Regina
GPS Validation Network

February 1997

Saskatchewan
Property Management
Corporation

SaskGeomatics Division

Natural Resources
Canada

Geodetic Survey Division

Regina GPS Validation Network

Prepared by

Geodetic Survey Division

Natural Resources Canada

in cooperation with

SaskGeomatics Division

Saskatchewan Property Management Corporation

Additional copies of this document are available from:

Map and Photo Distribution Centre
Main Floor 2151 Scarth Street
Regina, Saskatchewan
S4P 3V7

Tel: (306) 787-2799
Fax: (306) 787-3335

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 Regina GPS Validation Network. Please contact the Map and Photo Distribution Centre, SaskGeomatics Division, for information related to this network that is not included in this document.

Table of Contents

Page

1. Introduction to GPS Validation Networks 1

Background..1
Applications 1
Characteristics..3

2. The Regina GPS Validation Network... 4

Description 4
Determination of Network Validation Values...4

Appendices

A. Station Descriptions and Site Sketches..7

Notice to Users 7
Station 90V100 Pier 1 8
Station 90V101 Pier 2 9
Station 90V103 Pier 4 10
Station 90V106 Pier 7 11
Station 90V107 Pier 8 12
Station 90V108 Pier 9 13
Station 90V109 Pier 10 14
Station 90V110 Pier 11 15
Station 90V111 Pier 12 16
Station 90V112 Pier 13 17
Station 90V113 Pier 14 18

B. Tables of Values...19

1. Ellipsoidal Coordinates 19
2. Geocentric Cartesian Coordinates 20
3. UTM Mapping Plane Coordinates...20
4. Interstation Cartesian Coordinate Differences 21
5. Absolute 95% 3-D Confidence Ellipsoids..23
6. Absolute 95% Horizontal Confidence Ellipses..23
7. Absolute 95% Vertical Confidence Intervals 23
8. Relative 95% 3-D Confidence Ellipsoids..24
9. Relative 95% Horizontal Confidence Ellipses...26
10. Relative 95% Vertical Confidence Intervals 26

C. Contacts for Additional Information 28

D. Pier Design - Regina GPS Validation Network Forced Centering Pillars...29

1. Cross Section 29
2. Pier Construction...30
3. Forced Centering Plate 31

1. Introduction to GPS Validation Networks

Background

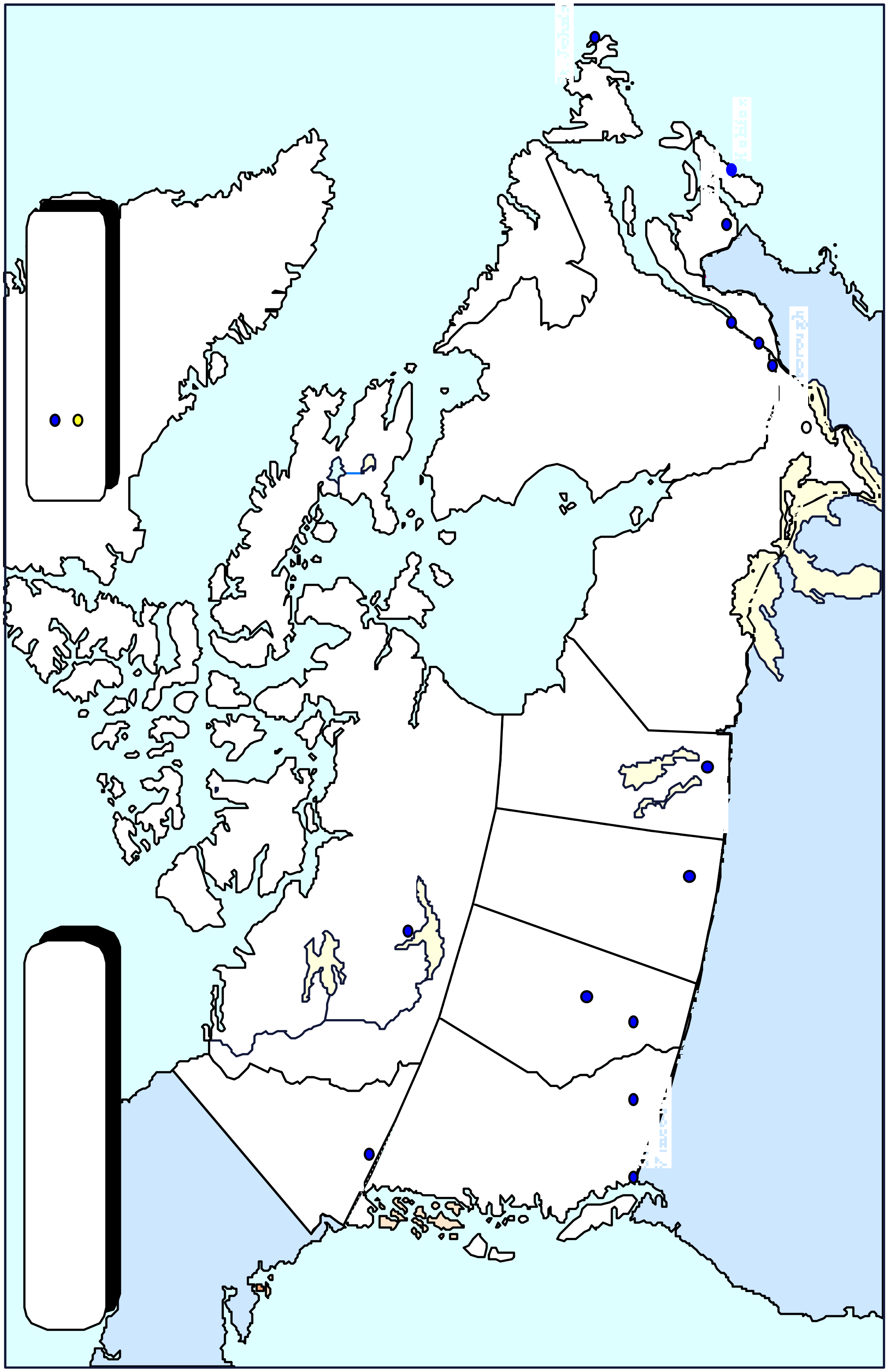
The Global Positioning System (GPS) has dramatically reshaped surveying and navigation in many parts of the world. The use of GPS positioning has become increasingly widespread. The need for a “truth” against which to test GPS positioning accuracy and precision has led to the establishment of GPS validation 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 Regina basenet, this responsibility is shared with the provincial survey agencies.

GSD, NRCan is responsible for establishing the validation coordinates for the network through precise GPS measurements. Each GPS validation network is 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 Regina GPS validation network, and a brief explanation of the determination of coordinates listed in this document.

2. The Regina GPS Validation Network

Description

The Regina GPS validation network was constructed in 1990 by the SaskGeomatics Division, Saskatchewan Property Management Corporation, and is comprised of eleven forced centering pillars. Three of these pillars, 90V100, 90V101 and 90V103, are also coincident with the Regina-Davin baseline which is used for EDM calibration. One of the pillars in the network, station 90V107, is also a Canadian Base Network (CBN) station.

Most of the piers are located within a 10 kilometre radius of Davin, Saskatchewan, about 36 kilometres southeast of Regina. One pier is located 60 kilometres south of Davin, and 2 piers are located 20 kilometres and 40 kilometres, respectively, east of the main cluster. The basic configuration of the network, as shown on the following map, provides baseline lengths ranging from 1 to 76 kilometres.

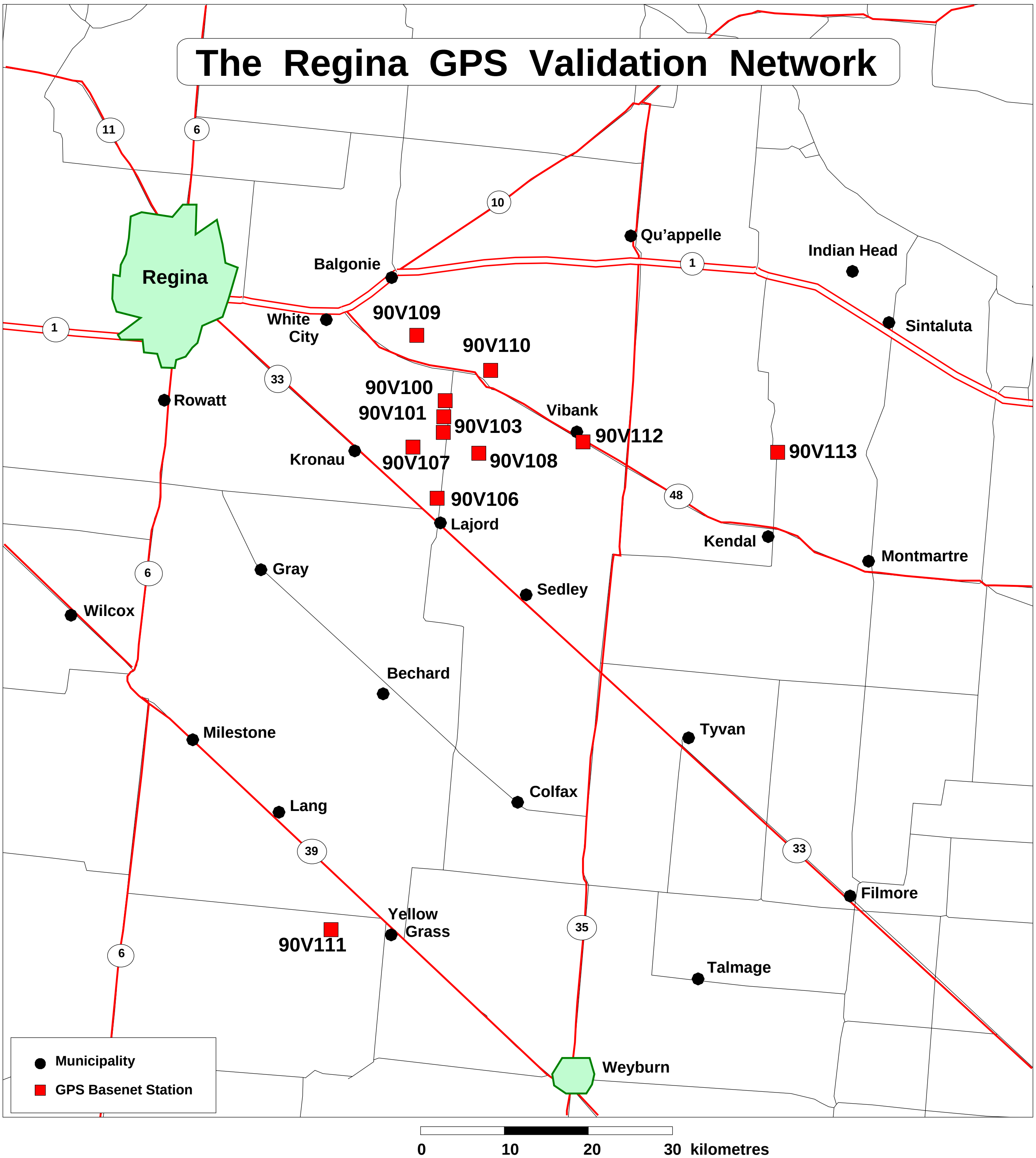
The Regina basenet was first observed with GPS in 1991 by GSD, NRCan, with a second series of measurements carried out in 1992. Ashtech M-XII dual frequency GPS receivers were used to collect the observations.

In addition to the three-dimensional positions established with GPS, all the pillars in the network have orthometric heights established through first order levelling. 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 Regina GPS validation network were determined using data from two complete sets of observations carried out in 1991 and 1992, as shown in the following table. 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 the sessions from the two measurement epochs together in a minimally constrained three-dimensional least squares adjustment. Station 90V107 was constrained (using the CBN covariance matrix as weights) to its NAD83 Canadian Spatial Reference System (CSRS) coordinates. 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.


The Regina GPS Validation Network
Regina
Balgonie
White City
Rowatt
Kronau
Lajord
Vibank
Qu'appelle
Indian Head
Sintaluta
Kendal
Montmartre
Gray
Wilcox
Sedley
Bechard
Milestone
Tyvan
Colfax
Lang
Filmore
Yellow Grass
Talmage
Weyburn
90V109
90V110
90V100
90V101
90V103
90V107
90V108
90V112
90V113
90V106
90V111
11
6
10
1
33
48
39
35
Municipality
GPS Basenet Station
0
10
20
30 kilometres

Measurement History - Regina GPS Validation Network

Year	Receiver Type	Number of Receivers	Session Length (hours)	Number of Sessions	GPS Processing Software
1991	Ashtech M-XII	6	4.5	8	Bernese v3.3
1992	Ashtech M-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 Map and Photo Distribution Centre, SGD (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 Regina 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

NGDB* Number	Station Name
90V100	Pier 1
90V101	Pier 2
90V103	Pier 4
90V106	Pier 7
90V107	Pier 8
90V108	Pier 9
90V109	Pier 10
90V110	Pier 11
90V111	Pier 12
90V112	Pier 13
90V113	Pier 14

***** NGDB: National Geodetic Data Base

Notice to Users

- The Regina 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.
- The adjacent roads are not paved; please try to keep dust levels at a minimum by driving at a moderate rate of speed.
- Users are also asked to assist in the preservation of the network pillars. Please report any damage or potential dangers to:

SaskGeomatics Division
Geodetic Surveys Branch
3rd Floor
2151 Scarth Street
Regina, Saskatchewan
S4P 3V7

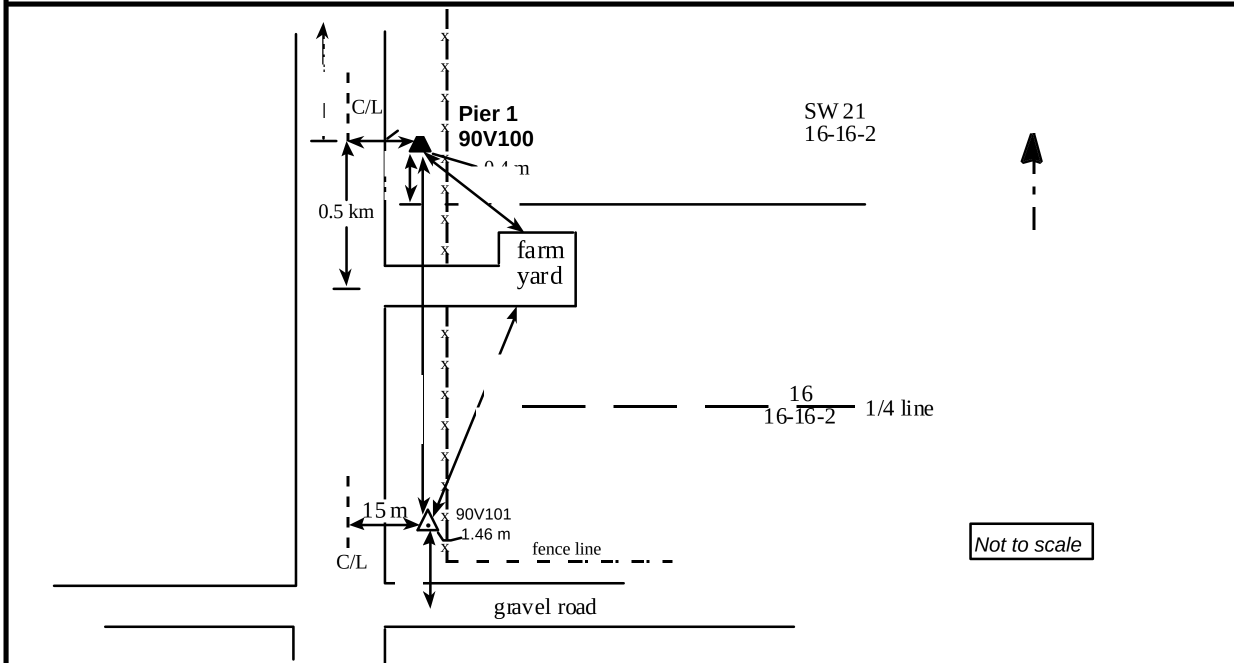
Tel: (306) 787-2836
Fax: (306) 787-4617

90V100

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 1
UNIQUE NO. 90V100

SCALED COORDINATES
LAT: 50°21'18"
LON: 104°09'34"
ELEV: 659 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 16 km to the intersection with grid road #621. Turn south on the grid road for 4.7 km to the top of a prominent hill.

From Regina via Highway #33
From Regina proceed south-easterly on Highway #33 for 24 km to the organized hamlet of Kronau. Then go east on the paved road to Oyama Regional Park, approximately 5 km. Follow the road around Oyama Lake and continue easterly on a gravel road for approximately another 3.2 km to the intersection with grid road #621. Then proceed northerly on grid road #621 for about 5 km to the top of a prominent hill.

Monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground at the top of the backslope on the east side of the grid road.

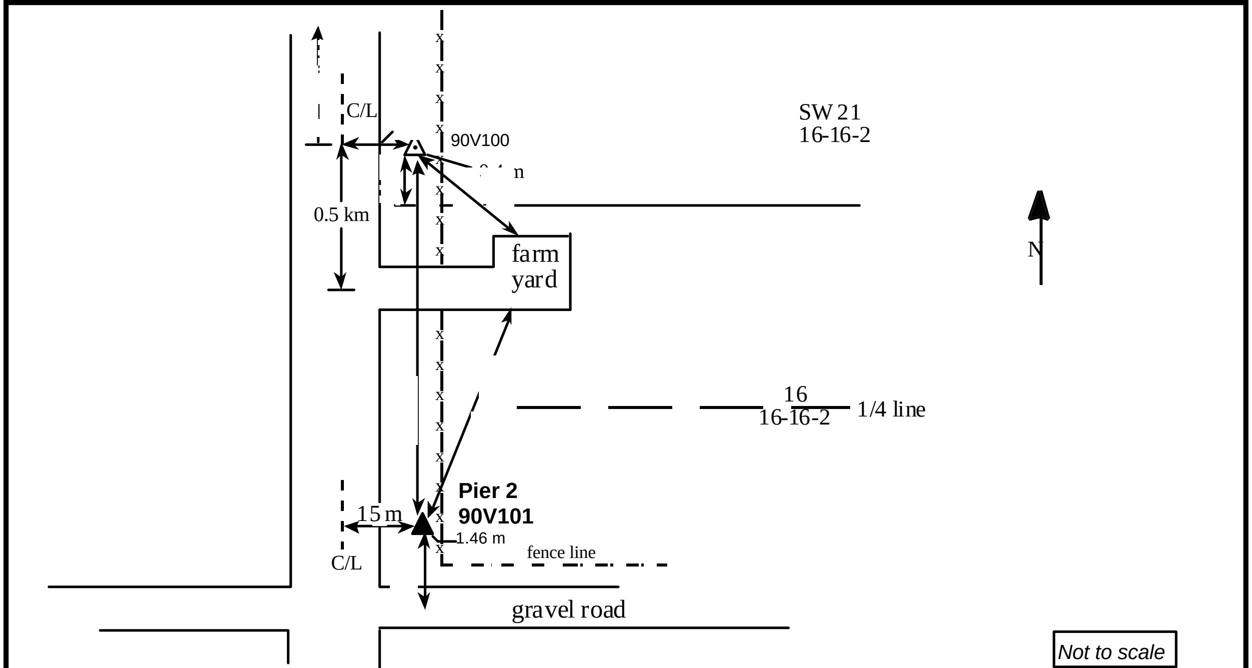
OWNER: Road allowance

90V101

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 2
UNIQUE NO. 90V101

SCALED COORDINATES
LAT: 50°20'26"
LON: 104°09'33"
ELEV: 636 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 16 km to the intersection with grid road #621. Turn south on the grid road for approximately 6.3 km. Pier is on the east side of grid road.

From Regina via Highway #33
From Regina proceed south-easterly on Highway #33 for 24 km to the organized hamlet of Kronau. Then go east on the paved road to Oyama Regional Park, approximately 5 km. Follow the road around Oyama Lake and continue easterly on a gravel road for approximately another 3.2 km to the intersection with grid road #621. Then proceed northerly on grid road #621 for about 3.4 km.

The monument is a 12-inch diameter concrete pier protruding 1.5 m above the ground on the east side of the grid road.

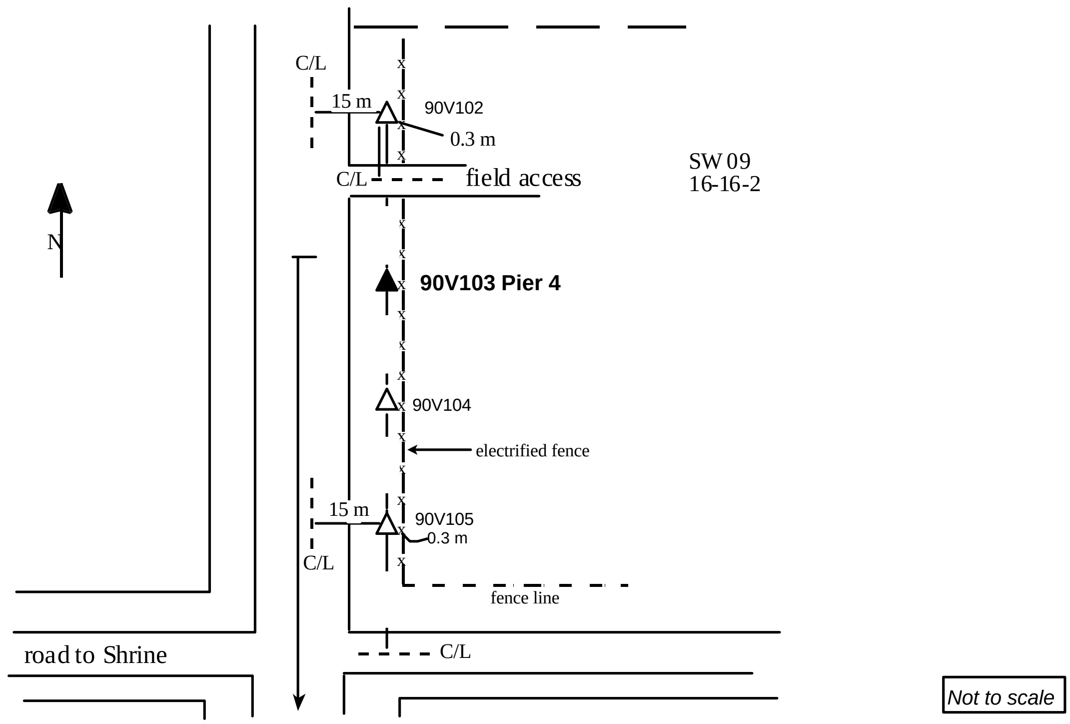
OWNER: Road allowance

90V103

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 4
UNIQUE NO. 90V103

SCALED COORDINATES
LAT: 50°19'39"
LON: 104°09'33"
ELEV: 628 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 16 km to the intersection with grid road #621. Turn south on the grid road for 7.7 km.

From Regina via Highway #33
From Regina proceed south-easterly on Highway #33 for 24 km to the organized hamlet of Kronau. Then go east on the paved road to Oyama Regional Park approximately 5 km. Follow the road around Oyama Lake continue easterly on a gravel road for approximately another 3.2 km to the intersection with grid road #621. Then proceed northerly on grid road #621 for about 2.0 km.

Monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground on the east side of the grid road.

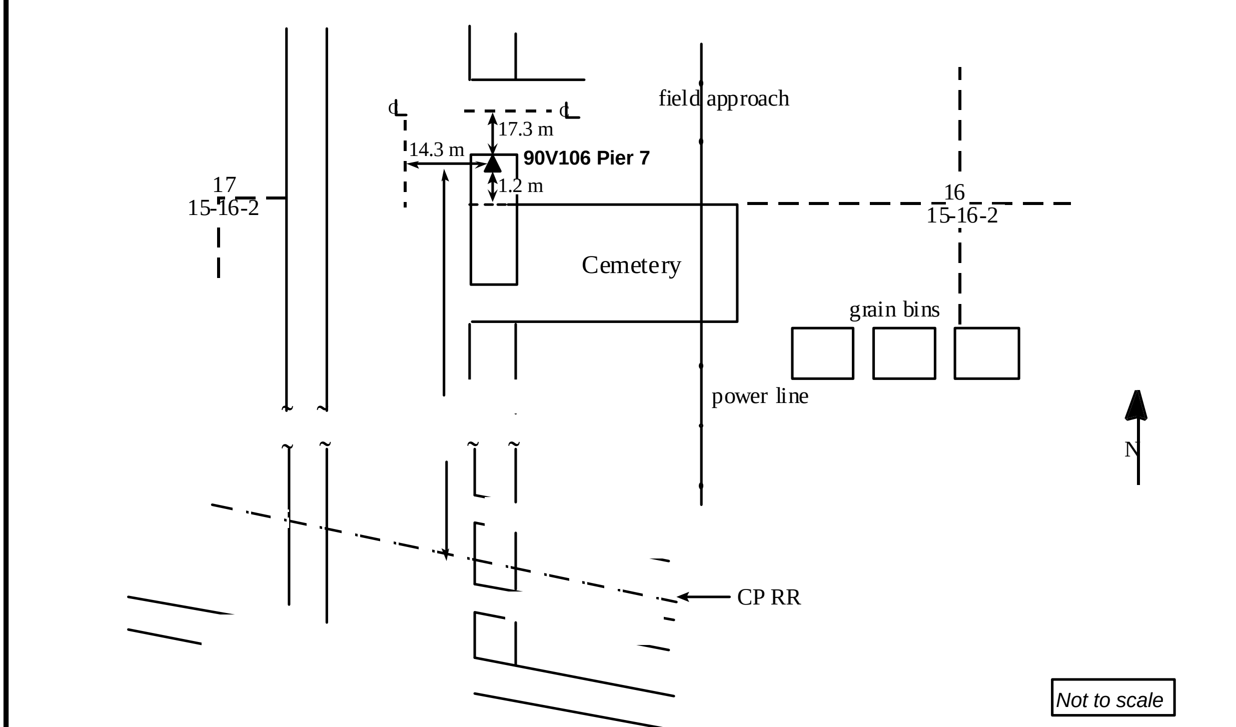
OWNER: Road allowance

90V106

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 7
UNIQUE NO. 90V106

SCALED COORDINATES
LAT: 50°15'31"
LON: 104°09'33"
ELEV: 598 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 16 km to the intersection with grid road #621. Turn south on the grid road for about 15.4 km.

From Regina via Highway #33
From Regina proceed south-easterly on Highway #33 for 36 km to the hamlet of Lajord. Then go north on grid road #621 for approximately 1.8 km.

The monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground at the east side of the grid road at the north-west corner of a cemetary.

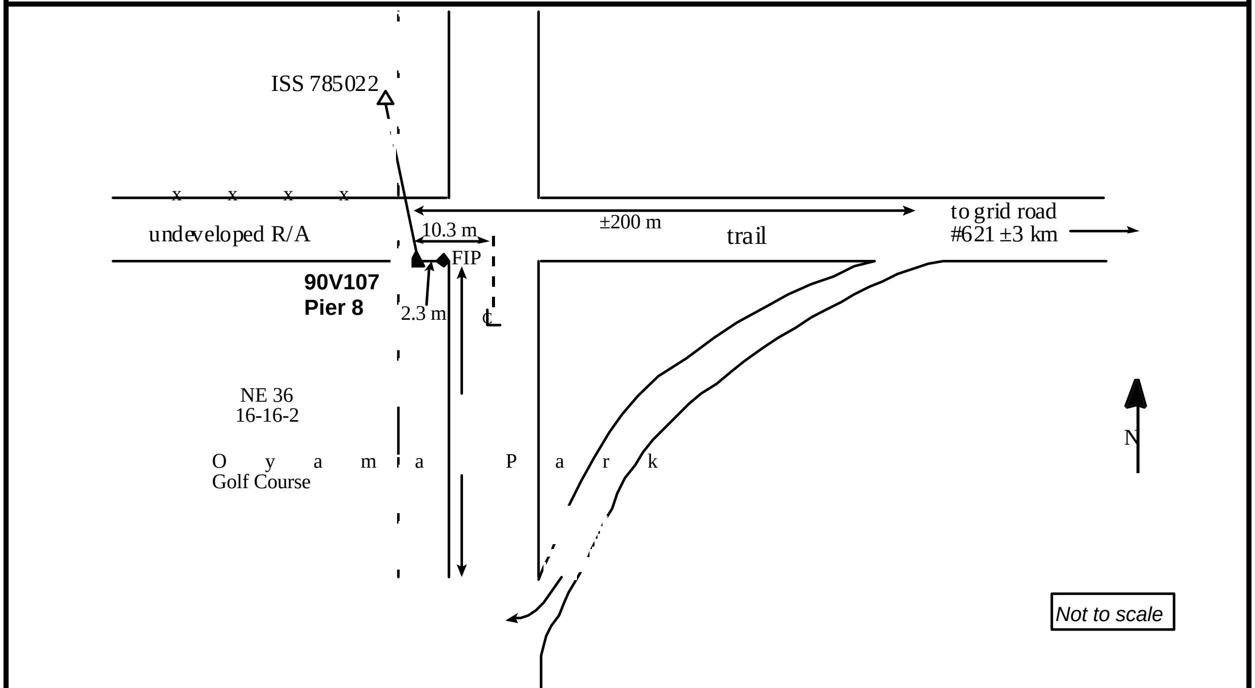
OWNER: Road allowance

90V107

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 8
UNIQUE NO. 90V107

SCALED COORDINATES
LAT: 50H18'34"
LON: 104H12'20"
ELEV: 607 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C .11 thread in a 23 cm diameter stainless steel plate set in top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 16 km to the intersection with grid road #621. Turn south on the grid road for 9.7 km to the intersection with an east-west gravel road then west for about 3.0 km to where the road curves south. Continue westerly along a trail for approximately 200 metres. Pier is on west side of north/south trail.

From Regina via Highway #33
From Regina proceed south-easterly on Highway #33 for 24 km to the organized hamlet of Kronau. Then go east on the paved road to Oyama Regional Park, approximately 5 km. Follow the road around Oyama Lake until it curves easterly. Follow a dirt trail north from the curve for approximately 200 metres. Pier is on west side of north/south trail.

The monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground at the north-east corner of the Oyama Park Golf Course.

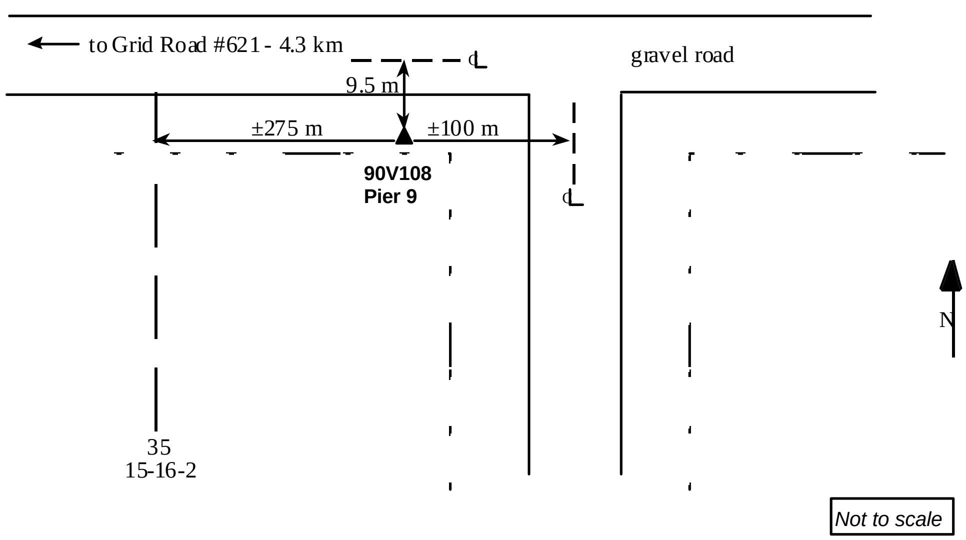
OWNER: Undeveloped road allowance

90V108

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 9
UNIQUE NO. 90V108

SCALED COORDINATES
LAT: 50°18'34"
LON: 104°05'55"
ELEV: 607 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in the top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 16 km to the intersection with grid road #621. Turn south on the grid road 9.7 km to the intersection with an east-west gravel road. Then go east for about 4.3 km to about 100 metres west of entrance to the Speers Colony.

From Regina via Highway #33
From Regina proceed south-easterly on Highway #33 for 24 km to the organized hamlet of Kronau. Then go east on the paved road to Oyama Regional Park, approximately 5 km. Follow the road around Oyama Lake and continue easterly on a gravel road for approximately another 7.3 km to about 100 metres west of the entrance to the Speers Colony.

The monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground at the south side of the gravel road.

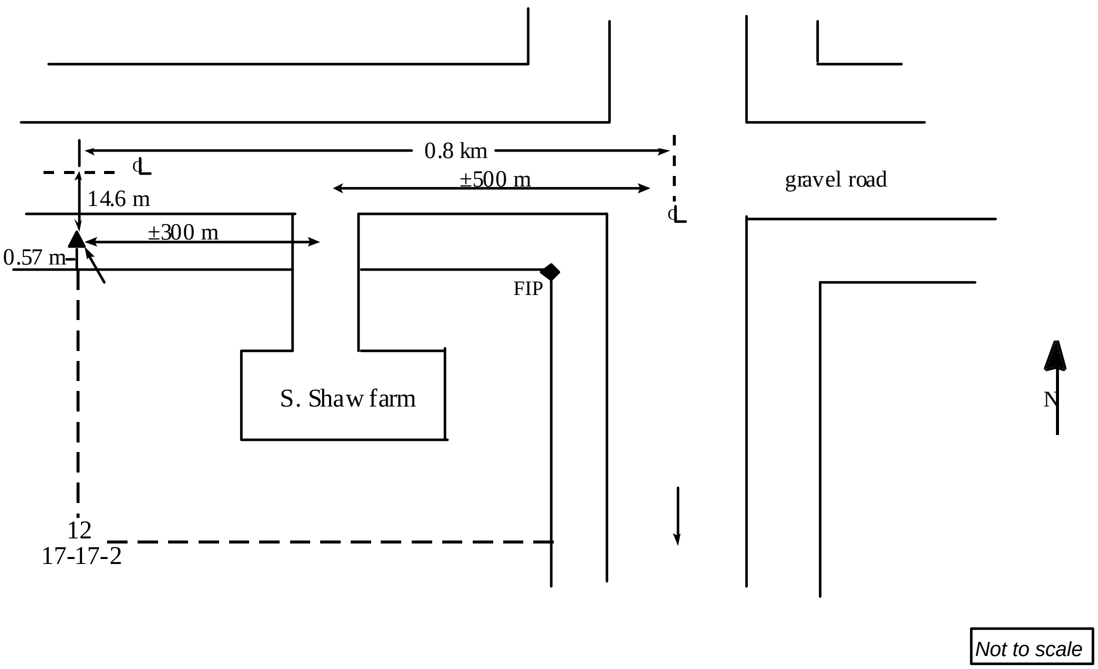
OWNER: Road allowance

90V109

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 10
UNIQUE NO. 90V109

SCALED COORDINATES
LAT: 50°25'33"
LON: 104°13'01"
ELEV: 607 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in the top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 12.5 km to the intersection with a north-south gravel road. Travel north on the gravel road for 3.2 km to an east-west gravel road, then west for about 800 metres.

The monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground on the south side of the road.

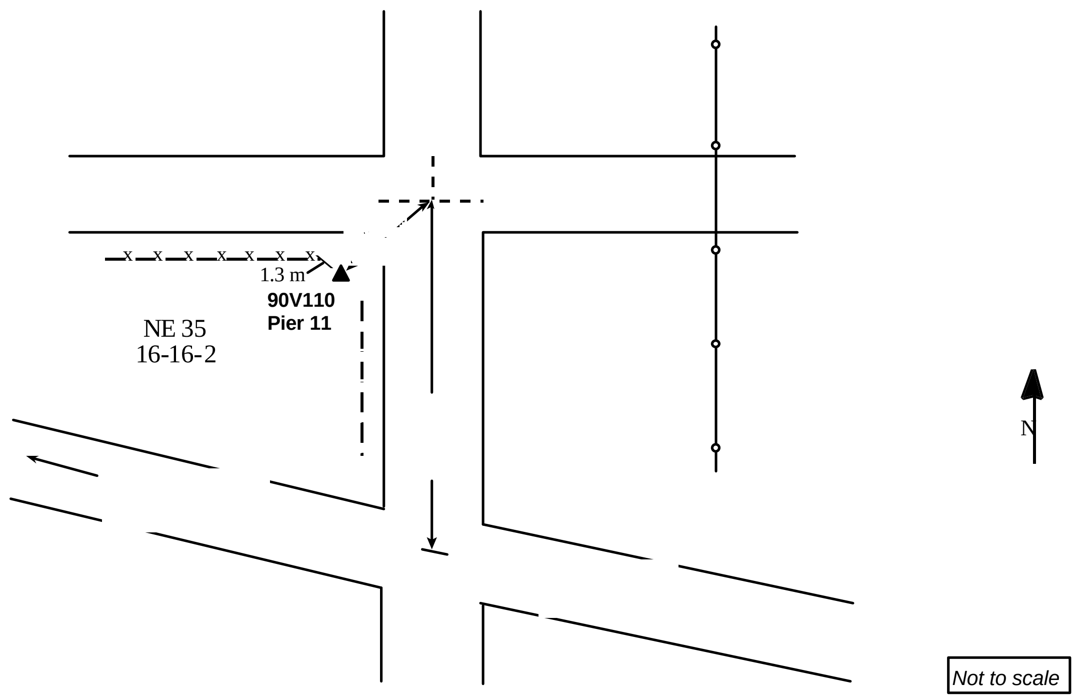
OWNER: Road allowance

90V110

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 11
UNIQUE NO. 90V110

SCALED COORDINATES
LAT: 50°23'48"
LON: 104°05'28"
ELEV: 673 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 1 1 thread in a 23 cm diameter stainless steel plate set in the top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City . Then travel south-easterly on Highway #48 for 22 km to the intersection with a north-south gravel road 1.5 km past the organized hamlet of Davin. Travel north on the gravel road for about 2.1 km to an east-west gravel road.

Monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground in the south-west corner of the intersection.

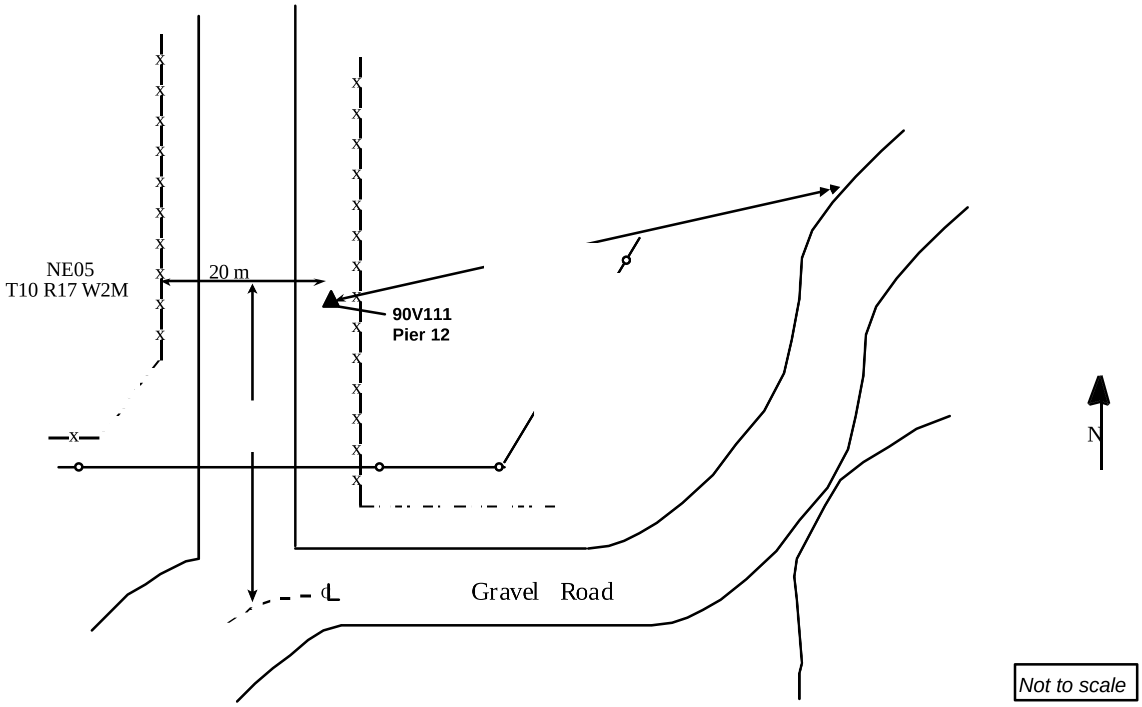
OWNER: Road allowance

90V111

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 12
UNIQUE NO. 90V111

SCALED COORDINATES
LAT: 49°47'58"
LON: 104°15'53"
ELEV: 581 M



DESCRIPTION: Marked by a 10 mm long 5/8 inch threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #6***
From Regina proceed southerly on Highway #6 for 45 km to the junction with Highway #39. Then travel south-easterly on Highway #39 for 40 km to the town of Yellow Grass. Take a gravel road, 1 km west of Yellow Grass, west for 6.1 km to the junction with another gravel road. Proceed southerly for 1 km to the north end of Ibsen Lake. Follow the road around the west side of Ibsen Lake for about 1.2 km, then northerly on a dirt trail along the north-south road allowance for about 125 metres. Pier is visible from the gravel road.

The monument is a 12 inch diameter concrete pier protruding 1.5 m above the ground on the east side of the road allowance.

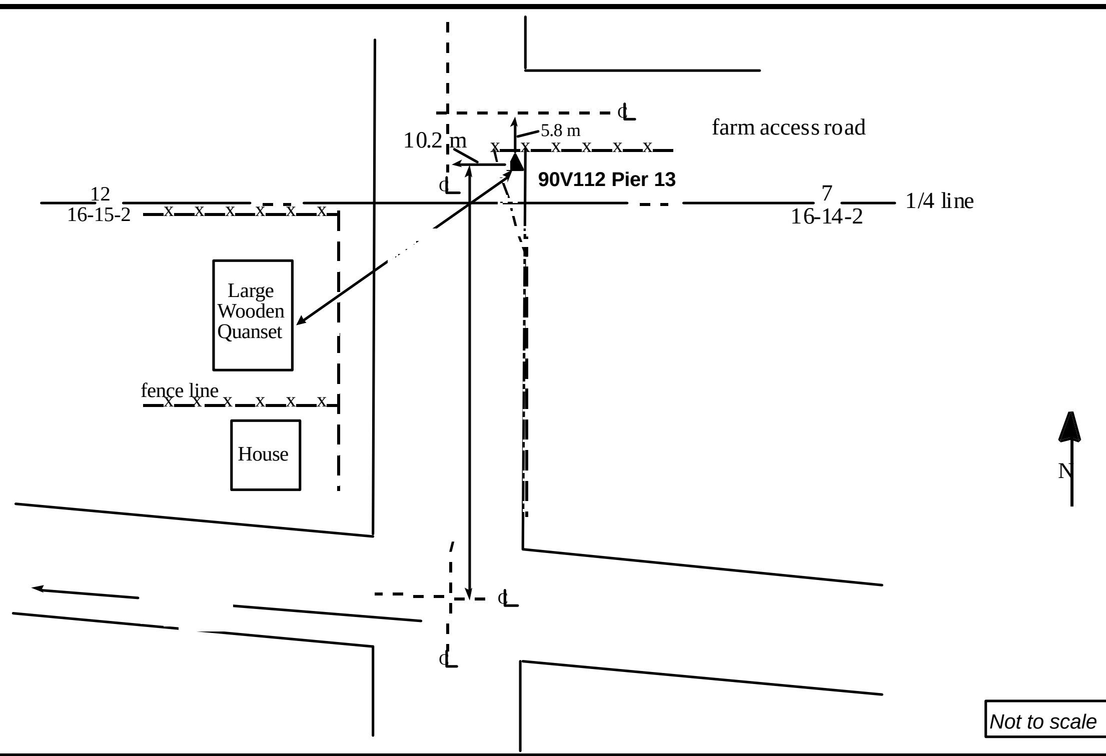
OWNER: Undeveloped road allowance

90V112

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 13
UNIQUE NO. 90V112

SCALED COORDINATES
LAT: 50°19'53"
LON: 103°55'50"
ELEV: 671 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in the top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for 34 km to the intersection with a north-south grid road 1 km past the village of Vibank. Travel north on the grid road for about 0.5 km.

The monument is a 12 inch diameter concrete pier protruding 1.5 m above the ground on the east side of the road.

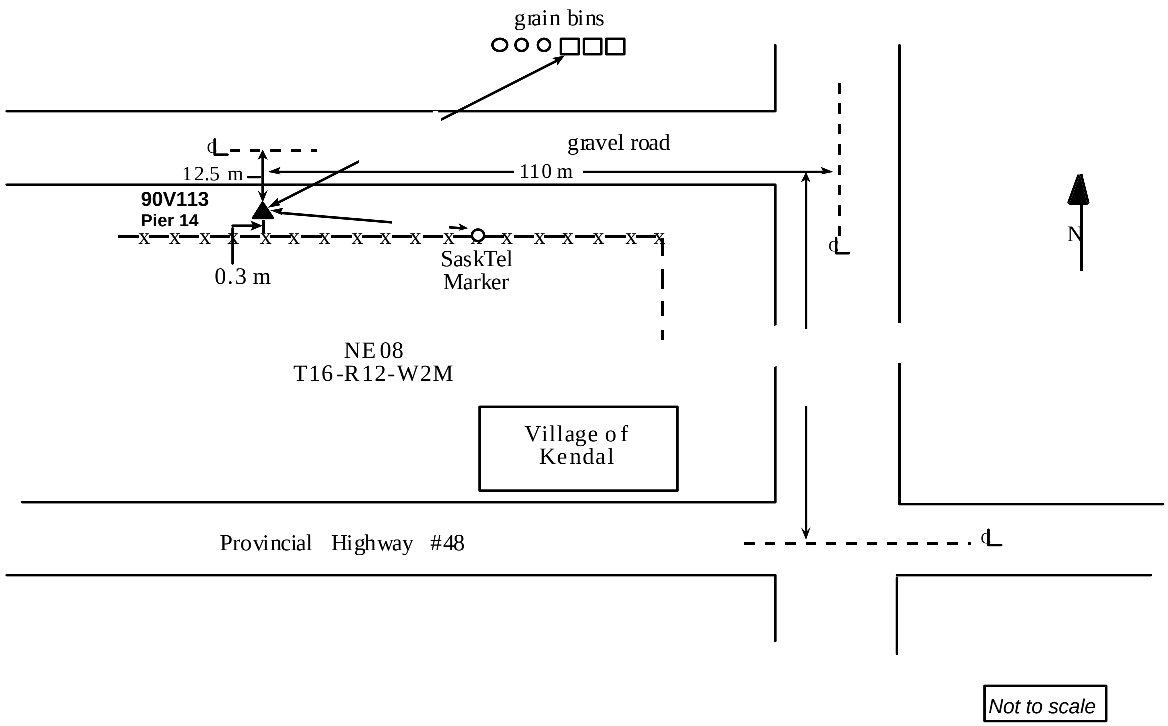
OWNER: Road allowance

90V113

REGINA GPS VALIDATION NETWORK

STATION NAME - PIER 14
UNIQUE NO. 90V113

SCALED COORDINATES
LAT: 50°20'19"
LON: 103°36'46"
ELEV: 674 M



DESCRIPTION: Marked by a 10 mm long 5/8" threaded bolt with N.C. 11 thread in a 23 cm diameter stainless steel plate set in the top of a 32 cm diameter concrete pier.

ACCESS: ***From Regina via Highway #1***
From Regina proceed easterly on Highway #1 for 15 km to the junction with Highway #48 at White City. Then travel south-easterly on Highway #48 for about 59 km to the intersection with grid road #619 at the village of Kendal. Travel north on the grid road for about 9.6 km, then west on a gravel road for about 110 metres.

Monument is a 12 inch diameter concrete pier protruding 1.5 metres above the ground on the south side of the gravel road.

OWNER: Road allowance

Appendix B

Tables of Values

(Regina GPS Validation Network - 1991 & 1992 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 SGD as described in Appendix C. Note that station 90V107 was constrained to its NAD83(CSRS) value in the adjustment that produced these coordinates.

Table 1: Ellipsoidal Coordinates

Station #	Latitude North (d m s)			Longitude West (d m s)			Ellipsoidal Height (m)
90V107	50	18	33.92406	104	12	20.30107	587.396
90V100	50	21	17.71414	104	09	33.70596	639.535
90V101	50	20	26.21009	104	09	33.43150	616.725
90V103	50	19	39.45709	104	09	33.19143	608.307
90V106	50	15	31.04041	104	09	32.59067	578.869
90V108	50	18	33.95072	104	05	54.61278	618.177
90V109	50	25	33.06947	104	13	01.02503	639.270
90V110	50	23	48.46053	104	05	28.04085	653.943
90V111	49	47	57.76611	104	15	52.97302	561.985
90V112	50	19	52.79055	103	55	49.88938	651.660
90V113	50	20	18.71413	103	36	45.88224	654.038

Table 2: Geocentric Cartesian Coordinates

Station #	X (m)	Y (m)	Z (m)
90V107	-1001688.598	-3956997.088	4885293.071
90V100	-997547.392	-3954059.425	4888564.073
90V101	-997838.325	-3955234.812	4887530.888
90V103	-998104.456	-3956309.114	4886602.211
90V106	-999532.940	-3962020.024	4881675.403
90V108	-994292.417	-3958881.648	4885317.283
90V109	-1000028.075	-3947161.513	4893594.820
90V110	-991965.992	-3951773.503	4891546.047
90V111	-1016481.911	-3998103.031	4848844.929
90V112	-982235.325	-3959980.543	4886898.608
90V113	-960112.297	-3964769.512	4887411.772

Table 3: UTM Mapping Plane Coordinates

Station #	Northing (m)	Easting (m)	Zone
90V107	5573336.459	556562.967	13
90V100	5578431.422	559800.930	13
90V101	5576840.737	559824.325	13
90V103	5575396.788	559845.383	13
90V106	5567724.433	559943.902	13
90V108	5573424.163	564191.509	13
90V109	5586273.666	555621.214	13
90V110	5583144.432	564598.417	13
90V111	5516584.519	552914.462	13
90V112	5576017.479	576117.300	13
90V113	5577191.412	598718.857	13

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 Station	To Station	Δ X (m)	Δ Y (m)	Δ Z (m)	Spatial Distance (m)
90V107	90V100	4141.206	2937.663	3271.003	6039.778
90V107	90V101	3850.273	1762.276	2237.817	4789.368
90V107	90V103	3584.142	687.974	1309.141	3877.272
90V107	90V106	2155.658	-5022.936	-3617.668	6554.713
90V107	90V108	7396.181	-1884.560	24.212	7632.539
90V107	90V109	1660.523	9835.576	8301.750	12977.478
90V107	90V110	9722.606	5223.585	6252.977	12685.213
90V107	90V111	-14793.313	-41105.943	-36448.141	56894.706
90V107	90V112	19453.273	-2983.454	1605.538	19746.103
90V107	90V113	41576.301	-7772.423	2118.702	42349.596
90V100	90V101	-290.934	-1175.387	-1033.186	1591.744
90V100	90V103	-557.064	-2249.689	-1961.862	3036.498
90V100	90V106	-1985.548	-7960.599	-6888.671	10712.951
90V100	90V108	3254.975	-4822.223	-3246.791	6662.608
90V100	90V109	-2480.683	6897.913	5030.747	8890.636
90V100	90V110	5581.400	2285.922	2981.974	6728.271
90V100	90V111	-18934.519	-44043.606	-39719.144	62257.254
90V100	90V112	15312.067	-5921.117	-1665.465	16501.297
90V100	90V113	37435.095	-10710.086	-1152.301	38954.077
90V101	90V103	-266.130	-1074.302	-928.676	1444.780
90V101	90V106	-1694.614	-6785.212	-5855.485	9121.268
90V101	90V108	3545.909	-3646.836	-2213.605	5547.335
90V101	90V109	-2189.750	8073.299	6063.932	10331.720
90V101	90V110	5872.333	3461.309	4015.159	7911.161
90V101	90V111	-18643.585	-42868.219	-38685.959	60678.422
90V101	90V112	15603.001	-4745.731	-632.279	16321.010
90V101	90V113	37726.029	-9534.700	-119.116	38912.439
90V103	90V106	-1428.484	-5710.910	-4926.809	7676.490
90V103	90V108	3812.039	-2572.534	-1284.929	4774.999
90V103	90V109	-1923.619	9147.601	6992.609	11673.710
90V103	90V110	6138.464	4535.611	4943.836	9093.625
90V103	90V111	-18377.455	-41793.917	-37757.282	59245.883
90V103	90V112	15869.131	-3671.429	296.397	16290.996
90V103	90V113	37992.159	-8460.398	809.561	38931.194

continued on next page...

Table 4 (continued)

From Station	To Station	Δ X (m)	Δ Y (m)	Δ Z (m)	Spatial Distance (m)
90V106	90V108	5240.523	3138.376	3641.880	7111.665
90V106	90V109	-495.135	14858.511	11919.418	19055.000
90V106	90V110	7566.948	10246.521	9870.645	16114.574
90V106	90V111	-16948.971	-36083.007	-32830.473	51643.886
90V106	90V112	17297.615	2039.481	5223.206	18183.752
90V106	90V113	39420.643	-2749.488	5736.370	39930.599
90V108	90V109	-5735.658	11720.135	8277.538	15452.410
90V108	90V110	2326.425	7108.145	6228.765	9733.215
90V108	90V111	-22189.494	-39221.383	-36472.353	57973.469
90V108	90V112	12057.092	-1098.895	1581.326	12209.899
90V108	90V113	34180.120	-5887.864	2094.490	34746.718
90V109	90V110	8062.083	-4611.991	-2048.773	9511.315
90V109	90V111	-16453.836	-50941.518	-44749.891	69773.345
90V109	90V112	17792.750	-12819.030	-6696.212	22929.211
90V109	90V113	39915.778	-17607.999	-6183.048	44062.922
90V110	90V111	-24515.919	-46329.528	-42701.118	67607.994
90V110	90V112	9730.667	-8207.039	-4647.439	13551.386
90V110	90V113	31853.695	-12996.008	-4134.275	34650.344
90V111	90V112	34246.586	38122.488	38053.679	63829.737
90V111	90V113	56369.614	33333.519	38566.843	76000.384
90V112	90V113	22123.028	-4788.969	513.164	22641.244

Table 5: Absolute 95% 3-D Confidence Ellipsoids

Station #	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)
90V107	0.02	331	86	0.02	345	-3	0.02	75	1
90V100	0.03	14	89	0.02	5	-1	0.02	95	0
90V101	0.03	10	89	0.02	6	-1	0.02	96	0
90V103	0.03	15	89	0.02	5	-1	0.02	95	0
90V106	0.03	10	88	0.02	8	-2	0.02	98	0
90V108	0.03	71	88	0.02	2	-1	0.02	92	-2
90V109	0.03	24	89	0.02	6	-1	0.02	96	0
90V110	0.03	59	88	0.02	3	-1	0.02	93	-2
90V111	0.03	22	88	0.02	9	-2	0.02	99	0
90V112	0.03	24	89	0.02	9	-1	0.02	99	0
90V113	0.03	20	89	0.02	8	-1	0.02	98	0

Table 6: Absolute 95% Horizontal Confidence Ellipses

Station #	Major Semi-axis		Minor Semi-axis	
	length (m)	az. (deg)	length (m)	az. (deg)
90V107	0.02	341	0.02	71
90V100	0.02	5	0.02	95
90V101	0.02	6	0.02	96
90V103	0.02	5	0.02	95
90V106	0.02	8	0.02	98
90V108	0.02	3	0.02	93
90V109	0.02	6	0.02	96
90V110	0.02	3	0.02	93
90V111	0.02	9	0.02	99
90V112	0.02	10	0.02	100
90V113	0.02	8	0.02	98

Table 7: Absolute 95% Vertical Confidence Intervals

Station #	+/- length (m)
90V107	0.02
90V100	0.02
90V101	0.02
90V103	0.02
90V106	0.02
90V108	0.02
90V109	0.02
90V110	0.02
90V111	0.02
90V112	0.02
90V113	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 Station	To Station	Major Semi-axis length (m)	Major Semi-axis az. (deg)	Major Semi-axis inc. (deg)	Medium Semi-axis length (m)	Medium Semi-axis az. (deg)	Medium Semi-axis inc. (deg)	Minor Semi-axis length (m)	Minor Semi-axis az. (deg)	Minor Semi-axis inc. (deg)
90V107	90V100	0.015	111	88	0.007	8	1	0.005	98	-2
90V107	90V101	0.015	103	88	0.007	9	0	0.005	99	-2
90V107	90V103	0.015	103	88	0.007	8	0	0.005	98	-2
90V107	90V106	0.016	90	88	0.007	10	0	0.005	100	-2
90V107	90V108	0.019	102	86	0.009	5	1	0.007	95	-4
90V107	90V109	0.016	98	87	0.007	9	0	0.005	99	-3
90V107	90V110	0.018	99	86	0.008	6	0	0.006	96	-4
90V107	90V111	0.019	67	88	0.009	11	-1	0.006	101	-2
90V107	90V112	0.019	93	88	0.009	11	0	0.006	101	-2
90V107	90V113	0.019	103	88	0.008	10	0	0.006	100	-2
90V100	90V101	0.015	125	87	0.007	8	1	0.005	98	-3
90V100	90V103	0.014	131	88	0.007	10	1	0.005	99	-2
90V100	90V106	0.016	117	88	0.007	12	0	0.005	102	-2
90V100	90V108	0.019	107	86	0.009	5	1	0.007	95	-4
90V100	90V109	0.015	120	88	0.007	11	1	0.005	101	-2
90V100	90V110	0.017	108	86	0.008	7	1	0.006	97	-4
90V100	90V111	0.020	87	88	0.009	11	-1	0.007	101	-2
90V100	90V112	0.019	107	88	0.009	11	0	0.007	101	-2
90V100	90V113	0.019	127	88	0.009	11	1	0.006	101	-2
90V101	90V103	0.015	124	87	0.007	8	1	0.005	98	-3
90V101	90V106	0.016	107	88	0.008	11	0	0.006	101	-2
90V101	90V108	0.019	106	86	0.009	5	1	0.007	95	-4
90V101	90V109	0.016	111	87	0.007	10	0	0.006	100	-3
90V101	90V110	0.017	106	86	0.008	6	1	0.006	96	-4
90V101	90V111	0.020	84	88	0.009	11	-1	0.007	101	-2
90V101	90V112	0.019	105	88	0.009	11	0	0.007	101	-2
90V101	90V113	0.019	118	88	0.009	11	1	0.006	101	-2
90V103	90V106	0.016	112	88	0.007	12	0	0.005	102	-2
90V103	90V108	0.019	105	86	0.009	6	1	0.007	95	-4
90V103	90V109	0.016	115	88	0.007	11	1	0.005	101	-2
90V103	90V110	0.017	106	86	0.008	7	1	0.006	97	-4
90V103	90V111	0.020	84	88	0.009	11	-1	0.007	101	-2
90V103	90V112	0.019	104	88	0.009	11	0	0.007	101	-2
90V103	90V113	0.019	124	88	0.009	11	1	0.006	101	-2

continued on next page...

Table 8 (continued)

From Station	To Station	Major Semi-axis length (m)	Major Semi-axis az. (deg)	Major Semi-axis inc. (deg)	Medium Semi-axis length (m)	Medium Semi-axis az. (deg)	Medium Semi-axis inc. (deg)	Minor Semi-axis length (m)	Minor Semi-axis az. (deg)	Minor Semi-axis inc. (deg)
90V106	90V108	0.020	95	86	0.009	12	0	0.007	102	-4
90V106	90V109	0.016	111	88	0.007	12	0	0.005	102	-2
90V106	90V110	0.018	102	86	0.008	9	0	0.006	99	-4
90V106	90V111	0.019	81	87	0.009	11	-1	0.006	101	-3
90V106	90V112	0.019	101	87	0.009	12	0	0.007	102	-3
90V106	90V113	0.018	114	88	0.008	12	0	0.006	102	-2
90V108	90V109	0.021	103	86	0.009	8	0	0.007	98	-4
90V108	90V110	0.022	104	85	0.010	5	1	0.008	94	-5
90V108	90V111	0.023	89	86	0.010	9	-1	0.008	99	-4
90V108	90V112	0.022	100	86	0.010	9	0	0.008	99	-4
90V108	90V113	0.022	103	86	0.010	9	0	0.008	99	-4
90V109	90V110	0.017	104	86	0.008	8	0	0.006	98	-4
90V109	90V111	0.019	82	87	0.009	11	-1	0.007	101	-3
90V109	90V112	0.020	102	87	0.009	12	0	0.007	102	-3
90V109	90V113	0.018	118	88	0.008	12	1	0.006	102	-2
90V110	90V111	0.021	89	86	0.010	9	-1	0.007	99	-4
90V110	90V112	0.021	98	86	0.010	9	0	0.007	99	-4
90V110	90V113	0.020	108	87	0.009	9	1	0.007	99	-3
90V111	90V112	0.021	83	87	0.010	13	-1	0.007	103	-2
90V111	90V113	0.020	89	87	0.009	12	-1	0.007	102	-3
90V112	90V113	0.020	105	87	0.010	12	0	0.007	102	-3

Table 9: Relative 95% Horizontal Confidence Ellipses

From Station	To Station	Major Semi-axis length (m)	Major Semi-axis az (deg)	Minor Semi-axis length (m)	Minor Semi-axis az (deg)
90V107	90V100	0.006	8	0.005	98
90V107	90V101	0.006	9	0.005	99
90V107	90V103	0.006	8	0.005	98
90V107	90V106	0.006	10	0.005	100
90V107	90V108	0.008	5	0.006	95
90V107	90V109	0.006	9	0.005	99
90V107	90V110	0.007	5	0.005	95
90V107	90V111	0.007	11	0.006	101
90V107	90V112	0.008	11	0.006	101
90V107	90V113	0.007	10	0.005	100
90V100	90V101	0.006	8	0.004	98
90V100	90V103	0.006	9	0.004	99
90V100	90V106	0.006	11	0.005	101
90V100	90V108	0.008	5	0.006	95
90V100	90V109	0.006	11	0.005	101
90V100	90V110	0.007	6	0.005	96
90V100	90V111	0.008	11	0.006	101
90V100	90V112	0.008	10	0.006	100
90V100	90V113	0.008	11	0.006	101
90V101	90V103	0.006	8	0.004	98
90V101	90V106	0.007	11	0.005	101
90V101	90V108	0.008	5	0.006	95
90V101	90V109	0.007	10	0.005	100
90V101	90V110	0.007	6	0.005	96
90V101	90V111	0.008	12	0.006	102
90V101	90V112	0.008	11	0.006	101
90V101	90V113	0.008	11	0.006	101

Table 10: Relative 95% Vertical Confidence Intervals

From Station	To Station	+/- length (m)
90V107	90V100	0.010
90V107	90V101	0.010
90V107	90V103	0.011
90V107	90V106	0.011
90V107	90V108	0.013
90V107	90V109	0.011
90V107	90V110	0.012
90V107	90V111	0.013
90V107	90V112	0.013
90V107	90V113	0.013
90V100	90V101	0.010
90V100	90V103	0.010
90V100	90V106	0.011
90V100	90V108	0.013
90V100	90V109	0.011
90V100	90V110	0.012
90V100	90V111	0.014
90V100	90V112	0.014
90V100	90V113	0.013
90V101	90V103	0.010
90V101	90V106	0.011
90V101	90V108	0.014
90V101	90V109	0.011
90V101	90V110	0.012
90V101	90V111	0.014
90V101	90V112	0.013
90V101	90V113	0.013

continued on next page...

Table 9 (continued)

From Station	To Station	Major Semi-axis length (m)	Major Semi-axis az. (deg)	Minor Semi-axis length (m)	Minor Semi-axis az. (deg)
90V103	90V106	0.006	12	0.005	102
90V103	90V108	0.008	5	0.006	95
90V103	90V109	0.006	11	0.005	101
90V103	90V110	0.007	6	0.005	96
90V103	90V111	0.008	11	0.006	101
90V103	90V112	0.008	11	0.006	101
90V103	90V113	0.008	11	0.006	101
90V106	90V108	0.008	12	0.006	102
90V106	90V109	0.006	12	0.005	102
90V106	90V110	0.007	9	0.006	99
90V106	90V111	0.008	11	0.006	101
90V106	90V112	0.008	12	0.006	102
90V106	90V113	0.007	12	0.005	102
90V108	90V109	0.008	7	0.006	97
90V108	90V110	0.009	4	0.007	94
90V108	90V111	0.009	10	0.007	100
90V108	90V112	0.009	9	0.007	99
90V108	90V113	0.009	9	0.007	99
90V109	90V110	0.007	8	0.005	98
90V109	90V111	0.008	12	0.006	102
90V109	90V112	0.008	12	0.006	102
90V109	90V113	0.007	11	0.005	101
90V110	90V111	0.009	10	0.007	100
90V110	90V112	0.009	9	0.007	99
90V110	90V113	0.008	9	0.006	99
90V111	90V112	0.008	13	0.006	103
90V111	90V113	0.008	12	0.006	102
90V112	90V113	0.008	12	0.006	102

Table 10 (continued)

From Station	To Station	+/- length (m)
90V103	90V106	0.011
90V103	90V108	0.014
90V103	90V109	0.011
90V103	90V110	0.012
90V103	90V111	0.014
90V103	90V112	0.014
90V103	90V113	0.013
90V106	90V108	0.014
90V106	90V109	0.011
90V106	90V110	0.013
90V106	90V111	0.013
90V106	90V112	0.013
90V106	90V113	0.013
90V108	90V109	0.014
90V108	90V110	0.015
90V108	90V111	0.016
90V108	90V112	0.015
90V108	90V113	0.015
90V109	90V110	0.012
90V109	90V111	0.014
90V109	90V112	0.014
90V109	90V113	0.013
90V110	90V111	0.015
90V110	90V112	0.015
90V110	90V113	0.014
90V111	90V112	0.014
90V111	90V113	0.014
90V112	90V113	0.014

Appendix C

Contacts for Additional Information

The following information is available in various formats and on different media, including computer diskette, from the Map and Air Photo Distribution Centre (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

SaskGeomatics Division
Map and Air Photo Distribution Centre
1st Floor
2151 Scarth Street
Regina, Saskatchewan
S4P 3V7

Tel: (306) 787-2799
Fax: (306) 787-3335

Email: ingeodetic@sgd.sask.net

For more information on the Davin/Regina EDM calibration baseline, please request a copy of the SGD publication “Saskatchewan Precise Calibration Baselines” available at the above address.

For more information on the Regina 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

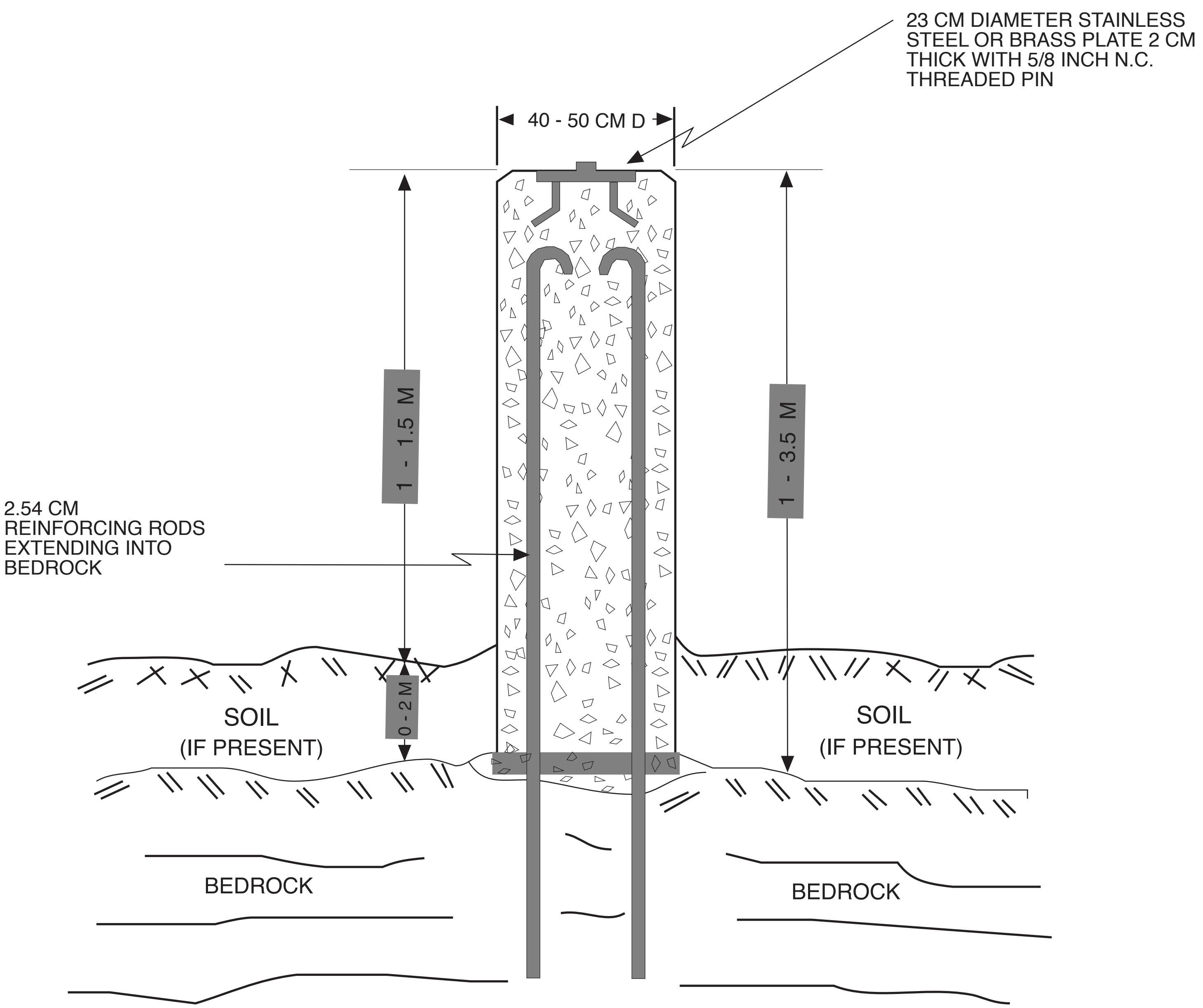
Saskatchewan Property Management Corporation

SaskGeomatics Division

Pier Design

Forced Centering Pillars

D.1 Cross Section



D.2 Pier Construction

The piers are 12 inches in diameter by about 5.5 meters in length, set a minimum of 4 meters below grade. They are constructed of type 5 concrete and are reinforced with four “size 10” rebars placed vertically in each pier from bottom to about 3 inches below the top of each pier. Rebars are cross-tied by 3 circular “size 10” rebars set near the top, middle and bottom of the vertical rebar.

Each pier protrudes about 1.5 meters above the ground and is capped with a custom manufactured stainless steel plate to allow forced centering of a Wild tribrach. The stainless steel plate is 22.86 cm (9 inches) in diameter and has a 10 mm long, 1.59 cm (5/8 inch) diameter threaded bolt with N.C. 11 thread.

Reconnaissance for the network was done by Tim Flaman of Eagle Surveys Ltd. and SGD staff members.

D-3 Forced Centering Plate