

**Prince George Calibration Baseline
1999 Adopted Values**

Author: L. Hennessey

Baseline Site

The baseline is located on the north side of Highway 16 (Yellowhead Highway), 28 Km east of the Yellowhead Bridge over the Fraser River on east side of Prince George.

This linear baseline consists of six (6) concrete piers, built to Geodetic Survey Division's specifications, which protrude an average of 1.5 meters above ground level.

Only pier 3 can be accessed easily by vehicle. All other piers require the vehicle to be parked on the narrow paved shoulder of Highway 16 (a very busy highway!). Pier 6 is the most dangerous of these piers since the access to the pier is on the crest of a hill. Access to piers 1, 2, 4, and 5 requires the descent of a steep 3 meter drop off the side of the road and to piers 1 and 2, the ascent of a 3 meter rise. There is a need to improve the accessibility of the piers on this baseline from the viewpoint of safety.

In 1999 the survey crew followed the standard safety practices for working on a busy highway (i.e. road signs on both sides of the highway, a bank of flashing lights on the government truck, and individual road safety vests).

The profile of this baseline is poor with interpier slopes that exceed Geodetic's maximum criterion of 3 percent. These steep lines are on the relatively short lines between piers 1, 2, 3 and 4. On such short, steep lines mirror pointing and other factors may produce larger variation in results than would be normally expected and may be reflected in a large variance factor for the adjusted data. Another difficulty associated with the profile is that there are six interpier lines of sight that are on average over 4 meters above ground level. Such elevated lines can cause poor internal data consistency due to the inability to model the meteorological conditions at such heights using the end-point meteorological measurements.

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

Measurements

The 1999 measurements of this baseline were made by Hennessey from July 10-13, using the ME5000 (serial number 357061). See Table 1 for the measurement history on this baseline.

Table 1: Measurement history

Date	Observer	Instrument	Serial Number
July 22-24/1992	Hennessey	Mekometer ME5000	357061
July 16-19/1993	Lafrance	Mekometer ME5000	357061
July 08-10/1998	Hennessey	Mekometer ME5000	357061
July 10-13/1999	Hennessey	Mekometer ME5000	357061

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

NGBL Calibration

The scale bias for the Mekometer ME5000 was determined from two independent calibration surveys on the National Geodetic Baseline (NGBL). The constant bias from the NGBL calibration was used as a gross check on the value determined from the Prince George baseline adjustment. The average scale bias from the two NGBL calibrations was applied to all distance observations. See Table 2 for the 1999 NGBL biases.

Table 2: Mekometer ME5000 biases derived from 1999 NGBL measurements

Date	Measurement Sets	Constant Bias Value \pm Std.Dev. (mm)	Scale Bias Value \pm Std.Dev. (ppm)
May 25-27	3	-0.4 \pm 0.1	+0.20 \pm 0.20
August 18-21	3	-0.3 \pm 0.1	+0.16 \pm 0.14
Average		-0.4 \pm 0.1	+0.18 \pm 0.17

Baseline Adjustment

The 1999 Prince George baseline measurements were processed with the 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 1992, 1993, 1998 and 1999 adjustments are summarized in Appendix B. For the adjustment and analysis of the measurements done prior to 1999, the reader is referred to the reports issued for those years.

The constant bias from the CALIB adjustment was -0.4 ± 0.1 mm, which agrees with the estimate obtained from the NGBL calibrations (see Table 2). The variance factor for the 1999 adjustment was 0.855, with 84 degrees of freedom, and passes the Chi-square test. There were no residual outliers in the adjustment using all the observations. 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 1992, 1993, 1998 and 1999 adjustments were compared to check for any scale differences and pier movements between epochs. The analyses were performed with the baseline comparison program LINCOMP (version 1.3 May 95). The reader is referred to the reports issued for 1992, 1993 and 1998 for details of those measurements.

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 1992, 1993, 1998 and 1999 epochs, the piers in Table 3 were found to have moved. The coordinate differences are estimated from a combined CALIB adjustment (least squares, L2-norm) of the two epochs. A positive sign for the movement implies that the pier has moved away from pier 1 (the distance has lengthened over time).

Table 3: Pier movement on the Prince George baseline

Comparison		Pier	Coordinate Differences	
From	To		Value \pm Std.Dev. (mm)	95% Confidence Interval (mm)
1992	1993	4	+1.5 \pm 0.1	+1.3 to +1.7
1993	1998	3	+0.8 \pm 0.1	+0.7 to +0.9
		5	+5.0 \pm 0.1	+4.7 to +5.3
1998	1999	3	+1.0 \pm 0.1	+0.9 to +1.1

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 \pm Std.Dev. (ppm)	95% Confidence Interval (ppm)
1992	1993	1,2,3,5,6	-0.26 \pm 0.37	-0.98 to +0.48
1993	1998	1,2,4,6	+1.10 \pm 0.26	+0.60 to +1.60
1998	1999	1,2,4,5,6	-0.54 \pm 0.25	-1.03 to -0.05

The estimated scale differences between 1993 and 1998 (with 2 piers removed) and between 1998 and 1999 (with 1 pier removed) are 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 Prince George baseline are given in Appendix C and are based on the 1999 measurements. This table gives the adjusted interpier slope distances,

estimated standard deviations and elevation differences. A cautionary note about the detected movement at pier 3 has been added to the table.

Recommendations

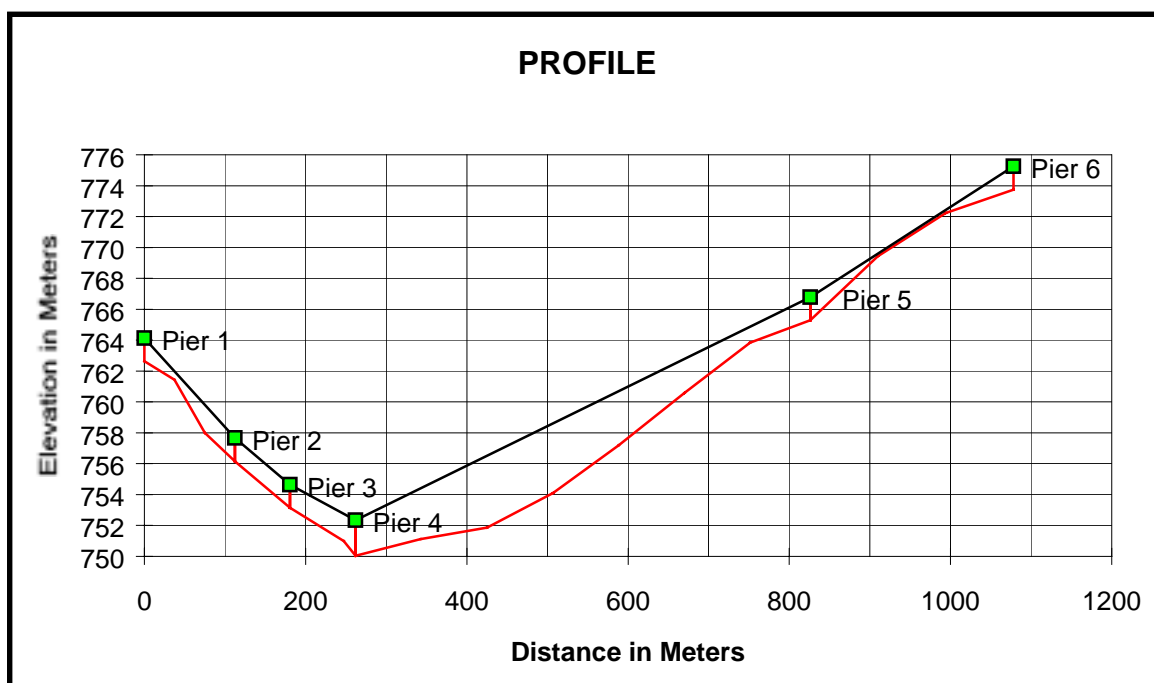
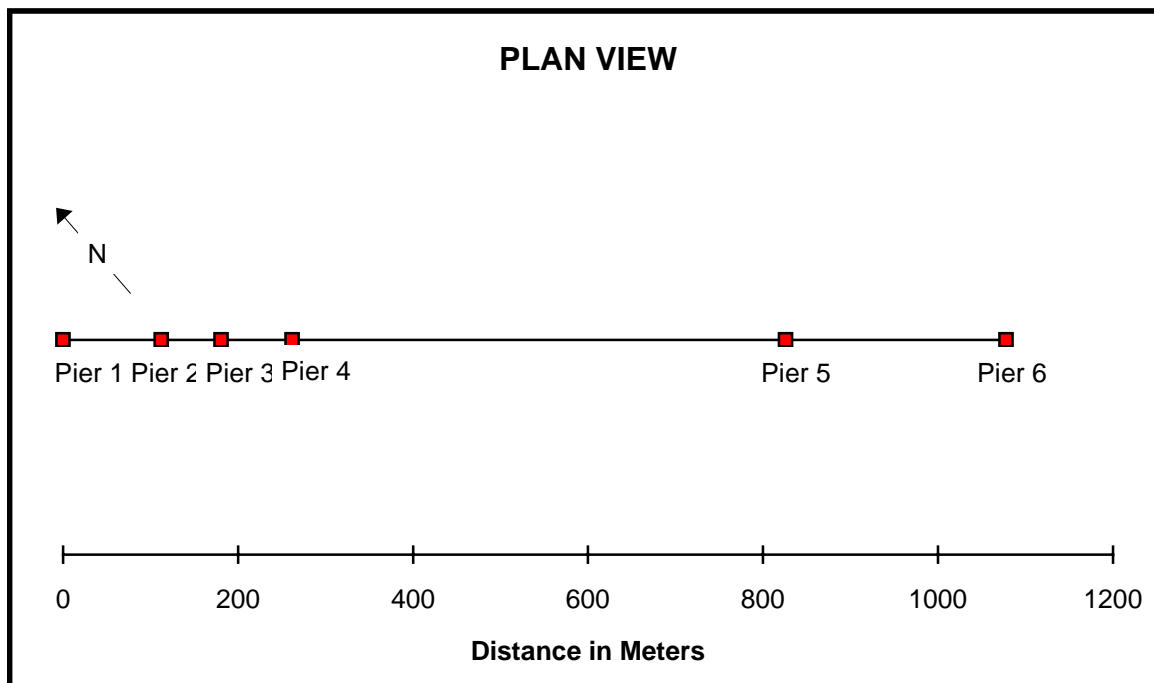
Due to the statistically different coordinate difference at pier 3 between 1998 and 1999, it is recommended that care be taken in using the value for this pier listed in Appendix C. Such minor movement is not considered physically significant since movements of a millimeter are possible on a diurnal or seasonal basis in piers which are stable from epoch to epoch.

With five stable piers and only minor movement detected at one other, a remeasurement is not required at this time. The baseline should only be remeasured at the request of the controlling agency.

Hennessey
March 2000

PRINCE GEORGE BASELINE

APPENDIX A



CALIB LEAST SQUARES ADJUSTMENT SUMMARY

APPENDIX B

BASELINE NAME: PRINCE GEORGE, BRITISH COLUMBIA

Epoch Dates	Degrees of Freedom	Variance Factor	Statistical Tests		Derived Constant mm \pm S.D.	Input Scale ppm \pm S.D.	Comments
			V.F.	G.O.F.			
July 22-24 1992	84	1.662	Fail	Pass	+0.0 \pm 0.1	-0.8 \pm 0.2	No outliers
July 16-19 1993	85	0.847	Pass	Pass	-0.1 \pm 0.1	+0.1 \pm 0.2	No outliers
July 8-10 1998	84	0.888	Pass	Pass	-0.4 \pm 0.1	+0.2 \pm 0.1	No outliers
July 10-13 1999	84	0.855	Pass	Pass	-0.4 \pm 0.1	+0.2 \pm 0.2	No outliers

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.

1999 ADOPTED BASELINE DISTANCES**APPENDIX C**BASELINE NAME: **PRINCE GEORGE, BRITISH COLUMBIA**

Calib Version 1.1

1999 Epoch

March 1, 2000

Geodetic Survey Division, Geomatics Canada

From Pier	To Pier	Elevation Difference Metres (m)	Slope Distance Metres (m)	Std Dev (mm)
1	2	-6.474	112.5200	0.1
	3	-9.478	180.8312	0.1
	4	-11.783	262.3001	0.1
	5	2.642	826.0298	0.2
	6	11.116	1078.1571	0.3
2	1	6.474	112.5200	0.1
	3	-3.004	68.3152	0.1
	4	-5.309	149.7958	0.1
	5	9.116	713.7498	0.2
	6	17.590	965.9258	0.2
3	1	9.478	180.8312	0.1
	2	3.004	68.3152	0.1
	4	-2.305	81.4852	0.1
	5	12.120	645.5560	0.2
	6	20.594	897.7525	0.2
4	1	11.783	262.3001	0.1
	2	5.309	149.7958	0.1
	3	2.305	81.4852	0.1
	5	14.425	564.1739	0.1
	6	22.899	816.3845	0.2
5	1	-2.642	826.0298	0.2
	2	-9.116	713.7498	0.2
	3	-12.120	645.5560	0.2
	4	-14.425	564.1739	0.1
	6	8.474	252.2162	0.1
6	1	-11.116	1078.1571	0.3
	2	-17.590	965.9258	0.2
	3	-20.594	897.7525	0.2
	4	-22.899	816.3845	0.2
	5	-8.474	252.2162	0.1

NOTE: There has been movement of about +1.0 mm at pier 3 between 1998 to 1999.