

CANADA LANDS SURVEYS RECORDS
F.B. 3 3 4 0 6
DATE 29 APR. 1985



CANADA LANDS SURVEYS RECORDS
F.B. 3 3 4 0 6



McElhenny

PETRO-CANADA INC.
Navigation And Positioning of the
Semi-Submersible Drilling Platform
"BOW DRILL 1"
On Offshore Exploratory
Well Location Petro-Canada
Et Al Bonnet P-23

JOB NUMBER 083747

submitted by:

McELHANNEY SERVICES LTD.
101 Thornhill Drive
Burnside Industrial Park
Dartmouth, Nova Scotia
B3B 1S2

Telephone: (902) 463-0041

MARCH 1984



FB 33404

TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 EQUIPMENT AND PERSONNEL	1
2.1 MV Balder Cabot	1
2.2 Bow Drill 1	4
3.0 SURVEY DATA	5
3.1 Coordinates	5
3.2 Coordinate Frame	5
3.3 ARGO DM-54 Information	7
3.4 Survey Targets - Proposed Location	7
4.0 FIELD SURVEYS	10
4.1 Operations Summary	10
4.2 Antenna Offsets	11
4.3 ARGO Calibration and Ongoing Accuracy Checks	14
4.3.1 ARGO Calibration	14
4.3.2 Ongoing Accuracy Checks	15
4.4 Final Position of Well Location	17
4.5 Final Position Confirmation	18
4.6 Accuracy Analysis	18

FB 33404

FIGURES

<u>NO.</u>		<u>Page</u>
1	Hardware Schematic	3
2	Tentative Plan of Survey	8
3	Proposed Buoy Pattern - Bow Drill 1 at Petro-Canada Et Al Bonnet P-23	9
4	Antenna Offsets - Bow Drill 1	12 (a)
5	Difference in Satellite and MRS III Antenna Offsets	13
6	Position Comparisons - Bow Drill 1 at Petro-Canada Et Al Bonnet P-23	19

TABLES

1	Equipment and Personnel - Balder Cabot	2
2	Equipment and Personnel - Bow Drill 1	4
3	ARGO Tower and Monument Coordinates	6
4	Daily Meaned ARGO/Satellite Comparisons	16

APPENDICES

A	Final Plan of Survey for Petro-Canada Et Al Bonnet P-23	21
B	Magnavox 1107 Position Convergence Data	22
C	ARGO DM-54 Resection Data	23

FB 33404

1.0 INTRODUCTION

During late December 1983 and January of 1984, McElhanney Services Ltd. of Dartmouth, Nova Scotia provided the navigation and positioning services required for the positioning of the semi-submersible drilling rig Bow Drill 1 at Petro-Canada et at Bonnet P-23. The M.V. Balder Cabot was used as the survey boat for the move.

The final position of the drillstem (1927 NAD) as determined by 34 3D satellite passes, single point solution is:

Latitude 42° 22' 48.64" N
Longitude 65° 03' 01.89" W

This situates the drillstem 41.4 M at 298° 39' from the proposed location.

The following report summarizes the survey activities, personnel, equipment and final results pertaining to that rig move.

2.0 EQUIPMENT AND PERSONNEL

2.1 MV Balder Cabot

The integrated navigation and positioning system onboard that Balder Cabot was developed in-house by McElhanney Surveying & Engineering Ltd. The major components of this system, as installed on the Balder Cabot, are:

- An ARGO DM-54 Range/Range system;
- A Magnovox MX 1107RS Satellite Receiver;
- A Motorola Mini-Ranger III Receiver;
- HP 9825 & 9826 Computers;
- NAVPAK Software.

Figure 1 is a schematic diagram of the systems components while Table 1 lists the components and personnel employed.

FB 33404

For this rig move the ARGO DM-54 system was used as the prime means of navigation on the Balder Cabot. The NAVPAK software (documentation available from McElhanney Services Ltd., Dartmouth, Nova Scotia) allows for range input from multiple sensors which are used in a weighted least squares solution to yeild position. The software controls speed and heading outputs to the satellite receiver, compares satellite fix position to the navigation position, allows for tape-recording and hard copy of position solution and error statistics and presents the helmsman and operator with a graphics display of the ship's track in relationship to various target points.

The Motorola Mini-Ranger III System was used to obtain ranges from the M.V. Balder Cabot to the rig. These ranges were used in a least squares range resection program in conjunction with the survey ships position by ARGO DM-54 to determine the rigs confirmation position (See Section 4.5). The Magnavox MX 1107 satellite receiver was used as a check on the ARGO DM-54 calibration (sub-section 4.3.2) and to obtain and maintain ARGO lane count.

TABLE 1
EQUIPMENT AND PERSONNEL - BALDER CABOT

Equipment

- 2 ARGO DM-54 Range Processing Unit
- 2 ARGO DM-54 Antenna Loading Unit
- 1 Magnavox 1107RS Satellite Receiver
- 1 Motorola Mini-Ranger III Console and Receiver/Transmitter
- 1 HP 9826 CDU Emulator
- 1 HP 9826 Navigation Computer
- 1 HP 9825 Computer
- 1 HP I/O Expander
- 1 Microline 82A Navigation Printer
- 1 Microline 82A Graphics Printer
- 1 Clock Model 3
- 2 CRT's
- 2 Power Supplies Interfaces

FB 33404



FB 33404

Personnel

Percy Roberts Senior Surveyor	December 31, 1983 to January 12, 1984
Robert Ashley Navigator	December 31, 1983 to January 12, 1984
John Brigden Client Representative	December 31, 1983 to January 10, 1984

2.2 Bow Drill 1

Onboard the Bow Drill 1 the survey equipment consisted of a Motorola Mini-Ranger III transponder and a Petro-Canada owned Magnavox MX 1107RS satellite receiver. The reference oscillator in the receiver belonged to McElhanney Services Ltd.

The Mini-Ranger III transponder was used in conjunction with the Mini-Ranger III receiver onboard the Balder Cabot to provide ranges from the Balder Cabot to the drilling rig. These ranges would be used along with the ship's position (which was provided by the ARGO system) in a least squares solution to obtain the drillstem's location. The MX 1107 satellite receiver onboard the Bow Drill 1 was used to obtain the final 3D position by a single point method.

TABLE 2
EQUIPMENT AND PERSONNEL - BOW DRILL 1

Equipment

- 1 Magnavox 1107RS satellite Receiver and Antenna
- 1 Motorola Mini-Ranger III Transponder and Power Supply

Personnel

Barry Ryan Senior Surveyor	December 29, 1983 to January 12, 1984
Robert Clark Surveyor	February 8, 1984 to February 9, 1984

FB 33404

3.0 SURVEY DATA

3.1 Shore Coordinates

Three ARGO shore stations were used for this rig move. These stations are were located at Baccaro Point and Indian Point, mainland Nova Scotia and H-58 on Sable Island. All three monuments have been translocated using MX 1502 satellite receivers but only H-58 is registered as of yet (CLSR 68362). The conventional ties from the monuments to each of the ARGO towers is shown in Table 3 and can be seen on the final plan of survey for this rig move in Appendix A. The coordinates used for Baccaro Point during the actual rig positioning have since been changed. All resections and satellite/ARGO pass comparisons presented in this report have been adjusted to reflect the change.

3.2 Coordinate Frame

Geographic coordinates are referred to the 1927 North American Datum (NAD 27) using the Clark 1866 ellipsoidal parameters.

Semi-major axis (a)=	6378206.4
Semi-minor axis (b)=	6356583.8
Reciprocal of flattening (1/f)=	294.97869

Universal Transverse Mercator (UTM) coordinates were computed for Zone 20, central meridian 63° W.

The values used in NAVPAK for conversion from satellite datum (NWL 10 D Broadcast Ephemeris) to 1927 NAD were:

ΔX	=	-39 m
ΔY	=	155 m
ΔZ	=	187 m

FB 33404

TABLE 3
ARGO TOWER AND MONUMENT COORDINATES

Station	Monument Coordinates Geographics (NAD 1927)	ARGO Ties		ARGO Tower Coordinates Geographic (NAD 27)	ARGO Tower Coordinates UTM Zone 20 CM 63 W	
		Distance	Bearing			
Baccaro Point	43° 26' 59.689" N	34.6 ²⁷	318° 36' 41" True ⁴⁰	43° 27' 00.508" N	4813560.09 N	✓
	65° 28' 21.750" W			65° 28' 22.803" W	299899.07 E	✓
Indian Point	44° 28' 14.468" N	2.75m	128.5 Mag	44° 28' 14.441" N	4924240.82 N	
	63° 47' 32.883" W			63° 47' 32.765" W	436969.67 E	
H - 58 (Sable Island)	43° 57' 28.040" N	0	0	43° 57' 28.040" N	4870980.22 N	
	60° 07' 39.176" W			60° 07' 39.176" W	730469.72 E	

FB 33400

3.3 ARGO DM-54 Information

Range Frequency-	1788.0 kHz
Lane Identification Frequency-	1966.0 kHz
Assumed Propagation Velocity-	299670 km/sec
Lane Width (calculated)-	83.800336 m

3.4 Survey Targets - Proposed Location

Bonnet P-23 Proposed Location

1927 NAD

Latitude 42° 22' 48.0" N

Longitude 65° 03' 00.3" W

UTM Zone 20 CM 63° W

Northing 4,693,790.2

Easting 331,222.8

Approximate Water Depth 131 m

Figure 2 is the tentative Plan of survey for: Petro-Canada et al Bonnet P-23

Target Area

100 m radius circle with the final position in Unit P.

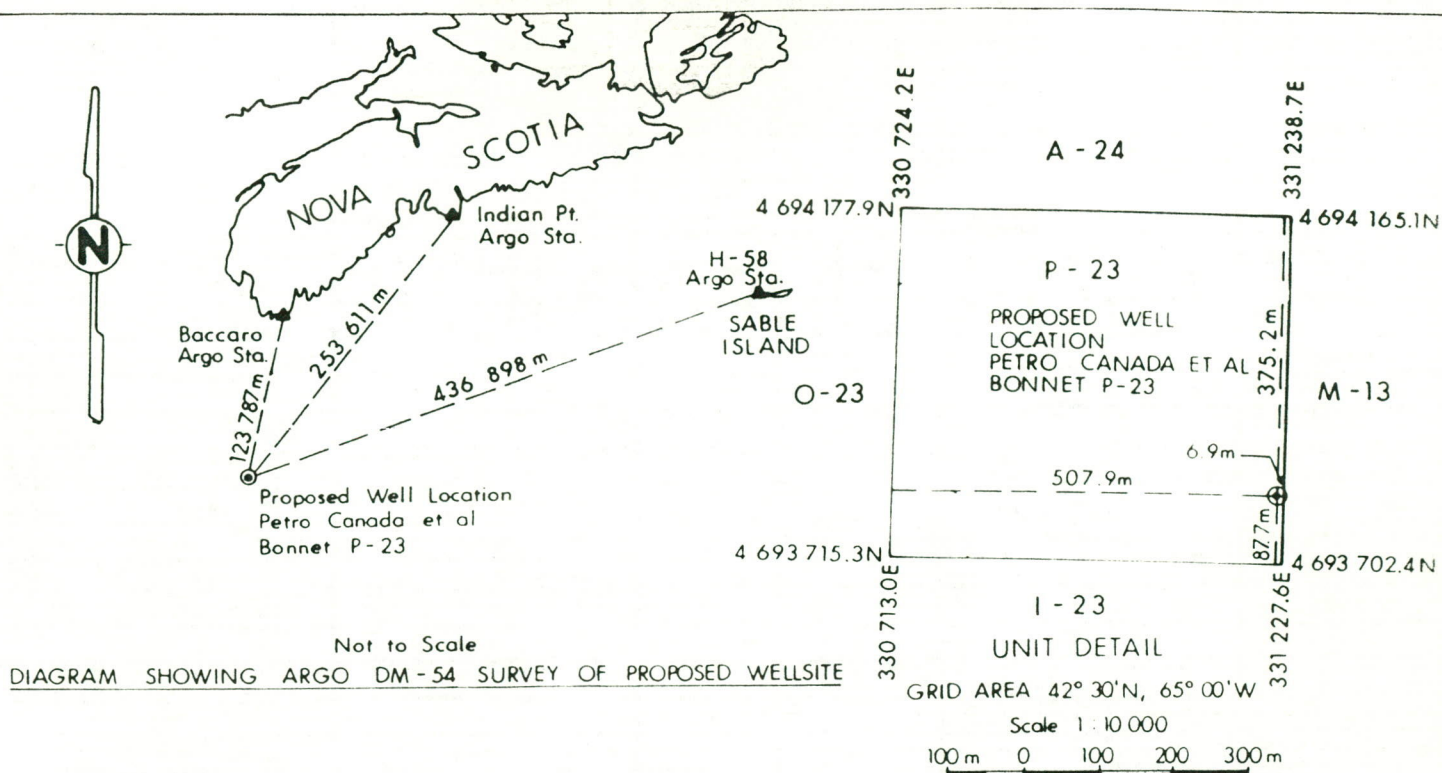
Rig Heading

290° True

Proposed Buoy Pattern

See Figure 3

FB33404



ARGO SHORE STATION CO-ORDINATES				
STATION	GEOGRAPHICS	UTM	SURFACE DISTANCE TO BONNET P-23	SHOWN ON PLAN CLSR
BACCARO ARGO STATION	43° 27' 00.174" N 65° 28' 23.087" W	4 813 549.32 N 299 891.62 E	123 787 m	—
INDIAN PT. ARGO STATION	44° 28' 14.435" N 63° 47' 32.744" W	4 924 240.66 N 436 970.24 E	253 611 m	—
H-58 ARGO STATION	43° 57' 28.040" N 60° 07' 39.176" W	4 870 980.22 N 730 469.72 E	436 898 m	68362

TENTATIVE PLAN OF SURVEY
for
PETRO-CANADA ET AL BONNET P-23
EXPLORATORY WELL LOCATION

LATITUDE 42° 22' 48.0" N
LONGITUDE 65° 03' 00.3" W

UTM CO-ORDINATES

4 693 790.2 N
331 222.8 E

APPROX. WATER DEPTH 131 m

CO-ORDINATES ARE REFERRED TO NAD 1927 DATUM
UTM CO-ORDINATES ZONE 20 CENTRAL MERIDIAN 63° W

DETERMINATION OF FINAL WELL CO-ORDINATES

PRIMARY POSITIONING BY CUBIC ARGO DM-54 RANGES FROM
SHORE STATIONS ON NOVA SCOTIA COAST AND SABLE
ISLAND CONFIRMATION BY DOPPLER SATELLITE POINT
POSITIONING (20 PASS MINIMUM)



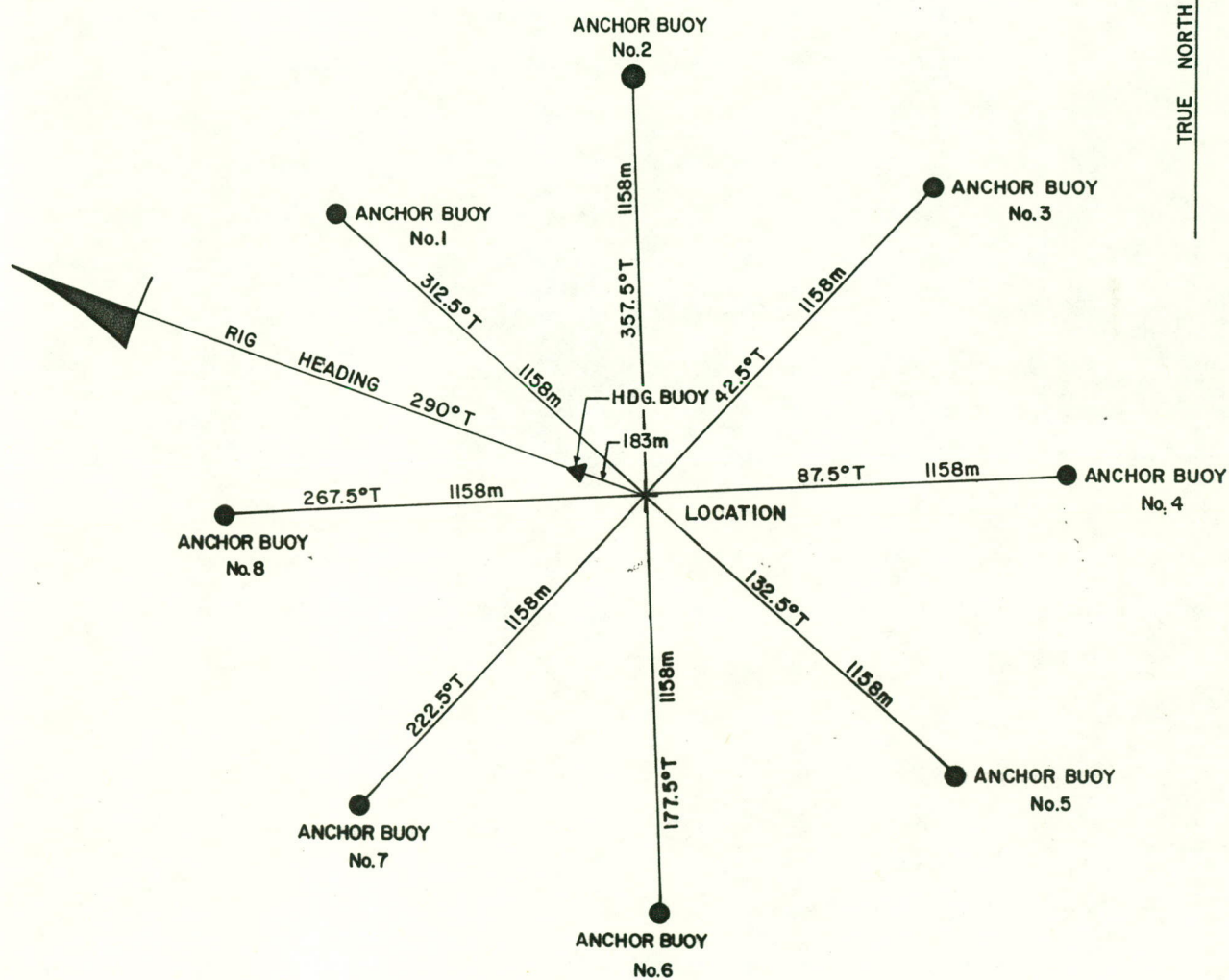
FB 33404

FIGURE 3

PROPOSED BUOY PATTERN

BOWDRILL 1 AT

PETRO-CANADA ET AL BONNET P-23



SCALE

1: 20 000



1-B 33404

4.0 FIELD SURVEYS

4.1 Operations Summary

On 31 December 1983 the Bow Drill 1 departed its St. Paul P-91 location enroute to Bonnet P-23. On the same day the M.V. Balder Cabot departed Mulgrave to first go calibrate the ARGO by baseline crossings and extensions.

On 02 January 1984 the M.V. Balder Cabot was completed calibrating the navigation and positioning system and on its way to Bonnet P-23.

On the 03 & 04 January 1984 the M.V. Balder Cabot deployed the proposed buoy pattern in preparing for the rigs arrival.

At 08:00 G.M.T. on 05 January 1984 the Bow Drill 1 started its final approach to location. At 12:00 G.M.T. the first anchor was out. The M.V. Balder Cabot assisted the rig during the day by supplying the rig with positions and acting as a target for supply boats as they hauled out anchors.

The 06 January 1984 was spent rehauling anchors and moving the rig closer to proposed location. The M.V. Balder Cabot assisted in both operations.

On 07 January 1984 an attempt at pre-tensioning was made. Due to a number of anchors slipping, the operation had to be halted until more anchors were shipped to the rig.

On 10 January 1984 the additional anchors arrived and were deployed.

At 02:10 G.M.T. on 11 January 1984 all anchors were out and pre-tensioned. At 02:34 G.M.T. the satellite receiver on the rig was initialized for the final positioning. At 18:00 G.M.T. the M.V. Balder Cabot completed the final range resection and obtained the rig position as a confirmation to back the satellite final position. At 23:10 G.M.T. the M.V. Balder Cabot was cleared from the rig to proceed to Baccaro Point to recheck its navigation system's calibration.

FB 33404

At 13:30 G.M.T. on 12 January 1984 the McElhanney Surveyor onboard the Bow Drill 1 completed collecting satellite passes. At 14:30 G.M.T. the surveyor departed the rig. At 19:00 G.M.T. the M.V. Balder Cabot arrived in Shelburne and the two McElhanney surveyors got off.

At 17:00 G.M.T. on 08 February 1984 a McElhanney surveyor departed Halifax for Bow Drill 1. At 20:30 G.M.T. he arrived on the rig and reinitialized the satellite receiver to collect another string of satellite passes to be used for the rigs final position.

On 11 February 1984 at 13:30 G.M.T. the surveyor departed the Bow Drill 1 for Halifax.

4.2 Antenna Offsets

Antenna offsets to the Mini-Ranger and Satellite Antenna were measured parallel and perpendicular to the rigs heading. The Satellite Antenna offsets were measured in metres and the Mini-Ranger offsets in feet. The distance between the two antennas were also measured to yield a redundant observation. Figures 4 & 5 show how the offsets were measured and the redundant check. The sea level heights were obtained from combination of rig drawings, measured distances and draft.

The following is the break down of measured distances to obtain the satellite and Mini-Ranger offsets (See Figure 4 for the correlation between the letters and distances measured).

FB 33404

Satellite Antenna Offset

Forward

Starboard
(Ballasted)

Sea Level Height

A = 3.77 m

B = 6.16 m

C = 3.04 m

D = 10.79 m ✓

E = 3.92 m ✓

G = 9.24 m

K = -0.21 m

36.71 m

I = 6.13 m

F = 6.06 m

J = - 0.20 m

11.99 m

24.85 m

Mini-Ranger Antenna Offset

Forward

Starboard
(Ballasted)

Sea Level Height

H = 27' 6"

E = 12' 9 3/4" ✓

D = 35' 5 3/4" ✓

C = 9' 11"

L = 21' 3 1/2"

M = 7' 9"

N = 4' 1/2"

115' 45 1/2"

36.21 m

I = 20' 1"

F = 20' 0"

40' 1"

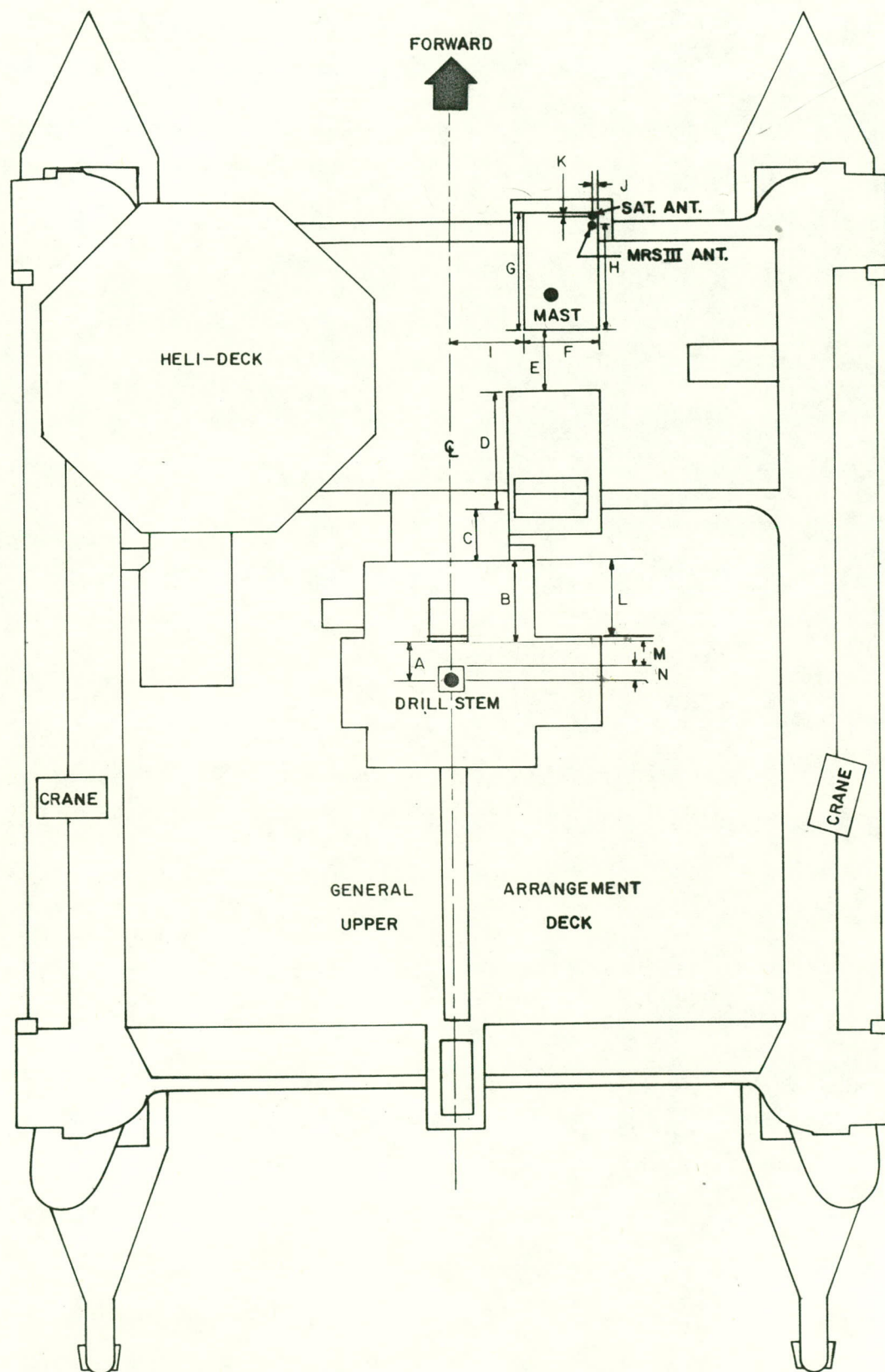
12.22 m

23.60 m

FB 33404

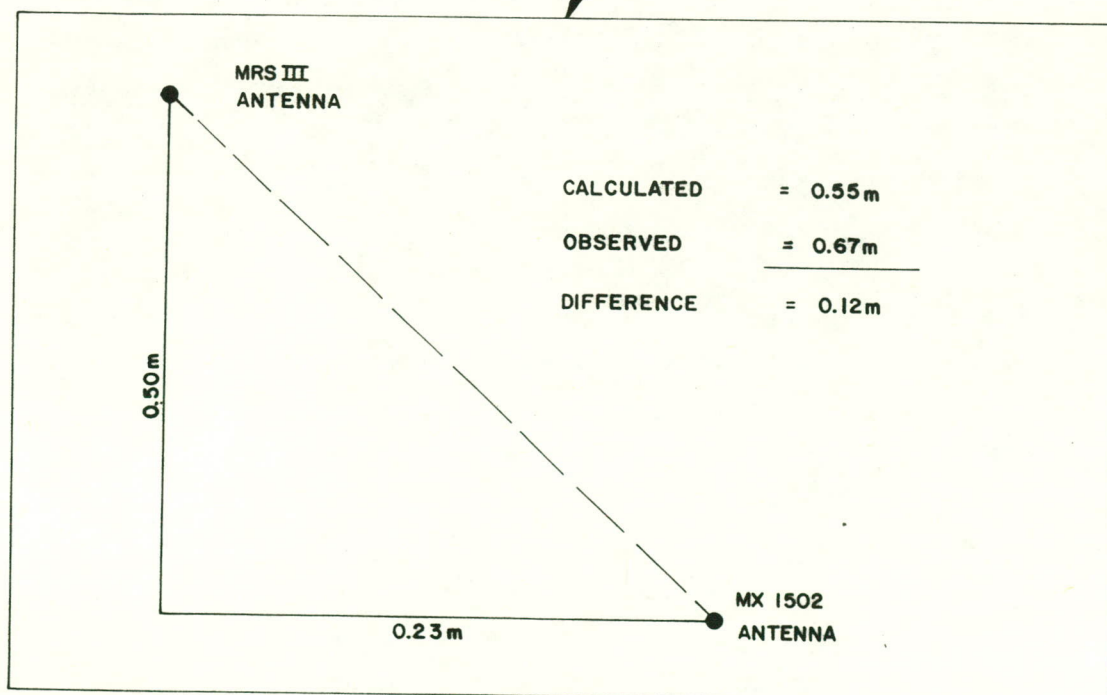
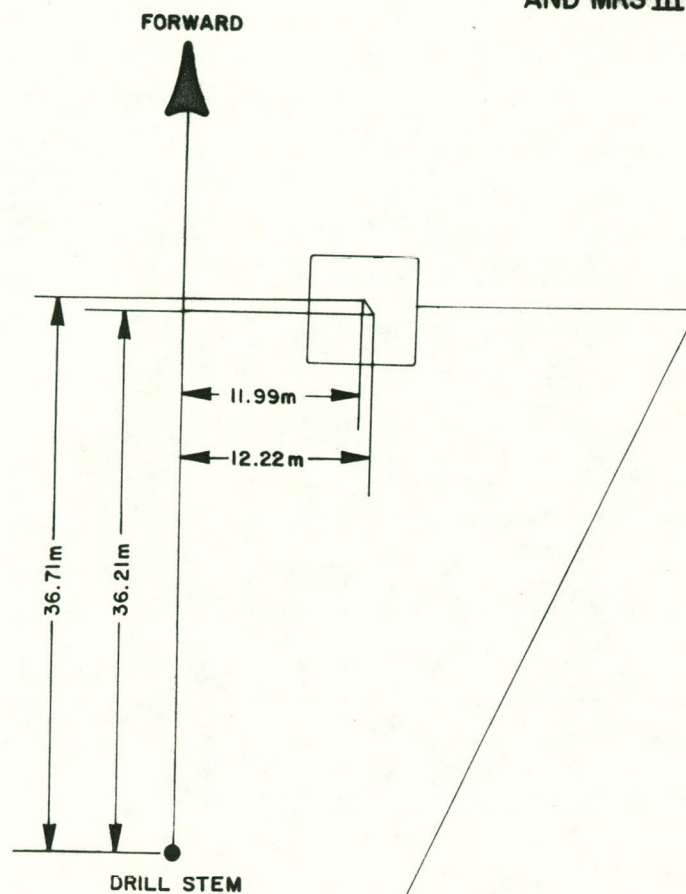
FIGURE 4

ANTENNA OFFSETS — BOWDRILL I



FB 33400

FIGURE 5
DIFFERENCE IN SATELLITE
AND MRS III ANTENNA OFFSETS



FB 33409

4.3 ARGO Calibration and Ongoing Accuracy Checks

Before any radio navigation aid such as ARGO is used to navigate or position with, the system must be calibrated. With an ARGO system this calibration is necessary to minimize the effects of local inductance, instrument error, and incorrect propagation velocities (propagation velocity assumed). Once a system is calibrated, it is monitored constantly to verify the accuracy of the calibration and to determine if the calibration requires periodic adjustment. The next two sub-sections deal with the calibration and accuracy checks of the ARGO system used for the Bow Drill 1 move to Petro-Canada et al Bonnet P-23.

4.3.1 ARGO Calibration

The ARGO system was calibrated by baseline crossings and extensions. The results follow:

Computed Baseline distance Baccaro Point/H-58 =	434473.4 m ✓
	5184.63 lanes ✓
Computed Baseline distance Baccaro Point/Indian Point=	176208.4 m ✓
	2102.72 lanes ✓
Observed crossing Baccaro Point/H-58=	5184.39 lanes
Observed extension Baccaro Point/H-58=	5184.65 lanes
Observed crossing Baccaro Point/Indian Point=	2102.59 lanes
Observed extension Baccaro Point/Indian Point=	2102.82 lanes

$$\text{Baccaro Calibration} = \frac{\Delta - \Sigma}{2} \quad 1$$

$$\text{H-58 Calibration} = \frac{2 \text{ B/L} - \Sigma - \Delta}{2} \quad 2$$

Where: Δ = Baseline Extension Observed

Σ = Baseline Crossing Observed

B/L = Computed Baseline Distance

FB 33404

Using Formulas 1 & 2 the calibration corrections are computed as:

Baccaro Point = 0.12 lanes

H-58 = 0.11 lanes

The original calibration in the system at the time of calibration was:

	<u>Baccaro Point</u>	<u>Indian Point</u>	<u>H-58</u>
Original Calibration	0.60	0.50	0.50
Calibration Corrections	<u>0.12</u>	--	<u>0.11</u>
New Calibration	0.72	--	0.61

Indian Point could not be calibrated from the crossings and extensions due to excessive amounts of land path. Indian Point was calibrated instead by observing the least squares solution residual with Baccaro Point and H-58 weighted. The residual (in metres) was divided by the lane width to obtain a calibration value in partial lanes.

The final calibration values used for the rig move were:

Baccaro Point=	0.72
Indian Point=	0.68
H-58=	0.61

4.3.2 Ongoing Accuracy Checks

Table 4 is a summary of daily meaned ARGO/satellite comparisons collected during the survey while in the Bonnet P-23 area.

FB 33404

TABLE 4

DAILY MEANED ARGO/SATELLITE COMPARISONS

Date	No. of Passes	Daily Mean Values		
		R1	R2	R3
3 January 1984	5	7	-17	-13
4 January 1984	7	-17	-6	-13
5 January 1984	11	1	5	18
6 January 1984	11	-5	-5	4
7 January 1984	10	-14	-10	-2
8 January 1984	4	-25	-3	21
9 January 1984	6	-1	1	-1
10 January 1984	1	-33	-5	23
11 January 1984	4	-10	-14	-15
12 January 1984	1	0	-20	-14

△ R1: Difference in metres between satellite derived ARGO range and observed range for station Baccaro Point

△ R2: For station Indian Point.

△ R3: For station H-58.

After the final resection on the 11 January 1984 the M.V. Balder Cabot sailed back to Baccaro Point and did baseline crossings and extensions once again. The Baccaro Point range checked to within 1 m and the H-58 range to within 6 m. The Indian Point range could not be checked due to land path.

FB 33404

4.4 Final Position of Well Location

The final position of the Bow Drill 1 on Petro-Canada et al Bonnet P-23 was determined by a single point solution using a Magnavox 1107 in 3-D Mode. Thirty-four satellite passes were used in the solution. Documentation for the 3-D program can be obtained from Magnavox, Torrance, California, U.S.A.

The NWL 10D broadcast position of the satellite antenna is:

Latitude	42° 22' 49.56" N
Longitude	65° 03' 01.92" W

This position was traversed back to the drillstem using a rig heading of 287° (determined by Gyro and confirmed by Survey Boat) and offsets of:

36.71 m	Forward
11.99 m	Starboard

The position of the drillstem in NWL 10D is:

Latitude	42° 22' 48.84" N
Longitude	65° 03' 00.54" W

This drill stem position was converted to NAD 27 by using datum shifts published for Shearwater, Halifax Co., Nova Scotia.

$\Delta X =$	-40 m
$\Delta Y =$	159 m
$\Delta Z =$	182 m

Geoid Height = 25.7 m

Sea Level Height = 26.6 m (calculated by satellite receiver)

Ellipsoid Height = 0.9 m

FB 33404

The final NAD position of the drillstem is:

Latitude: 42° 22' 48.64" N
Longitude: 65° 03' 01.89" W

*30' per
Tel-con Wallis-McElkenny
25-04-85*

This places the drillstem 41.4 m at a bearing of 298° 39' from proposed location.

Appendix B contains the pass by pass positions as computed by the Magnavox software and a scatter plot of the same.

4.5 Final Position Confirmation

The final position was confirmed by a least squares range resection using an ARGO DM-54 and Mini-Ranger III ranges to a transponder onboard the rig.

The confirmation position determined was:

Latitude: 42° 22' 48.86" N
Longitude: 65° 03' 01.48" W

This position situates the rig 37.9 m at a bearing of 314° 30' from proposed location.

The satellite final and ARGO DM-54 confirmation positions differ by 11.6 m.

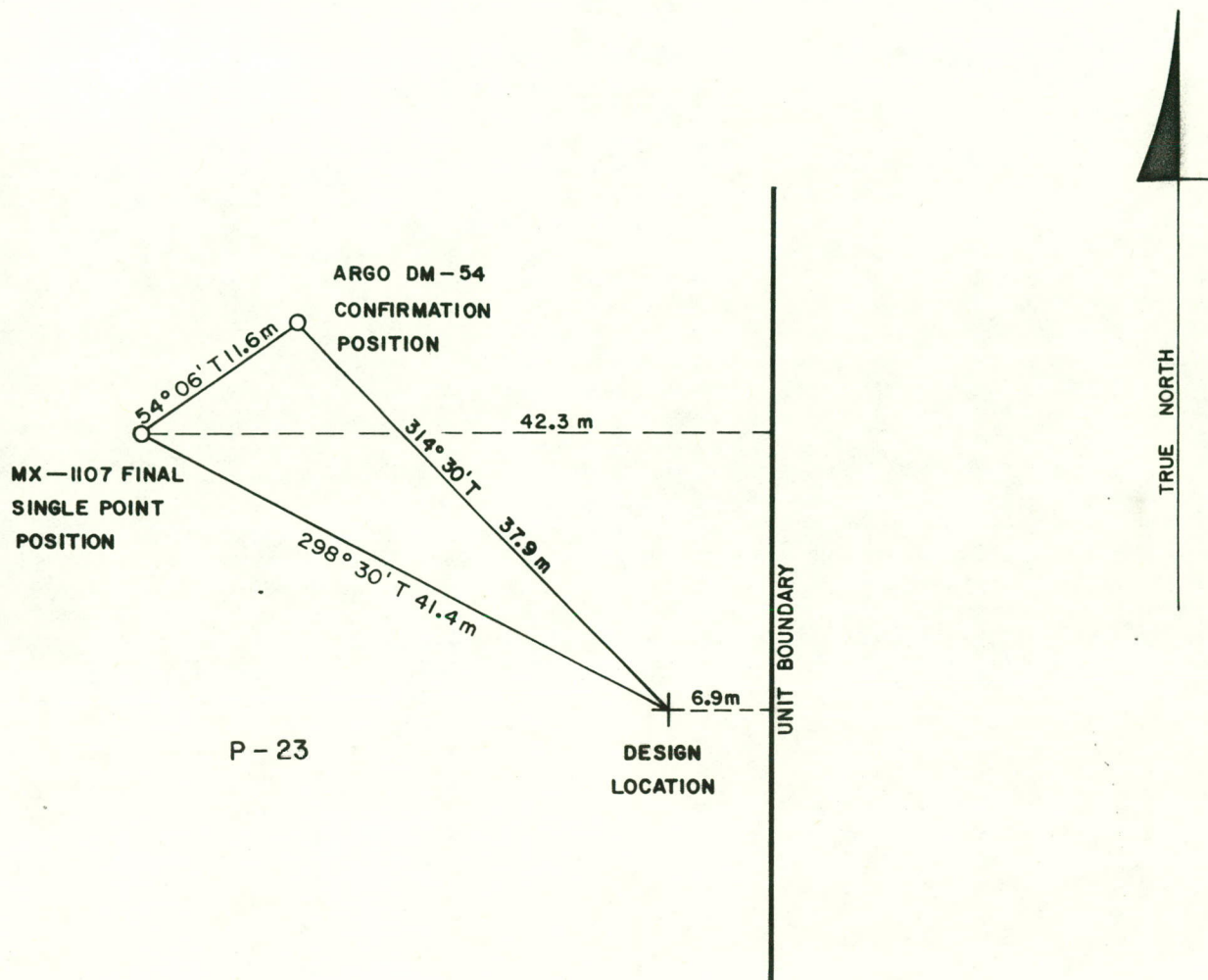
Appendix C contains the ARGO DM-54 resection data. Figure 6 is a sketch of the satellite, ARGO DM-54 and proposed location positions.

4.6 Accuracy Analysis

The Petro-Canada survey requirement was that the final drillstem position be within a 100 m radius of the proposed location. As can be seen from Section 4.4 and Figure 6, the final position is well within the 100 m tolerance requirement.

FB 33404

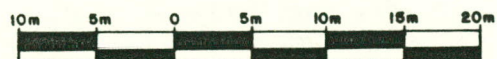
FIGURE 6
POSITION COMPARISONS
BOWDRILL 1 AT
PETRO-CANADA ET AL BONNET P-23



P - 23

SCALE

1: 500



FB 33404

In order to ensure the accuracy and repeatability of the final coordinates of an offshore Exploratory Well, Energy, Mines and Resources Canada (EMRC) has stipulated in a document titled "Surveying Offshore Canada Lands for Mineral Resource Development", that the final position meet fourth order accuracy requirements with respect to the nearest geodetic shore control station. According to "Specifications and Recommendations for Control Surveys and Survey Markers" (EMRC, Surveys and Mapping Branch, 1978), a position is classified as being fourth order if the semi-major axis of the 95% confidence ellipse, with respect to the nearest shore control, is less than or equal to:

$$r = c (d + 0.2)$$

Equation 1

where,

c = Factor assigned according to the order of Survey, for fourth order c = 30

d = Distance to nearest shore control in kilometres

r = Semi-major axis in centimetres

The distance from Bonnet P-23 to station Baccaro Point is 123.7 KM. Substituting the given values (c = 30, d = 123.7 KM) into equation 1 produces the result that for fourth order classification the semi-major axis of the 95% confidence ellipse must be less than or equal to 37.17 metres.

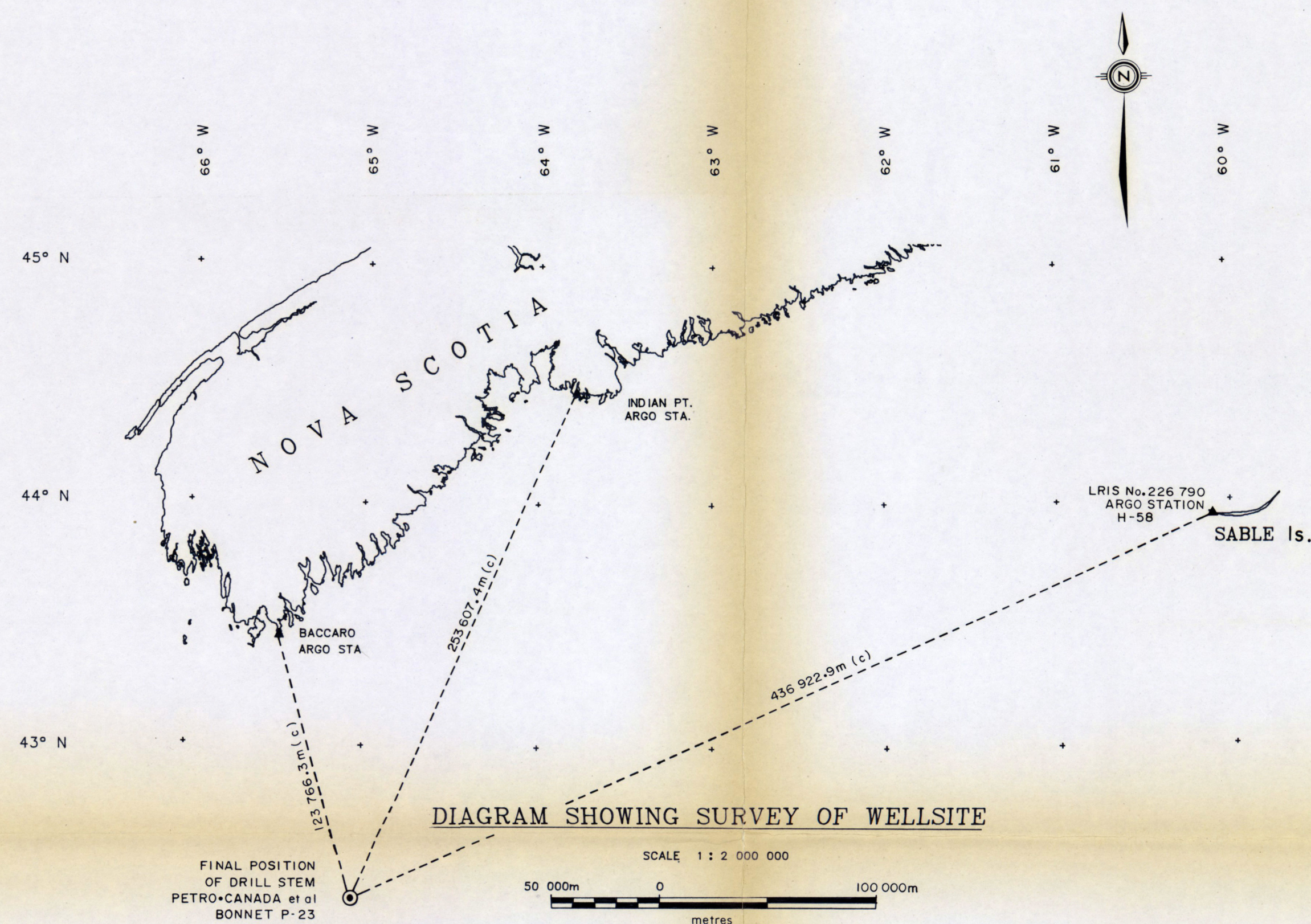
The final position was determined using 34-3 dimensional satellite passes collected on the Magnavox 1107RS receiver. Many papers and books have been written on the accuracy of single point positioning; one being Electronic Surveying & Navigation by Simo Laurila, 1976. In this book the author states maximum radial errors to be 10.4 metres with 25 passes and 9.6 metres with 50 passes. Assuming a maximum standard error of 10 metres, multiplying by 2.45 gives a value of 24.5 metres error at the 95% level. This is felt to be a pessimistic estimation of the achievable accuracy of single point positioning but still falls within the fourth order criteria.

FB 33404

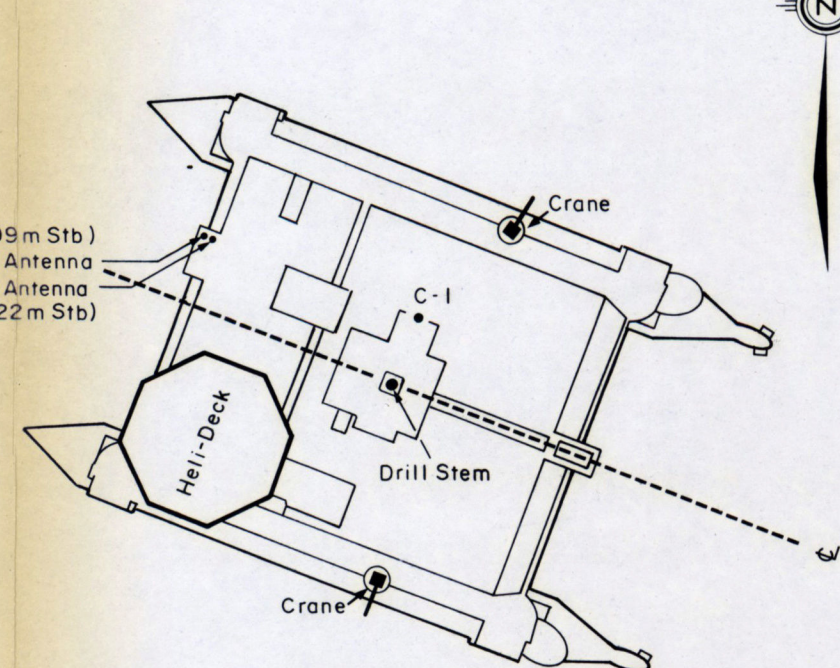
APPENDIX A

**Final Plan of Survey for
Petro-Canada Et Al Bonnet P-23**

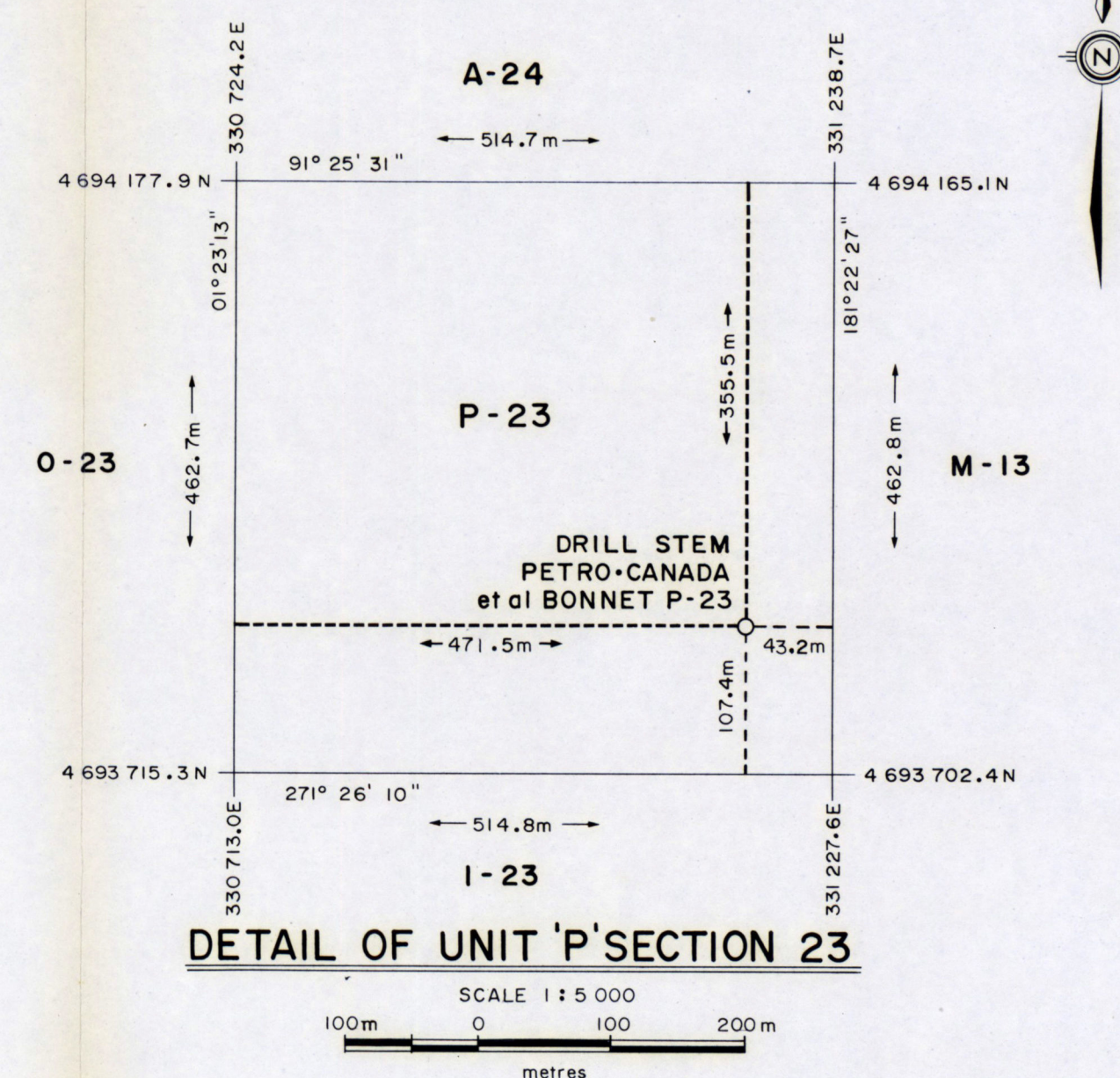
FB 33404



SATELLITE & MINI-RANGER ANTENNA
OFFSETS FROM DRILL STEM ON
BOWDRILL I



CONFIRMATION SURVEY			
ARGO SHORE STATION COORDINATES, NAD 27			
STATION	GEOGRAPHICS	UTM, ZONE 20 CM 63°W	SURFACE DISTANCE TO DRILL STEM (COMPUTED)
BACCARO *	43° 27' 00.508"N 65° 28' 22.803"W	4 813 559.44N 299 898.31E	123 766.3m
INDIAN Pt *	44° 28' 14.441"N 63° 47' 32.765"W	4 924 240.85N 436 969.78E	253 607.4m
H-58 LRIS No. 226 790	43° 57' 28.040"N 60° 07' 39.176"W	4 870 980.20N 730 469.70E	436 922.9m
DRILL STEM POSITION BY ARGO-RESECTION	42° 22' 48.86"N 65° 03' 01.48"W	4 693 817.38N 331 196.46E	11.6m
* AWAITING CLSR REGISTRATION			
ARGO DM-54 INFORMATION			
FREQUENCY	1 788.0kHz		
PROPAGATION VELOCITY (ASSUMED)	299 670.0 km/sec		
LANE WIDTH (COMPUTED)	83.800 336m		



OIL & GAS GRID COORDINATES, 1927 NAD					
	CORNER	GEOGRAPHIC		UTM, ZONE 20, CM 63°W	
		LATITUDE, N	LONGITUDE, W	NORTHING (m)	EASTING (m)
GRID AREA	NE	42° 30'	65° 00'	4 707 017.0	335 660.2
	NW	42° 30'	65° 15'	4 707 532.0	315 116.8
	SE	42° 20'	65° 00'	4 689 510.0	335 224.3
	SW	42° 20'	65° 15'	4 689 024.7	314 626.3
UNIT P SECTION 23	NE			4 694 165.1	331 238.7
	NW			4 694 177.9	330 724.2
	SE			4 693 702.4	331 227.6
	SW			4 693 715.3	330 713.0

FINAL WELLSITE COORDINATES, 1927 NAD				
	GEOGRAPHIC		UTM, ZONE 20, CM 63°W	
	LATITUDE, N	LONGITUDE, W	NORTHING (m)	EASTING (m)
MAGNAVOX MX 1107 ANTENNA	42° 22' 49.36"	65° 03' 03.27"	4 693 833.79	331 155.90
PLATFORM CI	42° 22' 49.01"	65° 03' 01.73"	4 693 822.14	331 190.86
BOWDRILL I DRILL STEM AS DETERMINED BY SATELLITE SURVEY	42° 22' 48.64"	65° 03' 01.89"	4 693 810.82	331 186.92

PRIMARY SURVEY			
SUMMARY OF DOPPLER SATELLITE POINT SURVEY			
	OBSERVED GEOCENTRIC ANTENNA COORDINATES (broadcast ephemeris datum)	PUBLISHED DATUM SHIFT ②	DERIVED 1927 NAD COORDINATES (Geocentric minus datum shift)
CARTESIAN COORDINATES $\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$	$\begin{bmatrix} 1\ 990\ 401.73\text{ m} \\ -4\ 278\ 277.68\text{ m} \\ 4\ 276\ 912.54\text{ m} \end{bmatrix}$	$\begin{bmatrix} -40\text{ m} \\ 159\text{ m} \\ 182\text{ m} \end{bmatrix}$	$\begin{bmatrix} 1\ 990\ 441.73\text{ m} \\ -4\ 278\ 436.68\text{ m} \\ 4\ 276\ 730.54\text{ m} \end{bmatrix}$
LATITUDE ϕ	42° 22' 49.56" N		42° 22' 49.36" N
LONGITUDE λ	65° 03' 01.92" W		65° 03' 03.27" W
Ht. above sea level (H)	26.6 m		26.6 m
GEOID Ht (GEM IOB) ② (N)	-25.7 m		7.2 m
Ht. above ELLIPSOID (h)	0.9 m		33.8 m
No. OF ACCEPTED PASSES	34		-
① Coordinates are on the geocentric World Geodetic System (WGS 72) as provided by the satellite's broadcast ephemeris.			
② GEM IOB is the Goddard Earth Model of the geoid for which the given heights are computed relative to an eccentric 1927 NAD.			
The eccentricity used to compute the geoid height was the published datum shift at station SHEARWATER $x_0 = -40$, $y_0 = +159$, $z_0 = +182$ (in Surveying Offshore Canada Lands for Mineral Resource Development, Third Edition, 1982).			
DRILL STEM POSITION BY SATELLITE 3-D POSITIONING	GEOGRAPHIC COORDINATES, NAD 27		UTM ZONE 20, CM 57°W
	42° 22' 48.64"N	65° 03' 01.89"W	4 693 810.82mN 331 186.92mE

PETRO-CANADA LTD.

PLAN AND FIELD NOTES
OF SURVEY OF OFFSHORE
EXPLORATORY WELL LOCATION

PETRO-CANADA et al
BONNET P-23

LATITUDE : 42° 22' 48.64"N

LONGITUDE : 65° 03' 01.89"W

GRID AREA: 42° 30' N 65° 00' W

SURVEYED DEC. 29, 1983 To JAN. 12, 1984

BY: McELHANNEY SERVICES LTD.

FOR: PETRO-CANADA LTD.

NOTE:

The final position was determined by DOPPLER SATELLITE OBSERVATIONS using a MAGNAVOX MX1107RS satellite positioning system (three dimensional solution with 34 acceptable passes). Documentation for its program can be obtained from Magnavox of Torrance, California. The values used for the local datum shift from broadcast ephemeris datum to NAD 27 were $\Delta X = -40$, $\Delta Y = +159$, $\Delta Z = +182$ m for station SHEARWATER and were obtained from GEODETIC SURVEYS of CANADA.

The final position was confirmed by the survey vessel M/V BALDER CABOT using an ARGO DM-54 positioning system with shore stations on the coast of Nova Scotia. The position of the drill stem with respect to the survey vessel was derived by RANGE RESECTION. Information about the ARGO DM-54 radio positioning system can be obtained from CUBIC CORPORATION, San Diego, California.

Bearings and distances shown on the "UNIT DETAIL" are UTM plane referred to ZONE 20, CENTRAL MERIDIAN 63° W, using a false easting of 500 000 m. (c) indicates calculated distances on the ellipsoid.

All other distances are surface distances, and are NOT reduced to UTM plane unless indicated.

All GEOGRAPHIC COORDINATES are referred to 1927 North American Datum (1927 NAD) CLARKE 1866 ELLIPSOID.

Water depth at the location is approximately 133.5 metres.

The final 3-D satellite passes were collected on February 8 and 9, 1984.

I HEREBY CERTIFY THAT THE SURVEY REPRESENTED ON THIS PLAN
IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE

J. Andrew Power
CLS

Raymond Pottier
WITNESS

April 5, 1984
DATE

PETRO-CANADA

J. S. Brindle

10 April 84

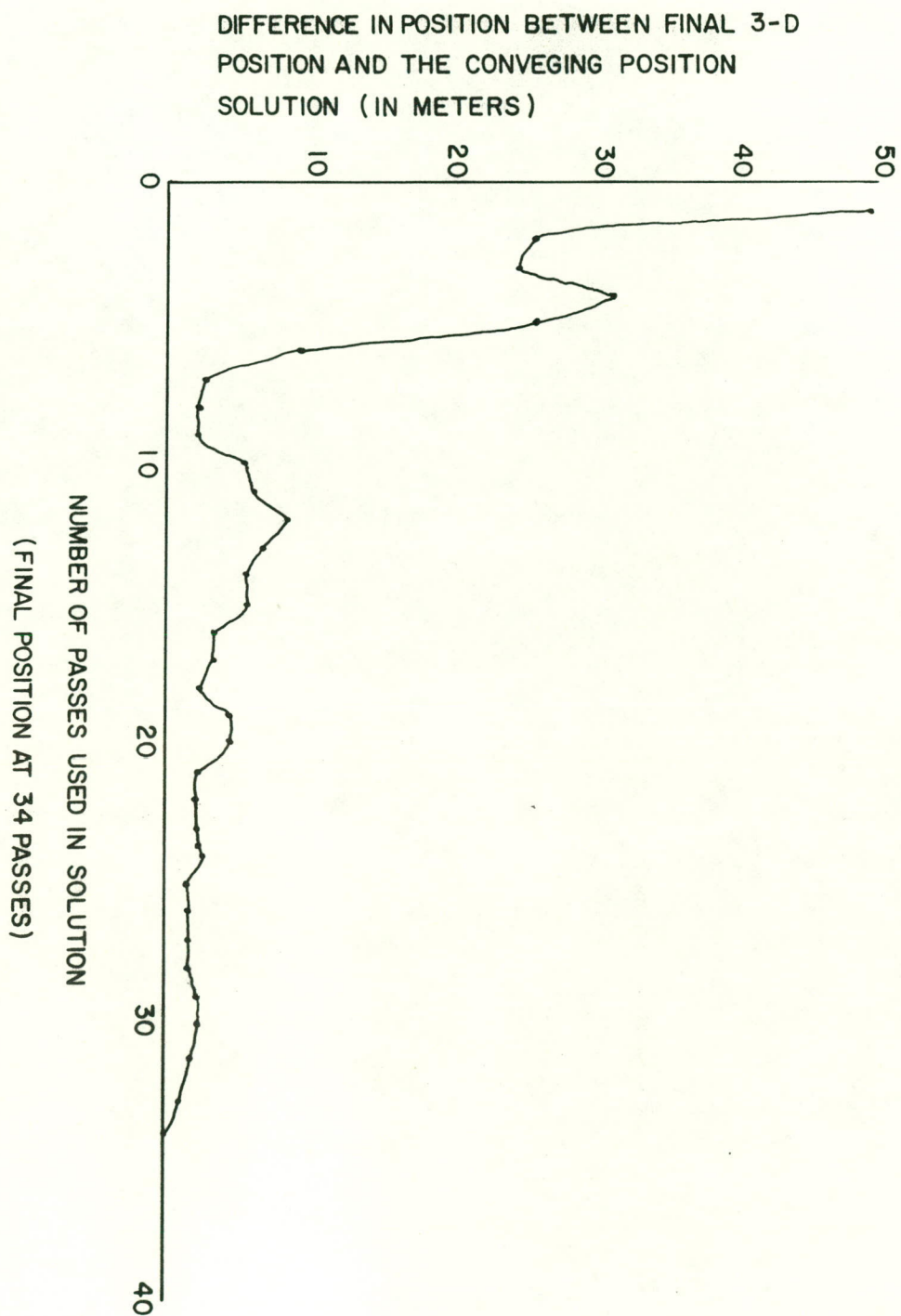
DATE

APPENDIX B

Magnavox 1107RS Position Convergence Data

FB 33406

MAGNAVOX 1107 POSITION CONVERGENCE
BOWDRILL 1 AT BONNET P-23



FB 33404

APPENDIX C

ARGO DM-54 Resection Data

FB 33404

SUBJECT <i>Bowditch I</i>	DESIGN <i>R</i>	CHECK	JOB NO.	PAGE
<i>Resection #13 Recalculated</i>	DATE <i>14 March 84</i>	DATE	<i>253747</i>	

MRS Range

1
↓
598

LINE	0.00
EVNT	0.00
DATE	0 0 0
TIME	0 00 00.0
LAT	42 22 57.3
LON	-65 02 38.3
NRTH	4694064.4
EAST	331732.7
OFST	0.0
TRCK	4694064.4
TPDP	0.0 0.0
SPHD	
401	-0.3 123661
601	0.4 253149
801	-0.3 436322

2

LINE	452	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 47.9	
LON	-65 02 43.1	
NRTH	4693776.2	
EAST	331616.9	
OFST	0.0	
TRCK	4693776.2	
TPDP	0.0 0.0	
SPHD		
401	-2.1 123911	
601	3.2 253457	
801	-2.0 436546	

3

LINE	444	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 41.2	
LON	-65 02 47.3	
NRTH	4693573.1	
EAST	331515.3	
OFST	0.0	
TRCK	4693573.1	
TPDP	0.0 0.0	
SPHD		
401	0.7 124079	
601	-1.1 253688	
801	0.7 436719	

4

LINE	480	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 35.1	
LON	-65 02 53.8	
NRTH	4693390.1	
EAST	331362.1	
OFST	0.0	
TRCK	4693390.1	
TPDP	0.0 0.0	
SPHD		
401	-0.2 124218	
601	0.4 253917	
801	-0.2 436934	

5

LINE	488	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 33.6	
LON	-65 03 04.7	
NRTH	4693347.1	
EAST	331112.3	
OFST	0.0	
TRCK	4693347.1	
TPDP	0.0 0.0	
SPHD		
401	1.6 124195	
601	-2.4 254063	
801	1.6 437178	

6

LINE	480	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 36.7	
LON	-65 03 15.1	
NRTH	4693449.6	
EAST	330876.7	
OFST	0.0	
TRCK	4693449.6	
TPDP	0.0 0.0	
SPHD		
401	1.0 124037	
601	-1.5 254067	
801	0.9 437352	

7

LINE	444	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 43.5	
LON	-65 03 20.8	
NRTH	4693663.3	
EAST	330749.9	
OFST	0.0	
TRCK	4693663.8	
TPDP	0.0 0.0	
SPHD		
401	0.6 123798	
601	-0.8 253924	
801	0.5 437382	

8

LINE	483	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 51.3	
LON	-65 03 24.3	
NRTH	4693905.1	
EAST	330677.2	
OFST	0.0	
TRCK	4693905.1	
TPDP	0.0 0.0	
SPHD		
401	0.2 123547	
601	-0.3 253735	
801	0.2 437351	

9

LINE	428	0.00
EVNT	0.00	
DATE	0 0 0	
TIME	0 00 00.0	
LAT	42 22 58.1	
LON	-65 03 18.1	
NRTH	4694110.9	
EAST	330825.7	
OFST	0.0	
TRCK	4694110.9	
TPDP	0.0 0.0	
SPHD		
401	-0.2 123385	
601	0.4 253485	
801	-0.2 437132	

FB 33404

SUBJECT	Bowditch	DESIGN	B	CHECK		JOB NO		PAGE	
	Resection # 13 Resampled	DATE	14 March 84	DATE		083747			

10

LINE 470 0.00
 EVNT 0.00
 DATE 0 0 0
 TIME 0 00 00.0
 LAT 42 23 03.9
 LON -65 03 10.7
 NRTH 4694285.2
 EAST 330996.9
 OFST 0.0
 TRCK 4694285.2
 TPDP 0.0 0.0
 SPHD
 401 0.6 123259
 201 -1.0 253256
 X01 0.6 436904

11

LINE 518 0.00
 EVNT 0.00
 DATE 0 0 0
 TIME 0 00 00.0
 LAT 42 23 06.6
 LON -65 02 59.6
 NRTH 4694362.7
 EAST 331251.5
 OFST 0.0
 TRCK 4694362.7
 TPDP 0.0 0.0
 SPHD
 401 -0.5 123249
 201 0.8 253078
 X01 -0.5 436641

12

LINE 514 0.00
 EVNT 0.00
 DATE 0 0 0
 TIME 0 00 00.0
 LAT 42 23 02.8
 LON -65 02 48.6
 NRTH 4694240.4
 EAST 331500.8
 OFST 0.0
 TRCK 4694240.4
 TPDP 0.0 0.0
 SPHD
 401 -1.4 123432
 201 2.0 253084
 X01 -1.3 436463

FB 33406

SUBJECT *Resection #13*
*Recomputed*DESIGN *B*

CHECK

JOB NO

PAGE

DATE *4 March 84*

DATE

*083747*LEAST SQUARES
RANGE RESECTIONMID-LAT 42.50
CENT MER -63.00
CAL 8.20
TARGET HT 3.00FIX NO 1.00
NORTH 4694064.40
EAST 331732.70
3.15 598.00FIX NO 2.00
NORTH 4693776.20
EAST 331616.90
-4.78 452.00FIX NO 4.00
NORTH 4693390.10
EAST 331362.10
2.95 480.00FIX NO 5.00
NORTH 4693347.10
EAST 331112.30
0.04 488.00FIX NO 6.00
NORTH 4693449.60
EAST 330876.70
-1.91 480.00FIX NO 7.00
NORTH 4693663.80
EAST 330749.90
-0.09 444.00FIX NO 8.00
NORTH 4693905.10
EAST 330677.20
1.95 483.00FIX NO 9.00
NORTH 4694110.90
EAST 330825.70
-1.41 428.00FIX NO 10.00
NORTH 4694285.20
EAST 330996.90
-2.28 470.00FIX NO 11.00
NORTH 4694362.70
EAST 331251.50
3.09 518.00FIX NO 12.00
NORTH 4694240.40
EAST 331500.80
-0.57 514.00-----
POSITION FIXNORTH 4693840.39
EAST 331166.06
42 22 49.5819
λ -65 03 02.8330
MRS Ant

GEO-TRAV PT-PT

ELLIPSOID DATA

a = 6378206.40
b = 6356583.80
1/f = 294.978698
L FCT 1.0000000MRS Ant.
42 22 49.5819
λ -65 03 02.8330
AZ 197 00 00.00
D(m) 12.217
AZ 16 59 59.89
42 22 49.2033
λ -65 03 02.9892C.I.
C.I.
42 22 49.2033
λ -65 03 02.9892
AZ 107 00 00.00
D(m) 36.208
AZ 287 00 01.02
42 22 48.8602
λ -65 03 01.4756
Drillstem (ARGO)

FB 3340 b