

CANADA LANDS SURVEYS RECORDS
FB. 3 3 3 5 6
Date 3 APR. 1984



McElhanney

CANADA LANDS SURVEYS RECORDS
FB. 3 3 3 5 6

PETRO-CANADA

**NAVIGATION AND POSITIONING OF THE
DRILLSHIP "PELERIN" ON OFFSHORE
EXPLORATORY WELL LOCATION,
PETRO-CANADA ET AL PINING E-16**

JOB 083562

**Submitted by:
McELHANNEY OFFSHORE SURVEYS LTD.
10 Austin Street
Donna Building
O'Leary Industrial Park
St. John's, Newfoundland
A1B 4B8**

Telephone: (709) 726-4252

DECEMBER, 1983



FB 33356

TABLE OF CONTENTS

| | <u>Page</u> |
|--|-------------|
| 1.0 INTRODUCTION | 1 |
| 2.0 EQUIPMENT AND PERSONNEL | 1 |
| 2.1 MV Balder Cabot | 1 |
| 2.2 Pelerin | 4 |
| 3.0 SURVEY DATA | 5 |
| 3.1 ARGO Station Coordinates | 5 |
| 3.2 ARGO DM-54 Information | 6 |
| 3.3 Mini-Ranger Station Coordinates | 6 |
| 3.4 Proposed Well Location | 6 |
| 4.0 FIELD SURVEYS | 8 |
| 4.1 Antenna Offsets | 8 |
| 4.2 Operations Summary | 8 |
| 4.3 ARGO Calibration and Accuracy Checks | 12 |
| 4.3.1 ARGO Calibration | 12 |
| 4.3.2 Ongoing Accuracy Checks | 15 |
| 4.4 Final Position of Well Location | 17 |
| 4.5 Final Position Confirmation | 20 |
| 5.0 CONCLUSIONS AND RECOMMENDATIONS | 23 |
| 5.1 Position Comparisons | 23 |
| 5.2 Survey Accuracy Analysis | 23 |
| 5.3 Problems | 26 |
| 5.4 Recommendations | 27 |

FB 33356

LIST OF TABLES

| | | Page |
|------------|---|------|
| TABLE 1 - | BALDER CABOT PERSONNEL AND EQUIPMENT | 3 |
| TABLE 2 - | PELERIN PERSONNEL AND EQUIPMENT | 4 |
| TABLE 3 - | ARGO SHORE STATION COORDINATES | 5 |
| TABLE 4 - | ANTENNA OFFSETS ON DRILLSHIP PELERIN | 7 |
| TABLE 5 - | RESECTION RIG POSITION SUMMARY | 11 |
| TABLE 6 - | ARGO/SATELLITE CALIBRATION SUMMARY | 13 |
| TABLE 7 - | DAILY MEAN ARGO/SATELLITE COMPARISONS | 15 |
| TABLE 8 - | ARGO RANGE RESECTION DATA FOR FINAL POSITION | 17 |
| TABLE 9 - | MINI-RANGER RESIDUAL DATA FOR FINAL POSITION | 19 |
| TABLE 10 - | SUMMARY OF SATELLITE ANTENNA POSITIONS FOR CONFIRMATION SURVEY | 20 |
| TABLE 11 - | SUMMARY OF SATELLITE POSITIONS TRAVERSED TO DRILLSTEM | 21 |

LIST OF FIGURES

| | | |
|------------|--|----|
| FIGURE 1 - | SCHEMATIC OF EQUIPMENT ON BALDER CABOT | 2 |
| FIGURE 2 - | TENTATIVE PLAN OF SURVEY | 7 |
| FIGURE 3 - | ANTENNA OFFSETS | 9 |
| FIGURE 4 - | FINAL POSITION COMPARISON | 24 |
| FIGURE 8 - | PROPOSED BUOY PATTERN | |

APPENDICES

| | |
|--------------|---|
| APPENDIX A - | OUTPUT FROM GEOPAN FOR ACCURACY ANALYSIS |
| APPENDIX B - | FINAL PLAN PETRO-CANADA ET AL PINING E-16 |

FB 33356

1.0 INTRODUCTION

Part of the Labrador program for Petro-Canada during the season of 1983 involved the spudding of a new hole for which McElhanney Offshore Surveys provided navigation and positioning for the drillship Pelerin at Offshore Exploratory Well Location Petro-Canada et al Pining E-16. The following report summarizes the onshore and offshore activities pertaining to that rig move, details the results, discusses any problems encountered and suggests recommendations for future moves of this type.

The final drillstem position (1927 NAD) as determined using a combination of ARGO DM-54 and Mini-Ranger III ranges is:

| | |
|-----------|------------------|
| Latitude | 54° 45' 22.47" N |
| Longitude | 55° 02' 49.06" W |

This situates the drillstem 11.6 m at 271° from the design location.

2.0 EQUIPMENT AND PERSONNEL

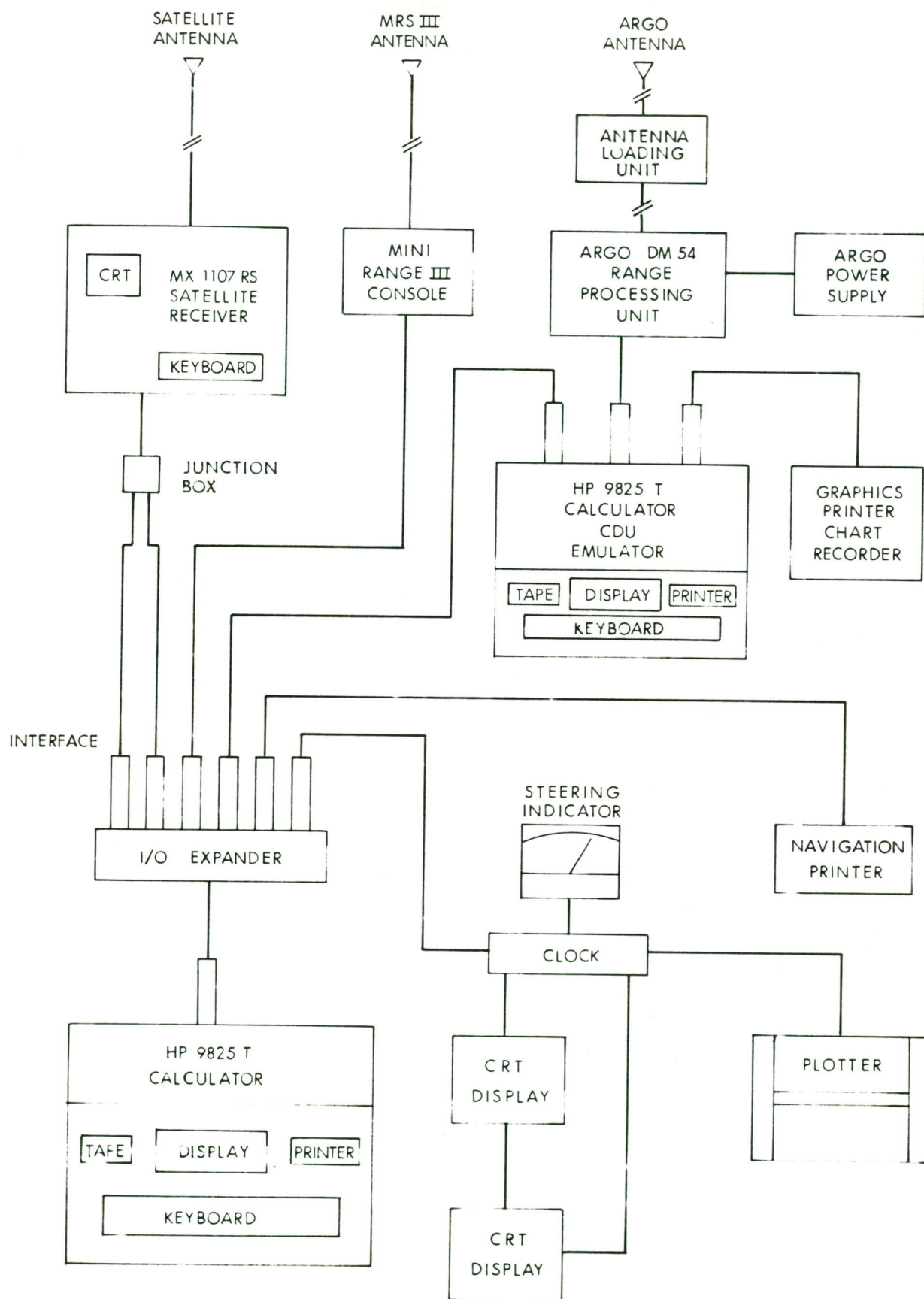
2.1 MV Balder Cabot

The integrated navigation and positioning system onboard the 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 Magnavox MX 1107 RS Satellite Receiver;
- A Motorola Mini-Ranger III receiver;
- HP 9825 T computers.
- NAVPAK software

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

FB 3 3354



SYSTEM COMPONENTS

FIGURE 1

FB 33354

For this rig move the ARGO DM-54 system was used as the prime means of positioning. The NAVPAK software (documentation available from McElhanney Offshore Surveys Ltd., St. John's, Newfoundland) allows for range input from multiple sensors which are used in a weighted least squares solution to yield 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 intended to be used as the means of calibrating the ARGO system, but due to shore station equipment problems and extensive ice coverage near the coast line at the time of the move the ARGO was instead calibrated by Satellite/ARGO comparisons. Section 4.3 "ARGO Calibration and Accuracy Checks" details this aspect of the move. The MX 1107 Satellite Receiver was also used to obtain and maintain ARGO lane count on the survey vessel.

TABLE 1
BALDER CABOT

Equipment

| | |
|---|--|
| 1 | ARGO DM-54 Range Processing Unit |
| 1 | ARGO DM-54 Antenna Loading Unit |
| 1 | Magnavox 1107RS Satellite Receiver |
| 1 | Motorola Mini-Ranger III Console and Transponder |
| 1 | HP 9825T CDU Emulator |
| 1 | HP 9825T Navigation computer |
| 1 | HP I/O Expander |
| 1 | Microline 82A Navigation Printer |
| 1 | Microline 82A Graphics Printer |
| 1 | Houston Instruments Track Plotter |

FB 33350

Personnel

| | |
|---|-------------------------|
| Max Sullivan Senior Surveyor/Party Chief N.L.S. | June 20 to July 4, 1983 |
| Bob Hinchley Senior Surveyor C.L.S. | June 20 to July 4, 1983 |
| Pat Power Navigator | June 20 to July 4, 1983 |

2.2 Drillship Pelerin

Onboard the drillship Pelerin the survey equipment consisted of a Motorola Mini-Ranger III transponder and a Magnavox MX 1107 RS satellite receiver.

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 drillships location (see Section 4.0). The MX 1107 satellite receiver onboard the Pelerin was used to obtain a confirmation position by doppler satellite point positioning.

TABLE 2
DRILLSHIP PELERIN

Equipment

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

Personnel

| | |
|-------------------------|-------------------------|
| Terry Walker - Surveyor | June 24 to July 7, 1983 |
|-------------------------|-------------------------|

FB 33354

3.0 SURVEY DATA

3.1 ARGO Station Coordinates

Four ARGO shore stations were used for this rig move. These stations were located at Spotted Island, Cape Harrison, Cape Harrigan (all under CLSR # 64857) and Stirrup Island (CLSR # 67305). ARGO Antenna coordinates and the chain configuration for these four stations are given in Table 3.

TABLE 3
ARGO SHORE STATION COORDINATES

| ARGO STATION | CODE | MODE | GEOGRAPHICS (NAD 1927) | UTM COORDINATES ZONE 21/CM 57°W | MSL ELEV (M) |
|-------------------|-------|-------|---------------------------|------------------------------------|--------------------|
| Spotted Island | 1-ODD | Slave | 53°30'58.673" N | N 5 930 216.223 | 84 |
| 1983 ARGO Station | AR 1 | | 55°45'02.429" W | E 582 840.078 | |
| CLSR # 64857 | | | | | |
| Cape Harrison | 2-ODD | Relay | 54°55'28.777" N | N 6 086 596.012 | 180 |
| 1983 ARGO Station | AR 2 | | 57°56'20.674" W | E 439 814.929 | |
| CLSR # 64857 | | | | | |
| Cape Harrigan | 3-ALL | Slave | 55°50'29.959" N | N 6 193 226.256 | 79 |
| 1983 ARGO Station | AR 3 | | 60°19'09.703" W | E 292 168.385 | |
| CLSR #64857 | | | | | |
| Stirrup Island | 4-ALL | Slave | 57°34'10.982" N | N 6 388 805.132 | 72 |
| 1983 ARGO Station | AR 4 | | 61°18'56.756" W | E 241 939.830 | |
| CLSR #67305 | | | | | |

FB 33354

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 21, central meridian 57° W.

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

| | |
|--------------|-------|
| $\Delta X =$ | -38 m |
| $\Delta Y =$ | 158 m |
| $\Delta Z =$ | 184 m |

3.2 ARGO DM-54 Information

| | |
|---------------------------------|------------------|
| Range Frequency - | 1766.0 kHz |
| Lane Identification Frequency - | 1942.6 kHz |
| Assumed Propagation Velocity - | 299670 km/sec |
| Lane Width (calculated) - | 84.844281 meters |

3.3 Mini-Ranger Station Co-ordinates

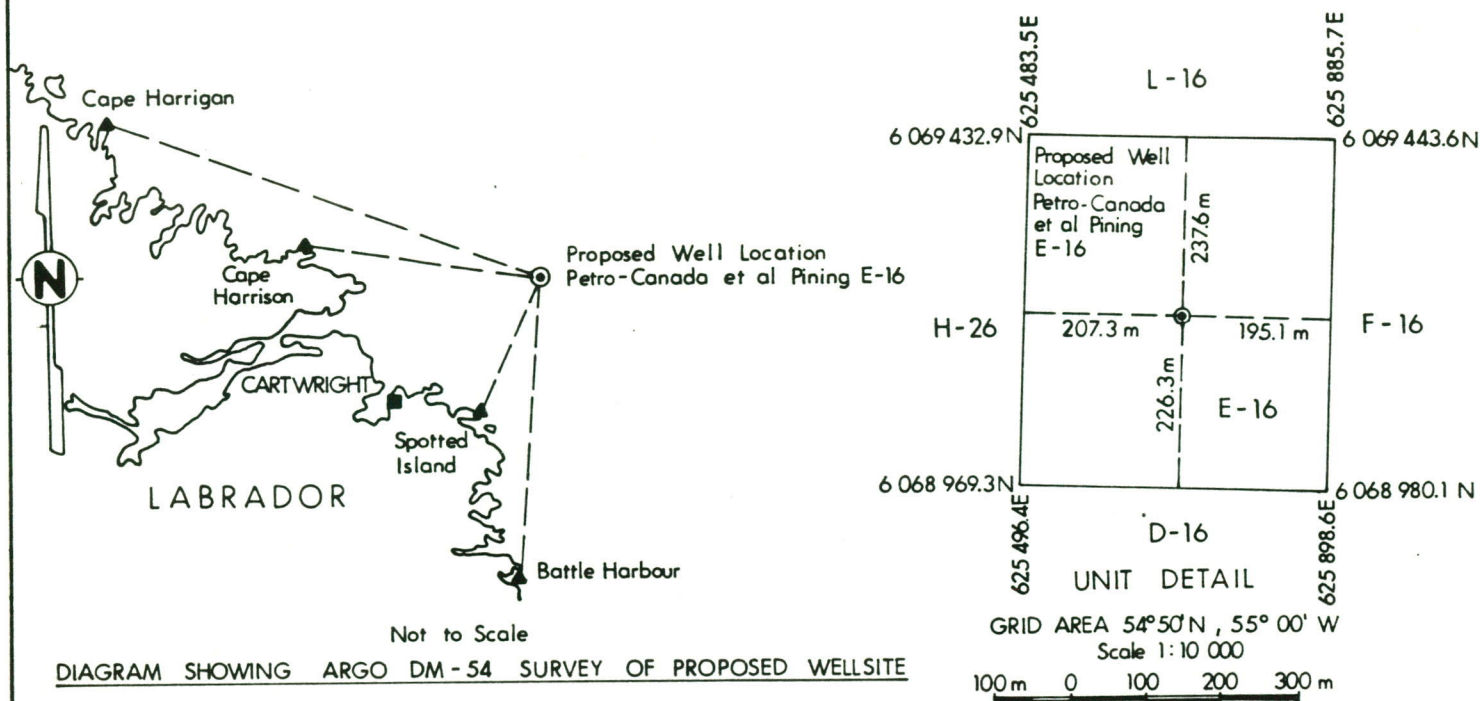
Two Mini-Ranger III stations were also installed. As these stations were not used during the survey the station names and coordinates are not given here.

3.4 Proposed Well Location

A Tentative Plan of Survey (Figure 2) was prepared and submitted for C.O.G.L.A. approval based on coordinates supplied by Petro-Canada.

| | | |
|-----------|------------------|----------|
| Latitude | 54° 45' 22.46" N | |
| Longitude | 55° 02' 48.41" W | (NAD 27) |

FB 33350



ARGO SHORE STATION CO-ORDINATES

| STATION | GEOGRAPHICS | UTM | SURFACE DISTANCE TO PINING E-16 | SHOWN ON PLAN CLSR |
|-------------------|--------------------------------------|--------------------------------|------------------------------------|-----------------------|
| BATTLE HARBOUR | 52° 16' 38.38" N 55° 34' 59.58" W | 5 792 611.46 N 596 661.68 E | 278 178 m | 67305 |
| SPOTTED ISLAND | 53° 30' 58.67" N 55° 45' 02.43" W | 5 930 216.22 N 582 840.08 E | 145 481 m | 64857 |
| CAPE HARRISON | 54° 55' 28.78" N 57° 56' 20.67" W | 6 086 596.01 N 439 814.93 E | 186 760 m | 64857 |
| CAPE HARRIGAN | 55° 50' 29.96" N 60° 19' 09.70" W | 6 193 226.25 N 292 168.39 E | 355 937 m | 64857 |

TENTATIVE PLAN OF SURVEY for PETRO-CANADA ET AL PINING E-16 EXPLORATORY WELL LOCATION

LATITUDE 54° 45' 22.46" N
LONGITUDE 55° 02' 48.41" W

UTM CO-ORDINATES

6 069 200.96 N
625 697.29 E

APPROX. WATER DEPTH 183 m.

CO-ORDINATES ARE REFERRED TO NAD 1927 DATUM
UTM CO-ORDINATES ZONE 21 CENTRAL MERIDIAN 57° W

DETERMINATION OF FINAL WELL CO-ORDINATES

PRIMARY POSITIONING BY CUBIC ARGO DM-54 RANGES FROM
SHORE STATIONS ON LABRADOR COAST CONFIRMATION BY
DOPPLER SATELLITE

DATE : DEC. 15, 83

McELHANNEY SERVICES LTD. 083562

FB 33354

4.0 FIELD SURVEYS

4.1 Antenna Offsets

All antenna offsets (Figure 3) were measured (in feet and meters) twice in directions parallel and perpendicular to the rigs heading. Antenna heights above sea level were determined using a combination of measured distance to deck levels and the drillship draft. Rig headings were determined using the Pelerin's gyro compass.

TABLE 4
ANTENNA OFFSETS ON DRILLSHIP PELERIN

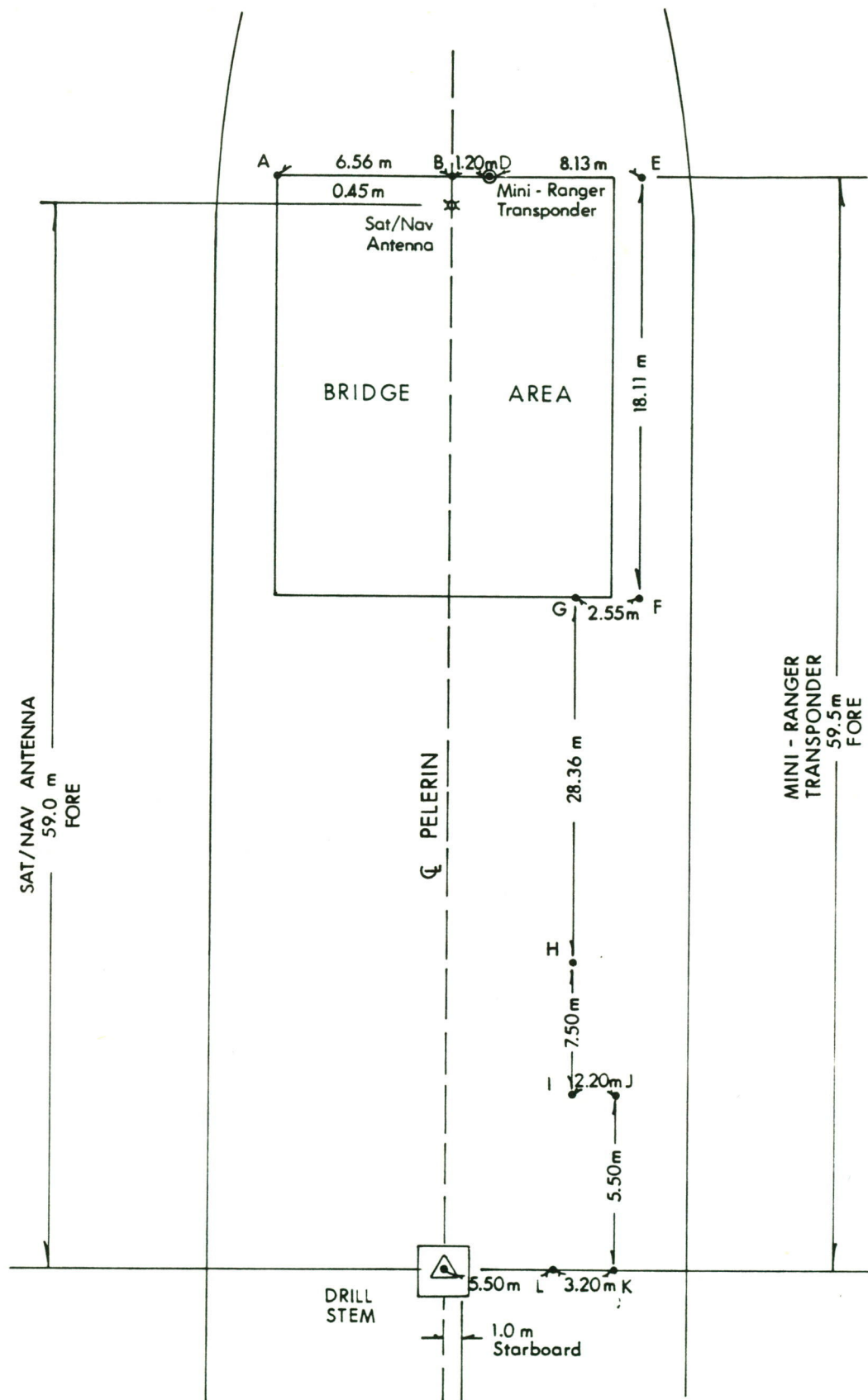
| ANTENNA | HEIGHT (m) A.M.S.L. | DISTANCE FROM DRILLSTEM (m) |
|---------------------------|------------------------|--------------------------------|
| 1107 RS Satellite Antenna | 24.1 | 59.0 m forward 0.0 m starboard |
| Motorola Mini-Ranger III | 21.1 | 59.5 m forward 1.0 m starboard |

4.2 Operations Summary

On 31 May 1983, Terry Drake of McElhanney arrived in Goose Bay and the following days were spent checking out the ARGO sites before the mobilization of the chain commenced.

On 9 June 1983, J. Muelaner and R. Friesen arrive in Goose Bay to assist in the ARGO and Mini-Ranger chain mobilization.

FB 33356



Not to Scale

SAT / NAV & MINI - RANGER OFFSETS

FIGURE 3

FB 33354

On 17 June 1983 Spotted Island ARGO was mobilized. On 18 June 1983 Cape Harrison ARGO, Quaker Hat Mini-Ranger and Cape Harrison Mini-Ranger were mobilized.

On 19 June 1983 Harrigan ARGO was installed, and on the 26 June 1983 Stirrup Island ARGO was mobilized, completing the South Labrador ARGO chain. These were the shore stations used for the Pelerin rig move to Petro-Canada et al Pining E-16.

For the Pelerin rig move the supply vessel Balder Cabot was used as the survey vessel. The survey equipment onboard was already installed as this boat was used for previous Petro-Canada rig moves.

On 21 June 1983 at approximately 21:54 G.M.T. the Balder Cabot departed St. John's Newfoundland for the Pining E-16 location. The McElhanney surveyors onboard were Max Sullivan, N.L.S., Senior Surveyor; Bob Hinchley, C.L.S., Senior Surveyor; and Pat Power, Navigator.

On 22 June 1983 a Mini-Ranger III transponder was installed by McElhanney Offshore Surveys Ltd. onboard the drillship Pelerin.

On 23 June 1983 at approximately 21:20 G.M.T. the Balder Cabot arrived at the Pining E-16 location and commenced collecting satellite passes to be used later to calibrate the ARGO system.

On 24 June 1983, Terry Walker, a McElhanney Senior Surveyor, checked onboard the drillship Pelerin, and on the 25 June 1983, at approximately 15:00 G.M.T. the drillship departed St. John's Newfoundland for the Pining E-16 location.

On 27 June 1983 at 14:07 G.M.T. the Balder Cabot deployed a buoy Southwest of proposed location to be used by the Pelerin while coming onto location. At 22:50 G.M.T. the Pelerin was within 200 m of proposed location and maneuvering on its taut wire (DP system). At 23:35 G.M.T. the Balder Cabot completed a resection around the Pelerin and found the rig's drillstem to be 79 m on a bearing

FB 33354

of 245° from the proposed location. After supplying this information to the Operation Manager on the Pelerin it was decided to move the rig closer.

On 28 June 1983 at 01:20 G.M.T. a second resection was completed around the Pelerin. This resection indicated that the rig's drillstem was 16 m in a direction of 064° from the proposed location. At 02:00 G.M.T. the Pelerin deployed its bottom transponders and at 10:00 G.M.T. the Pelerin finished moving about and requested that their position be determined. At 10:34 G.M.T. the Balder Cabot ended resection number 3. A fourth resection was completed on 28 June 1983 and at 23:55 G.M.T. the Balder Cabot was cleared from the Pelerin and headed for Cartwright to pick up passengers.

On 1 July 1983 at 10:27 G.M.T. the Balder Cabot arrived back at the Pining E-16 location. Between 17:32 G.M.T. and 18:36 G.M.T. resections 5 and 6 were performed around the Pelerin. Resection number 6 was used for the final position of Petro-Canada et al Pining E-16 as by this time the 30 inch casing was in place. Table 5 summarizes the 6 resections performed during the survey.

On 1 July 1983 a new satellite string was started onboard the Pelerin to confirm its position. By the 4 July 1983, 40 satellite passes were collected, 27 of which were used for the confirmation of position survey.

TABLE 5
SUMMARY OF RESECTIONS FOR RIG POSITION

| Date | Resection | Bearing and Distance to Location | | Positioning Devices |
|---------------|-----------|-------------------------------------|----------|------------------------|
| | | Bearing | Distance | |
| 27 June 1983 | 1 | 245° | 79 m | ARGO/MRS III |
| 28 June 1983 | 2 | 64° | 17 m | ARGO/MRS III |
| 28 June 1983 | 3 | 80° | 15 m | ARGO/MRS III |
| 28 June 1983 | 4 | 79° | 15 m | ARGO/MRS III |
| 01 July 1983 | 5 | 92° | 9 m | ARGO/MRS III |
| *01 July 1983 | 6 | 91° | 12 m | ARGO/MRS III |

* Used to compute final position.

FB 33356

4.3 ARGO Calibration and Accuracy Checks

Before any radio navigational 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 this calibration requires periodic adjustment. The next two subsections deal with the calibration and accuracy checks of the ARGO system used for the Pelerin move to Petro-Canada et al Pining E-16.

4.3.1 ARGO Calibration

The ARGO calibration for this rig move was obtained by ARGO/Satellite comparisons. This method first involved converting the positions generated by the satellite receiver (NWL10D Broadcast Ephemeris) to local datum (NAD 27) by using appropriate datum shift values. The datum shift values for this move are given in Section 3.1. These NAD 27 satellite positions were then inversed to the ARGO shore stations and yielded the true ARGO range values. The observed ARGO range readings were then compared to the satellite derived ranges and corrections applied accordingly. In order to obtain a valid calibration accuracy a number of ARGO/Satellite comparisons were made and the mean values applied. Initial calibration values (partial lane corrections) were left in the system from a previous survey, until the new values were obtained.

Table 6 is a list of the ARGO/Satellite comparisons used to calibrate the ARGO system.

FB 33354

TABLE 6
ARGO CALIBRATION BY ARGO/SATELLITE COMPARISONS

| Satfix Quality | | | | No. of Dop. | Range and Position Comparisons | | | | |
|------------------------|------|------|------|----------------|--------------------------------|--------------|--------------|------------|------------|
| Slat | Slon | Elev | Iter | | ΔR_1 | ΔR_2 | ΔR_3 | ΔN | ΔE |
| 20 | 28 | 42 | 3 | 32 | -9 | -23 | -21 | -3 | -23 |
| 23 | 40 | 50 | 2 | 33 | -27 | 2 | 10 | -29 | 0 |
| 16 | 28 | 53 | 3 | 36 | -40 | -51 | -41 | -26 | -52 |
| 13 | 18 | 41 | 2 | 33 | 15 | -10 | -14 | 18 | -8 |
| 31 | 25 | 23 | 3 | 29 | 6 | -2 | -4 | 6 | -2 |
| 17 | 31 | 50 | 2 | 35 | -16 | -14 | -9 | -13 | -14 |
| 19 | 25 | 42 | 3 | 36 | 26 | 11 | 4 | 24 | 13 |
| 28 | 29 | 32 | 3 | 29 | 63 | 0 | - | 64 | 6 |
| 23 | 31 | 41 | 3 | 33 | -1 | 23 | - | -8 | 22 |
| 22 | 47 | 58 | 3 | 31 | 48 | 45 | - | 35 | 49 |
| 16 | 29 | 52 | 3 | 33 | 30 | -31 | - | 40 | -28 |
| Σ | | | | | +95 | -50 | 75 | 108 | -37 |
| n | | | | | 11 | 11 | 7 | 11 | 11 |
| \bar{x} | | | | | +8.6 | -4.5 | -10.7 | 9.8 | -3.4 |
| Partial Lane | | | | | +0.10 | -0.05 | -0.13 | | |
| Old Calibration Values | | | | | 0.53 | 0.76 | 0.64 | | |
| New Calibration Values | | | | | 0.63 | 0.71 | 0.51 | | |

NOTE: The partial lane corrections were found by dividing the Mean (\bar{x}) by a lane width of 84.844281 m.

FB 33356

LEGEND FOR TABLE 6

| | |
|-----------------|---|
| Slat: | Standard deviation for fix latitude in meters. |
| Slon: | Standard deviation for fix longitude in meters. |
| Elev.: | Maximum elevation angle, in degrees, of the satellite above the horizon. |
| Iter: | Number of iterations (calculations) made to compute a position. |
| No. of Dop.: | Number of doppler counts obtained from the satellite. |
| ΔR_1 : | Difference in meters between satellite derived ARGO range and observed ARGO range for station Spotted Island. |
| ΔR_2 : | Difference in meters between satellite derived ARGO range and observed ARGO range for station Cape Harrison. |
| ΔR_3 : | Difference in meters between satellite derived ARGO range and observed ARGO range for station Cape Harrigan. |
| ΔN : | Difference in Northing between satellite position and ARGO position in meters (ARGO - Satellite). |
| ΔE : | Difference in Easting between satellite position and ARGO position in meters (ARGO - Satellite). |

Once ARGO ranges 1, 2, & 3 were calibrated using this method ARGO range 4 (Stirrup Island) was calibrated by observing its' least squares solution residual with ranges 1, 2, & 3 weighted. This residual (in meters) was then divided by the lane width (84.844281 m) to obtain a calibration value for that range. (This calibration value would make the observed range fit the least squares model).

The final calibration values used for the rig move were:

| | |
|---------------------------------|------|
| ΔR_1 (Spotted Island) = | 0.63 |
| ΔR_2 (Cape Harrison) = | 0.71 |
| ΔR_3 (Cape Harrigan) = | 0.51 |
| ΔR_4 (Stirrup Island) = | 0.32 |
| (Values in fractional lane) | |

FB 33354

4.3.2 Ongoing Accuracy Checks

As a check on the calibration values determined and to evaluate their accuracy, further satellite passes were collected and compared to the ARGO positions. In a properly calibrated system the mean comparisons are range differences with a magnitude of ± 10 meters. Larger variations are accounted for by a change in equipment performance (ie. cracked cable, poor grounding) or physical influence (ie. ice flows and land path changes). Table 7 is a summary of daily meaned ARGO/Satellite positions obtained after calibrating.

TABLE 7
DAILY MEANED ARGO/SATELLITE COMPARISONS

| Date | No. of Passes | Daily Mean Values | | | | |
|--------------|------------------|-------------------|--------------|--------------|------------|------------|
| | | ΔR_1 | ΔR_2 | ΔR_3 | ΔN | ΔE |
| 28 June 1983 | 9 | 3.3 | -4.2 | -5.2 | -4.7 | 4.2 |
| 1 July 1983 | 5 | -15.6 | -5.2 | -1.0 | 14.4 | 6.6 |
| 2 July 1983 | 11 | -13.4 | 2.5 | 6.1 | -8.5 | 3.5 |

NOTE: Between the period 28 June, 1983 at approximately 23:55 G.M.T. and 1 July, 1983 at 10:27 G.M.T. the Balder Cabot made a trip to Cartwright, Labrador and then back to the Pining E-16 location. No ARGO/Satellite comparisons were made for accuracy check purposes during this time period.

ΔR_1 , ΔR_2 , ΔR_3 , ΔN , and ΔE represent the same values as in Table 6 only they are daily means as opposed to single ARGO/Satellite comparisons.

As a further indication of the validity of the ARGO calibration and system accuracy the magnitude and sign (signature) of the least squares generated range residuals can be observed and monitored directly after calibration

FB 33354

values have been applied. Directly after the ARGO calibration on the 27 June 1983 a mean of 12 such least squares positions yielded range residuals of:

Range 1 (Spotted Island) residual = -1.0 m

Range 2 (Cape Harrison) residual = 2.2 m

Range 3 (Cape Harrigan) residual = -1.0 m

Range 4 (Stirrup Island) residual = -1.2 m

On the 1 July 1983 when the final position of the Pelerin on Pining E-16 was determined an identical analysis yielded residuals of:

Range 1 (Spotted Island) residual = 0.3 m

Range 2 (Cape Harrison) residual = -1.0 m

Range 3 (Cape Harrigan) residual = 0.9 m

Range 4 (Stirrup Island) residual = 0.1 m

As can be seen from a comparison of the residuals on both dates no significant changes in the residuals occurred. This indicates that the accuracy of the ARGO system is within the same order on the 1 July 1983 and on the 27 June 1983 right after calibrating.

A final check is observed when a comparison of the primary position of the Pelerin at Pining E-16 determined by ARGO is made with the satellite confirmation position. Both systems agreed within 6 m.

FB 33354

4.4 Final Position of Well Location

The final position of the drillship Pelerin on Petro-Canada et al Pining E-16 was determined on 1 July 1983 after the 30 inch casing was installed. The method used to determine this position was a range resection. The measurements for this method consisted of the ships' position as determined by ARGO and ranges observed to the drillship Pelerin by a Mini-Ranger III system.

Table 8 contains the observed ARGO ranges, ARGO range residuals, least squares adjusted ARGO position of the survey vessel, and the Mini-Ranger ranges as observed from the survey ship to the drillship.

TABLE 8
RANGE RESECTION DATA FOR FINAL POSITION
RESECTION # 6

| Fix | STA | ARGO Range (m) | Residual | UTM CM 57° W N/E | Mini-Ranger Range (m) |
|-----|-----|-------------------|----------|------------------------|--------------------------|
| 1 | AR1 | 144958.2 | 0.2 | 6,068,647 625716 | 545 |
| | AR2 | 186835.6 | -1.0 | | |
| | AR3 | 356150.0 | 1.1 | | |
| | AR4 | 499887.2 | -0.2 | | |
| 2 | AR1 | 145141.4 | -0.7 | 6,068,758 625,975 | 547 |
| | AR2 | 187080.8 | 0.2 | | |
| | AR3 | 356352.8 | 1.5 | | |
| | AR4 | 500016.2 | -1.8 | | |
| 3 | AR1 | 145379.8 | -0.7 | 6,068,953 626,149 | 565 |
| | AR2 | 187235.2 | 1.0 | | |
| | AR3 | 356449.5 | 0.1 | | |
| | AR4 | 500024.7 | -1.2 | | |
| 4 | AR1 | 145667.4 | 0.3 | 6,069,241 626,195 | 555 |
| | AR2 | 187257.3 | -2.6 | | |
| | AR3 | 356388.4 | 3.6 | | |
| | AR4 | 499875.4 | -1.1 | | |
| 5 | AR1 | 145873.6 | -0.7 | 6,069,475 626,133 | 564 |
| | AR2 | 187170.7 | 1.1 | | |
| | AR3 | 356252.7 | 0.1 | | |
| | AR4 | 499678.5 | -1.3 | | |

Fb 33354

TABLE 8 (Cont'd)

| Fix | STA | ARGO Range (m) | Residual | UTM CM 57° W N/E | Mini-Ranger Range (m) |
|-----|-----|-------------------|----------|------------------------|--------------------------|
| 6 | AR1 | 145964.4 | 1.1 | 6,069,636 | 510 |
| | AR2 | 186953.5 | -2.8 | 625,926 | |
| | AR3 | 356000.7 | 1.8 | | |
| | AR4 | 499413.8 | 1.1 | | |
| 7 | AR1 | 145972.0 | -0.7 | 6,069,717 | 505 |
| | AR2 | 186699.8 | 0.8 | 625,682 | |
| | AR3 | 355745.4 | 0.5 | | |
| | AR4 | 499177.1 | -.5 | | |
| 8 | AR1 | 145863.4 | -0.6 | 6,069,690 | 525 |
| | AR2 | 186419.9 | 1.5 | 625,399 | |
| | AR3 | 355490.7 | -0.9 | | |
| | AR4 | 498976.0 | -0.7 | | |
| 9 | AR1 | 145601.3 | 2.1 | 6,069,496 | 545 |
| | AR2 | 186194.2 | -5.1 | 625,148 | |
| | AR3 | 355319.4 | 2.9 | | |
| | AR4 | 498904.7 | 2.3 | | |
| 10 | AR1 | 145310.3 | 0.0 | 6,069,186 | 456 |
| | AR2 | 186226.4 | 1.2 | 625,158 | |
| | AR3 | 355441.5 | -2.1 | | |
| | AR4 | 499111.8 | 1.0 | | |
| 11 | AR1 | 145056.6 | 2.3 | 6,068,901 | 486 |
| | AR2 | 186323.1 | -5.0 | 625,222 | |
| | AR3 | 355596.0 | 2.2 | | |
| | AR4 | 499340.0 | 2.9 | | |
| 12 | AR1 | 144928.5 | 0.7 | 6,068,705 | 515 |
| | AR2 | 186544.6 | -1.0 | 625,430 | |
| | AR3 | 355862.4 | -0.2 | | |
| | AR4 | 499628.5 | 1.3 | | |

AR1: Spotted Island ARGO range in meters.

AR2: Cape Harrison ARGO range in meters.

AR3: Cape Harrigan ARGO range in meters.

AR4: Stirrup Island ARGO range in meters.

Residual: Residual computed for that range in meters.

N/E: Northing and Easting computed from the ranges using a least squares solution.

FB 33356

The ARGO derived positions (Northing & Easting) and observed Mini-Ranger III ranges (with a +16 m calibration value applied) were then entered into a McElhanney developed least squares range resection program, yielding the Mini-Ranger III transponder position on the drillship Pelerin and the residuals (Table 9) of each Mini-Ranger range.

TABLE 9
COMPUTED MINI-RANGER III RESIDUALS
RESECTION # 6

| | |
|---------|---------|
| Fix 1: | -0.44 m |
| Fix 2: | 0.36 m |
| Fix 3: | -2.52 m |
| Fix 4: | -0.54 m |
| Fix 5: | -3.30 m |
| Fix 6: | 3.12 m |
| Fix 7: | -1.07 m |
| Fix 8: | -0.98 m |
| Fix 9: | 1.35 m |
| Fix 10: | -3.57 m |
| Fix 11: | -0.85 m |
| Fix 12: | 1.72 m |

Final Mini-Ranger III Transponder Position onboard Pelerin:

| | | |
|------------|------------------|----------|
| Latitude: | 54° 45' 22.50" N | (NAD 27) |
| Longitude: | 55° 02' 52.39" W | |

The Mini-Ranger III transponder was offset from the drillstem by 59.5 m forward and 1.0 m starboard. The drillships heading as determined by its gyro was 270°. ?

FB 33354

With the above offset and drillship heading the final position of the Pelerin drillstem for Petro-Canada et al Pining E-16 is:

| | | |
|------------|------------------|----------|
| Latitude: | 54° 45' 22.47" N | (NAD 27) |
| Longitude: | 55° 02' 49.06" W | |

The proposed location for the Pelerin at Petro-Canada et al Pining E-16 was:

| | |
|------------|------------------|
| Latitude: | 54° 45' 22.46" N |
| Longitude: | 55° 22' 48.41" W |

A geographic inverse between the actual final position and the proposed location shows a difference of 11.6 m at 91°. (Final position to design location).

4.5 Final Position Confirmation

The final position of Petro-Canada et al Pining E-16 was confirmed by a doppler satellite point positioning method. Due to frequent changes in the drillship's heading several 3 D satellite strings had to be started. Table 10 shows the final position of each string.

TABLE 10
FINAL BROADCAST EPHEMERIS POSITIONS OF SATELLITE STRINGS
(1107 RS Antenna Position)

| Date | String | Passes/String | Latitude | Longitude |
|-------------|--------|---------------|------------------|------------------|
| 1 July 1983 | 1 | 10 | 54° 45' 23.10" N | 55° 02' 49.20" W |
| 2 July 1983 | 2 | 5 | 54° 45' 22.62" N | 55° 02' 48.00" W |
| 3 July 1983 | 3 | 12 | 54° 45' 20.40" N | 55° 02' 46.98" W |

FB 33356

These Broadcast Ephemeris satellite antenna coordinates were then traversed back to the drillstem using the rig's heading obtained from the gyro and the measured offset. Table 11 shows the drillstem coordinates computed from each satellite string.

TABLE 11
BROADCAST EPHEMERIS DRILLSTEM COORDINATES
FOR EACH SATELLITE STRING

| String | Rig Heading | Offset | Drillstem Coordinates | |
|--------|-------------|--------------|-----------------------|------------------|
| | | | Latitude | Longitude |
| 1 | 270° | 59 m forward | 54° 45' 23.10" N | 55° 02' 45.90" W |
| 2 | 300° | 59 m forward | 54° 45' 21.67" N | 55° 02' 45.14" W |
| 3 | 200° | 59 m forward | 54° 45' 22.19" N | 55° 02' 45.85" W |

NOTE: Satellite antenna on center line of rig. (No port or starboard offset.)

By taking the number of passes in each string as a weight factor and the Broadcast Ephemeris drillstem coordinates listed in Table 11, a weighted mean Broadcast Ephemeris latitude and longitude was computed for the drillstem.

Broadcast Ephemeris Drillstem Position (NWL 10 D) (Weighted Mean)

Latitude: 54° 45' 22.42" N

Longitude: 55° 02' 45.74" W

The above Broadcast Ephemeris position was then converted to local datum (NAD 27) using datum shift values for station Goose Bay (GSC 650001):

$\Delta X = -38$ m, $\Delta Y = 158$ m, $\Delta Z = 182$ m

a geoidal height of 12.3 m (obtained from GEM 10 B coefficients in the Magnavox receiver) and an antenna height above Mean Sea Level of 24.1 m.

FB 3354

The NAD 27 confirmation position as computed from 27 3 D satellite passes is:

| | | |
|------------|------------------|----------|
| Latitude: | 54° 45' 22.29" N | (NAD 27) |
| Longitude: | 55° 02' 49.06" W | |

FB 33356

5.0 CONCLUSIONS AND COMPARISONS

5.1 Position Comparisons

The **final** NAD 27 position of Petro-Canada et al Pining E-16 as determined by ARGO is:

| | |
|------------|------------------|
| Latitude: | 54° 45' 22.47" N |
| Longitude: | 55° 02' 49.06" W |

The NAD 27 **confirmation** position as determined by a doppler satellite point position is:

| | |
|------------|------------------|
| Latitude: | 54° 45' 22.29" N |
| Longitude: | 55° 02' 49.06" W |

Figure 4 shows the two positions relative to proposed location.

5.2 Survey Accuracy Analysis

The Petro-Canada survey requirement to be met 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 4 the ARGO Position for the drillship Pelerin at Petro-Canada et al Pining E-16 placed the rig only 11.6 metres from the proposed location and the satellite position placed it 12.8 m from the design location, well within the 100 m tolerance requirement.

The Canada Oil and Gas Lands Administration (COGLA) require that the survey system used be sufficient to ensure a survey connection to the nearest geodetic shore control with at least fourth order accuracy. To accomplish this objective we enter all the observed ARGO (shore to vessel) and Mini-Ranger (vessel to rig) ranges into program GEOPAN (documentation available from the Geodetic Survey of Canada). the coordinates of the four registered ARGO shore stations (section 3.1) are held fixed in the adjustment.

FB 33356

ARGO DM-54
FINAL POSITION
PETRO-CANADA ET AL
PINING E-16

271° 31'
11.6 m

PROPOSED
LOCATION

180° 00'
5.6m

12.8 m
245° 40"

SATELLITE
CONFIRMATION
POSITION



Scale 1 : 100



SKETCH SHOWING COMPARISON BETWEEN
ARGO AND SATELLITE POSITIONS WITH RESPECT
TO PROPOSED LOCATION

FIGURE 4

FB 33354

The final output is the error ellipse information for all positions obtained relative to the fixed control. The error ellipse of interest is the semi-major axis obtained for station PELERIN, whose value is 1.86 m.

Using the formula obtained from Surveying Offshore Canada Lands, Third Edition, December 1982.

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

where:

- r = the maximum dimension (semi-major axis) in cm.
- c = a constant depending on the order.
- d = the distance in km between the points under consideration.

therefore, we input

- c = 30
- d = 145.477 PELERIN to Spotted Island ARGO Station C.L.S.R. 64857

$$r = 30 (145.477 + 0.2)$$

$$r = 4370 \text{ cm.}$$

$$r = 43.7 \text{ m}$$

Thus, the accuracy of the determined positions of the PELERIN at PINING E-16 relative to Spotted Island ARGO Station is well within 4th order accuracy.

FB 33354

5.3 Problems

Upon departing St. John's it was observed that the MX 1107 Satellite Navigator was not updating. This problem was isolated to be a faulty cable between antenna and receiver. This cable was replaced and no further problem was experienced for the remainder of the job.

The Mini-Ranger III transponders established at Quakers Hat and Cape Harrison were both faulty and would not respond when interrogated. These were originally deployed for the purpose of calibrating the ARGO System and calibration had to be determined by Satellite Comparisons accumulated while around location. The ARGO system was calibrated later by base-line crossings and extensions, however, the values determined were found to be unsuitable while working near location due to the extensive ice flows between the Pining site and the shore stations.

The ice situation along the Labrador Coast was the worst observed in recent years and caused continuous problems with the ARGO calibration. One of the constants assumed by the ARGO system is a known propagation velocity, however, the velocity over salt water is not the same as that over ice and compensations had to be made frequently in order to maintain optimum positional accuracy.

Due to frequent changes in the drillships heading, problems were encountered onboard the rig when trying to collect 3 D Satellite String data.

FB 33354

5.4 Recommendations

When used during ice conditions as existed along the coast of Labrador this year, the ARGO position is less than optimum and therefore it is recommended that the satellite position be used as prime. In either case, time must be allowed for the surveyor onboard the drillship to complete a proper 3 D string with the drillship maintaining a constant heading. It is therefore recommended that the method used for determining the final position on a new wellsite be left to the discretion of the surveyor and that he be given full cooperation by the drillship and/or survey vessel crew in achieving that objective. Another possible solution is to use a long baseline acoustic array. The array could be deployed prior to the rigs arrival and calibrated using ARGO or alternatively it can be deployed for a site survey and left in place until the rig move. Once in location and calibrated it is a stand alone system which can be monitored by the drilling vessel during final positioning. It can be used for re-entry when a rig is forced off location by ice, requires repairs or another rig needs to re-occupy the same hole.

FB 33356

APPENDIX A
OUTPUT FROM GEOPAN USED FOR ACCURACY ANALYSIS

FB 33356

```

*****
* PETRO CANADA PINING E-16 ACCURACY ANALYSIS *
*
* 08-DEC-83 12:28:03
*****

```

OPTIONS IN EFFECT

PREANALYSIS OR ADJUSTMENT ADJUSTMENT

| | | |
|----------------|-------------------|----------------|
| FIXED STATIONS | WEIGHTED STATIONS | BLANK STATIONS |
| AR1 | NONE | NONE |
| AR2 | | |
| AR3 | | |
| AR4 | | |

MAP PROJECTION.....USER DEFINED TRANSVERSE MERCATOR

CONVENTIONAL LINEAR UNIT METRE

TEST USED FOR REJECTION OF RESIDUALS MAXIMUM TAU

MULTIPLY INVERSE OF NORMAL EQUATIONS BY ESTIMATED VARIANCE FACTOR? NO

MAXIMUM NUMBER OF ITERATIONS ALLOWED 5

CRITERION FOR SOLUTION CONVERGENCE 0.010000

MAKE OBSERVATION REDUCTIONS (TERRAIN TO ELLIPSOID)?..... NO

MAKE OBSERVATION REDUCTIONS (ELLIPSOID TO MAPPING PLANE)? YES

REDUCTIONS FROM TERRAIN TO MAPPING PLANE MADE FOR AZIMUTHS NO

ERROR ELLIPSES COMPUTED ABSOLUTE ONLY

FB 33354

SPECIFICATIONS OF THE MAP PROJECTION

PROJECTION USED : USER DEFINED TRANSVERSE MERCATOR

ORIGIN : EQUATOR:

LATITUDE = 0 0 0.000

NORTHING (Y) = 0.000 METRES

CENTRAL MERIDIAN:

LONGITUDE = -57 0 0.000

EASTING (X) = 500000.000 METRES

SCALE AT THE CENTRAL MERIDIAN : 0.9996000

REFERENCE ELLIPSOID :

SEMI-MAJOR AXIS= 6378206.500 METRES

SEMI-MINOR AXIS= 6356583.800 METRES

TRANSLATION COMPONENTS (FROM GEOCENTRE) USED:

X0= -38.000 METRES

Y0= 158.000 METRES

Z0= 182.000 METRES

FB 33356

INITIAL APPROXIMATE COORDINATES

FREE STATIONS:

| STATION | X (EASTING) | Y (NORTHING) | ORTHOMETRIC HEIGHT | GEOID HEIGHT | DEFLECTION COMPONENTS | LATITUDE | LONGITUDE | POINT SCALE | MERIDIAN CONVERGENCE |
|---------|----------------|-----------------|-----------------------|-----------------|--------------------------|-------------|-------------|----------------|-------------------------|
| PELERIN | 625628.669 | 6069199.853 | 0.000 | 0.000 | 0.0 0.0 | 54 45 22.49 | -55 2 52.25 | 0.999794 | 1 35 40.3 |
| R11 | 625716.000 | 6068647.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 4.53 | -55 2 48.23 | 0.999794 | 1 35 43.3 |
| R12 | 625975.000 | 6068758.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 7.89 | -55 2 33.58 | 0.999795 | 1 35 55.3 |
| R13 | 626149.000 | 6068953.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 14.04 | -55 2 23.55 | 0.999795 | 1 36 3.6 |
| R14 | 626195.000 | 6069241.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 23.31 | -55 2 20.52 | 0.999795 | 1 36 6.3 |
| R15 | 626133.000 | 6069475.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 30.93 | -55 2 23.62 | 0.999795 | 1 36 3.9 |
| R16 | 625926.000 | 6069636.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 36.32 | -55 2 34.95 | 0.999795 | 1 35 54.8 |
| R17 | 625682.000 | 6069717.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 39.16 | -55 2 48.46 | 0.999794 | 1 35 43.8 |
| R18 | 625399.000 | 6069690.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 38.54 | -55 3 4.33 | 0.999793 | 1 35 30.8 |
| R19 | 625148.000 | 6069496.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 32.49 | -55 3 18.66 | 0.999792 | 1 35 19.0 |
| R110 | 625158.000 | 6069186.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 22.46 | -55 3 18.58 | 0.999792 | 1 35 18.8 |
| R111 | 625222.000 | 6068901.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 13.19 | -55 3 15.45 | 0.999792 | 1 35 21.2 |
| R112 | 625430.000 | 6068705.000 | 0.000 | 0.000 | 0.0 0.0 | 54 45 6.67 | -55 3 4.12 | 0.999793 | 1 35 30.3 |

FIXED STATIONS:

| STATION | X (EASTING) | Y (NORTHING) | ORTHOMETRIC HEIGHT | GEOID HEIGHT | DEFLECTION COMPONENTS | LATITUDE | LONGITUDE | POINT SCALE | MERIDIAN CONVERGENCE |
|---------|----------------|-----------------|-----------------------|-----------------|--------------------------|-------------|--------------|----------------|-------------------------|
| AR1 | 582840.078 | 5930216.223 | 0.000 | 0.000 | 0.0 0.0 | 53 30 58.67 | -55 45 2.43 | 0.999684 | 1 0 16.4 |
| AR2 | 439814.929 | 6086596.012 | 0.000 | 0.000 | 0.0 0.0 | 54 55 28.78 | -57 56 20.67 | 0.999644 | 0-46 6.8 |
| AR3 | 292168.385 | 6193226.256 | 0.000 | 0.000 | 0.0 0.0 | 55 50 29.96 | -60 19 9.70 | 1.000130 | -2 44 51.8 |
| AR4 | 241939.830 | 6383805.132 | 0.000 | 0.000 | 0.0 0.0 | 57 34 10.98 | -61 18 56.76 | 1.000417 | -3 38 40.9 |

FB 33356

WARNING MORE STATION CONSTRAINTS THAN THE MINIMUM NECESSARY ARE BEING USED



McElharney

FB 33354

SUMMARY OF INPUT OBSERVATIONS, REDUCED OBSERVATIONS AND INITIAL MISCLOSEURES:

| | AT | FROM | TO | OBSERVED | STD.DEV | REDUCED OBS | MISCLOSURE |
|----------|-----|------|---------|------------|---------|-------------|------------|
| DISTANCE | AR1 | AR1 | R11 | 144958.200 | 0.200 | 144919.814 | -1.131 |
| DISTANCE | AR2 | AR2 | R11 | 186835.600 | 1.000 | 186769.920 | -4.358 |
| DISTANCE | AR3 | AR3 | R11 | 356150.000 | 1.100 | 356055.370 | -1.999 |
| DISTANCE | AR4 | AR4 | R11 | 499887.200 | 0.200 | 499789.256 | -3.924 |
| DISTANCE | R11 | R11 | PELERIN | 561.000 | 0.440 | 560.884 | -1.176 |
| DISTANCE | AR1 | AR1 | R12 | 145141.400 | 0.700 | 145103.017 | -1.516 |
| DISTANCE | AR2 | AR2 | R12 | 187080.800 | 0.200 | 187015.072 | -2.327 |
| DISTANCE | AR3 | AR3 | R12 | 356352.800 | 1.500 | 356258.132 | -0.918 |
| DISTANCE | AR4 | AR4 | R12 | 500016.200 | 2.800 | 499918.228 | -5.057 |
| DISTANCE | R12 | R12 | PELERIN | 563.000 | 0.360 | 562.884 | -1.476 |
| DISTANCE | AR1 | AR1 | R13 | 145379.800 | 0.700 | 145341.388 | -1.937 |
| DISTANCE | AR2 | AR2 | R13 | 187235.200 | 1.000 | 187169.443 | -1.973 |
| DISTANCE | AR3 | AR3 | R13 | 356449.500 | 0.100 | 356354.818 | -2.614 |
| DISTANCE | AR4 | AR4 | R13 | 500024.700 | 2.200 | 499926.724 | -4.657 |
| DISTANCE | R13 | R13 | PELERIN | 581.000 | 2.520 | 580.880 | -4.963 |
| DISTANCE | AR1 | AR1 | R14 | 145667.400 | 0.300 | 145628.922 | -0.841 |
| DISTANCE | AR2 | AR2 | R14 | 187257.300 | 2.600 | 187191.542 | -5.198 |
| DISTANCE | AR3 | AR3 | R14 | 356388.400 | 3.600 | 356293.737 | 1.258 |
| DISTANCE | AR4 | AR4 | R14 | 499875.400 | 1.100 | 499777.452 | -4.234 |
| DISTANCE | R14 | R14 | PELERIN | 571.000 | 0.540 | 570.883 | -3.059 |
| DISTANCE | AR1 | AR1 | R15 | 145873.600 | 0.700 | 145835.055 | -1.985 |
| DISTANCE | AR2 | AR2 | R15 | 187170.700 | 1.100 | 187104.963 | -1.910 |
| DISTANCE | AR3 | AR3 | R15 | 356252.700 | 0.100 | 356158.069 | -2.573 |
| DISTANCE | AR4 | AR4 | R15 | 499675.500 | 1.300 | 499580.592 | -4.646 |
| DISTANCE | R15 | R15 | PELERIN | 580.000 | 3.300 | 579.881 | -5.376 |
| DISTANCE | AR1 | AR1 | R16 | 145964.400 | 1.100 | 145925.789 | -0.223 |
| DISTANCE | AR2 | AR2 | R16 | 186953.500 | 3.800 | 186887.809 | -5.566 |
| DISTANCE | AR3 | AR3 | R16 | 356000.700 | 1.800 | 355906.123 | -0.662 |
| DISTANCE | AR4 | AR4 | R16 | 499413.800 | 1.100 | 499315.946 | -2.103 |
| DISTANCE | R16 | R16 | PELERIN | 526.000 | 3.120 | 525.892 | 1.962 |
| DISTANCE | AR1 | AR1 | R17 | 145972.000 | 0.700 | 145933.339 | -2.201 |
| DISTANCE | AR2 | AR2 | R17 | 186699.800 | 0.800 | 186634.163 | -2.255 |
| DISTANCE | AR3 | AR3 | R17 | 355745.400 | 0.500 | 355650.875 | -2.358 |
| DISTANCE | AR4 | AR4 | R17 | 499177.100 | 1.500 | 499079.296 | -4.863 |
| DISTANCE | R17 | R17 | PELERIN | 521.000 | 1.070 | 520.892 | -1.003 |
| DISTANCE | AR1 | AR1 | R18 | 145863.400 | 0.600 | 145824.711 | -2.229 |
| DISTANCE | AR2 | AR2 | R18 | 186419.900 | 1.500 | 186354.320 | -1.803 |
| DISTANCE | AR3 | AR3 | R18 | 355490.700 | 0.900 | 355396.225 | -3.696 |
| DISTANCE | AR4 | AR4 | R18 | 498976.000 | 1.700 | 498878.239 | -4.104 |



FB 33356

| | | | | | | | |
|----------|------|------|---------|------------|-------|------------|--------|
| DISTANCE | R18 | R18 | PELERIN | 541.000 | 0.980 | 540.888 | 0.399 |
| DISTANCE | AR1 | AR1 | R19 | 145601.300 | 2.100 | 145562.631 | 1.158 |
| DISTANCE | AR2 | AR2 | R19 | 186194.200 | 5.100 | 186128.663 | -8.386 |
| DISTANCE | AR3 | AR3 | R19 | 355319.400 | 2.900 | 355224.955 | -0.237 |
| DISTANCE | AR4 | AR4 | R19 | 498904.700 | 2.300 | 498806.957 | -1.561 |
| DISTANCE | R19 | R19 | PELERIN | 561.000 | 1.350 | 560.884 | 3.692 |
| DISTANCE | AR1 | AR1 | R110 | 145310.300 | 0.100 | 145271.710 | -1.598 |
| DISTANCE | AR2 | AR2 | R110 | 186226.400 | 1.200 | 186160.853 | -1.882 |
| DISTANCE | AR3 | AR3 | R110 | 355441.500 | 2.100 | 355347.023 | -4.837 |
| DISTANCE | AR4 | AR4 | R110 | 499111.800 | 1.000 | 499014.016 | -2.438 |
| DISTANCE | R110 | R110 | PELERIN | 472.000 | 4.100 | 471.902 | -1.029 |
| DISTANCE | AR1 | AR1 | R111 | 145056.600 | 2.300 | 145018.090 | -1.902 |
| DISTANCE | AR2 | AR2 | R111 | 186323.100 | 5.000 | 186257.529 | -7.977 |
| DISTANCE | AR3 | AR3 | R111 | 355596.000 | 2.200 | 355501.486 | 0.244 |
| DISTANCE | AR4 | AR4 | R111 | 499340.000 | 2.900 | 499242.171 | 1.132 |
| DISTANCE | R111 | R111 | PELERIN | 502.000 | 0.850 | 501.896 | 2.775 |
| DISTANCE | AR1 | AR1 | R112 | 144928.500 | 0.700 | 144890.065 | -0.304 |
| DISTANCE | AR2 | AR2 | R112 | 186544.600 | 1.000 | 186478.981 | -3.666 |
| DISTANCE | AR3 | AR3 | R112 | 355862.400 | 0.200 | 355767.828 | -2.671 |
| DISTANCE | AR4 | AR4 | R112 | 499628.500 | 1.300 | 499530.611 | -2.028 |
| DISTANCE | R112 | R112 | PELERIN | 531.000 | 1.720 | 530.890 | 2.354 |

FB 33354

SUMMARY OF ITERATIVE CORRECTIONS TO INITIAL APPROXIMATE COORDINATES:

ITERATION # 0

| STATION | OLD X | OLD Y | DX | DY | NEW X | NEW Y |
|---------|------------|-------------|----------|----------|------------|-------------|
| PELERIN | 625628.669 | 6069199.853 | -0.00759 | 0.21891 | 625628.661 | 6069200.072 |
| R11 | 625716.000 | 6068647.000 | 4.70997 | -0.30376 | 625720.710 | 6068646.696 |
| R12 | 625975.000 | 6068758.000 | 2.40484 | 0.39977 | 625977.405 | 6068758.400 |
| R13 | 626149.000 | 6068953.000 | 3.09016 | 0.81260 | 626152.090 | 6068953.813 |
| R14 | 626195.000 | 6069241.000 | 3.41172 | -0.25678 | 626198.412 | 6069240.743 |
| R15 | 626133.000 | 6069475.000 | 3.05433 | 0.81378 | 626136.054 | 6069475.814 |
| R16 | 625926.000 | 6069636.000 | 1.83736 | -0.63846 | 625927.837 | 6069635.362 |
| R17 | 625682.000 | 6069717.000 | 2.97867 | 0.98520 | 625684.979 | 6069717.985 |
| R18 | 625399.000 | 6069690.000 | 3.86388 | 1.10720 | 625402.864 | 6069691.107 |
| R19 | 625148.000 | 6069496.000 | 2.46801 | -1.60637 | 625150.468 | 6069494.394 |
| R110 | 625158.000 | 6069186.000 | 3.08165 | 0.72714 | 625161.082 | 6069186.727 |
| R111 | 625222.000 | 6068901.000 | 1.72775 | 2.43662 | 625223.728 | 6068903.437 |
| R112 | 625430.000 | 6068705.000 | 2.83157 | -0.13613 | 625432.832 | 6068704.864 |

ITERATION # 1

| STATION | OLD X | OLD Y | DX | DY | NEW X | NEW Y |
|---------|------------|-------------|----------|----------|------------|-------------|
| PELERIN | 625628.661 | 6069200.072 | -0.00336 | -0.01185 | 625628.658 | 6069200.060 |
| R11 | 625720.710 | 6068646.696 | -0.00023 | 0.00091 | 625720.710 | 6068646.697 |
| R12 | 625977.405 | 6068758.400 | 0.00016 | -0.00271 | 625977.405 | 6068758.397 |
| R13 | 626152.090 | 6068953.813 | 0.00019 | 0.00052 | 626152.090 | 6068953.813 |
| R14 | 626198.412 | 6069240.743 | -0.00377 | 0.00105 | 626198.408 | 6069240.744 |
| R15 | 626136.054 | 6069475.814 | -0.00015 | -0.00039 | 626136.054 | 6069475.813 |
| R16 | 625927.837 | 6069635.362 | -0.00202 | -0.00107 | 625927.835 | 6069635.360 |
| R17 | 625684.979 | 6069717.985 | -0.00141 | -0.00556 | 625684.977 | 6069717.980 |
| R18 | 625402.864 | 6069691.107 | 0.00551 | -0.00527 | 625402.869 | 6069691.102 |
| R19 | 625150.468 | 6069494.394 | 0.00239 | -0.00021 | 625150.470 | 6069494.393 |
| R110 | 625161.082 | 6069186.727 | -0.00015 | 0.00002 | 625161.081 | 6069186.727 |
| R111 | 625223.728 | 6068903.437 | -0.00550 | -0.00599 | 625223.722 | 6068903.431 |
| R112 | 625432.832 | 6068704.864 | -0.00034 | -0.00060 | 625432.831 | 6068704.863 |

ITERATION # 2

| STATION | OLD X | OLD Y | DX | DY | NEW X | NEW Y |
|---------|------------|-------------|----------|---------|------------|-------------|
| PELERIN | 625628.658 | 6069200.060 | -0.00001 | 0.00000 | 625628.658 | 6069200.060 |
| R11 | 625720.710 | 6068646.697 | 0.00000 | 0.00000 | 625720.710 | 6068646.697 |
| R12 | 625977.405 | 6068758.397 | 0.00000 | 0.00001 | 625977.405 | 6068758.397 |
| R13 | 626152.090 | 6068953.813 | 0.00000 | 0.00000 | 626152.090 | 6068953.813 |



FB 33356

| | | | | | | |
|------|------------|-------------|----------|----------|------------|-------------|
| R14 | 626198.408 | 6069240.744 | 0.00000 | 0.00000 | 626198.408 | 6069240.744 |
| R15 | 626136.054 | 6069475.813 | 0.00000 | 0.00000 | 626136.054 | 6069475.813 |
| R16 | 625927.835 | 6069635.360 | 0.00000 | 0.00000 | 625927.835 | 6069635.360 |
| R17 | 625684.977 | 6069717.980 | 0.00000 | 0.00000 | 625684.977 | 6069717.980 |
| R18 | 625402.869 | 6069691.102 | 0.00000 | 0.00000 | 625402.869 | 6069691.102 |
| R19 | 625150.470 | 6069494.393 | -0.00002 | -0.00003 | 625150.470 | 6069494.393 |
| R110 | 625161.081 | 6069186.727 | 0.00000 | 0.00000 | 625161.081 | 6069186.727 |
| R111 | 625223.722 | 6068903.431 | 0.00000 | -0.00001 | 625223.722 | 6068903.431 |
| R112 | 625432.831 | 6068704.863 | 0.00000 | 0.00000 | 625432.831 | 6068704.863 |

FB 33356

FINAL ADJUSTED COORDINATES

FREE STATIONS:

| STATION | X (EASTING) | Y (NORTHING) | LATITUDE | LONGITUDE | POINT SCALE | MERIDIAN CONVERGENCE |
|---------|----------------|-----------------|----------------|----------------|----------------|-------------------------|
| PELERIN | 625628.658 | 6069200.060 | 54 45 22.49342 | -55 2 52.24841 | 0.9997936 | 1 35 40.34 |
| R11 | 625720.710 | 6068646.697 | 54 45 4.51851 | -55 2 47.96396 | 0.9997939 | 1 35 43.49 |
| R12 | 625977.405 | 6068758.397 | 54 45 7.89872 | -55 2 33.44106 | 0.9997947 | 1 35 55.42 |
| R13 | 626152.090 | 6068953.813 | 54 45 14.05938 | -55 2 23.37105 | 0.9997952 | 1 36 3.77 |
| R14 | 626198.408 | 6069240.744 | 54 45 23.29490 | -55 2 20.33332 | 0.9997954 | 1 36 6.43 |
| R15 | 626136.054 | 6069475.813 | 54 45 30.95178 | -55 2 23.45186 | 0.9997952 | 1 36 4.04 |
| R16 | 625927.835 | 6069635.360 | 54 45 36.29847 | -55 2 34.84395 | 0.9997945 | 1 35 54.83 |
| R17 | 625684.977 | 6069717.980 | 54 45 39.18875 | -55 2 48.29343 | 0.9997938 | 1 35 43.90 |
| R18 | 625402.869 | 6069691.102 | 54 45 38.57349 | -55 3 4.10814 | 0.9997929 | 1 35 30.97 |
| R19 | 625150.470 | 6069494.393 | 54 45 32.43981 | -55 3 18.52504 | 0.9997922 | 1 35 19.07 |
| R110 | 625161.081 | 6069186.727 | 54 45 22.48239 | -55 3 18.40884 | 0.9997922 | 1 35 18.97 |
| R111 | 625223.722 | 6068903.431 | 54 45 13.26626 | -55 3 15.34634 | 0.9997924 | 1 35 21.29 |
| R112 | 625432.831 | 6068704.863 | 54 45 6.65817 | -55 3 3.96537 | 0.9997930 | 1 35 30.46 |

FIXED STATIONS:

| STATION | X (EASTING) | Y (NORTHING) | LATITUDE | LONGITUDE | POINT SCALE | MERIDIAN CONVERGENCE |
|---------|----------------|-----------------|----------------|-----------------|----------------|-------------------------|
| AR1 | 582840.078 | 5930216.223 | 53 30 58.67394 | -55 45 2.42910 | 0.9996842 | 1 0 16.37 |
| AR2 | 439814.929 | 6086596.012 | 54 55 28.77785 | -57 56 20.67388 | 0.9996444 | 0-46 6.82 |
| AR3 | 292168.385 | 6193226.256 | 55 50 29.95977 | -60 19 9.70272 | 1.0001298 | -2 44 51.76 |
| AR4 | 241939.830 | 6388805.132 | 57 34 10.98249 | -61 18 56.75567 | 1.0004166 | -3 38 40.89 |

FB 33354

SUMMARY OF REDUCED OBSERVATIONS, RESIDUALS AND ADJUSTED OBSERVATIONS:

| | AT | FROM | TO | REDUCED OBS | STD.DEV | RESIDUAL | STD.DEV | ADJ.OBSERVATION |
|----|----------|------|---------|-------------|---------|----------|---------|-----------------|
| 1 | DISTANCE | AR1 | R11 | 144919.814 | 0.200 | -0.027 | 0.200 | 144919.787 |
| 2 | DISTANCE | AR2 | R11 | 186769.920 | 1.000 | 0.359 | 1.000 | 186770.279 |
| 3 | DISTANCE | AR3 | R11 | 356055.370 | 1.100 | 2.519 | 1.100 | 356057.888 |
| 4 | DISTANCE | AR4 | R11 | 499789.256 | 0.200 | -0.114 | 0.200 | 499789.143 |
| 5 | DISTANCE | R11 | PELERIN | 560.884 | 0.440 | 0.083 | 0.440 | 560.967 |
| 6 | DISTANCE | AR1 | R12 | 145103.017 | 0.700 | -0.422 | 0.700 | 145102.595 |
| 7 | DISTANCE | AR2 | R12 | 187015.072 | 0.200 | 0.029 | 0.200 | 187015.101 |
| 8 | DISTANCE | AR3 | R12 | 356258.132 | 1.500 | 1.197 | 1.500 | 356259.329 |
| 9 | DISTANCE | AR4 | R12 | 499918.228 | 2.800 | -3.463 | 2.800 | 499914.764 |
| 10 | DISTANCE | R12 | PELERIN | 562.884 | 0.360 | -0.131 | 0.360 | 562.753 |
| 11 | DISTANCE | AR1 | R13 | 145341.388 | 0.700 | -0.240 | 0.700 | 145341.148 |
| 12 | DISTANCE | AR2 | R13 | 187169.443 | 1.000 | 1.027 | 1.000 | 187170.470 |
| 13 | DISTANCE | AR3 | R13 | 356354.818 | 0.100 | -0.001 | 0.100 | 356354.817 |
| 14 | DISTANCE | AR4 | R13 | 499926.724 | 2.200 | -2.802 | 2.200 | 499923.921 |
| 15 | DISTANCE | R13 | PELERIN | 580.880 | 2.520 | -2.418 | 2.520 | 578.463 |
| 16 | DISTANCE | AR1 | R14 | 145628.922 | 0.300 | -0.070 | 0.300 | 145628.851 |
| 17 | DISTANCE | AR2 | R14 | 187191.542 | 2.600 | -1.781 | 2.600 | 187189.761 |
| 18 | DISTANCE | AR3 | R14 | 356293.737 | 3.600 | 4.542 | 3.600 | 356298.279 |
| 19 | DISTANCE | AR4 | R14 | 499777.452 | 1.100 | -1.450 | 1.100 | 499776.002 |
| 20 | DISTANCE | R14 | PELERIN | 570.883 | 0.540 | 0.318 | 0.540 | 571.201 |
| 21 | DISTANCE | AR1 | R15 | 145835.055 | 0.700 | -0.302 | 0.700 | 145834.753 |
| 22 | DISTANCE | AR2 | R15 | 187104.963 | 1.100 | 1.057 | 1.100 | 187106.020 |
| 23 | DISTANCE | AR3 | R15 | 356158.069 | 0.100 | 0.008 | 0.100 | 356158.077 |
| 24 | DISTANCE | AR4 | R15 | 499580.592 | 1.300 | -2.818 | 1.300 | 499577.774 |
| 25 | DISTANCE | R15 | PELERIN | 579.881 | 3.300 | -2.394 | 3.300 | 577.487 |
| 26 | DISTANCE | AR1 | R16 | 145925.789 | 1.100 | -0.292 | 1.100 | 145925.497 |
| 27 | DISTANCE | AR2 | R16 | 186887.809 | 3.800 | -3.681 | 3.800 | 186884.129 |
| 28 | DISTANCE | AR3 | R16 | 355906.123 | 1.800 | 1.281 | 1.800 | 355907.404 |
| 29 | DISTANCE | AR4 | R16 | 499315.946 | 1.100 | -0.283 | 1.100 | 499315.663 |
| 30 | DISTANCE | R16 | PELERIN | 525.892 | 3.120 | 2.307 | 3.120 | 528.198 |
| 31 | DISTANCE | AR1 | R17 | 145933.339 | 0.700 | -0.390 | 0.700 | 145932.949 |
| 32 | DISTANCE | AR2 | R17 | 186634.163 | 0.800 | 0.622 | 0.800 | 186634.785 |
| 33 | DISTANCE | AR3 | R17 | 355650.875 | 0.500 | 0.094 | 0.500 | 355650.969 |
| 34 | DISTANCE | AR4 | R17 | 499079.296 | 1.500 | -3.200 | 1.500 | 499076.095 |
| 35 | DISTANCE | R17 | PELERIN | 520.892 | 1.070 | 0.080 | 1.070 | 520.973 |
| 36 | DISTANCE | AR1 | R18 | 145824.711 | 0.600 | -0.046 | 0.600 | 145824.665 |
| 37 | DISTANCE | AR2 | R18 | 186354.320 | 1.500 | 1.951 | 1.500 | 186356.271 |
| 38 | DISTANCE | AR3 | R18 | 355396.225 | 0.900 | -0.451 | 0.900 | 355395.774 |
| 39 | DISTANCE | AR4 | R18 | 498878.239 | 1.700 | -1.835 | 1.700 | 498876.404 |



McElhanney

FB 33356

| | | | | | | | | | |
|----|----------|------|------|---------|------------|-------|--------|-------|------------|
| 40 | DISTANCE | R18 | R18 | PELERIN | 540.888 | 0.980 | -0.423 | 0.980 | 540.465 |
| 41 | DISTANCE | AR1 | AR1 | R19 | 145562.631 | 2.100 | 0.339 | 2.100 | 145562.969 |
| 42 | DISTANCE | AR2 | AR2 | R19 | 186128.663 | 5.100 | -5.778 | 5.100 | 186122.885 |
| 43 | DISTANCE | AR3 | AR3 | R19 | 355224.955 | 2.900 | 2.638 | 2.900 | 355227.593 |
| 44 | DISTANCE | AR4 | AR4 | R19 | 498806.957 | 2.300 | 1.366 | 2.300 | 498808.323 |
| 45 | DISTANCE | R19 | R19 | PELERIN | 560.884 | 1.350 | 0.628 | 1.350 | 561.512 |
| 46 | DISTANCE | AR1 | AR1 | R110 | 145271.710 | 0.100 | -0.005 | 0.100 | 145271.705 |
| 47 | DISTANCE | AR2 | AR2 | R110 | 186160.853 | 1.200 | 1.118 | 1.200 | 186161.971 |
| 48 | DISTANCE | AR3 | AR3 | R110 | 355347.023 | 2.100 | -2.204 | 2.100 | 355344.819 |
| 49 | DISTANCE | AR4 | AR4 | R110 | 499014.016 | 1.000 | -0.537 | 1.000 | 499013.479 |
| 50 | DISTANCE | R110 | R110 | PELERIN | 471.902 | 4.100 | -4.136 | 4.100 | 467.767 |
| 51 | DISTANCE | AR1 | AR1 | R111 | 145018.090 | 2.300 | 0.925 | 2.300 | 145019.016 |
| 52 | DISTANCE | AR2 | AR2 | R111 | 186257.529 | 5.000 | -6.493 | 5.000 | 186251.035 |
| 53 | DISTANCE | AR3 | AR3 | R111 | 355501.486 | 2.200 | 1.007 | 2.200 | 355502.493 |
| 54 | DISTANCE | AR4 | AR4 | R111 | 499242.171 | 2.900 | 0.897 | 2.900 | 499243.068 |
| 55 | DISTANCE | R111 | R111 | PELERIN | 501.896 | 0.850 | 0.062 | 0.850 | 501.958 |
| 56 | DISTANCE | AR1 | AR1 | R112 | 144890.065 | 0.700 | 0.397 | 0.700 | 144890.462 |
| 57 | DISTANCE | AR2 | AR2 | R112 | 186478.981 | 1.000 | -0.835 | 1.000 | 186478.146 |
| 58 | DISTANCE | AR3 | AR3 | R112 | 355767.828 | 0.200 | 0.029 | 0.200 | 355767.857 |
| 59 | DISTANCE | AR4 | AR4 | R112 | 499530.611 | 1.300 | 0.233 | 1.300 | 499530.844 |
| 60 | DISTANCE | R112 | R112 | PELERIN | 530.890 | 1.720 | 1.621 | 1.720 | 532.511 |

FB 33356

SUMMARY OF REJECTION OF RESIDUALS AT THE 95.000 % CONFIDENCE LEVEL

(TAU MAX CRITERION USED)

COMPUTED FACTOR FOR STANDARD DEVIATION OF RESIDUAL = 3.1434

REJECTED RESIDUALS:

| OBSERVATION | AT | FROM | TO | RESIDUAL | STD.DEV RESIDUAL | CRITICAL POINT |
|-------------|----|------|----|----------|---------------------|----------------|
|-------------|----|------|----|----------|---------------------|----------------|

0 RESIDUALS (0 % OF THE OBSERVATIONS) WERE FLAGGED FOR REJECTION

FB 33356

STATISTICS SUMMARY

NUMBER OF ITERATIONS REQUIRED FOR CONVERGENCE --> 2
 MAXIMUM NUMBER OF ITERATIONS ALLOWED -----> 5

| NUMBER OF OBSERVATIONS | | NUMBER OF UNKNOWNNS | |
|------------------------|----|---------------------|----|
| DISTANCES | 60 | ZERO ERROR | 0 |
| DIRECTIONS | 0 | ORIENTATION | 0 |
| ANGLES | 0 | | |
| AZIMUTHS | 0 | | |
| COORDINATES | 0 | COORDINATES | 26 |
| TOTALS | 60 | | 26 |

THE NUMBER OF DEGREES OF FREEDOM IS 34

ESTIMATED VARIANCE FACTOR= 1.286112

CHI-SQUARE TEST ON THE VARIANCE FACTOR

(VARIANCE FACTOR UNKNOWN)

0.841347 < 1.000000 < 2.209314 ?

TEST ON VARIANCE FACTOR AT THE 95.000 % CONFIDENCE LEVEL PASSES

(0 RESIDUALS WERE FLAGGED FOR REJECTION)

FB 33354

CHI-SQUARE GOODNESS OF FIT TEST

ON THE STANDARDIZED DISTANCE RESIDUALS

THE NUMBER OF CLASSES IS 3
THE NUMBER OF DEGREES OF FREEDOM FOR THE TEST IS 1

SUMMARY OF THE COMPUTATION OF THE CHI-SQUARE STATISTIC

| CLASS INTERVAL | OBSERVED FREQ.(O) | EXPECTED FREQ.(E) | (O-E) | (O-E)**2 | (O-E)**2/E |
|----------------|-------------------|-------------------|-------|----------|------------|
| (-3.0 , -1.0) | 10 | 9 | 1 | 1 | 0.11 |
| (-1.0 , 1.0) | 46 | 40 | 6 | 36 | 0.90 |
| (1.0 , 3.0) | 4 | 9 | -5 | 25 | 2.78 |

TOTAL (CHI-SQUARE STATISTIC) --> 3.79

THE CHI-SQUARE CRITICAL VALUE AT THE 95.000 % CONFIDENCE LEVEL IS --> 3.75

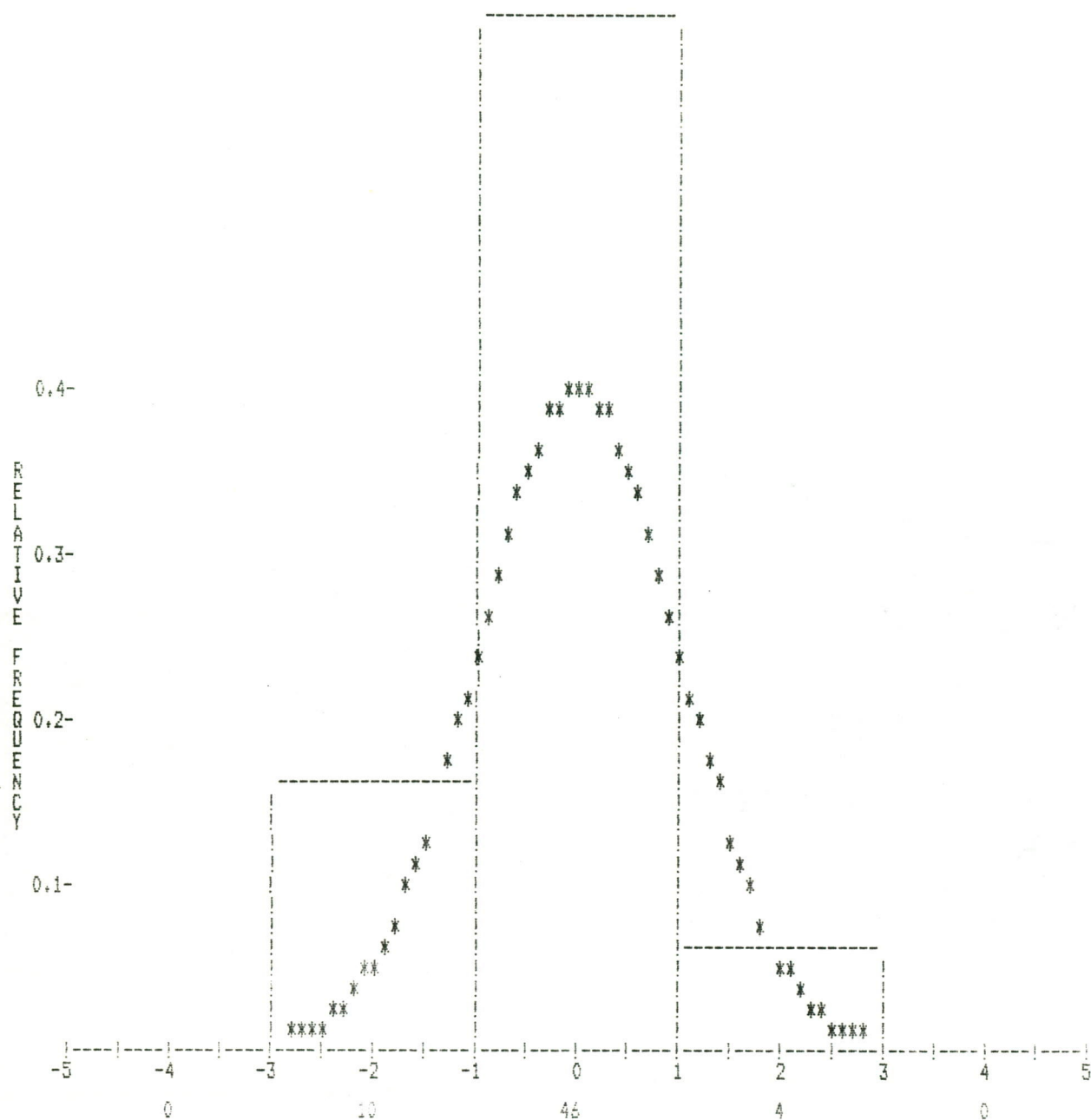
3.79 IS GREATER THAN 3.75

THE TEST FAILS

(SEE HISTOGRAM ON NEXT PAGE)

NOTE: THE HISTOGRAM IS FIRST PLOTTED WITH 3 CLASSES (THAT USED IN THE GOODNESS OF FIT TEST); THEN WITH 20 CLASSES SO THAT A MORE DETAILED REPRESENTATION OF THE ACTUAL RESIDUAL DISTRIBUTION IS GIVEN.

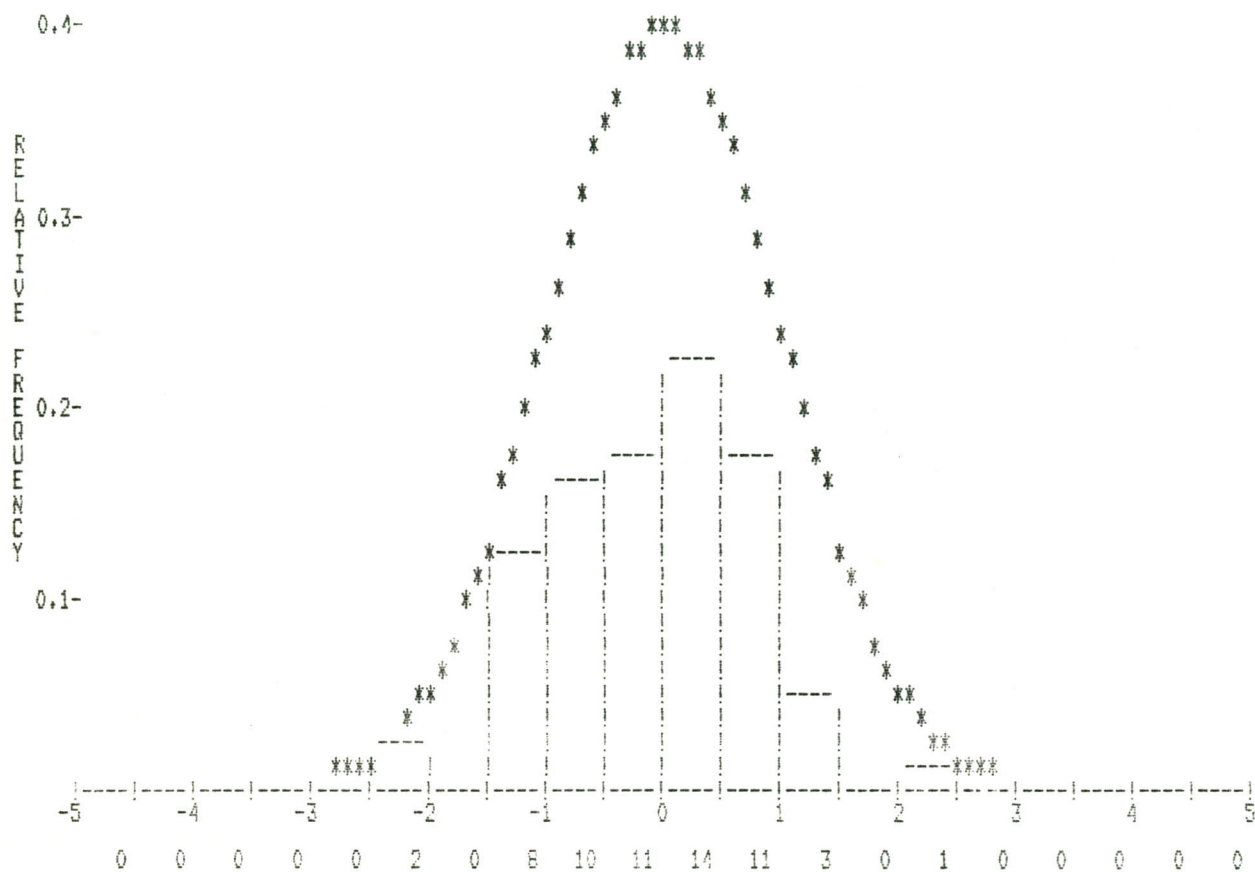
FB 33354



HISTOGRAM OF THE STANDARDIZED DISTANCE RESIDUALS

(WITH CLASSES AS USED IN THE GOODNESS OF FIT TEST; A MORE DETAILED REPRESENTATION IS PLOTTED ON THE NEXT PAGE)

FB 33354



FB 33356

CHI-SQUARE GOODNESS OF FIT TEST

ON THE STANDARDIZED RESIDUALS (ALL RESIDUALS INCLUDED)

THE NUMBER OF CLASSES IS 3
THE NUMBER OF DEGREES OF FREEDOM FOR THE TEST IS 1

SUMMARY OF THE COMPUTATION OF THE CHI-SQUARE STATISTIC

| CLASS INTERVAL | OBSERVED FREQ. (O) | EXPECTED FREQ. (E) | (O-E) | (O-E)**2 | (O-E)**2/E |
|----------------|--------------------|--------------------|-------|----------|------------|
| (-3.0 , -1.0) | 10 | 9 | 1 | 1 | 0.11 |
| (-1.0 , 1.0) | 46 | 40 | 6 | 36 | 0.90 |
| (1.0 , 3.0) | 4 | 9 | -5 | 25 | 2.78 |

TOTAL (CHI-SQUARE STATISTIC) --> 3.79

THE CHI-SQUARE CRITICAL VALUE AT THE 95.000 % CONFIDENCE LEVEL IS --> 3.75

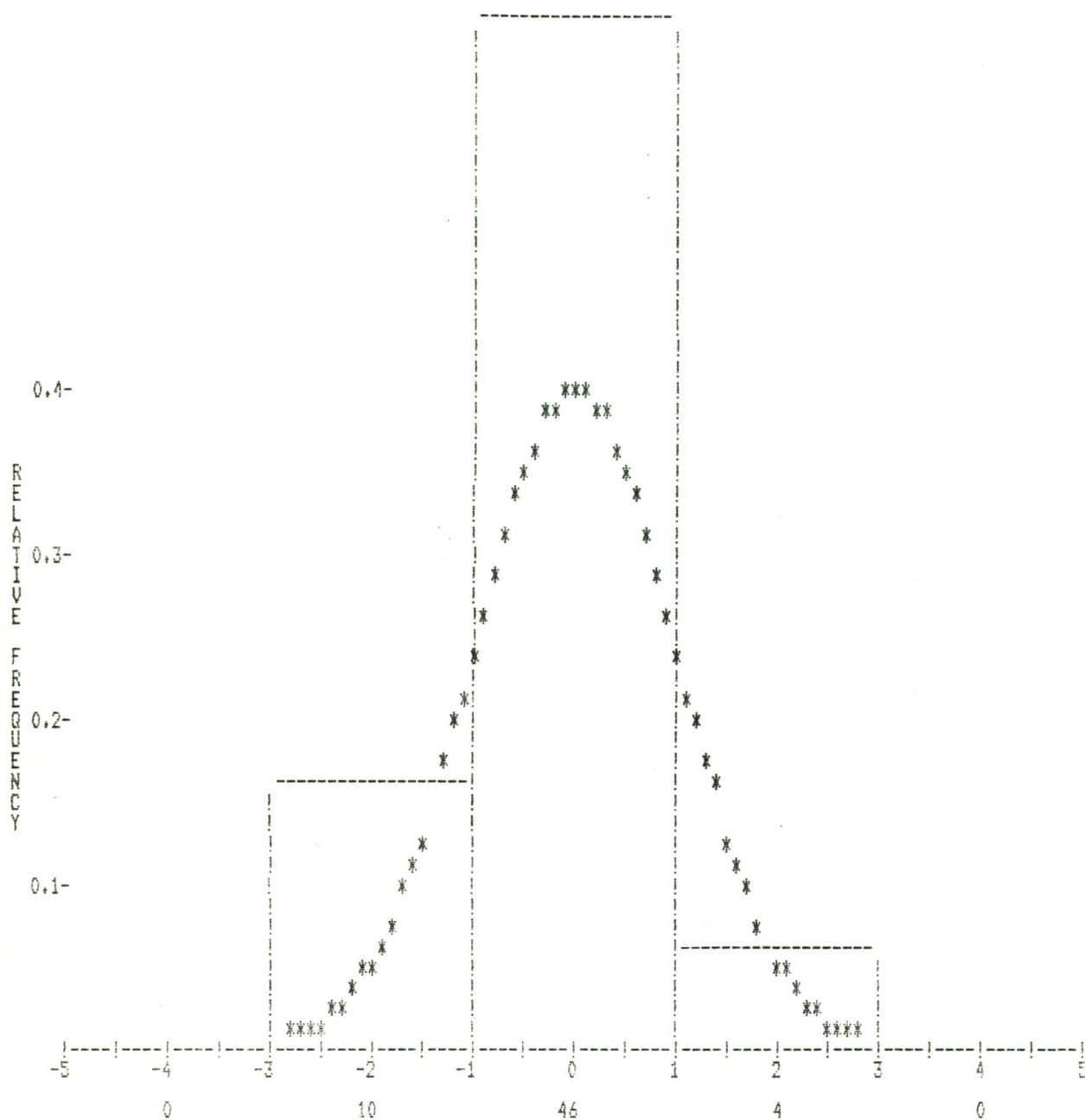
3.79 IS GREATER THAN 3.75

THE TEST FAILS

(SEE HISTOGRAM ON NEXT PAGE)

NOTE: THE HISTOGRAM IS FIRST PLOTTED WITH 3 CLASSES (THAT USED IN THE GOODNESS OF FIT TEST); THEN WITH 20 CLASSES SO THAT A MORE DETAILED REPRESENTATION OF THE ACTUAL RESIDUAL DISTRIBUTION IS GIVEN.

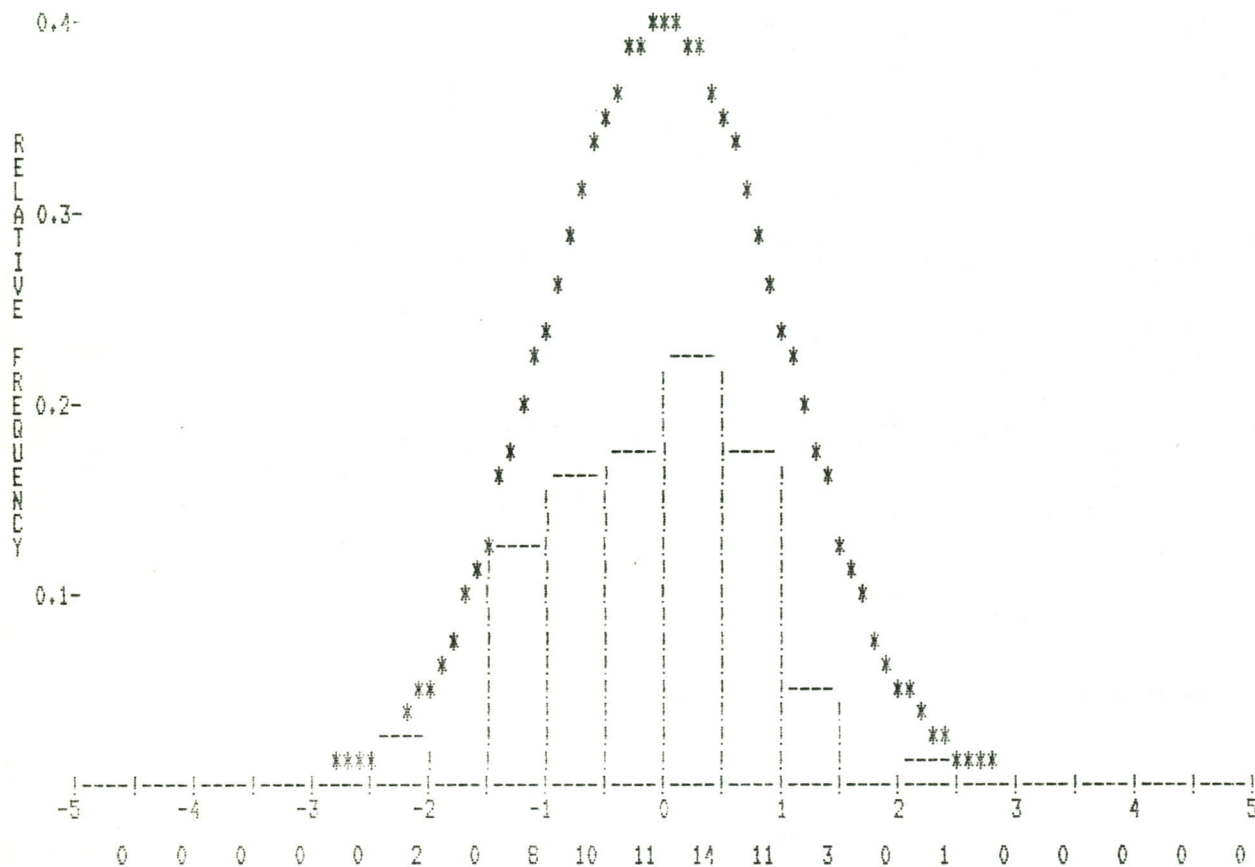
FB 33356



HISTOGRAM OF THE STANDARDIZED RESIDUALS (ALL RESIDUALS INCLUDED)

(WITH CLASSES AS USED IN THE GOODNESS OF FIT TEST) A MORE DETAILED REPRESENTATION IS PLOTTED ON THE NEXT PAGE)

FB 33356



HISTOGRAM OF THE STANDARDIZED RESIDUALS (ALL RESIDUALS INCLUDED)

FB 33856

STATION 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR UNKNOWN) = 2.5596

(COVARIANCE MATRIX OF PARAMETERS WAS NOT MULTIPLIED BY THE ESTIMATED VARIANCE FACTOR (1.286112)),

| STATION | SEMI-MAJOR AXIS | SEMI-MINOR AXIS | AZIMUTH OF SEMI-MAJOR AXIS | AREA OF ELLIPSE |
|---------|-----------------|-----------------|----------------------------|-----------------|
| PELERIN | 1.858 | 0.891 | 71 2 1 | 0.52012D+01 |
| R11 | 0.625 | 0.421 | 72 4 26 | 0.82629D+00 |
| R12 | 1.417 | 0.494 | 7 52 49 | 0.22004D+01 |
| R13 | 1.756 | 0.254 | 20 22 22 | 0.14029D+01 |
| R14 | 1.963 | 0.760 | 287 32 56 | 0.46850D+01 |
| R15 | 1.723 | 0.254 | 20 21 25 | 0.13767D+01 |
| R16 | 2.869 | 2.217 | 59 44 17 | 0.19977D+02 |
| R17 | 1.509 | 1.054 | 20 58 2 | 0.49945D+01 |
| R18 | 1.765 | 1.347 | 82 58 33 | 0.74695D+01 |
| R19 | 5.400 | 2.828 | 35 54 23 | 0.47980D+02 |
| R110 | 1.912 | 0.256 | 286 48 36 | 0.15359D+01 |
| R111 | 4.404 | 2.547 | 328 12 33 | 0.35240D+02 |
| R112 | 1.629 | 0.498 | 20 36 26 | 0.25455D+01 |

TOTAL AREA OF STATION ELLIPSES = 0.13544D+03

FB 33356

APPENDIX B
FINAL PLAN OF SURVEY
PETRO-CANADA ET AL PINING E-16

FB 33356

CANADA LANDS SURVEYS RECORDS
6 9 1 8 5
3 APR 1984

PLAN AND FIELD NOTES
OF SURVEY OF OFFSHORE
EXPLORATORY WELL LOCATION

PETRO-CANADA ET AL
PINING E-16

LATITUDE 54° 45' 22.47"N
LONGITUDE 55° 02' 49.06"W

GRID AREA 54° 50' N, 55° 00' W
SURVEYED JUNE 27 TO JULY 1, 1983
BY MCELHANNEY OFFSHORE SURVEYS LTD.
FOR PETRO-CANADA

LEGEND

Positioning was done by the survey vessel Balder Cabot using an ARGO DM-54 positioning system with shore stations on the coast of LABRADOR. Information about the ARGO DM-54 can be obtained from the Cubic Corporation, San Diego, California. The post-processing of the ARGO DM-54 ranges was carried out using NAVPAK and GEOPAK documentation for which is available from McElhanney Offshore Surveys Ltd. Monuments at Spotted Island, Cape Harrison, Cape Harrison and Stirrup Island are shown on Survey control plans C.L.S.R. 64857 and C.L.S.R. 67305.

The final position was confirmed by doppler satellite single point positioning using a Magnavox MX-1107RS satellite receiver (Three Dimensional solution with 27 acceptable passes). Documentation for its program can be obtained from Magnavox of Torrance, California. The values used for the local datum shift conversion from the broadcast ephemeris datum to NAD 1927 were $\Delta x = -38m$, $\Delta y = +158m$, $\Delta z = +182m$, and were obtained from the Geodetic Survey of Canada, for station Goose Bay (G.S.C. 650001).

Bearings and distances shown on the Unit Details are UTM plane referred to Zone 21, Central Meridian 57°W, using a false easting of 500 000m.

All other distances are surface distances and are not reduced to the UTM plane unless indicated.

All geographic co-ordinates are referred to 1927 North American Datum (1927 NAD) unless indicated.

Water depth at the location is approximately 183 metres.

(c) indicates calculated distance

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

R.T. Hinchley
C.L.S.
15 Dec. 1983
DATE

PETRO-CANADA EXPLORATION INC.

12 Jan 1984
DATE

CANADA LANDS SURVEYS RECORDS

FB 33356

OCTOBER 13, 1983

McELHANNEY OFFSHORE SURVEYS LTD. 083562

Examined by: 2240 9401-23

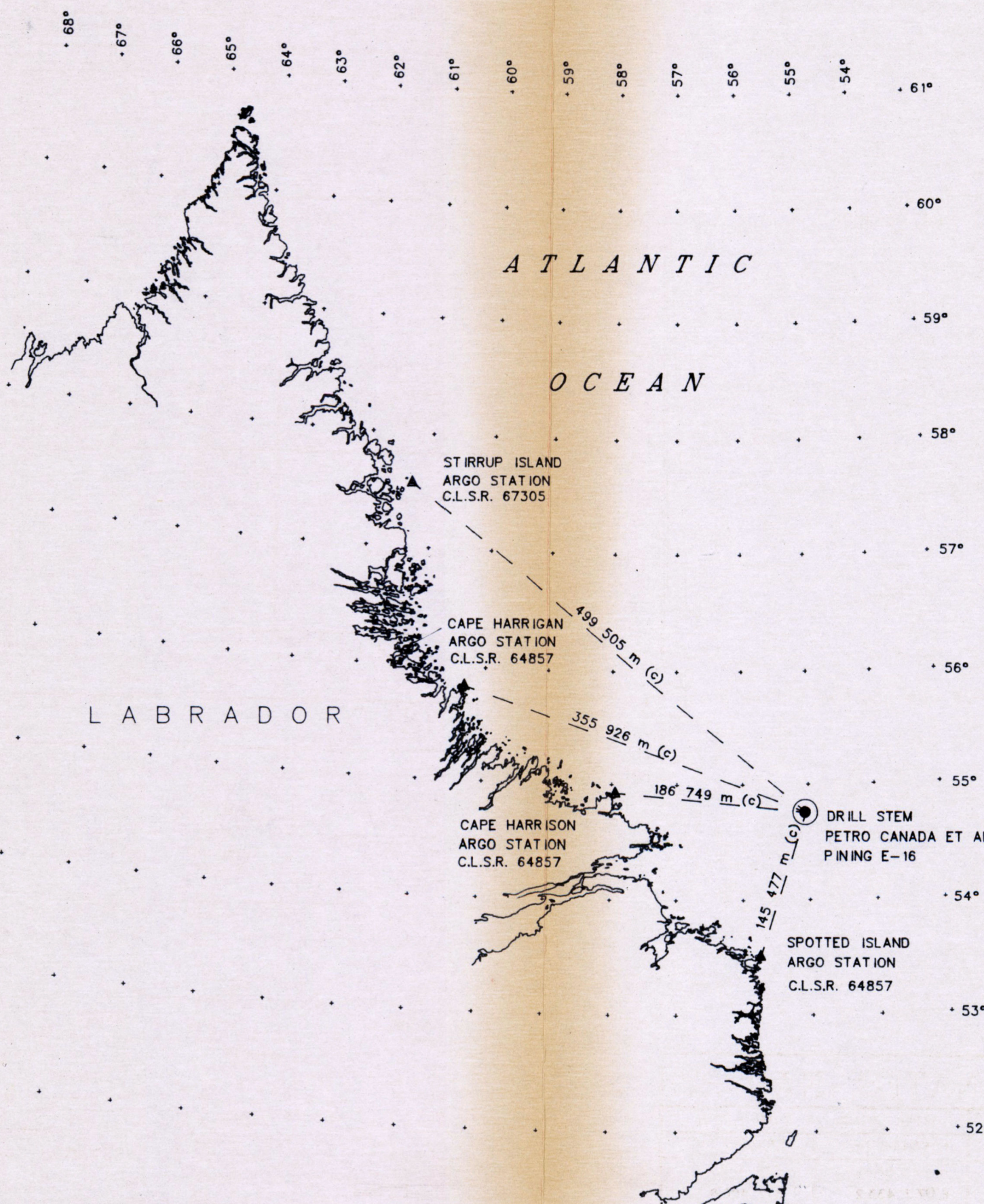
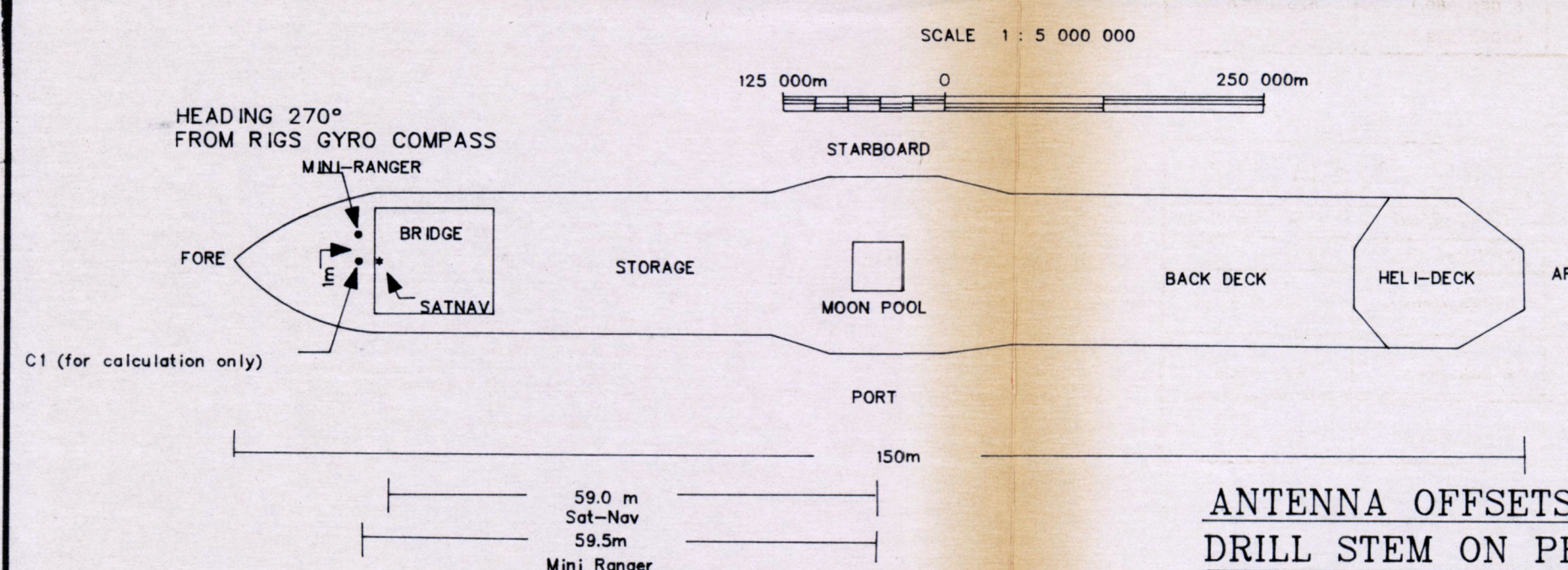


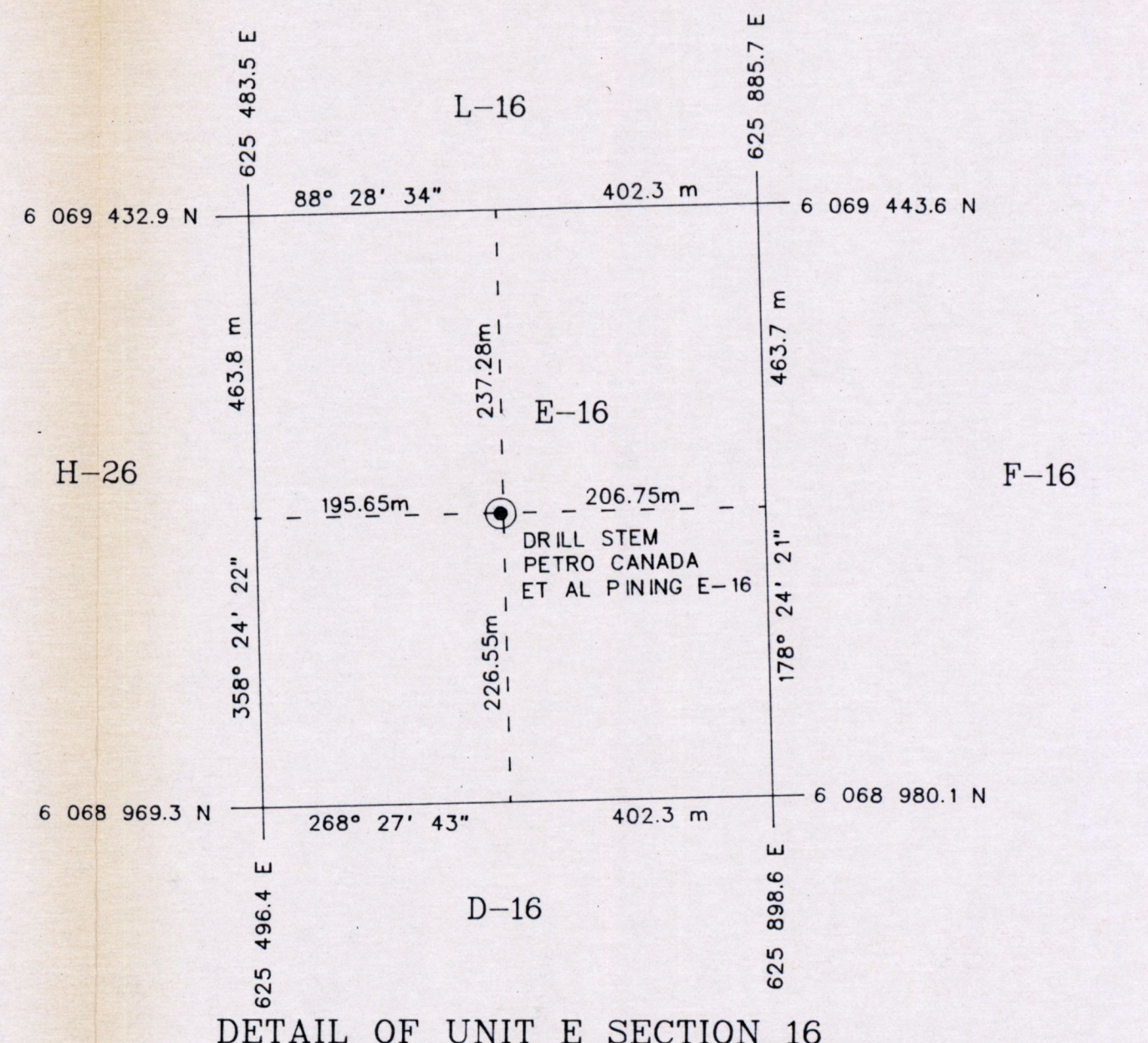
DIAGRAM SHOWING SURVEY OF WELLSITE



ANTENNA OFFSETS FROM
DRILL STEM ON PELLERIN

NOT TO SCALE

| CONFIRMATION SURVEY | | | |
|--|--|--|---|
| SUMMARY OF DOPPLER SATELLITE POINT SURVEY | | | |
| PUBLISHED DATUM SHIFTS | DRILLSTEM POSITION PELLERIN OBSERVED GEOCENTRIC CO-ORDINATES ① (broadcast ephemeris datum) | DRILLSTEM POSITION PELLERIN DERIVED 1927 NAD CO-ORDINATES (Geocentric minus Datum shift) | |
| cartesian co-ordinates x y z | -38 m +158 m +182 m | +2 113 385.49 m -3 023 394.97 m +5 185 799.41 m | +2 113 423.49 m -3 023 552.97 m +5 185 617.41 m |
| Latitude Longitude λ | 54° 45' 22.42"N 55° 02' 45.74" W | 54° 45' 22.29" N 55° 02' 49.06" W | 54° 45' 22.29" N 55° 02' 49.06" W |
| Ht. above sea level H | 24.1m | 24.1m | 24.1m |
| Geoid ht.(GEM 10B) ② N | 12.3m | 12.3m | 12.3m |
| Ht. above ellipsoid h | 36.4 m | 36.4 m | 36.4 m |
| Number of accepted passes | 27 | 27 | 27 |
| ① Co-ordinates are on the geocentric World Geodetic System (WGS 72) as provided by the satellite's broadcast ephemeris. traversed to the drillstem. ② GEM 10B is the Goddard Earth Model of the geoid for which the given heights are computed relative to an eccentric 1927 NAD ellipsoid. The eccentricity used was the published datum shift at station Goose Bay $x_s = -38$, $y_s = +158$, $z_s = +182$ (in Surveying Offshore Canada Lands for Mineral Resource Development, Third Edition, December, 1982). | | | |
| DRILL STEM POSITION BY SATELLITE 3-D POSITIONING (CONFIRMATION) | 1927 N. A. D. 54° 45' 22.29 N 55° 02' 49.06"W | UTM ZONE 21 C.M. 57° W 6 069 195.4 N 625 685.8E | |



DETAIL OF UNIT E SECTION 16

SCALE 1 : 5 000
100m 0 100 200m

| OIL AND GAS GRID CO-ORDINATES, NAD 27 | | | | | |
|---------------------------------------|--------|-------------|--------------|-------------------------|-------------|
| GRID AREA | CORNER | GEOGRAPHIC | | UTM, ZONE 21, C.M. 57°W | |
| | | LATITUDE, N | LONGITUDE, W | NORTHING (m) | EASTING (m) |
| | NE | 54° 50' | 55° 00' | 6 077 862.9 | 628 462.7 |
| | NW | 54° 50' | 55° 15' | 6 077 433.2 | 612 406.6 |
| | SE | 54° 40' | 55° 00' | 6 059 320.7 | 628 991.5 |
| | SW | 54° 40' | 55° 15' | 6 058 890.1 | 612 869.3 |
| UNIT E SECTION 16 | NE | | | 6 069 443.6 | 625 885.7 |
| | NW | | | 6 069 432.9 | 625 483.5 |
| | SE | | | 6 068 980.1 | 625 898.6 |
| | SW | | | 6 068 969.3 | 625 496.4 |

| FINAL WELL SITE CO-ORDINATES, NAD 27 | | | | |
|--|----------------|----------------|-------------------------|-------------|
| | GEOGRAPHIC | | UTM, ZONE 21, C.M. 57°W | |
| | LATITUDE, N | LONGITUDE, W | NORTHING (m) | EASTING (m) |
| MINI-RANGER ANTENNA | 54° 45' 22.50" | 55° 02' 52.39" | 6 069 200.2 | 625 626.1 |
| PLATFORM C1 | 54° 45' 22.47" | 55° 02' 52.39" | 6 069 199.3 | 625 626.2 |
| PELLERIN DRILL STEM AS DETERMINED BY RANGE RESECTION | 54° 45' 22.47" | 55° 02' 49.06" | 6 069 201.0 | 625 685.7 |

| PRIMARY SURVEY | | | |
|--|--------------------------------------|--------------------------------|---|
| ARGO SHORE STATION CO-ORDINATES, NAD 27 | | | |
| STATION | GEOGRAPHICS | UTM, ZONE 21 C.M. 57°W | SURFACE DISTANCE TO DRILLSTEM (COMPUTED) |
| SPOTTED ISLAND 1983 ARGO STATION C.L.S.R. PLAN 64857 | 53° 30' 58.673"N 55° 45' 02.429"W | 5 930 216.223N 582 840.078E | 145 477m |
| CAPE HARRISON 1983 ARGO STATION C.L.S.R. PLAN 64857 | 54° 55' 28.777"N 57° 56' 20.674"W | 6 086 596.012N 439 814.929E | 186 749m |
| CAPE HARRISON 1983 ARGO STATION C.L.S.R. PLAN 64857 | 55° 50' 29.959"N 60° 19' 09.703"W | 6 193 226.256N 292 168.385E | 355 926m |
| STIRRUP ISLAND 1983 ARGO STATION C.L.S.R. PLAN 67305 | 57° 34' 10.982"N 61° 18' 56.756"W | 6 388 805.132N 241 939.830E | 499 505m |
| DRILL STEM FINAL POSITION BY ARGO RANGE RESECTION | 54° 45' 22.47"N 55° 02' 49.06"W | 6 069 201.0 N 625 685.7 E | 0 |
| ARGO DM - 54 INFORMATION | | | |
| FREQUENCY | | 1 766.0 kHz | |
| PROPAGATION VELOCITY (ASSUMED) | | 299 670 km/sec | |
| LANE WIDTH (COMPUTED) | | 84.844 281 metres | |