

Okanagan GPS Validation Network

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Geographic Data BC



Natural Resources
Canada

Geodetic Survey
Division

Okanagan GPS Validation Network

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Natural Resources Canada

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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 Okanagan GPS Validation Network. Please contact Geographic Data BC, Ministry of Environment, Lands and Parks, for information related to this network that is not included in this document.

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1. Introduction to GPS Validation Networks

Background

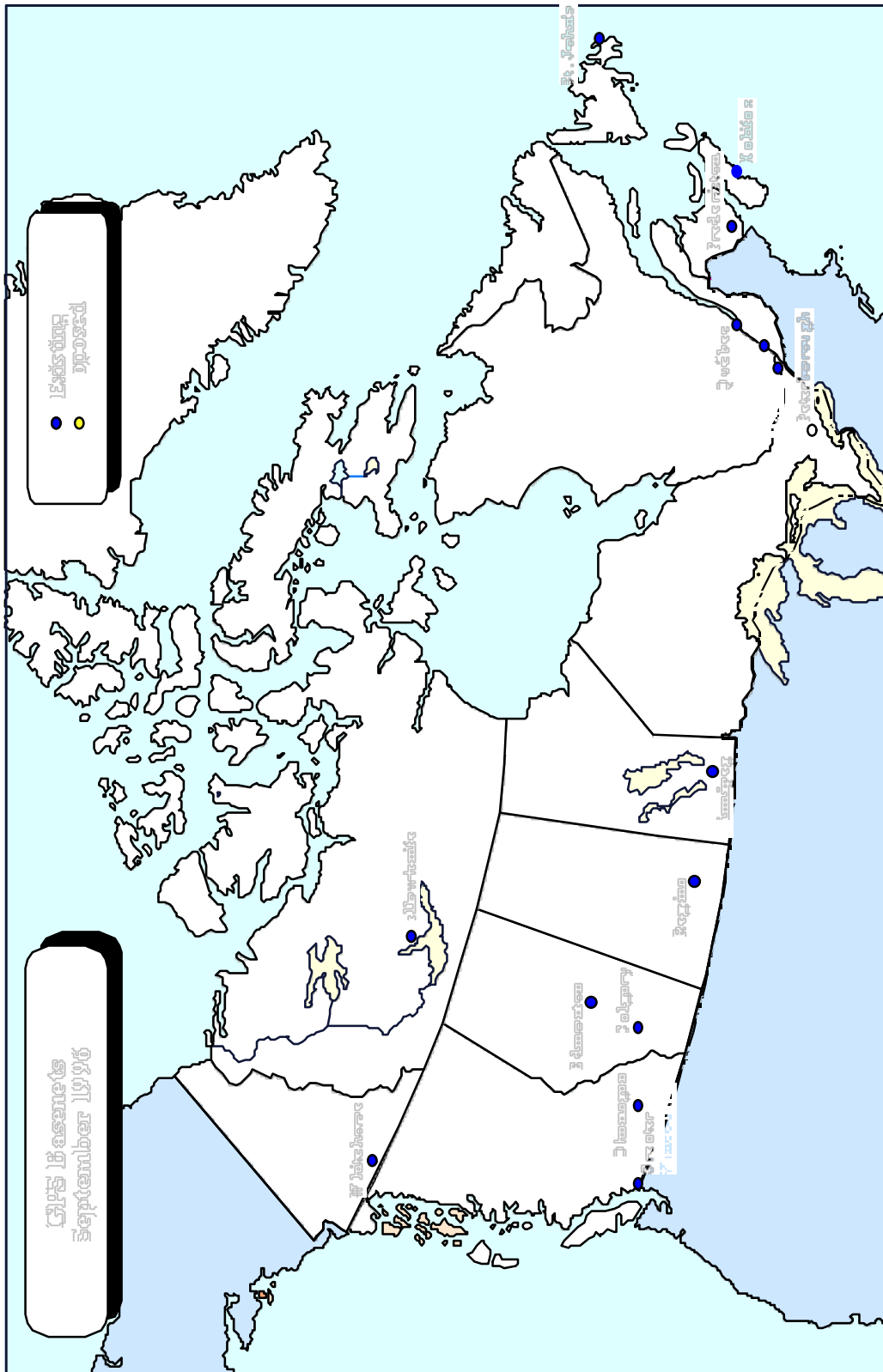
The Global Positioning System (GPS) has dramatically reshaped surveying and navigation in many parts of the world. The use of GPS positioning has become increasingly widespread. The need for a “truth” against which to test GPS positioning accuracy and precision has led to the establishment of GPS validation 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 the provincial agencies responsible for geodetic surveying within their jurisdictions. The map that follows shows the locations of other GPS validation networks in Canada. Geodetic Survey Division (GSD), Natural Resources Canada (NRCAN) maintains sole responsibility of the Ottawa network, including site maintenance and dissemination of basenet-related information such as data. For other GPS validation networks, including the Okanagan basenet, this responsibility is shared with the provincial survey agencies.

Geographic Data BC located, designed and installed the Okanagan and Greater Vancouver networks in order to serve the needs of provincial users. GSD, NRCAN established the validation coordinates for the networks through precise GPS measurements. Each GPS validation network was initially 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 Okanagan GPS validation network, and a brief explanation of the determination of coordinates listed in this document.

2. The Okanagan GPS Validation Network

Description

The Okanagan GPS validation network was constructed in 1990 by the B.C. Ministry of Environment, Lands and Parks, and is comprised of six concrete forced centering pillars. Two of these pillars, National Geodetic Data Base (NGDB) numbered stations 90HP1V (Pier 1) and 90HP6V (Pier 6), are also coincident with the Vernon EDM baseline which is located along Highway 97, approximately 8 kilometres south of Vernon. A cross reference list for corresponding provincial Geodetic Control Monument (GCM) numbers is provided in Appendices A and B.

The network pillars span the northern Okanagan region, with Pier 7 and Pier 8 within approximately 10 kilometres of Vernon, Pier 9 approximately 60 kilometres east of Vernon, and Pier 10 approximately 10 kilometres east of Kelowna. The basic configuration of the network, as shown on the following map, provides baseline lengths ranging from 1 to 66 kilometres.

The Okanagan basenet was first observed with GPS in 1990 by GSD, NRCan, with a second series of measurements carried out in 1991. Ashtech LD-XII dual frequency GPS receivers were used to collect the observations.

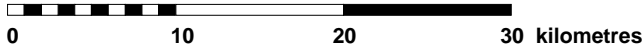
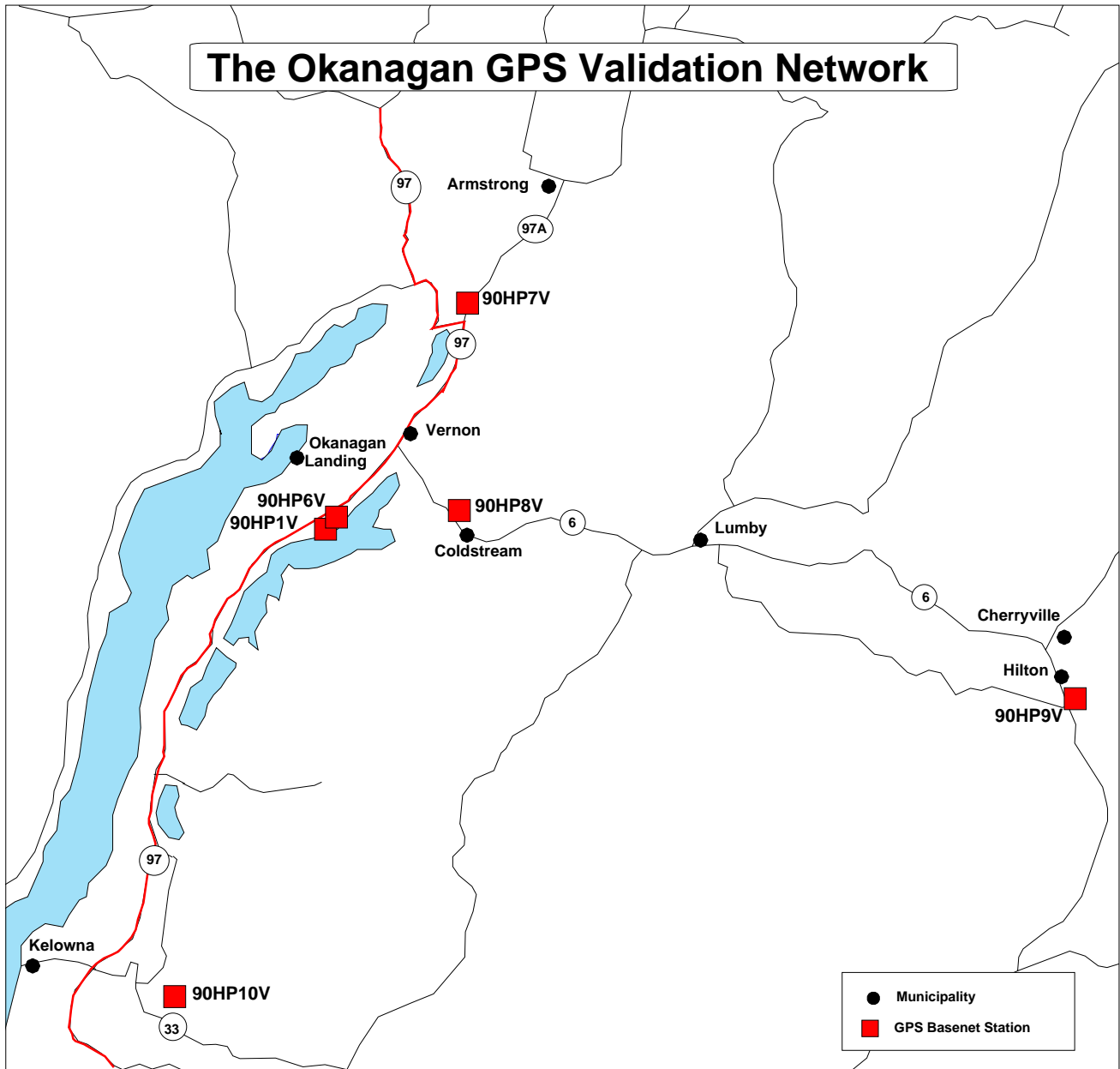
In addition to the three-dimensional positions established with GPS, all the pillars in the network have orthometric heights established through third order levelling, carried out by the province of B.C.. Descriptions and site sketches for each of the pillars, as well as a notice to users of this validation network, are provided in Appendix A.

Determination of Network Validation Values

Coordinate values for the Okanagan GPS validation network were determined using data from two complete sets of observations carried out in 1990 and 1991, as shown in the table that follows. For each epoch, or year, the GPS data was processed in session mode using the Bernese GPS processing software.

The network validation coordinates appearing in this document were produced by combining all sessions from the two measurement epochs together in a minimally constrained three-dimensional least squares adjustment. Station 90HP1V (Pier 1) was constrained to its NAD83 Canadian Spatial Reference System (CSRS) coordinates. In tests carried out, to check for pier movement and statistical compatibility and statistical compatibility between the epochs, there was no indication of significant pier movement or distortion.

The Okanagan GPS Validation Network



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

NGDB Number	GCM Number
90HP1V	436444
90HP6V	938951
90HP7V	584664
90HP8V	717892
90HP9V	461467
90HP10V	625756

* NGDB: National Geodetic Data Base
 ** GCM: Geodetic Control Marker

Measurement History - Okanagan GPS Validation Network

Year	Receiver Type	Number of Receivers	Session Length (hours)	Number of Sessions	GPS Processing Software
1990	Ashtech LD-XII	6	4.5	8	Bernese v3.2
1991	Ashtech LD-XII	5	5	5	Bernese v3.3

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 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 3-D confidence ellipsoids should be used when validating 3-D results. Similarly, the horizontal confidence ellipses should be used when validating only horizontal results. The vertical confidence intervals should be used when validating only vertical results. Separate horizontal and vertical validation tests must not be used together as a validation of 3-D results.

The coordinates given in this document are to be used **for validation purposes only**. If needed, adopted NAD83 survey control values are available from the Geo-Spatial Reference Unit, Geographic Data BC (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 Okanagan 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

GCM Number	NGDB Number	Station Name
436444	90HP1V	Pier 1
461467	90HP9V	Pier 9
584664	90HP7V	Pier 7
625756	90HP10V	Pier 10
717892	90HP8V	Pier 8
938951	90HP6V	Pier 6

Notice to Users

- The Okanagan 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.
- Some of the adjacent roads are not paved; please try to keep dust levels at a minimum by driving at a moderate rate of speed.
- Users may reserve the basenet, for validation purposes only, by contacting the agency specified on the station diagrams.
- Users are also asked to assist in the preservation of the network pillars. Please report any damage or potential dangers to:

Ministry of Environment, Lands and Parks
Geographic Data BC
Geo-Spatial Reference Unit
4th Floor, 1802 Douglas Street
Victoria, British Columbia
V8T 4K6
Tel: (250) 387-3164
Fax: (250) 356-7831

Station 436444 PIER 1

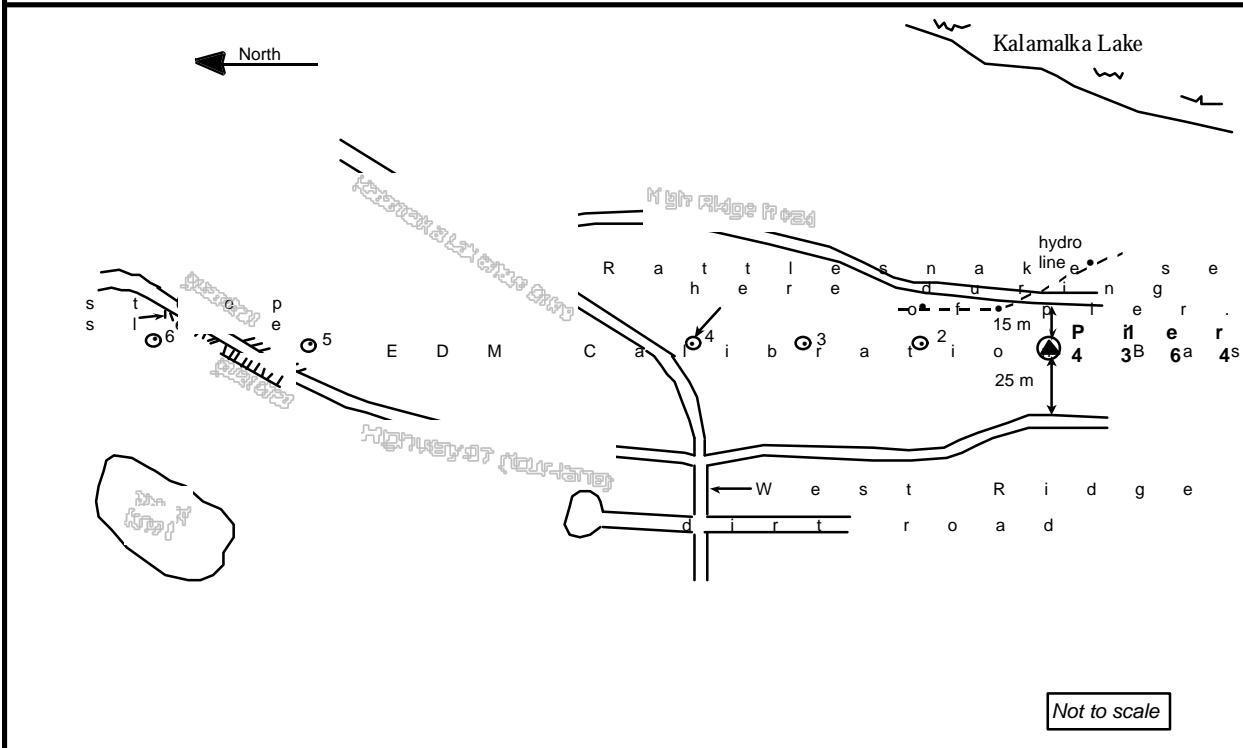
(NGDB 90HP1V)

OKANAGAN GPS VALIDATION NETWORK

STATION NAME - PIER 1
GCM NO. 436444 (NGDB 90HP1V)

SCALED COORDINATES

LAT: 50°11'42"
LON: 119°19'19"
ELEV: 473 m



- DESCRIPTION:** Marked by a cylindrical concrete pillar with a stainless steel forced centering baseplate set in top.
- ACCESS:** Located on the southern most pier (Pier 1) of the Vernon EDM Calibration Baseline. Proceed south from Vernon on Highway 97 (32nd Street in Vernon), 8.2 km from the intersection of 27th Avenue and 32nd Street. Turn left on Kalamalka Lakeview Drive. Proceed 0.5 km and then turn right onto High Ridge Road. Proceed south on Highridge 0.8 km to station site. Pier is located 15 m west of road and above road level on a flat bench area between High Ridge Road and Highway 97.
- NOTE:** The threaded bolt inserts required for mounting instruments on the piers are in the custody of Russell Shortt, BCLS, (2801 - 32nd Street, Vernon, B.C. V1T 5L8, 250-545-0511).
- OWNER:** Ministry of Transportation and Highways - Right-of-way

Station 461467 PIER 9

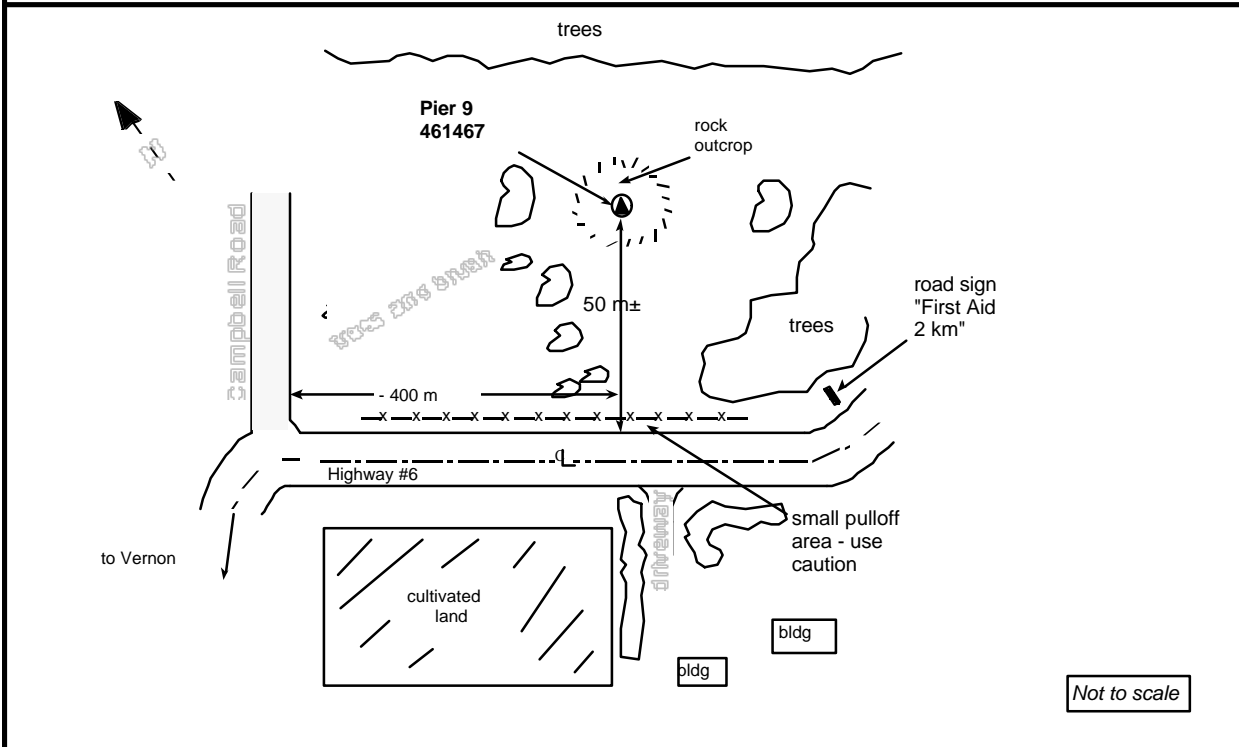
(NGDB 90HP9V)

OKANAGAN GPS VALIDATION NETWORK

SCALED COORDINATES

STATION NAME - PIER 9
GCM NO. 461467 (NGDB 90HP9V)

LAT: 50°12'53"
LON: 118°34'26"
ELEV: 722 m



DESCRIPTION: Marked by a cylindrical concrete pillar with a stainless steel forced centering baseplate set in top.

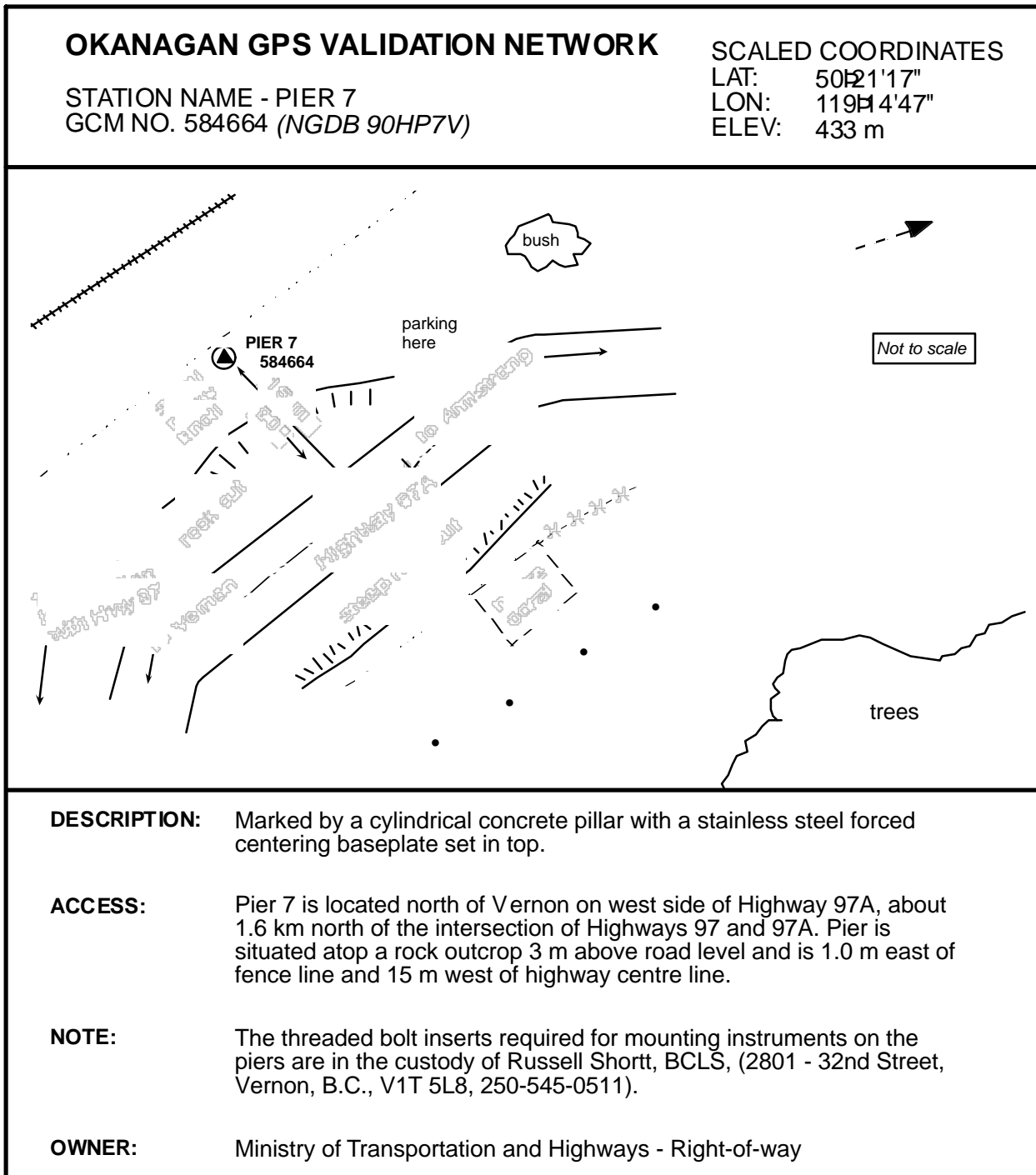
ACCESS: Pier 9 is located roughly 60 km east of Vernon on Highway 6, approximately 8.2 km east of junction of Highway 6 and road to Sugar Lake in Cherryville. Pier is on the northeast side of Highway 6 approximately 50 m from the road and about 400 m southeast of Campbell Road.

NOTE: The threaded bolt inserts required for mounting instruments on the piers are in the custody of Russell Shortt, BCLS, (2801 - 32nd Street, Vernon, B.C., V1T 5L8, 250-545-0511).

OWNER: Not known

Station 584664 PIER 7

(NGDB 90HP7V)



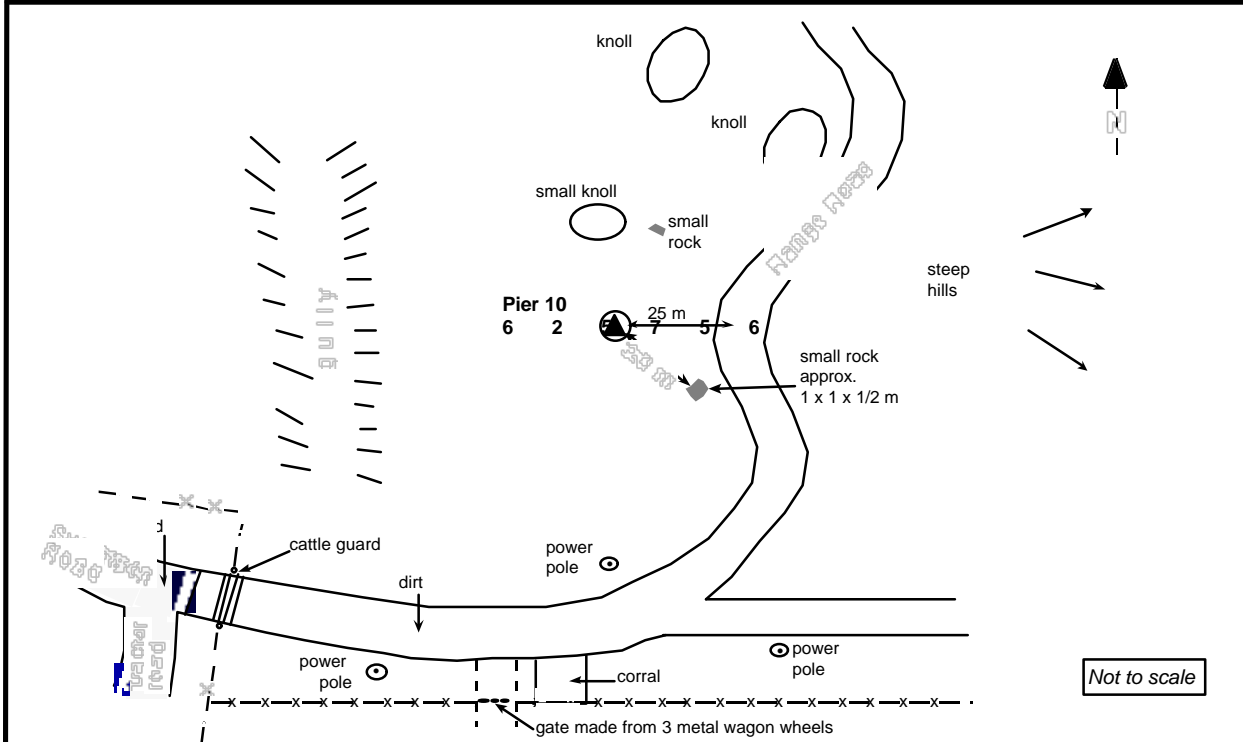
Station 625756 PIER 10

(NGDB 90HP10V)

OKANAGAN GPS VALIDATION NETWORK**SCALED COORDINATES**

STATION NAME - PIER 10
GCM NO. 625756 (NGDB 90HP10V)

LAT: 49~~53~~'19"
LON: 119~~20~~'36"
ELEV: 639 m



DESCRIPTION: Marked by a cylindrical concrete pillar with a stainless steel forced centering baseplate set in the top. The pillar is only 15 cm high and thus prone to obstructions.

ACCESS: From the intersection of Highways 97 and 33 (approximately 8 km south of entrance to Kelowna airport), proceed east on Highway 33 for 3.1 km to Muir Street. Turn north (left) on Muir and turn immediately right onto McKenzie Road. Follow McKenzie up the hill, keeping to the right on hairpin turn at El Paso Road (0.6 km from Muir Street). Stay on McKenzie a further 1.4 km to Swainson Road. Turn right on Swainson and go 1.9 km (many twists and turns) to junction with Treetop Road. Turn left leaving the pavement and pass through a cattle guard. Continue 250 m keeping to the left, to the station site which is about 25 m to the west of the dirt track.

NOTE: The threaded bolt inserts required for mounting instruments on the piers are in the custody of Russell Shortt, BCLS, (2801 - 32nd Street, Vernon, B.C., V1T 5L8, 250-545-0511).

OWNER: Not known.

Station 717892 PIER 8

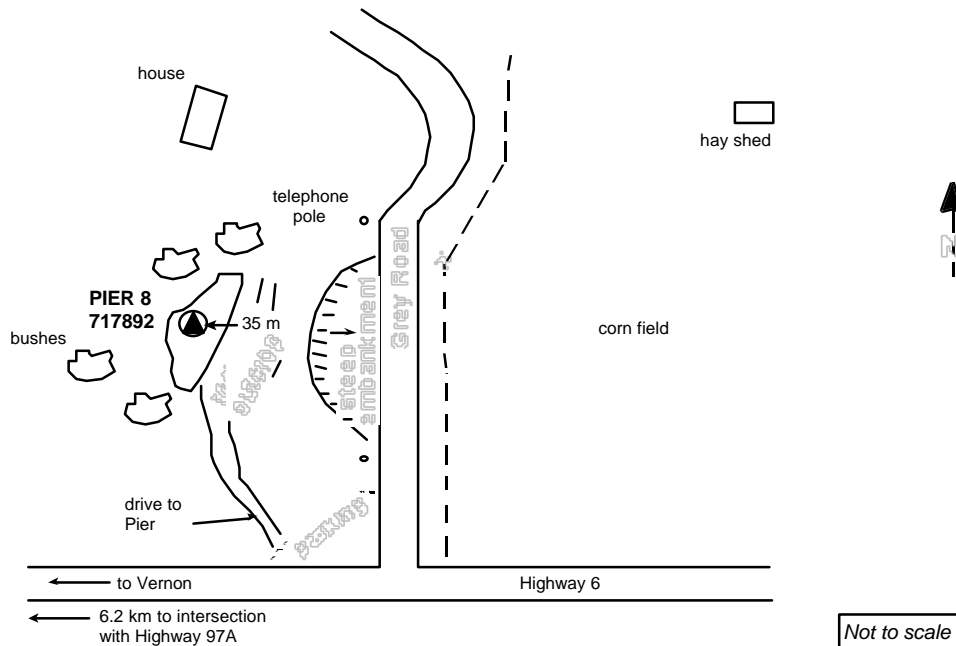
(NGDB 90HP8V)

OKANAGAN GPS VALIDATION NETWORK

SCALED COORDINATES

STATION NAME - PIER 8
GCM NO. 717892 (NGDB 90HP8V)

LAT: 50°13'42"
LON: 119°12'3"
ELEV: 493 m



- DESCRIPTION:** Marked by a cylindrical concrete pillar with a stainless steel forced centering baseplate set in the top.
- ACCESS:** From the junction of Highway 97A and Highway 6 in Vernon, proceed east on Highway 6 for 6.2 km to Grey Road. Turn north onto Grey Road and proceed approximately 85 m to Pier #8 located northwest of road, approximately 35 m from centre line and approximately 8 m above road level, on high point of gravel/mud embankment on top of a small rock outcrop.
- NOTE:** The threaded bolt inserts required for mounting instruments on the piers are in the custody of Russell Shortt, BCLS, (2801 - 32nd Street, Vernon, B.C., V1T 5L8, 250-545-0511).
- OWNER:** Ministry of Transportation and Highways - Right-of-way

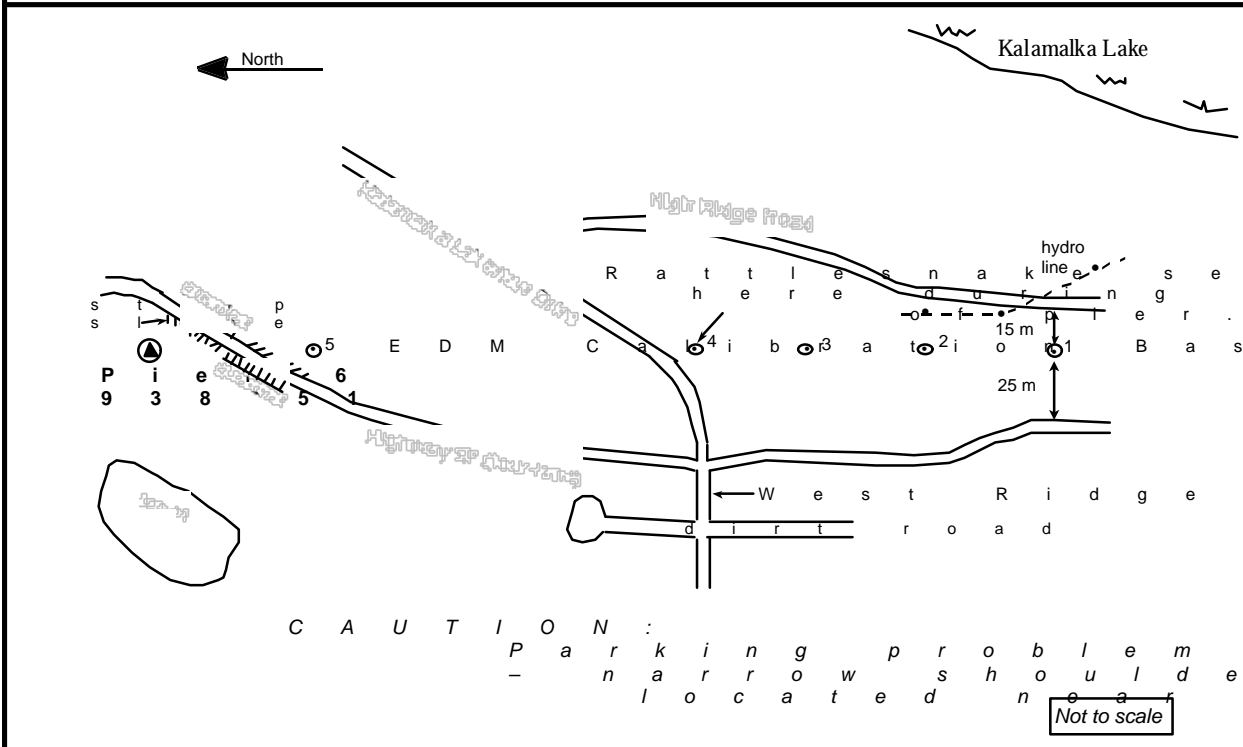
Station 938951 PIER 6

(NGDB 90HP6V)

OKANAGAN GPS VALIDATION NETWORK**SCALED COORDINATES**

STATION NAME - PIER 6
GCM NO. 938951 (NGDB 90HP6V)

LAT: 50°12'15"
LON: 119°18'52"
ELEV: 516 m



DESCRIPTION: Marked by a cylindrical concrete pillar with a stainless steel forced centering baseplate set in top.

ACCESS: From the junction of Highway 97 (32nd Street) and Highway 6 in Vernon, follow Highway 97 south for 7.4 km. Station is on the west side of highway about 1.1 km south of intersection with Birnie Road. Pillar is visible from the highway, situated on top of a cut approximately 8 m above road.

NOTE: The threaded bolt inserts required for mounting instruments on the piers are in the custody of Russell Shortt, BCLS, (2801 - 32nd Street, Vernon, B.C. V1T 5L8, 250-545-0511).

OWNER: Ministry of Transportation and Highways - Right-of-way

Appendix B

Tables of Values

(Okanagan GPS Validation Network - 1990 & 1991 epochs combined)

Warning to Users: These coordinates are to be used for validation only, and are not to be considered survey control values. Control coordinates may be obtained from the Geo-Spatial Reference Unit as described in Appendix C. Note that station 90HP1V (Pier 1) was constrained to its NAD83(CSRs) value in the adjustment that produced these coordinates.

Station Number Cross Reference List

GCM Number	NGDB Number	Station Name
436444	90HP1V	Pier 1
461467	90HP9V	Pier 9
584664	90HP7V	Pier 7
625756	90HP10V	Pier 10
717892	90HP8V	Pier 8
938951	90HP6V	Pier 6

Table 1: Ellipsoidal Coordinates

NGDB #	Latitude North (d m s)	Longitude West (d m s)	Ellipsoidal Height (m)
90HP8V	50 13 42.05225	119 12 02.67779	477.029
90HP1V	50 11 41.76820	119 19 18.60366	456.619
90HP6V	50 12 15.20370	119 18 51.57472	499.846
90HP7V	50 21 17.32242	119 14 46.95834	416.670
90HP9V	50 12 53.26354	118 34 25.93330	706.683
90HP10V	49 53 19.44716	119 20 35.61391	623.488

Table 2: Geocentric Cartesian Coordinates

NGDB #	X (m)	Y (m)	Z (m)
90HP8V	-1994748.217	-3569072.876	4879443.299
90HP1V	-2003678.992	-3567327.907	4877049.023
90HP6V	-2002836.433	-3566922.448	4877743.580
90HP7V	-1992283.737	-3558006.261	4888384.742
90HP9V	-1956204.806	-3591829.938	4878655.187
90HP10V	-2017857.505	-3589431.831	4855301.701

Table 3: UTM Mapping Plane Coordinates

NGDB #	Northing (m)	Easting (m)	Zone
90HP8V	5566337.461	343034.396	11
90HP1V	5562885.047	334282.853	11
90HP6V	5563900.910	334850.734	11
90HP7V	5580494.155	340204.219	11
90HP9V	5563698.356	387711.194	11
90HP10V	5528892.789	331688.518	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 the proper scale factors. UTM coordinates and distances should only be compared to other UTM coordinates and distances. For more information, please contact Geodetic Survey as described in Appendix C.

Table 4: Interstation Cartesian Coordinate Differences

From NGDB #	To NGDB #	ΔX (m)	ΔY (m)	ΔZ (m)	Spatial Distance (m)
90HP8V	90HP1V	-8930.775	1744.968	-2394.276	9409.368
90HP8V	90HP6V	-8088.216	2150.427	-1699.719	8540.060
90HP8V	90HP7V	2464.480	11066.614	8941.443	14439.287
90HP8V	90HP9V	38543.411	-22757.063	-788.112	44767.170
90HP8V	90HP10V	-23109.288	-20358.955	-24141.598	39132.378
90HP1V	90HP6V	842.558	405.459	694.558	1164.780
90HP1V	90HP7V	11395.255	9321.646	11335.719	18580.728
90HP1V	90HP9V	47474.185	-24502.031	1606.164	53448.364
90HP1V	90HP10V	-14178.513	-22103.924	-21747.322	34096.329
90HP6V	90HP7V	10552.696	8916.187	10641.161	17438.237
90HP6V	90HP9V	46631.627	-24907.490	911.607	52874.594
90HP6V	90HP10V	-15021.071	-22509.383	-22441.879	35155.979
90HP7V	90HP9V	36078.931	-33823.677	-9729.554	50402.327
90HP7V	90HP10V	-25573.768	-31425.570	-33083.041	52307.472
90HP9V	90HP10V	-61652.699	2398.107	-23353.486	65971.141

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)
90HP8V	0.04	34	87	0.02	2	-3	0.02	92	-2
90HP1V	0.05	31	87	0.02	4	-3	0.02	94	-1
90HP6V	0.05	31	87	0.02	5	-3	0.02	95	-1
90HP7V	0.05	32	87	0.02	5	-3	0.02	95	-1
90HP9V	0.05	24	87	0.02	5	-3	0.02	95	-1
90HP10V	0.05	28	86	0.02	4	-3	0.02	94	-1

Table 6: Absolute 95% Horizontal Confidence Ellipses

NGDB #	Major Semi-axis		Minor Semi-axis	
	length (m)	az. (deg)	length (m)	az. (deg)
90HP8V	0.02	3	0.01	93
90HP1V	0.02	5	0.02	95
90HP6V	0.02	5	0.02	95
90HP7V	0.02	6	0.02	96
90HP9V	0.02	5	0.02	95
90HP10V	0.02	5	0.02	95

Table 7: Absolute 95% Vertical Confidence Intervals

NGDB #	+/- length (m)
90HP8V	0.03
90HP1V	0.03
90HP6V	0.03
90HP7V	0.03
90HP9V	0.03
90HP10V	0.03

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			Medium			Minor		
		length (m)	axis az. (deg)	Semi- inc. (deg)	length (m)	axis az. (deg)	Semi- inc. (deg)	length (m)	axis az. (deg)	Semi- inc. (deg)
90HP8V	90HP1V	0.017	11	87	0.008	12	-3	0.005	102	0
90HP8V	90HP6V	0.019	17	87	0.009	12	-3	0.006	102	0
90HP8V	90HP7V	0.018	16	86	0.008	13	-4	0.005	103	0
90HP8V	90HP9V	0.018	9	86	0.008	12	-4	0.006	102	0
90HP8V	90HP10V	0.018	9	86	0.008	12	-4	0.005	102	0
90HP1V	90HP6V	0.018	20	88	0.008	9	-2	0.006	99	0
90HP1V	90HP7V	0.017	16	86	0.008	11	-4	0.005	101	0
90HP1V	90HP9V	0.016	15	86	0.008	7	-4	0.005	97	-1
90HP1V	90HP10V	0.016	12	87	0.008	7	-3	0.005	97	0
90HP6V	90HP7V	0.019	20	86	0.009	12	-3	0.006	102	0
90HP6V	90HP9V	0.019	16	86	0.008	9	-4	0.006	99	0
90HP6V	90HP10V	0.018	14	87	0.008	10	-3	0.006	100	0
90HP7V	90HP9V	0.017	16	86	0.008	10	-4	0.005	100	0
90HP7V	90HP10V	0.017	14	86	0.008	11	-4	0.005	101	0
90HP9V	90HP10V	0.016	13	85	0.008	7	-5	0.005	97	0

**Table 9: Relative 95%
Horizontal Confidence Ellipses**

From NGDB #	To NGDB #	Major Semi-axis		Minor Semi-axis	
		length (m)	az. (deg)	length (m)	az. (deg)
90HP8V	90HP1V	0.007	12	0.005	102
90HP8V	90HP6V	0.008	12	0.005	102
90HP8V	90HP7V	0.007	14	0.005	104
90HP8V	90HP9V	0.007	12	0.005	102
90HP8V	90HP10V	0.007	12	0.005	102
90HP1V	90HP6V	0.007	9	0.005	99
90HP1V	90HP7V	0.007	11	0.005	101
90HP1V	90HP9V	0.007	8	0.004	98
90HP1V	90HP10V	0.007	8	0.004	98
90HP6V	90HP7V	0.008	12	0.005	102
90HP6V	90HP9V	0.007	10	0.005	100
90HP6V	90HP10V	0.007	10	0.005	100
90HP7V	90HP9V	0.007	10	0.005	100
90HP7V	90HP10V	0.007	11	0.005	101
90HP9V	90HP10V	0.007	7	0.004	97

**Table 10: Relative 95%
Vertical Confidence Intervals**

From NGDB #	To NGDB #	+/- length (m)
90HP8V	90HP1V	0.012
90HP8V	90HP6V	0.013
90HP8V	90HP7V	0.012
90HP8V	90HP9V	0.012
90HP8V	90HP10V	0.012
90HP1V	90HP6V	0.013
90HP1V	90HP7V	0.012
90HP1V	90HP9V	0.012
90HP1V	90HP10V	0.011
90HP6V	90HP7V	0.013
90HP6V	90HP9V	0.013
90HP6V	90HP10V	0.013
90HP7V	90HP9V	0.012
90HP7V	90HP10V	0.012
90HP9V	90HP10V	0.011

Appendix C

Contacts for Additional Information

The following information is available in various formats and on different media, from the Geo-Spatial Reference Unit (see below):

- Adopted NAD83 survey control values for network piers
- Official validation coordinates (in ellipsoidal, mapping plane or Cartesian format) as they appear in this document
- Coordinates and associated covariance matrix for network piers

*Ministry of Environment, Lands and Parks
Geographic Data BC
Geo-Spatial Reference Unit
4th Floor, 1802 Douglas Street
Victoria, British Columbia
V8T 4K6*

*Tel: (250) 387-3164
Fax: (250) 356-7831
WWW: <http://www.env.gov.bc.ca/gdbc/>*

For more information on the Vernon EDM calibration baseline, please contact the above address.

For more information on the Okanagan GPS validation network analysis, and determination of coordinate values contained in this guide, contact:

*Client Services Section
Geodetic Survey Division
Natural Resources Canada
615 Booth Street
Ottawa, Ontario
K1A 0E9*

*Tel. (613) 995-4410 or 992-2061
Fax. (613) 995-3215
Email: information@geod.nrcan.gc.ca*

Appendix D

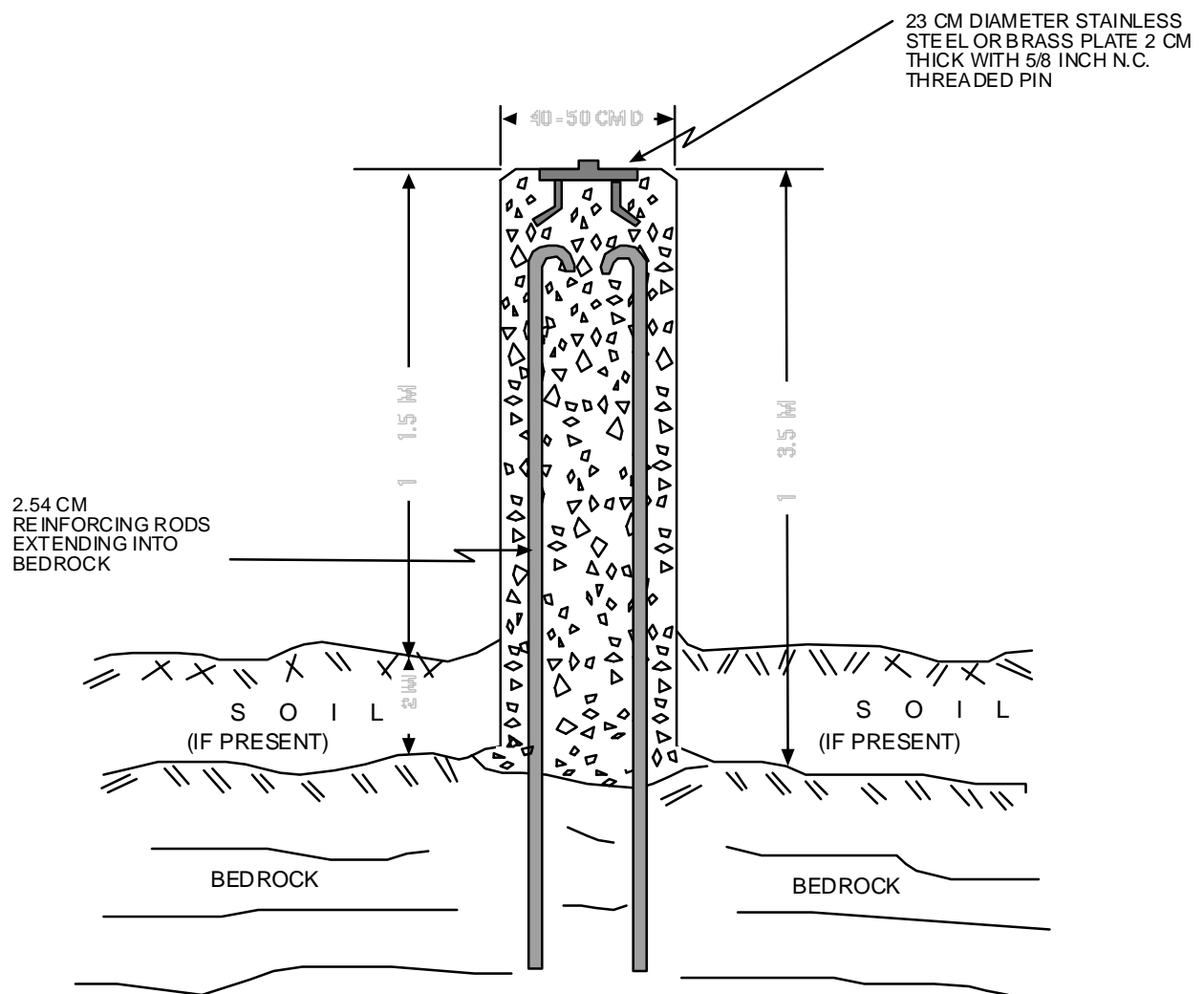
Ministry of Environment, Lands and Parks

Geographic Data BC

Pier Design - Okanagan GPS Validation Network

Forced Centering Pillars

D.1 Cross Section



D-2 Forced Centering Plate

