

Calgary GPS Validation Network

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Alberta
Environmental Protection

Resource Data Division



Natural Resources
Canada

Geodetic Survey
Division

Calgary GPS Validation Network

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Foreword

The purpose of this booklet is to provide the basic information required for users to test their GPS equipment and positioning methodology on the Calgary GPS Validation Network. Please contact Resource Data Division, Alberta Environmental Protection, for information related to this network that is not included in this document.

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1. Introduction to GPS Validation Networks

Background

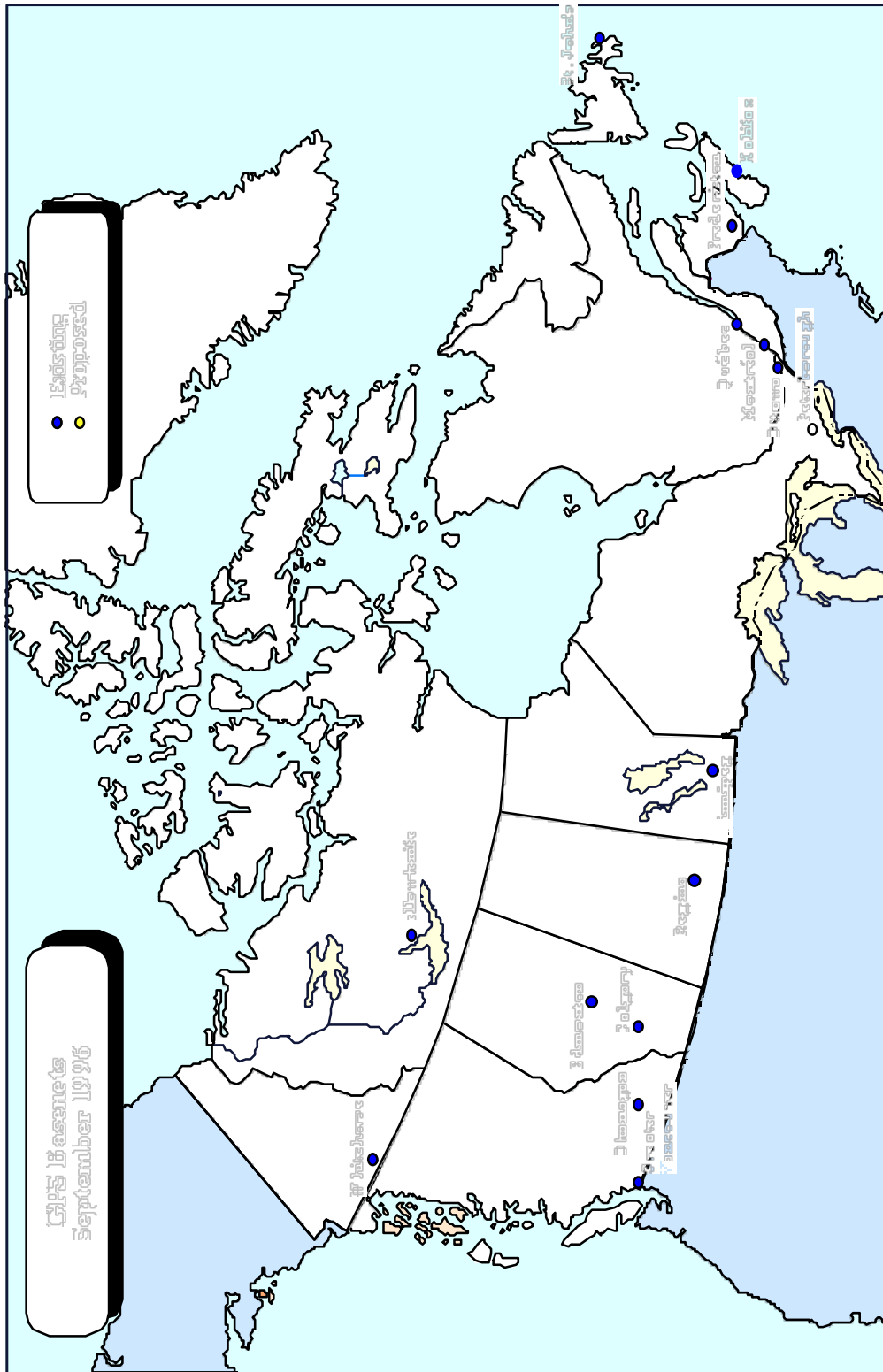
The Global Positioning System (GPS) has dramatically reshaped surveying and navigation in many parts of the world. The use of GPS positioning has become increasingly widespread. The need for a “truth” against which to test GPS positioning accuracy and precision has led to the establishment of GPS validation networks across Canada, also known as basenets, to serve as a physical standard for evaluating GPS equipment, software and positioning methodologies.

The first GPS validation network was established in the Ottawa region in 1988. Since that time other such networks have been established across the country, in collaboration with provincial geodetic surveying agencies. The map on the following page shows the locations of other GPS validation networks in Canada.

Responsibility for the Calgary GPS Validation network, first established in 1995, is shared between the Geodetic Survey Division (GSD), Natural Resources Canada (NRCan) and the Resource Data Division (RDD), Alberta Environmental Protection. RDD is responsible for site maintenance and dissemination of basenet related information such as data, whereas GSD, NRCan is responsible for establishing the validation coordinates for the network through precise GPS measurements. Each GPS validation network is established using at least two separate measurement campaigns in different years. Subsequent measurements may be performed periodically to check on pier movement.

Applications

GPS validation networks are mainly used to evaluate results obtained using a specific combination of GPS equipment, software, and observation procedures. The full range of GPS equipment, from hand-held C/A code receivers to geodetic quality dual frequency receivers, may be checked. Similarly, the accuracies obtainable from different observation procedures such as single point positioning, differential code, kinematic or static positioning techniques may be assessed.



The validation networks may also be used to evaluate proposals from GPS survey contractors. A "validation survey" on a GPS basenet may be required to assess the proposed GPS positioning system, and determine with confidence whether it can meet contract accuracy requirements. A positioning system in this context includes the equipment and procedures used for data collection as well as the software and procedures used for the data processing and adjustment.

Characteristics

A GPS validation network is typically comprised of between 5 and 10 forced centering pillars or piers. Usually two of these pillars are also part of an Electronic Distance Measurement (EDM) calibration baseline and form the core of the network. The network design provides GPS baselines of varying lengths, usually ranging between 1 and 100 kilometres, and the design and location of pillars is such that:

- forced centering is used to eliminate centering error ;
- sites are easily accessible;
- sites are generally clear of obstructions above 10 degrees from the horizon;
- and
- for stability and longevity, pillar monumentation is carried out using the same specifications as for EDM calibration baseline pillars. (See Appendix D.)

The following section contains a description and map of the Calgary GPS validation network, and a brief explanation of the determination of coordinates listed in this document.

2. The Calgary GPS Validation Network

Description

The Calgary GPS validation network was constructed in 1994 by Alberta Environmental Protection in conjunction with the City of Calgary, Engineering Services Department. The basenet consists of eleven stations surrounding the city of Calgary: seven conventional forced centering concrete pillars and four piers flush with the ground that permit the user to insert a bolt for forced centering (see Appendix D - D.1). Three of these pillars, National Geodetic Data Base (NGDB) numbered stations 77X1058, 946011, and A374512 are also Canadian Base Network (CBN) stations. Six of the pillars, 77X1056, 77X1057, 77X1058, 77X1059, 77X1060, and 77X1061 are coincident with the Calgary EDM calibration baseline. A cross reference list for corresponding Alberta Survey Control Marker (ASCM) numbers is provided in Appendices A and B.

The basic configuration of the network, as shown on the following map, provides baseline lengths ranging from 325 metres to 42 kilometres. Nine of the pillars allow for shorter baselines ranging between 325 metres and 3 kilometres. When a GPS validation on longer baselines is required, distances of up to 42 kilometres can be accommodated through positioning at pillars A374512 and 946011. When a validation is required using baselines longer than 42 kilometres, the Edmonton GPS Validation Network should be considered. (Please see Appendix C for information on obtaining a publication describing the Edmonton network.)

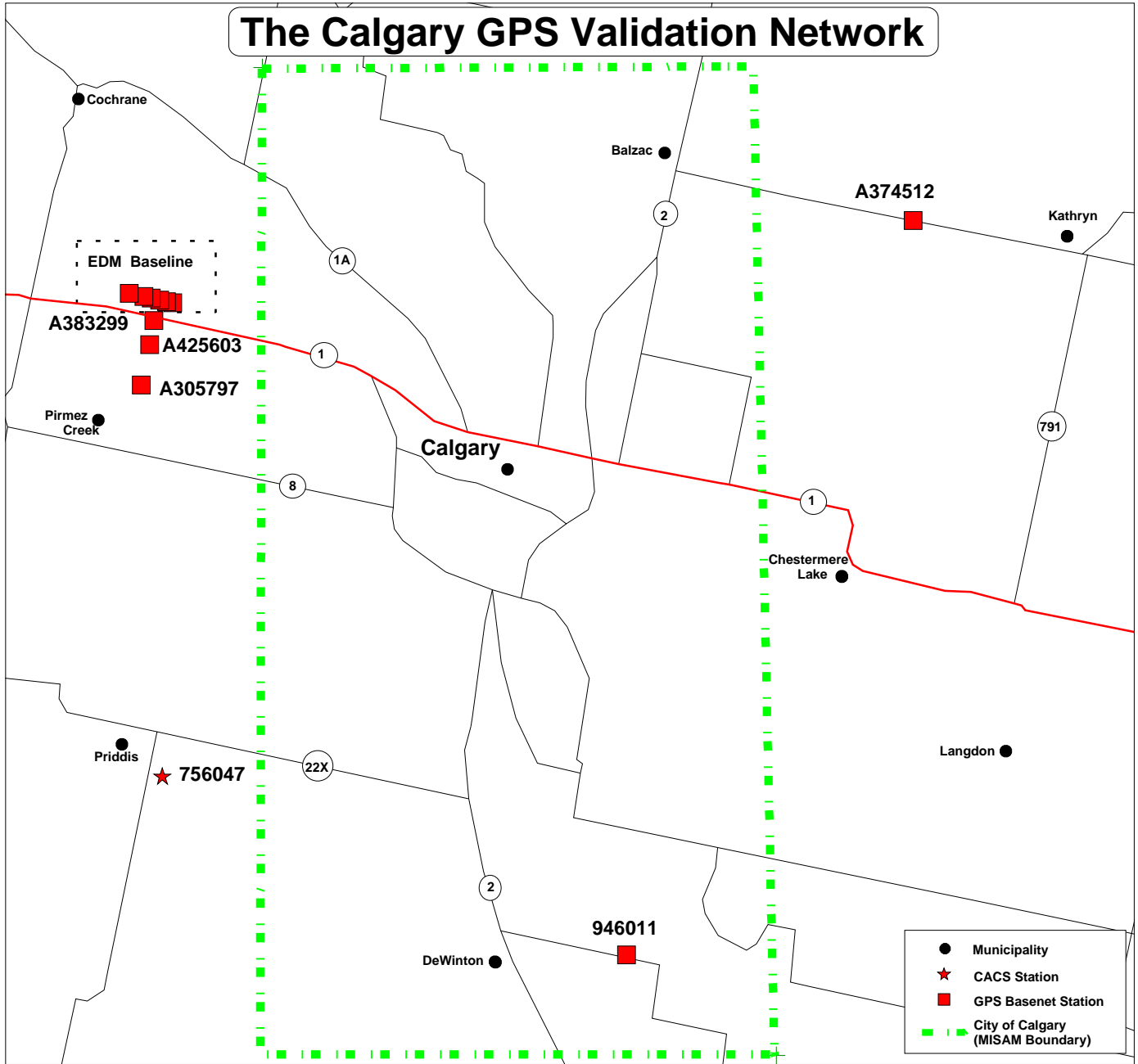
The Calgary basenet was first observed with GPS in 1995 by GSD, NRCan, with a subsequent measurement carried out in 1996. All of the observational data was collected by GSD. Ashtech Z-12 dual frequency receivers were used to collect the observations.

In addition to the three-dimensional positions established with GPS, all of the Calgary basenet pillars have orthometric heights established through first order levelling. Descriptions and site sketches for each of the pillars, as well as a notice to users of this network, are provided in Appendix A.

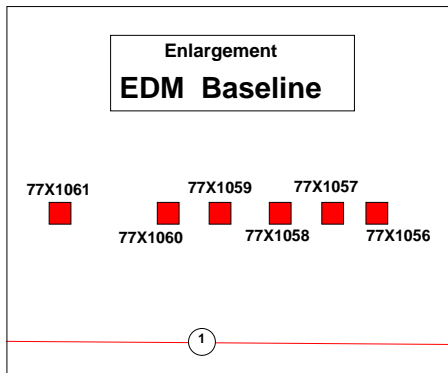
Determination of Basenet Validation Values

Coordinate values for the Calgary GPS validation network were determined using data from four complete sets of observations carried out in 1995 and 1996, as shown in the table that follows. For each epoch, or year, the GPS data was processed by GSD in Ottawa, using Bernese GPS processing software in session mode.

The Calgary GPS Validation Network



0 5 10 15 kilometers



Note: Points on this map have been identified by their NGDB* station number. Corresponding ASCM** station numbers are provided below:

NGDB Number	ASCM Number
77X1056	11718
77X1057	149203
77X1058	25320
77X1059	249060
77X1060	189506
77X1061	157800
A305797	305797
A374512	374512
A383299	383299
A425603	425603
946011	385377

* NGDB : National Geodetic Data Base
**ASCM : Alberta Survey Control Marker

The validation coordinates appearing in this document were produced by combining all sessions from the three measurement epochs together in a minimally constrained three-dimensional least squares adjustment. Station 77X1058 (Pier 4) was constrained (using the CBN covariance matrix as weights) to its NAD83 Canadian Spatial Reference System (CSRS) coordinates [from a 1996 adjustment of Canadian Base Network (CBN) data]. In tests carried out, to check for pier movement and statistical compatibility between the epochs, there was no indication of significant pier movement or distortion.

Measurement History - Calgary GPS Validation Network

Year	Receiver Type	Number of Receivers	Session Length (hours)	Number of Sessions	GPS Processing Software
1994 (6 EDM Baseline Stations)	Ashtech Z-12	6	24	1	Bernese v3.2
1995	Ashtech Z-12	6	6	7	Bernese v3.4
1996	Ashtech Z -12	6	24	3	Bernese v3.5

All coordinate values and error estimates can be found in Appendix B. The ellipsoidal, geocentric Cartesian, and mapping plane coordinates for network piers are given in Tables 1, 2 and 3, respectively. The Cartesian coordinate differences between each of the pillars can be found in Table 4. Absolute 95% confidence regions are provided in Tables 5, 6, and 7, while relative 95% confidence regions are provided in Tables 8, 9, and 10. Note that corresponding covariance data is also available as described in Appendix C.

Separate confidence regions are given for the three-dimensional (3-D), horizontal (2-D) and vertical (1-D) coordinates. This is necessary because the expansion factors used to compute the 95% confidence regions are different for each case.

The coordinates given in this document are to be used **for validation purposes only**, and differ from provincial NAD83 adopted values. If needed, adopted NAD83 survey control values are available from Client Services Branch, Resource Data Division (RDD), Alberta Environmental Protection (see Appendix C).

The descriptions, sketches and coordinate values provided in this booklet are intended to provide all the basic information needed to use the Calgary GPS validation network as a physical standard for testing and validating GPS positioning systems to suit specific applications. Details on obtaining further information, data or documents are given in Appendix C.

Appendix A

Station Descriptions and Site Sketches

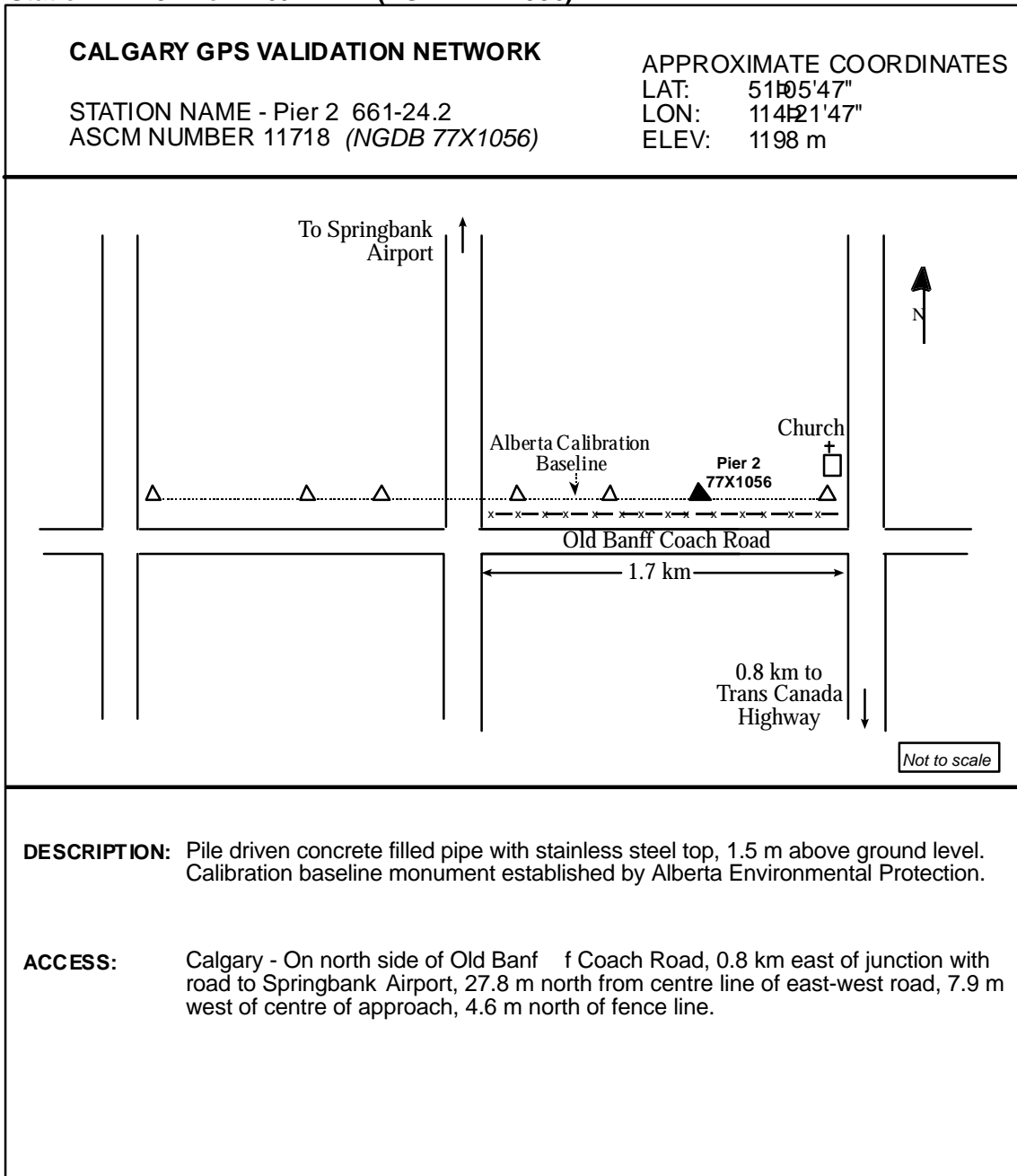
ASCM Number	NGDB Number	Station Name
11718	77X1056	Pier 2 (661-24.2)
25320	77X1058	Pier 4 (661-24.4)
149203	77X1057	Pier 3 (661-24.3)
157800	77X1061	Pier 7 (661-24.7)
189506	77X1060	Pier 6 (661-24.6)
249060	77X1059	Pier 5 (661-24.5)
305797	A305797	GPS 500
374512	A374512	Kathy
383299	A383299	GPS 100
385377	946011	Marker Farm CBN Pillar
425603	A425603	GPS 400

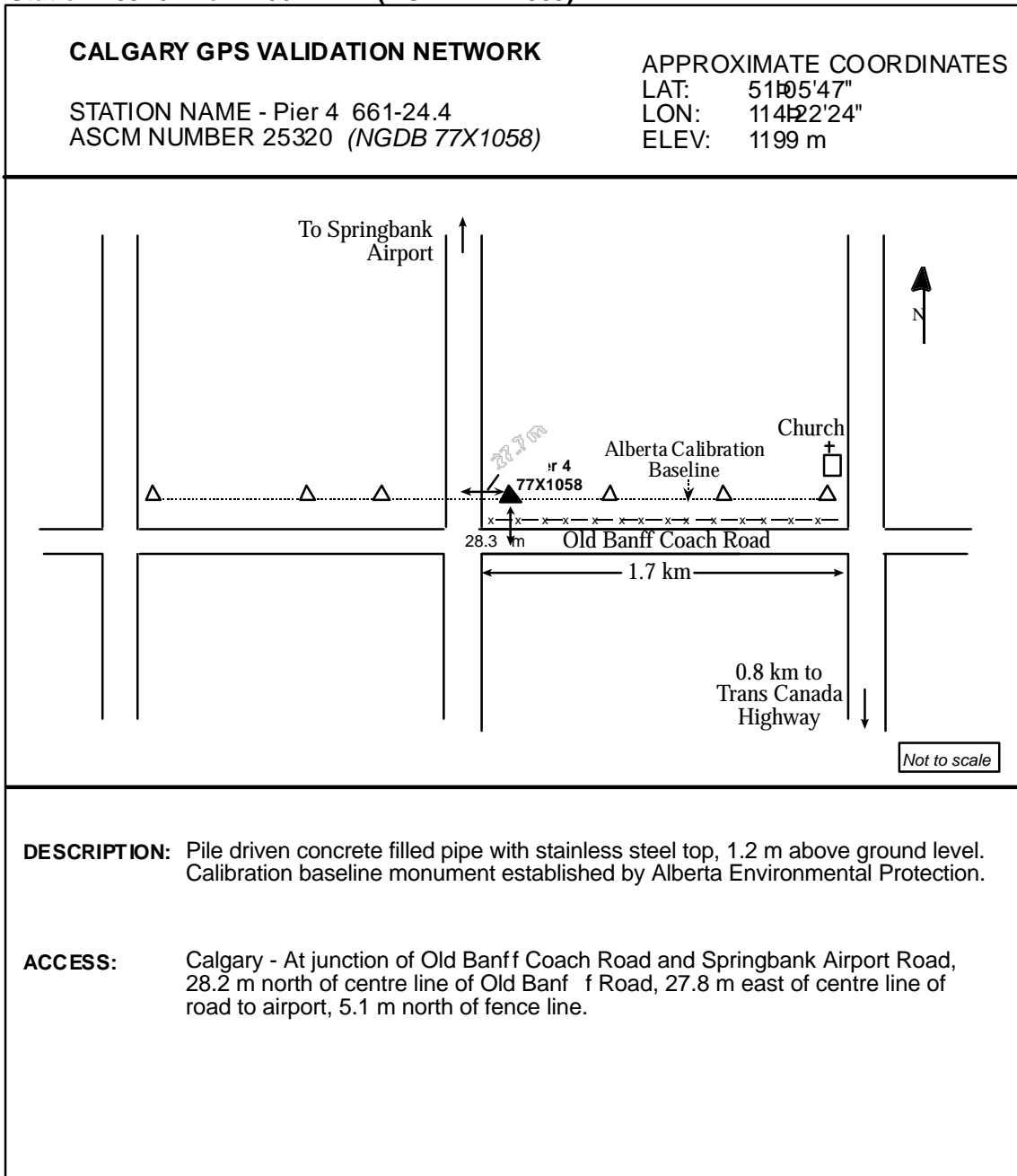
Notice to Users

- The Calgary GPS validation network is located on public property. Any damage to private or public property which may occur during the use of the network is the responsibility of the user.
- Users must obey normal traffic safety laws.
- The network was installed with the cooperation of local residents, and common courtesy should be observed during occupations.
- Users may reserve the basenet, for validation purposes only, by contacting the Resource Data Division.
- Users are also asked to assist in the preservation of the network pillars. Please report any damage or potential dangers to:

***Resource Data Division
Alberta Environmental Protection
15th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6***

***Tel: (403) 427-3138
Fax: (403) 427-1493***

Station 11718 Pier 2 661-24.2 (NGDB 77X1056)

Station 25320 Pier 4 661-24.4 (NGDB 77X1058)

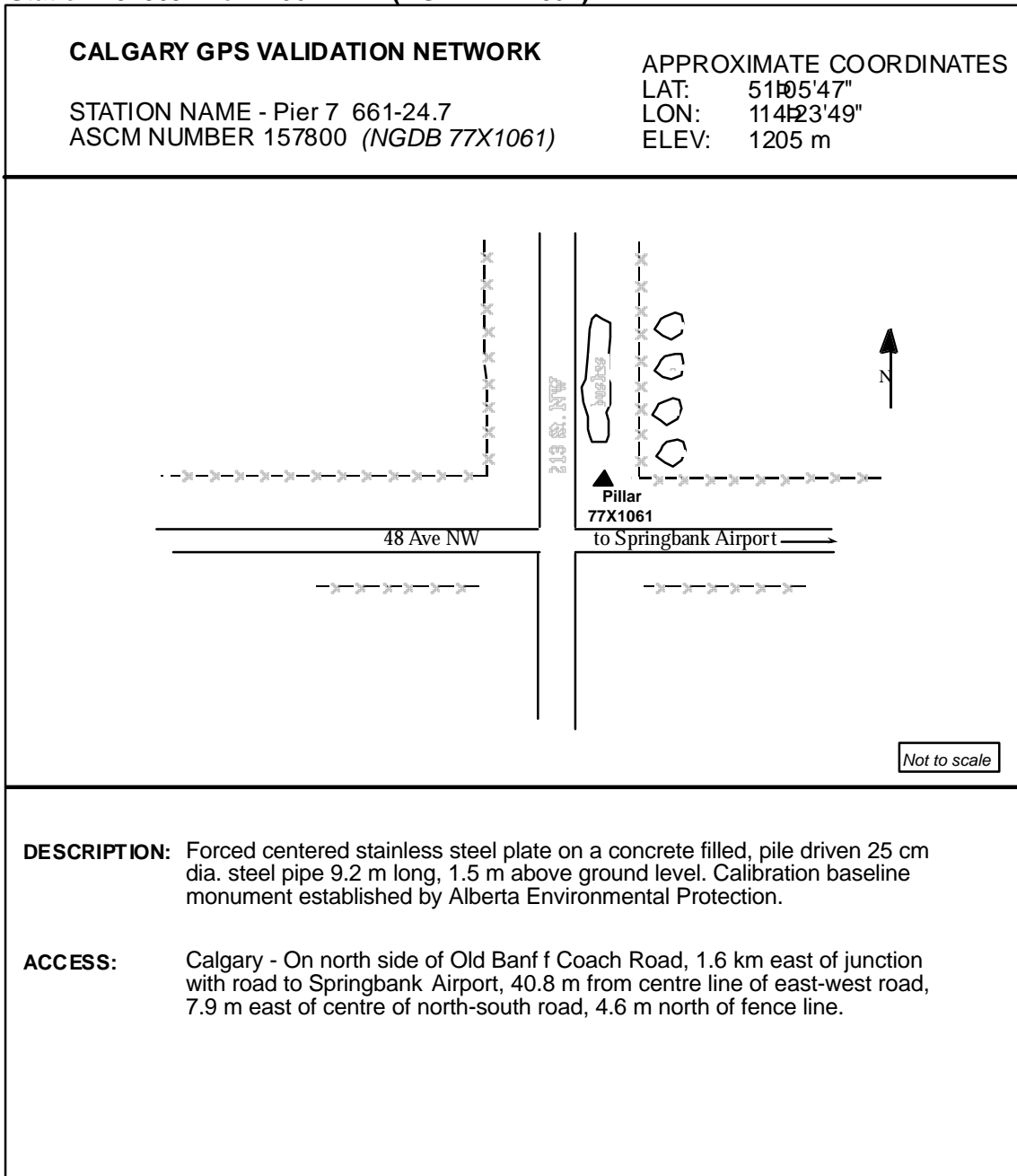
Station 149203 Pier 3 661-24.3 (NGDB 77X1057)

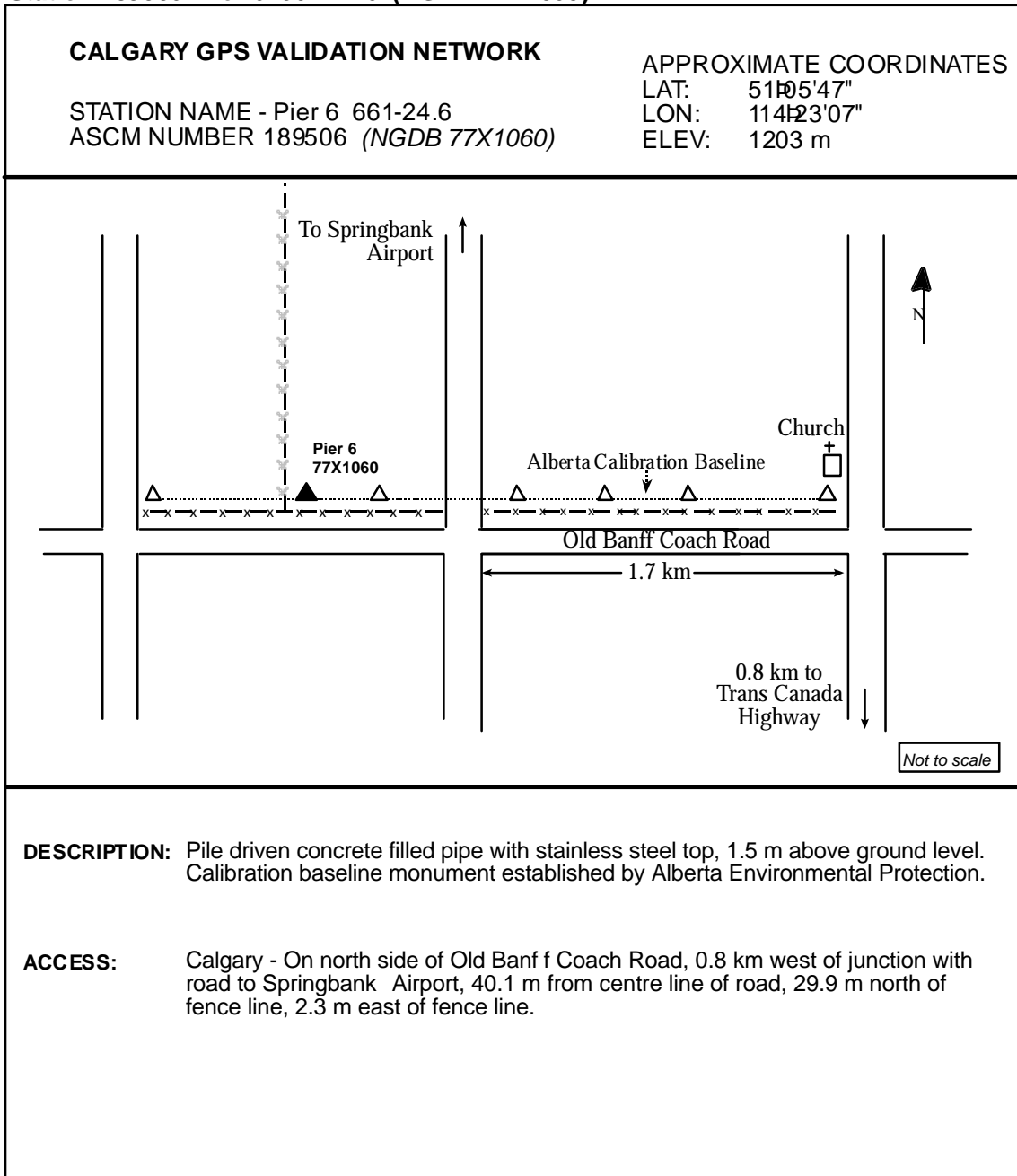
CALGARY GPS VALIDATION NETWORK		APPROXIMATE COORDINATES
STATION NAME - Pier 3 661-24.3		LAT: 51°05'47"
ASCM NUMBER 149203 (NGDB 77X1057)		LON: 114°22'04"
		ELEV: 1198 m

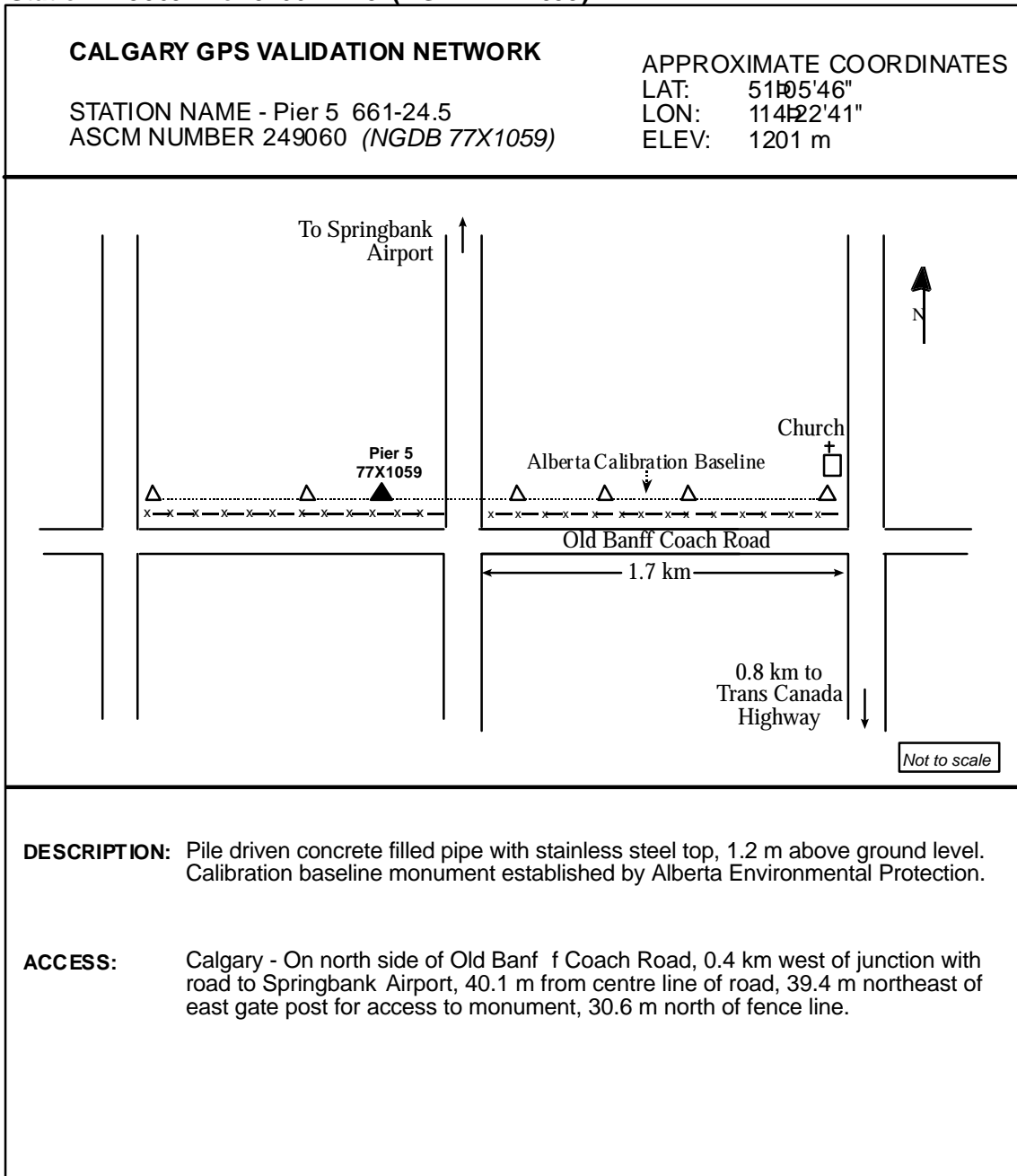
Not to scale

DESCRIPTION: Pile driven concrete filled pipe with stainless steel top, 1.5 m above ground level. Calibration baseline monument established by Alberta Environmental Protection.

ACCESS: Calgary - On north side of Old Banff Coach Road, 0.5 km east of junction with road to Springbank Airport, 28.1 m from centre line of road, 8.7 m west of centre of approach, 5.0 m north of fence line.

Station 157800 Pier 7 661-24.7 (NGDB 77X1061)

Station 189506 Pier 6 661-24.6 (NGDB 77X1060)

Station 249060 Pier 5 661-24.5 (NGDB 77X1059)

DESCRIPTION: Pile driven concrete filled pipe with stainless steel top, 1.2 m above ground level. Calibration baseline monument established by Alberta Environmental Protection.

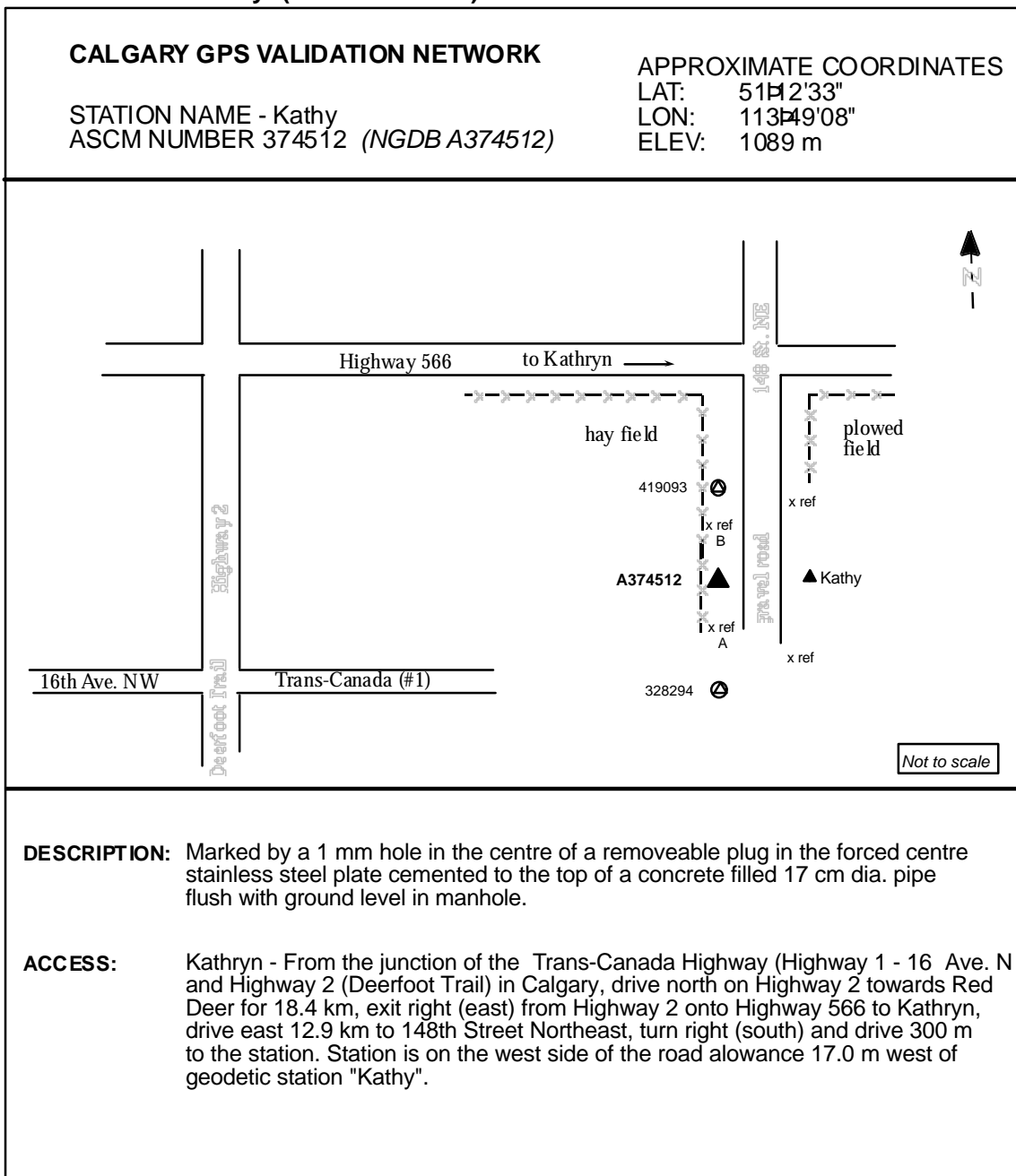
ACCESS: Calgary - On north side of Old Banff Coach Road, 0.4 km west of junction with road to Springbank Airport, 40.1 m from centre line of road, 39.4 m northeast of east gate post for access to monument, 30.6 m north of fence line.

Station 305797 GPS 500 (NGDB A305797)

CALGARY GPS VALIDATION NETWORK		APPROXIMATE COORDINATES
STATION NAME - GPS 500		LAT: 51°03'18"
ASCM NUMBER 305797 (NGDB A305797)		LON: 114°22'21"
		ELEV: 1187 m

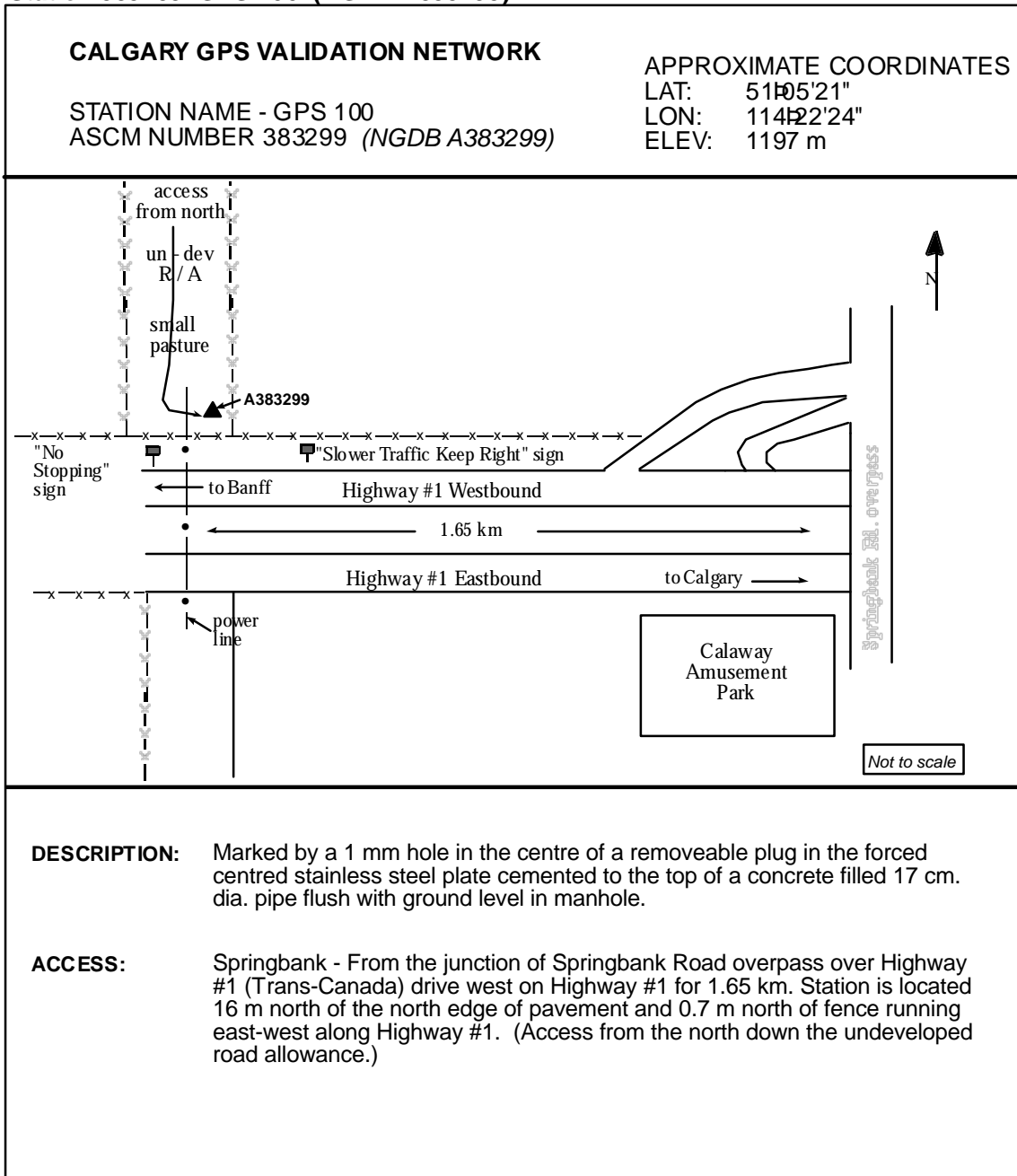
DESCRIPTION: Marked by a 1 mm hole in the centre of a removeable plug in the forced centre stainless steel plate cemented to the top of a concrete filled 17 cm dia. pipe flush with ground level in manhole.

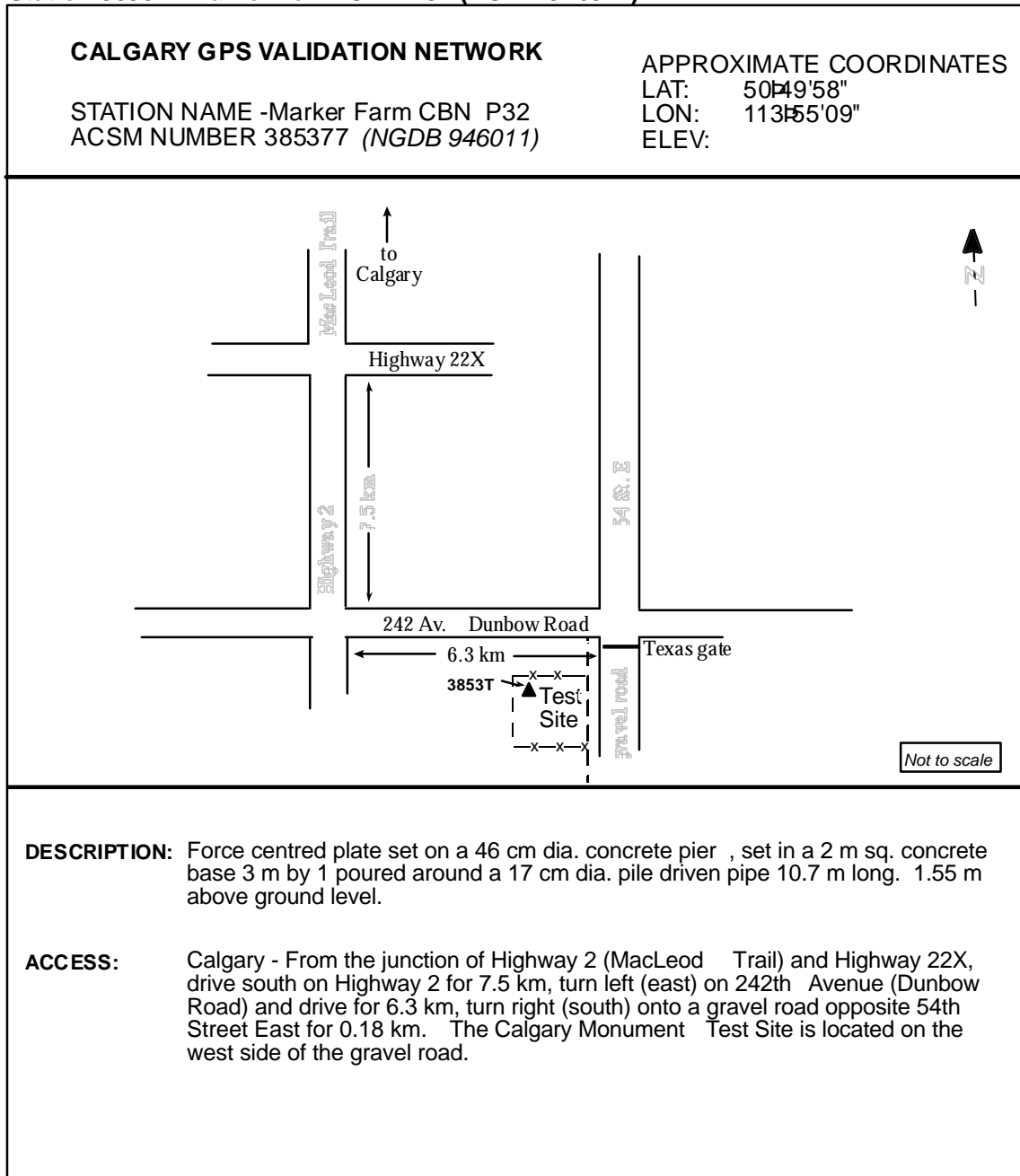
ACCESS: Springbank - From the junction of Springbank Road overpass over Highway #1 (Trans-Canada) drive 1.5 km south on Springbank Road, turn right (west) onto Huggard Road for a distance of 1.65 km to a 90° turn to the left (south). Continue south and drive 1.35 km past the intersection with 7th Ave. South-west. The station is located on the crest of a hill 30 m north of BM 457101 on the east side of Huggard Road, 7 m east of the centre line.

Station 374512 Kathy (NGDB A374512)


DESCRIPTION: Marked by a 1 mm hole in the centre of a removeable plug in the forced centre stainless steel plate cemented to the top of a concrete filled 17 cm dia. pipe flush with ground level in manhole.

ACCESS: Kathryn - From the junction of the Trans-Canada Highway (Highway 1 - 16 Ave. N and Highway 2 (Deerfoot Trail) in Calgary, drive north on Highway 2 towards Red Deer for 18.4 km, exit right (east) from Highway 2 onto Highway 566 to Kathryn, drive east 12.9 km to 148th Street Northeast, turn right (south) and drive 300 m to the station. Station is on the west side of the road allowance 17.0 m west of geodetic station "Kathy".

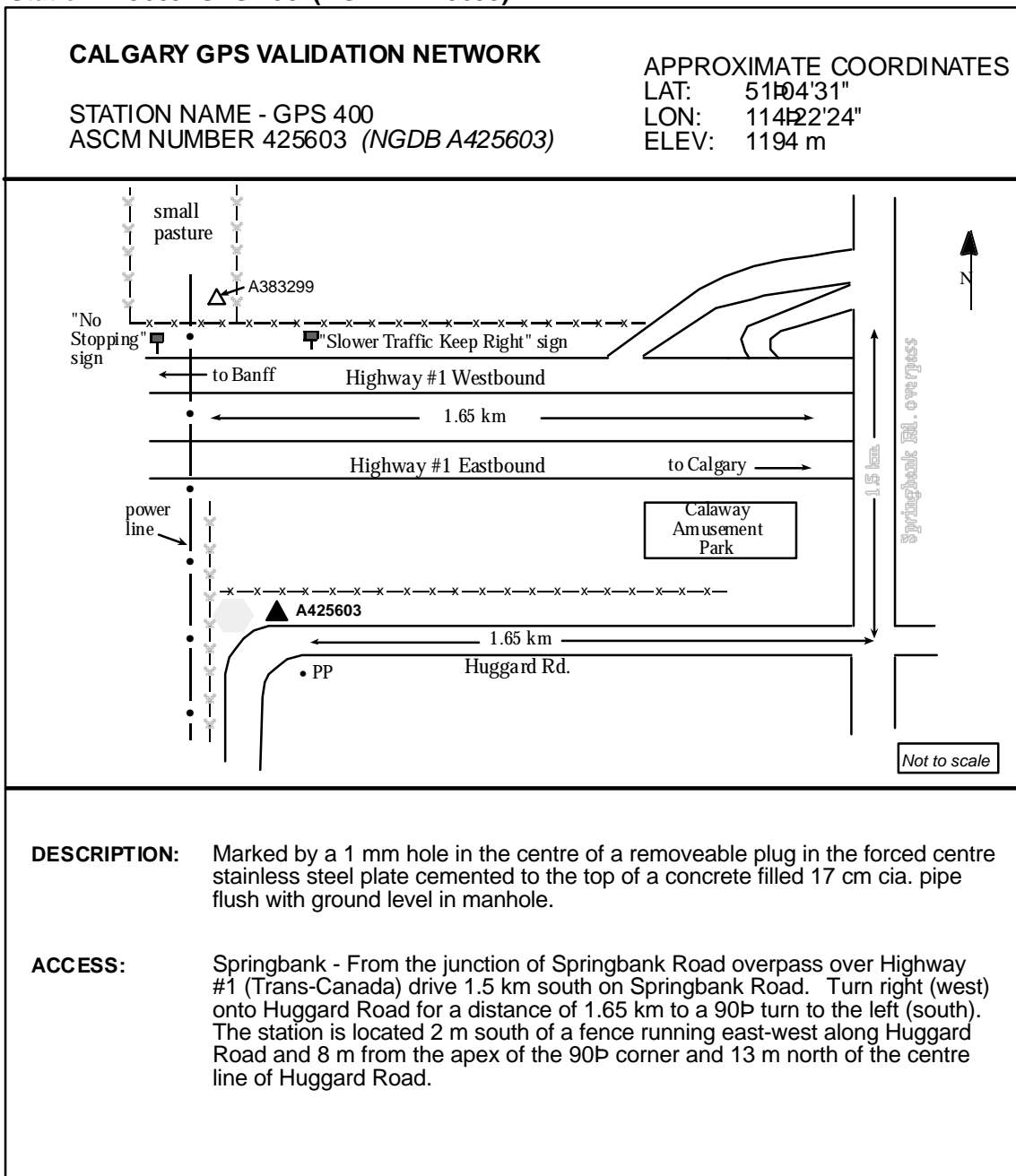
Station 383299 GPS 100 (NGDB A383299)

Station 385377 Marker Farm CBN P32 (NGDB 946011)


DESCRIPTION: Force centred plate set on a 46 cm dia. concrete pier , set in a 2 m sq. concrete base 3 m by 1 m poured around a 17 cm dia. pile driven pipe 10.7 m long. 1.55 m above ground level.

ACCESS: Calgary - From the junction of Highway 2 (MacLeod Trail) and Highway 22X, drive south on Highway 2 for 7.5 km, turn left (east) on 242th Avenue (Dunbow Road) and drive for 6.3 km, turn right (south) onto a gravel road opposite 54th Street East for 0.18 km. The Calgary Monument Test Site is located on the west side of the gravel road.

Station 425603 GPS 400 (NGDB A425603)



DESCRIPTION: Marked by a 1 mm hole in the centre of a removeable plug in the forced centre stainless steel plate cemented to the top of a concrete filled 17 cm dia. pipe flush with ground level in manhole.

ACCESS: Springbank - From the junction of Springbank Road overpass over Highway #1 (Trans-Canada) drive 1.5 km south on Springbank Road. Turn right (west) onto Huggard Road for a distance of 1.65 km to a 90° turn to the left (south). The station is located 2 m south of a fence running east-west along Huggard Road and 8 m from the apex of the 90° corner and 13 m north of the centre line of Huggard Road.

Appendix B

Tables of Values

(Calgary GPS Validation Network - 1995 and 1996 epochs combined)

Warning to Users: These coordinates are to be used for validations only, and are not to be considered adopted NAD83 survey control values. Control coordinates may be obtained from Client Services Branch as described in Appendix C. Note that station 77X1058 (Pier 4) was constrained to its NAD83(CSRs) value in the adjustment that produced these coordinates.

Station Number Cross Reference List

ASCM Number	NGDB Number	Station Name
11718.	77X1056	Pier 2 (661-24.2)
25320.	77X1058	Pier 4 (661-24.4)
149203	77X1057	Pier 3 (661-24.3)
157800	77X1061	Pier 7 (661-24.7)
189506	77X1060	Pier 6 (661-24.6)
249060	77X1059	Pier 5 (661-24.5)
305797	A305797	GPS 500
374512	A374512	Kathy
383299	A383299	GPS 100
385377	946011	Marker Farm CBN Pillar
425603	A425603	GPS 400

Table 1: Ellipsoidal Coordinates

NGDB #	Latitude (d m s)	North	Longitude (d m s)	West	Ellipsoidal Height (m)
77X1058	51 05	47.10009	114 22	24.08775	1183.359
77X1056	51 05	47.10419	114 21	47.08920	1182.698
77X1057	51 05	47.10478	114 22	03.88661	1182.439
77X1059	51 05	47.09669	114 22	47.27075	1185.184
77X1060	51 05	47.08501	114 23	07.32457	1187.821
77X1061	51 05	47.06967	114 23	48.77818	1189.132
946011	50 49	58.28888	113 55	09.35695	1005.456
A305797	51 03	15.98840	114 22	24.53903	1171.755
A374512	51 12	32.69195	113 49	07.84218	1071.861
A383299	51 05	20.14858	114 22	25.19295	1181.927
A425603	51 04	27.22673	114 22	24.93479	1178.511

Table 2: Geocentric Cartesian Coordinates

NGDB #	X (m)	Y (m)	Z (m)
77X1058	-1656679.605	-3656648.615	4941208.764
77X1056	-1656023.459	-3656945.254	4941208.330
77X1057	-1656321.188	-3656810.221	4941208.140
77X1059	-1657091.088	-3656463.509	4941210.118
77X1060	-1657447.375	-3656304.148	4941211.944
77X1061	-1658182.651	-3655972.058	4941212.667
946011	-1636837.625	-3690383.409	4922601.520
A305797	-1658184.130	-3659948.123	4938265.200
A374512	-1617242.066	-3663514.682	4948985.254
A383299	-1656966.344	-3657229.378	4940684.454
A425603	-1657486.091	-3658388.737	4939654.208

Table 3: UTM Mapping Plane Coordinates

NGDB #	Northing (m)	Easting (m)	Zone
77X1058	5663828.545	683914.621	11
77X1056	5663854.409	684634.120	11
77X1057	5663842.730	684307.463	11
77X1059	5663812.365	683463.789	11
77X1060	5663798.130	683073.818	11
77X1061	5663769.071	682267.691	11
946011	5635300.007	294439.129	12
A305797	5659161.370	684072.398	11
A374512	5676852.334	303110.098	12
A383299	5662995.418	683922.839	11
A425603	5661361.183	683986.192	11

Warning to Users: Distances derived from UTM coordinates are distorted. They cannot be compared to spatial distances derived from Cartesian or ellipsoidal coordinates without applying appropriate scale factors. UTM coordinates and distances should only be compared to other UTM coordinates and distances. For more information, please contact either of the agencies referred to in Appendix C.

Table 4: Interstation Cartesian Coordinate Differences

From NGDB #	To NGDB #	ΔX (m)	ΔY (m)	ΔZ (m)	Spatial Distance (m)
77X1058	77X1056	656.146	-296.639	-0.434	720.085
77X1058	77X1057	358.417	-161.606	-0.624	393.166
77X1058	77X1059	-411.483	185.106	1.354	451.203
77X1058	77X1060	-767.770	344.467	3.180	841.510
77X1058	77X1061	-1503.046	676.557	3.903	1648.300
77X1058	946011	19841.980	-33734.794	-18607.244	43335.551
77X1058	A305797	-1504.525	-3299.508	-2943.564	4670.644
77X1058	A374512	39437.539	-6866.067	7776.489	40779.114
77X1058	A383299	-286.739	-580.763	-524.310	833.310
77X1058	A425603	-806.486	-1740.122	-1554.557	2468.824
77X1056	77X1057	-297.729	135.033	-0.190	326.920
77X1056	77X1059	-1067.629	481.745	1.789	1171.287
77X1056	77X1060	-1423.916	641.106	3.615	1561.591
77X1056	77X1061	-2159.193	973.196	4.337	2368.384
77X1056	946011	19185.834	-33438.155	-18606.810	42806.773
77X1056	A305797	-2160.671	-3002.869	-2943.130	4727.339
77X1056	A374512	38781.393	-6569.428	7776.924	40095.316
77X1056	A383299	-942.885	-284.124	-523.876	1115.439
77X1056	A425603	-1462.632	-1443.483	-1554.122	2576.477
77X1057	77X1059	-769.900	346.712	1.979	844.369
77X1057	77X1060	-1126.187	506.073	3.804	1234.675
77X1057	77X1061	-1861.464	838.163	4.527	2041.466
77X1057	946011	19483.563	-33573.188	-18606.620	43046.190
77X1057	A305797	-1862.942	-3137.903	-2942.940	4688.057
77X1057	A374512	39079.122	-6704.461	7777.114	40405.582
77X1057	A383299	-645.156	-419.158	-523.686	930.680
77X1057	A425603	-1164.903	-1578.516	-1553.932	2502.682
77X1059	77X1060	-356.287	159.361	1.826	390.307
77X1059	77X1061	-1091.563	491.451	2.548	1197.097
77X1059	946011	20253.463	-33919.900	-18608.598	43669.696
77X1059	A305797	-1093.042	-3484.614	-2944.918	4691.463
77X1059	A374512	39849.022	-7051.173	7775.135	41208.207
77X1059	A383299	124.744	-765.869	-525.664	937.251
77X1059	A425603	-395.003	-1925.228	-1555.911	2506.669

continued on next page...

Table 4 (continued)

From NGDB #	To NGDB #	ΔX (m)	ΔY (m)	ΔZ (m)	Spatial Distance (m)
77X1060	77X1061	-735.276	332.090	0.722	806.793
77X1060	946011	20609.750	-34079.261	-18610.424	43960.274
77X1060	A305797	-736.755	-3643.976	-2946.744	4743.908
77X1060	A374512	40205.309	-7210.534	7773.309	41579.839
77X1060	A383299	481.031	-925.231	-527.490	1168.627
77X1060	A425603	-38.716	-2084.589	-1557.737	2602.605
77X1061	946011	21345.027	-34411.351	-18611.147	44565.974
77X1061	A305797	-1.478	-3976.065	-2947.467	4949.410
77X1061	A374512	40940.586	-7542.624	7772.587	42348.977
77X1061	A383299	1216.308	-1257.320	-528.213	1827.366
77X1061	A425603	696.560	-2416.679	-1558.459	2958.772
946011	A305797	-21346.505	30435.285	15663.680	40340.188
946011	A374512	19595.559	26868.727	26383.734	42450.157
946011	A383299	-20128.719	33154.030	18082.934	42794.247
946011	A425603	-20648.466	31994.672	17052.688	41723.043
A305797	A374512	40942.064	-3566.558	10720.054	42472.256
A305797	A383299	1217.786	2718.745	2419.254	3837.625
A305797	A425603	698.039	1559.386	1389.008	2201.882
A374512	A383299	-39724.278	6285.303	-8300.800	41066.124
A374512	A425603	-40244.025	5125.945	-9331.046	41628.419
A383299	A425603	-519.747	-1159.359	-1030.247	1635.744

Table 5: Absolute 95% 3-D Confidence Ellipsoids

NGDB #	Major Semi-axis			Medium Semi-axis			Minor Semi-axis		
	length (m)	az. (deg)	inc. (deg)	length (m)	az. (deg)	inc. (deg)	length (m)	az. (deg)	inc. (deg)
77X1058	0.03	62	84	0.02	356	-2	0.02	86	-5
77X1056	0.03	62	86	0.02	1	-2	0.02	91	-4
77X1057	0.03	62	86	0.02	1	-2	0.02	91	-4
77X1059	0.03	62	86	0.02	1	-2	0.02	91	-4
77X1060	0.03	62	86	0.02	1	-2	0.02	91	-4
77X1061	0.03	62	86	0.02	1	-2	0.02	91	-4
946011	0.03	59	86	0.02	358	-2	0.02	88	-4
A305797	0.03	62	86	0.02	2	-2	0.02	92	-3
A374512	0.03	63	86	0.02	358	-2	0.02	88	-4
A383299	0.03	61	86	0.02	2	-2	0.02	92	-3
A425603	0.03	62	86	0.02	1	-2	0.02	91	-4

Table 6: Absolute 95% Horizontal Confidence Ellipses

NGDB #	Major Semi-axis		Minor Semi-axis	
	length (m)	az. (deg)	length (m)	az. (deg)
77X1058	0.02	18	0.02	108
77X1056	0.02	14	0.02	104
77X1057	0.02	14	0.02	104
77X1059	0.02	14	0.02	104
77X1060	0.02	14	0.02	104
77X1061	0.02	15	0.02	105
946011	0.02	10	0.02	100
A305797	0.02	14	0.02	104
A374512	0.02	10	0.02	100
A383299	0.02	14	0.02	104
A425603	0.02	15	0.02	105

Table 7: Absolute 95% Vertical Confidence Intervals

NGDB #	+/- length (m)
77X1058	0.02
77X1056	0.02
77X1057	0.02
77X1059	0.02
77X1060	0.02
77X1061	0.02
946011	0.02
A305797	0.02
A374512	0.02
A383299	0.02
A425603	0.02

Note: the semi-axes of the absolute confidence regions are shown to the nearest centimetre (rather than millimetre), because absolute accuracy with respect to the reference system NAD83 (CSRS) is known only at the centimetre level.

Table 8: Relative 95% 3-D Confidence Ellipsoids

From NGDB #	To NGDB #	Major Semi-axis			Medium Semi-axis			Minor Semi-axis		
		length (m)	az. (deg)	inc. (deg)	length (m)	az. (deg)	inc. (deg)	length (m)	az. (deg)	inc. (deg)
77X1058	77X1056	0.009	213	90	0.001	2	0	0.001	92	0
77X1058	77X1057	0.009	214	90	0.001	1	0	0.001	91	0
77X1058	77X1059	0.010	230	90	0.001	2	0	0.001	92	0
77X1058	77X1060	0.010	242	90	0.001	1	0	0.001	91	0
77X1058	77X1061	0.010	235	90	0.001	1	0	0.001	91	0
77X1058	946011	0.014	60	87	0.002	356	-1	0.002	86	-2
77X1058	A305797	0.011	233	90	0.002	3	0	0.001	93	0
77X1058	A374512	0.014	69	87	0.003	359	-1	0.002	89	-3
77X1058	A383299	0.011	268	90	0.002	3	0	0.001	93	0
77X1058	A425603	0.010	241	90	0.001	3	0	0.001	93	0
77X1056	77X1057	0.008	240	90	0.001	3	0	0.001	93	0
77X1056	77X1059	0.010	220	90	0.001	2	0	0.001	92	0
77X1056	77X1060	0.011	227	90	0.002	2	0	0.001	92	0
77X1056	77X1061	0.010	222	90	0.001	2	0	0.001	92	0
77X1056	946011	0.015	63	88	0.003	359	-1	0.002	89	-1
77X1056	A305797	0.011	219	89	0.002	3	0	0.001	93	0
77X1056	A374512	0.016	71	88	0.003	2	-1	0.002	92	-2
77X1056	A383299	0.012	244	90	0.002	3	0	0.001	93	0
77X1056	A425603	0.010	217	89	0.002	3	0	0.001	93	0
77X1057	77X1059	0.010	221	90	0.001	1	0	0.001	91	0
77X1057	77X1060	0.011	229	90	0.002	1	0	0.001	91	0
77X1057	77X1061	0.010	225	90	0.001	1	0	0.001	91	0
77X1057	946011	0.015	61	88	0.003	359	-1	0.002	89	-1
77X1057	A305797	0.011	219	90	0.002	3	0	0.001	93	0
77X1057	A374512	0.015	70	88	0.003	1	-1	0.002	91	-2
77X1057	A383299	0.012	247	90	0.002	2	0	0.001	92	0
77X1057	A425603	0.010	220	89	0.002	3	0	0.001	93	0
77X1059	77X1060	0.010	226	90	0.001	1	0	0.001	91	0
77X1059	77X1061	0.009	236	90	0.001	2	0	0.001	92	0
77X1059	946011	0.016	62	89	0.003	359	-1	0.002	89	-1
77X1059	A305797	0.012	232	90	0.002	2	0	0.001	92	0
77X1059	A374512	0.016	71	88	0.003	1	-1	0.002	91	-2
77X1059	A383299	0.012	253	90	0.002	3	0	0.001	93	0
77X1059	A425603	0.011	236	90	0.002	2	0	0.001	92	0

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Table 8 (continued)

From NGDB #	To NGDB #	Major Semi-axis			Medium Semi-axis			Minor Semi-axis		
		length (m)	az. (deg)	inc. (deg)	length (m)	az. (deg)	inc. (deg)	length (m)	az. (deg)	inc. (deg)
77X1060	77X1061	0.010	236	90	0.001	2	0	0.001	92	0
77X1060	946011	0.016	59	89	0.003	359	-1	0.002	89	-1
77X1060	A305797	0.012	235	90	0.002	2	0	0.001	92	0
77X1060	A374512	0.016	69	88	0.003	1	-1	0.002	91	-2
77X1060	A383299	0.013	263	90	0.002	2	0	0.001	92	0
77X1060	A425603	0.011	247	90	0.002	2	0	0.001	92	0
77X1061	946011	0.016	59	89	0.003	358	-1	0.002	88	-1
77X1061	A305797	0.012	232	90	0.002	2	0	0.001	92	0
77X1061	A374512	0.016	68	88	0.003	1	-1	0.002	91	-2
77X1061	A383299	0.012	262	90	0.002	2	0	0.001	92	0
77X1061	A425603	0.011	243	90	0.002	1	0	0.001	91	0
946011	A305797	0.017	64	89	0.003	1	-1	0.002	91	-1
946011	A374512	0.014	65	87	0.003	357	-1	0.002	87	-3
946011	A383299	0.017	57	89	0.003	0	-1	0.002	90	-1
946011	A425603	0.015	62	89	0.003	0	-1	0.002	90	-1
A305797	A374512	0.017	72	88	0.003	3	-1	0.002	93	-1
A305797	A383299	0.013	247	90	0.002	3	0	0.001	93	0
A305797	A425603	0.010	222	90	0.002	2	0	0.001	92	0
A374512	A383299	0.017	67	89	0.003	2	-1	0.002	92	-1
A374512	A425603	0.016	70	88	0.003	2	-1	0.002	92	-2
A383299	A425603	0.011	257	90	0.002	3	0	0.001	93	0

Table 9: Relative 95% Horizontal Confidence Ellipses						Table 10: Relative 95% Vertical Confidence Intervals			
From NGDB #	To NGDB #	NGDB #	Major Semi-axis		Minor Semi-axis		From NGDB #	To NGDB #	+/- length (m)
			length (m)	az. (deg)	length (m)	az. (deg)			
77X1058	77X1056		0.001	2	0.001	92	77X1058	77X1056	0.007
77X1058	77X1057		0.001	1	0.001	91	77X1058	77X1057	0.007
77X1058	77X1059		0.001	2	0.001	92	77X1058	77X1059	0.007
77X1058	77X1060		0.001	1	0.001	91	77X1058	77X1060	0.007
77X1058	77X1061		0.001	1	0.001	91	77X1058	77X1061	0.007
77X1058	946011		0.002	0	0.002	90	77X1058	946011	0.010
77X1058	A305797		0.001	3	0.001	93	77X1058	A305797	0.008
77X1058	A374512		0.002	3	0.002	93	77X1058	A374512	0.010
77X1058	A383299		0.001	3	0.001	93	77X1058	A383299	0.008
77X1058	A425603		0.001	3	0.001	93	77X1058	A425603	0.007
77X1056	77X1057		0.001	3	0.001	93	77X1056	77X1057	0.005
77X1056	77X1059		0.001	2	0.001	92	77X1056	77X1059	0.007
77X1056	77X1060		0.001	2	0.001	92	77X1056	77X1060	0.007
77X1056	77X1061		0.001	2	0.001	92	77X1056	77X1061	0.007
77X1056	946011		0.002	1	0.002	91	77X1056	946011	0.011
77X1056	A305797		0.001	3	0.001	93	77X1056	A305797	0.008
77X1056	A374512		0.002	4	0.002	94	77X1056	A374512	0.011
77X1056	A383299		0.002	3	0.001	93	77X1056	A383299	0.009
77X1056	A425603		0.001	3	0.001	93	77X1056	A425603	0.007
77X1057	77X1059		0.001	1	0.001	91	77X1057	77X1059	0.007
77X1057	77X1060		0.001	1	0.001	91	77X1057	77X1060	0.007
77X1057	77X1061		0.001	2	0.001	92	77X1057	77X1061	0.007
77X1057	946011		0.002	0	0.002	90	77X1057	946011	0.011
77X1057	A305797		0.001	3	0.001	93	77X1057	A305797	0.008
77X1057	A374512		0.002	3	0.002	93	77X1057	A374512	0.011
77X1057	A383299		0.002	3	0.001	93	77X1057	A383299	0.009
77X1057	A425603		0.001	3	0.001	93	77X1057	A425603	0.007
77X1059	77X1060		0.001	1	0.001	91	77X1059	77X1060	0.007
77X1059	77X1061		0.001	2	0.001	92	77X1059	77X1061	0.007
77X1059	946011		0.002	1	0.002	91	77X1059	946011	0.011
77X1059	A305797		0.002	2	0.001	92	77X1059	A305797	0.008
77X1059	A374512		0.002	3	0.002	93	77X1059	A374512	0.011
77X1059	A383299		0.002	3	0.001	93	77X1059	A383299	0.009
77X1059	A425603		0.001	3	0.001	93	77X1059	A425603	0.007

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Table 9 (continued)						Table 10 (continued)		
From NGDB #	To NGDB #	Major Semi-axis		Minor Semi-axis		From NGDB #	To NGDB #	+/- length (m)
		length (m)	az. (deg)	length (m)	az. (deg)			
77X1060	77X1061	0.001	3	0.001	93	77X1060	77X1061	0.007
77X1060	946011	0.002	0	0.002	90	77X1060	946011	0.011
77X1060	A305797	0.002	2	0.001	92	77X1060	A305797	0.009
77X1060	A374512	0.002	3	0.002	93	77X1060	A374512	0.011
77X1060	A383299	0.002	2	0.001	92	77X1060	A383299	0.009
77X1060	A425603	0.001	2	0.001	92	77X1060	A425603	0.008
77X1061	946011	0.002	0	0.002	90	77X1061	946011	0.011
77X1061	A305797	0.002	2	0.001	92	77X1061	A305797	0.008
77X1061	A374512	0.002	2	0.002	92	77X1061	A374512	0.011
77X1061	A383299	0.002	2	0.001	92	77X1061	A383299	0.009
77X1061	A425603	0.001	2	0.001	92	77X1061	A425603	0.008
946011	A305797	0.003	2	0.002	92	946011	A305797	0.012
946011	A374512	0.002	3	0.002	93	946011	A374512	0.010
946011	A383299	0.002	1	0.002	91	946011	A383299	0.012
946011	A425603	0.002	1	0.002	91	946011	A425603	0.011
A305797	A374512	0.003	4	0.002	94	A305797	A374512	0.012
A305797	A383299	0.002	3	0.001	93	A305797	A383299	0.009
A305797	A425603	0.001	2	0.001	92	A305797	A425603	0.007
A374512	A383299	0.002	4	0.002	94	A374512	A383299	0.012
A374512	A425603	0.002	4	0.002	94	A374512	A425603	0.011
A383299	A425603	0.001	4	0.001	94	A383299	A425603	0.008

Appendix C

Contacts for Additional Information

The following information is available in various formats and media, including digital:

- Adopted NAD83 coordinate values for all basenet pillars
- Official validation coordinates for all basenet pillars as shown in this document (i.e., ellipsoidal geographic, Transverse Mercator or Cartesian)
- Coordinates and associated covariance data for basenet pillars

Contact:

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Appendix D

Alberta Environmental Protection Resource Data Division

Pillar Design Calgary GPS Validation Network Forced Centering Pillars

D.1 Pillar Construction

The 7 pillars that make up part of the Calgary EDM baseline, described as “Pier” in the list below, consist of a 250 mm diameter by 9.2 metre driven pipe and filled with concrete. Pillar 946011 is constructed of a 170 mm pipe which was driven to a depth of 7.5 metres and is encased in concrete. All of these pillars have a stainless steel forced centering (5/8” NC) plate affixed to the top of the pillar, and an identification plaque is affixed to its side.

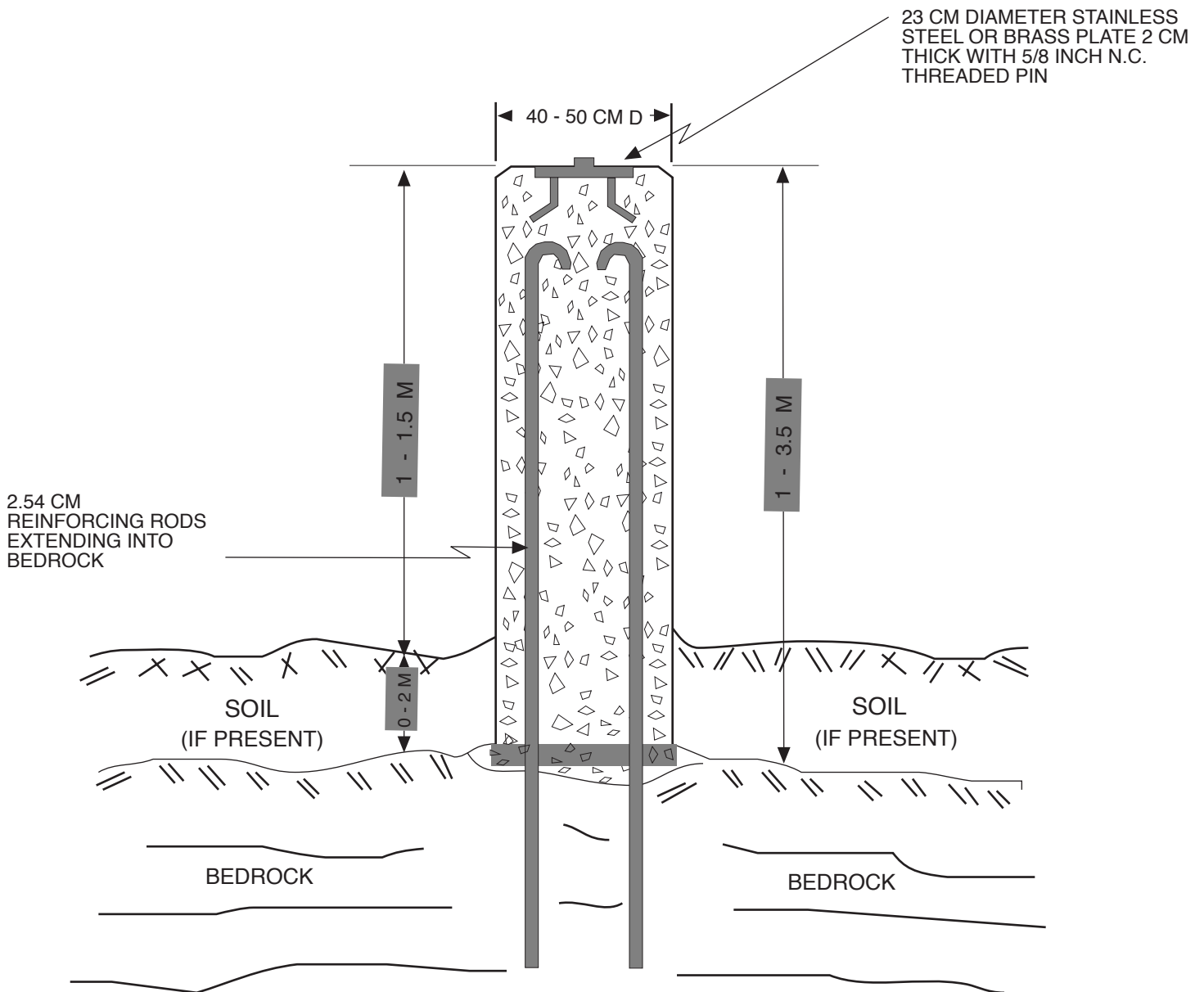
The other 4 pillars (A305797, A383299, A374512 and A425603), described as “Pier flush with grnd” in the list below, are constructed of 170 mm diameter by 4.3 metre driven pipe and filled with concrete. Each pillar has a stainless steel plate with a plug which allows the user to insert a bolt (5/8” NC) for forced centering. The pillars are contained within manholes, with guard posts for identification purposes.

ASCM #	NGDB #	Station Name	Construction
11718	77X1056	Pier 2 (661-24.2)	Pier
25320	77X1058	Pier 4 (661-24.4)	Pier
149203	77X1057	Pier 3 (661-24.3)	Pier
157800	77X1061	Pier 7 (661-24.7)	Pier
189506	77X1060	Pier 6 (661-24.6)	Pier
249060	77X1059	Pier 5 (661-24.5)	Pier
305797	A305797	GPS 500	Pier flush with grnd
374512	A374512	Kathy	Pier flush with grnd
383299	A383299	GPS 100	Pier flush with grnd
385377	946011	Marker Farm CBN Pillar	Pier
425603	A425603	GPS 400	Pier flush with grnd

D.2 Cross Section

946011 is constructed according to federal specifications for "ACP Pillar Not on Bedrock", and A305797, A383299, A374512 and A425603 are smaller diameter driven pipe with conical bottoms. These four markers also sit in manholes.

All other points in the network are constructed as shown on the diagram below.



D-3 Forced Centering Plate

