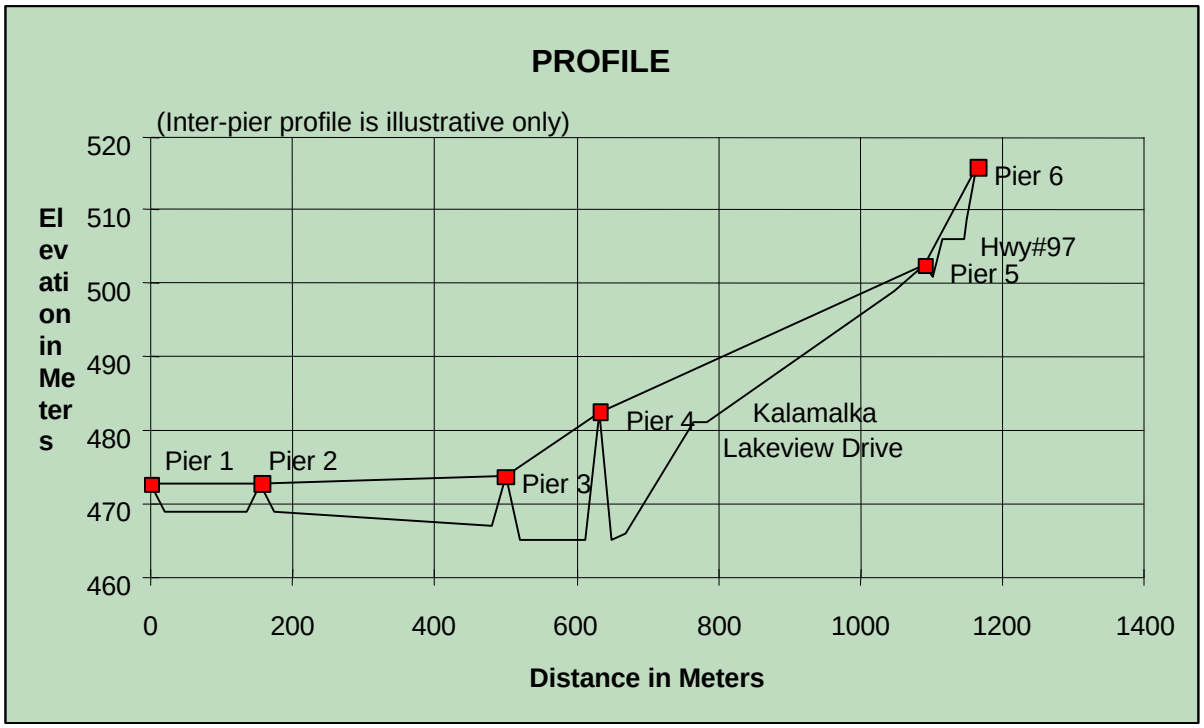

PLAN VIEW
N
Pier 1
Pier 2
Pier 3
Pier 4
Pier 5
Pier 6
0
200
400
600
800
1000
1200
1400
Distance in Meters


PROFILE
(Inter-pier profile is illustrative only)
Elevation in Meters
520
510
500
490
480
470
460
Pier 1
Pier 2
Pier 3
Pier 4
Pier 5
Pier 6
Hwy#97
Kalamalka
Lakeview Drive
0
200
400
600
800
1000
1200
1400
Distance in Meters

CALIB LEAST SQUARES ADJUSTMENT SUMMARY **APPENDIX B**

BASELINE NAME: VERNON, B.C.

Epoch Dates	Degrees of Freedom	Variance Factor	Statistical Tests		Derived Constant	Input Scale	Comments
			V.F.	G.O.F.	mm ± S.D.	ppm ± S.D.	
Aug. 14-18 1990	98	2.670	Fail	Pass	-0.0 ± 0.1	-0.4 ± 0.3	No Outliers
Sept. 02-05 1991	99	2.542	Fail	Pass	+0.0 ± 0.1	-0.7 ± 0.3	No Outliers
July 03-04 1996	79	1.327	Pass	Pass	-0.1± 0.1	-0.2 ± 0.2	No Outliers
July 14-16 1997	73	0.594	Fail	Pass	-0.4 ± 0.1	+0.4 ± 0.1	1 Outlier Kept

LEGEND: V.F. - Variance Factor Test
G.O.F. - Goodness of Fit Test

NOTE: All statistical and outlier tests performed with a 95% Confidence Level.

1997 ADOPTED BASELINE DISTANCES **APPENDIX C**

BASELINE NAME: **VERNON, B.C.**

Calib Version 1.1 1997 Epoch December, 1997

Geodetic Survey Division, Geomatics Canada

From Pier	To Pier	Elevation Difference Metres (m)	Slope Distance Metres (m)	Std Dev (mm)
1	2	0.087	155.7809	0.1
	3	1.087	499.2364	0.1
	4	9.937	632.6401	0.1
	5	29.838	1090.3961	0.1
	6	43.228	1164.7837	0.2
2	1	-0.087	155.7809	0.1
	3	1.000	343.4557	0.1
	4	9.850	476.8827	0.1
	5	29.751	934.6801	0.1
	6	43.141	1009.1224	0.1
3	1	-1.087	499.2364	0.1
	2	-1.000	343.4557	0.1
	4	8.850	133.6199	0.1
4	1	-9.937	632.6401	0.1
	2	-9.850	476.8827	0.1
	3	-8.850	133.6199	0.1
	5	19.901	457.8579	0.1
	6	33.291	532.4597	0.1
5	1	-29.838	1090.3961	0.1
	2	-29.751	934.6801	0.1
	4	-19.901	457.8579	0.1
	6	13.390	75.1943	0.1
6	1	-43.228	1164.7837	0.2
	2	-43.141	1009.1224	0.1
	4	-33.291	532.4597	0.1
	5	-13.390	75.1943	0.1