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Submitted for
Co-Editorial Board Review
Date _____

DIGITAL SEISMIC SURVEY
of the
FORT SIMPSON AREA
for period
DECEMBER 1969 - to - MARCH 1970
for
CANADIAN FINA OIL LIMITED
by
GEOPHYSICAL SERVICE INCORPORATED
on Permits
4348, 4352, 4353, 4354, 4355, 4360, 4376, 4377, (Group 254)
by L. Morris (G.S.I.) and E. W. Redmond (Fina)
Date of Report - July 1970
Project Number - 690 - 6 - 4 - 70 - 1



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- 1) Field and Office Procedures (including Statistical Data and Data Processing)
- 2) Final Report (Results and Interpretation) including the following maps (in pocket):
 - a - Shot Point Location
 - b - Hume Structure
 - c - Cambrian Structure
 - d - Hume to Cambrian Isochron
 - e - Spence River to Hume Isochron
 - f - Hume to Cold Lake Salt Isochron
 - g - Cold Lake Salt to Cambrian Isochron

DIGITAL SEISMIC SURVEY

of the

FORT SIMPSON AREA

for

CANADIAN FINA OIL LIMITED

736 8th AVENUE S.W.

CALGARY, ALBERTA

by

GEOPHYSICAL SERVICE INCORPORATED

640 12th AVENUE S.W.

CALGARY, ALBERTA

PARTY 416

PARTY CHIEF - L. MORRIS

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DECEMBER 1969 - MARCH 1970



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CO-ORDINATES OF SEISMIC CONTROL POINTS

IN FEET NORTH AND EAST OF AN ORIGIN
LOCATED AT 62° 00' N. LATITUDE AND 121° 30' W. LONGITUDE

<u>POINT NUMBER</u>	<u>NORTH CO-ORDINATE</u>	<u>EAST CO-ORDINATE</u>
1 (S.E.)	- 97,918.1	50,127.5
2 (S.E.)	- 97,759.8	70,444.7
3 (S.E.)	-119,690.2	70,686.8
4 (S.E.)	- 66,550.5	69,777.5
5 (S.E.)	- 24,511.7	68,099.9
6 (S.E.)	- 24,554.2	28,683.4
7 (S.E.)	- 57,609.6	2,407.5
8 (S.W.)	- 58,070.0	- 64,583.1
9 (S.W.)	- 9,985.1	- 64,076.0
10 (N.W.)	1,447.2	- 43,618.0
11 (N.W.)	18,161.8	- 45,161.6
12 (N.W.)	35,337.8	- 45,219.9
13 (N.W.)	74,036.7	- 77,043.1
14 (N.W.)	94,240.2	- 73,216.3

WELL
LOCATIONS

4A	- 80,932.7	45,151.9
P13	18,295.5	- 6,412.8
J70	119,085.4	- 76,417.8

ENCLOSURE III



ABSTRACT

The purpose of this report is to outline the recording and processing procedures followed by Geophysical Service Incorporated, Party 416, on a digital seismic reflection survey conducted in the Fort Simpson region of the Northwest Territories. The prospect extended from approximately $61^{\circ} 40'$ to $62^{\circ} 20'$ north latitude, and from $121^{\circ} 00'$ to $122^{\circ} 00'$ west longitude (see Program Location Map, Plate 1, and Line Location Map, Plate 2).

Party headquarters were located in the field, with Fort Simpson serving as the supply and staging center.

Field recording was begun on January 5, 1970, and was completed on March 26, 1970. During this time approximately 3400 reflection profiles and 700 refraction profiles were shot, comprising a total of 331 miles of line. The reflection field records were processed at G.S.I.'s TIAC Computing Center in Calgary.

For the purpose of simplified communications, the survey area was arbitrarily divided into four quadrants. The north-west quadrant was defined as that area bounded by the Mackenzie River on the south and $121^{\circ} 30'$ on the east; the north-east quadrant that area bounded by the Mackenzie River on the south and $121^{\circ} 30'$ on the west; the south-west quadrant that area bounded by the Mackenzie River on the north and the Liard River on the east; and the south-east quadrant that area bounded by the Mackenzie River on the north and the Liard River on the west.



These four quadrants will be referred to a number of times in the report.

Permission to conduct the survey was gained through Oil and Gas Exploratory License #1293 granted to Canadian Fina Oil Limited. Permission to cut lines in the area was granted to Canadian Fina Oil Limited under Timber Cutting Permit #4093.



II

FIELD PROCEDURES

A. RECORDING

All data were recorded digitally on magnetic tape using Texas Instruments 21 - Track DFS III Digital Field System with binary gain seismic amplifiers. Gain information was recorded on tape in four special bit locations, making possible the recovery of true amplitude information when the data were processed.

Normally the field recordings were displayed on Dri-write paper as "direct" or "read-after-write" (R.A.W.) monitors. The direct monitor is produced by reading the recorded data from tape just after it has been written by the write head. Therefore, on the direct monitor the time break and timing lines are displayed at true time and all other displayed information, including uphole break and seismic data are delayed an amount dependent on tape speed. For data recorded at a two millisecond sample period, the time required for the data written on tape to travel from write to read heads is 6.7 milliseconds.

The digital recordings were played back for a number of shot points. Playbacks can be made as either amplifier playbacks or direct playbacks.

Amplifier playbacks are made through the binary gain amplifier system, where bandpass filtering and playback gain can be selected as desired. No auxiliary information is displayed on this type of playback.



Direct playbacks display all seismic traces and auxiliary information. The playback signals are generated from the digital-to-analog converter, smoothed by the playback filter cards, and go to the camera. Since all data are read from tape, seismic and auxiliary data retain their true relationship except for the phase shift in the filters for the galvanometers.

Primary recording parameters are listed in the following table:

Sample rate	2 milliseconds
Recording filters	Low = 8 Hz (36 db/octave slope) High = 124 Hz (72 db/octave slope)
Record length	2.0 seconds
Uphole seismometer offset..	10 feet
Gain mode	Operate
Gain constant	30 db.
Initial gain	Varied depending on area
Final gain	84 or 90 db.
Upper set limit	75% of full scale
Lower set limit	25% of full scale
Gain release rate	Medium, Jan. 5 - Feb. 11 Fast, Feb. 12 - Mar. 26
Trip delay	.192 seconds
60 Hz notch filter	Out

Instrument tests to check dynamic range, amplifier noise, DFS noise, and A.G.C. circuitry were run daily before commencing production shooting.



B. SHOOTING PROCEDURE AND SPREAD DETAILS

Normal field procedure called for two-fold C.D.P. shooting. However, after recording and examining lines A, 3 and 6 in the S.E. Quadrant, it was decided to change to three-fold shooting in an attempt to improve the quality of the stacked section. The remaining lines in the S.E. Quadrant (1, 2, 4 and 5), and all lines in the S.W. and N.E. Quadrants were shot using a three-fold technique. With improved field data evidenced in the N.E. Quadrant, it was decided to revert to two-fold shooting in the N.W. Quadrant.

Off-end refraction profiles were recorded in conjunction with reflection shots at a frequency of at least once per mile, and wherever possible reverse profiles were recorded. However, in several parts of the prospect, notably the N.E. and S.E. Quadrants, refraction shots had to be offset as much as one-half mile in order to penetrate below the weathering, and therefore weathering control was often inadequate, especially at the ends of lines where profiles were recorded in one direction only.

Spread details are listed below:

Type of coverage	2-fold CDP (as noted above) 3-fold CDP (as noted above)
Spread layout, reflections	Split, roll-along shooting, 1320' - 0 - 1320', with 55' from center of shot point to center of group 12 and 13 (See Plates 3a and 3b)
Spread layout, refractions	Offend, with near trace offset one group on normal shots, to as far as 24 groups in areas of deep weathering. (See Plate 4)



Number of groups	24 groups, group length of 96'
Group spacing	110', center to center
Group pattern	Inline with spread
Shot Point spacing	660' for 2-fold 440' for 3-fold
Shot Pattern	Single holes in N.E. and N.W. Quadrants 2 holes at 100' spacing in S.E. and S.W. Quadrants
Seismometer data	Hall Sears 14 Hz phones, 9 phones per group at 12' intervals
Charge size	Single hole pattern: 1 x 1 1/4 lbs. 2-hole patterns: Lines 1, 2, 4, 5, C, 13E = 2 x 5/8 lbs. Lines D, 12W, 13W, 14W, 17, 18= 2 x 1 lbs. Lines 3, 6, 12E, 14E, 15, 16 = 2 x 1 1/4 lbs. Line A = 2 x 2 1/2 lbs.
Hole depth	45 feet

C. EQUIPMENT

Equipment used on the prospect was wheel mounted. Basic party equipment used by Party 416 is listed below:

1. Vehicular Equipment

<u>Unit Designation</u>	<u>Purpose</u>
62158	Party Manager Unit
96102-R	Recording Unit
8610E	Shooting Unit
9602S	Survey Unit
8611S	Survey Unit
9605-CT	Cable Unit
8609-CT	Cable Unit
3267-MD	Drill Unit
7208-CD	Drill Unit

Geoserve Contract	Drill Unit
Kuntz Contract	Drill Unit
Sando Contract	Drill Unit
Hall Contract	Drill Unit
Combination Contract	Drill Unit
3253	Water Unit
2206R	Water Unit
Hall Contract	Water Unit
Haining Contract	Water Unit
Robertson Geophysical	
Rentals	Supply Unit
4212	Fuel Storage Unit

2. Camp Equipment

- G.I.C. camp on wheels, consisting of two kitchen units, two wash units, four sleeper units, one bunk-office unit
- 2-30 Kw Diesel electric power plants
- 1 Mobile shop unit
- Single side band camp radio

D. SURVEYING

The horizontal survey was obtained by gyroscopic theodolite and by Cubic Autotape, an electronic positioning system subcontracted by Canadian Engineering Surveys Ltd.

The Cubic Autotape makes use of microwave signals emanating from two responders which are interpreted by an interrogator located at a third position, usually the point whose location is to be determined. For the Fort Simpson survey, a helicopter containing the interrogator hovered over fourteen selected seismic control points and three existing well locations, thereby fixing their positions (see Enclosure II). The location of each point was then converted to U.T.M. co-ordinates and subsequently to latitude and longitude. Note that the locations of the wells



determined by electronic positioning sometimes differ considerably from the previously published locations of these wells.

The computed U.T.M. co-ordinates, having no real meaning in a seismic survey of limited extent, were revised to a system of latitudes and departures in feet north and east of an origin established at $62^{\circ} 00' N.$ and $121^{\circ} 30' W.$ The arbitrary values assigned to the origin were 0 feet North and 0 feet East. See Enclosure III for a listing of the revised co-ordinates.

Once the hover control points had been established, horizontal control points were tied to them making use of a gyroscopic theodolite. Numerous turning-points were established along each line, with accurate distances being maintained by chainage. Shot points were then located at either 440 foot or 660 foot intervals along the traverse lines. Latitudes and departures from the origin for the hover points and for numerous turning-points were then computed by G.S.I. and compared to C.E.S. computations. In all instances the differences between the two sets of values were well within tolerance.

The vertical survey was obtained by transit. Two readings were taken at each turning-point to ensure accurate control elevations. Each traverse was double-run to check elevations at control stations. Vertical control elevations, supplied by Canadian Fina and by the Department of Public Works in Fort Simpson are as follows:



<u>Quadrant</u>	<u>Supplied By</u>	<u>Purpose</u>	<u>Location</u>	<u>Elevation</u>
S.E.	D.P.W.	Take-off	D.P.W. BM #550	565.6 Ft.
S.W.	Fina	Take-off	SP 800, 1L-1	591.0
N.E.	Fina	Take-off	I.O.L. B.M. T.V. 221	580.81
N.E.	Fina	Check-point	SP 9432, 1L-3	605.0
N.W.	Fina	Take-off	SP 23D-138, 1L-9	441.0
N.W.	Fina	Take-off	I.O.L. B.M. 12-46	660.0
N.W.	Fina	Check-Point	SP 1221, 1L-4	534.0
N.W.	Fina	Check-Point	SP 23D-415, 1L-5	616.0
N.W.	Fina	Check-Point	I.O.E. Triad Ebbutt J-70	862.0

Enclosure I shows all shot point locations.

E. DRILLING

The drill power was provided by basically seven drilling rigs, all on trucks. Five of the rigs were auger drills and two were water conventionals. Below is a table of the drill equipment:

<u>Unit</u>	<u>Type of Drill</u>
7208 CD	G.S.I. owned Carey drill with water tank
3267 MD	G.S.I. owned 1000 Mayhew with water truck
Sando Drilling	Sewell with water tank
Geoserve Drilling	Sewell with water tanks
Kuntz Drilling	Sewell with water tank
Combination Drilling	Carey drill with water tank
Hall Drilling	1000 Mayhew (long mast) and water truck
Dell Haining	1700 Gallon water tanker



Drilling conditions varied throughout the prospect. In the S.E. quadrant, muskeg and deep sand were encountered. In places sand was found to a depth of 80 feet. Much of the sand had to be drilled with the conventionals using heavy mud to enable the holes to be loaded.

In the S.W. quadrant, drilling was generally good with a large patch of gravel running northwest-southeast and centered around Line D. Some sand was encountered as well.

In the N.E. quadrant, muskeg, surface boulders, and hard sandstone overlying clay and shale was encountered. The surface boulders and hard sandstone caused considerable hindrance in drilling, especially for the auger drills.

The N.W. quadrant could be considered poor to fair drilling and consisted of deep muskeg, clay, shale and hard sandstone. Patches of surface boulders and gravel throughout the area caused drill problems.

Air drills would be of no use in any of the four blocks because of excessive ground moisture.

The drill production averaged out to 42.8 feet per hour of drill time for the job.

A split camp, to enable the drills to move ahead on their own, proved to be a great benefit.



F. BULLDOZING AND LINE CLEAN-UP

The bulldozing and line clean-up was subcontracted to Line Loppers Ltd., at a flat turnkey rate for the entire job.

All lines were new cut. All lines were cleaned up according to Forestry specifications and a Forestry clearance was received upon completion of the job.

Some difficulty with breaking through muskeg was experienced in December, 1969, but was no problem from January through March.

The bulldozing equipment consisted of two D7E cats with power shifts and hydraulic winches, one wide pad D6C cat and one direct drive D7E cat used part time.

The bulldozing and line clean-up men worked together and lived in the same camp. This greatly increased the efficiency of the whole operation.

G. FIELD CONDITIONS

Terrain was generally flat and muskeg-covered, with numerous small lakes, marshes and beaver dams. Several areas of floating muskeg were encountered. Only thin stands of conifers existed in these areas. Lines, however, were not as rough as expected and the base camp completed the job with only five camp moves. The drilling camp, however, moved nine times during the winter to cut down daily travel time.

Thicker stands of larger coniferous and deciduous trees grew on higher elevations and along rivers and creeks.



The weather was very cold in January, but was moderate during February and March. Snow on an average was about 18 inches deep. One bad storm in early January blew in some lines but generally wind was not a problem.

H. PRODUCTION STATISTICS

Number of Reflection Profiles	3403
Number of Refraction Profiles	693
Surface Coverage	331.46 miles
Number of Days Production Shooting	77
Reflection Profiles per Day	44.2
Refraction Profiles per Day	9.0
Number of Holes Drilled	5364
Total Footage	241,395 feet
Average Hole Depth	45 feet
Footage Drilled per Day	3135 feet
Footage Drilled per Hour	42.8 feet
Total Dynamite used	7106.25 pounds
Average Dynamite per Profile	1.72 pounds

I. REMARKS AND RECOMMENDATIONS ON FIELD PROCEDURE

1. Air drills would not be of much value because of excessive ground moisture. A mixture of auger drills and water conventional drills is necessary.
2. 3-Fold stack produced slightly better stack sections than 2-fold due to the fact that 200% stack consists mainly of near and far traces stacked together, whereas 300% stack had a mixture of near, intermediate and far traces.



3. A split camp, with recording crew in one camp and drills in another camp increased production by eliminating long driving times.
4. A combined supply and fuel truck was a necessity because of a lack of facilities in the area.
5. Binary gain recording instruments are a necessity in such a shallow geologic section.
6. Single holes seemed to produce about the same results as two-hole patterns in areas where patterns were used. There was somewhat less noise observed on pattern shots after deconvolution, but when the data were stacked there was little difference seen between the two techniques.
7. Combining a reflection and refraction survey was difficult in this area because reflection spreads had to be short, and refraction spreads often had to be quite long. For better weathering control, more refraction shots, with reverse profiles, would have to be shot.
8. A horizontal survey utilizing a helicopter cubic autotape system was a great aid in establishing control and tying all areas together with a high degree of accuracy.



III

OFFICE PROCESSING PROCEDURES

A. GENERAL

The shallow geologic section, having a comparatively short seismic time period, restricted the parameters that could be used in processing the data. Because of these limitations, the only experimental processing conducted was to evaluate the application of digital filtering to several shot points before and after deconvolution.

Two different routes were followed in the processing sequence (see Plate 5), the underlying difference being in the manner in which normal moveout functions were determined for each line or line segment. An empirical field record T_0 vs ΔT approach was taken wherever field record quality was such to support a reliable velocity evaluation. Poor reflection signal quality on the field records in specific areas necessitated a second route of deconvolution and digital filtering prior to T_0 - ΔT velocity evaluation. While this second route added one extra step to the processing sequence, it was deemed necessary to achieve a reliable end product, and was used throughout the majority of the prospect.

The second stage of processing consisted of manually picking the reflection times of a consistent event in the Cambrian zone, and flattening this event to .400 seconds. If the record quality was satisfactory, the data were stacked at the same time as the statics were applied. On poorer quality data, a paper display was made after statics application, trim statics were applied if necessary, and then the data were stacked.



Concurrent with the second stage of processing, first break plots were being constructed and interpreted to produce structural computation times to reference the seismic section to a 500 foot datum plane.

The final processing step consisted of applying the structural statics to the flattened stack section.

In all cases, only the first 1.5 seconds of the 2.0 second recorded field data was processed.

B. EXPERIMENTAL PROCESSING

Experimentation was confined to a digital filter analysis applied to two separate shot points before and after deconvolution (Enclosures IVA - IVd). The frequency spectrum was divided into five cycle and ten cycle frequency increments in order to exhibit the frequency content of the records as a function of time and space.

C. PRODUCTION PROCESSING

After determining the bandpass filters to be applied, all data were processed following one of the two alternative routes shown on Plate 5. An explanation of each of the processing steps follows.

1. Binary Gain True Amplitude Recovery (T.A.R.)

The application of T.A.R. ensures that a true relative amplitude relationship in a horizontal sense is established for all events, each event being proportional in amplitude to its reflection coefficient.



T.A.R. has three objectives:

- (a) removal of field recorded gain
- (b) compensation for loss in amplitude due to shot - receiver distance by addition of a spherical divergence correction
- (c) compensation for inelastic attenuation by applying an appropriate exponent to the records

In the Fort Simpson survey, an exponent of 6.50 db per sec. was applied over a gate of 0.0 to 1.490 seconds.

2. Normal Moveout (N.M.O.)

The two-dimensional time lag effects due to finite signal propagation velocities and shot to receiver distances make it necessary to apply space (shot-geophone distances) and time (average velocity with depth) corrections if common depth point stacking methods are to be used effectively. Field recording geometry must be known, and an accurate velocity picture, or velocity function, must be used to apply normal moveout corrections.

A number of wells and corresponding well tops were used initially to project a general area trend and geologic picture. Wells scattered around the survey area served as velocity grid control. These wells were:

<u>Well Name</u>	<u>Published Location</u>
I.O.E. Triad Ebbutt J-70	62° 19' 30" N 121° 47' 03" W
I.O.E. Triad Ebbutt D-50	62° 19' 01" N 122° 24' 05" W
I.O.E. Trail River P-13	62° 02' 59" N 121° 32' 13" W



I.O.E. Strong Point	G-24	61° 53' 16" N	120° 49' 36" W
Westerol	4-A	61° 46' 49" N	121° 14' 46" W

Velocity functions were derived from sonic log analyses of the first four wells listed above. The Westerol well served only as a geologic control point since no velocity information was available. Plate 6 relates the well locations to the seismic line locations.

Once the general shape of the velocity functions had been determined, a T_0 vs ΔT analysis was performed on the Hume and Cambrian markers. The average velocity ($\bar{V}$) to both markers was determined from the raw two-way reflection times (T_0) to the markers versus the amount of moveout (ΔT) on these reflectors along the survey lines where record quality permitted a reliable analysis. In most instances, the acceleration between the Hume and Cambrian on the T_0 vs ΔT computations was found to follow very closely the accelerations seen on the sonigram-derived functions. Thus, wherever possible the velocity function was hinged on the Hume horizon by using the $\bar{V}$ calculated by the T_0 vs ΔT method, and the sonigram-derived function was appended to the T_0 vs ΔT function to obtain average velocities below and immediately above the Hume. Because a very slight variation in ΔT at the Cambrian level would produce a large difference in the average velocity at that point, the Cambrian velocity computed by T_0 vs ΔT served mainly to verify the Cambrian velocity as seen on the appended function. Only when the Hume



velocity could not be determined was the velocity function hinged on the Cambrian and appended back to the surface.

A total of sixty-five functions were used throughout the survey on the different lines and line segments. Rather than listing the functions and the shot points to which they were applied, it should be sufficient to note that the raw arrival time of the Hume varied from .230 seconds to .460 seconds and the average velocity at the Hume varied from 11,280 ft./second to 6250 ft./second. The shallower arrival times at the Hume could be related to the higher average velocities, and the deeper arrival times at the Hume would be related to the lower average velocities. Although part of this effect could be attributed to increased elevation above the Hume, it was for the most part found to be associated with deep weathering channels that were filled with low velocity glacial drift.

3. Deconvolution (DCN)

Deconvolution simply means that a function such as a shot wavelet, or a reverberation, which has been linearly convolved with the impulse response of the earth at the time of recording is approximately removed with an inverse filter. The result desired is a seismogram which represents the earth's acoustical boundaries as a series of sharply defined impulses. To achieve this, a "whitening" filter is designed from correlation functions. The filter thus designed produces the following effects: (i) increases the bandwidth of the signal and collapses the time function, (ii) attenuates periodic events, short or long order,



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depending on the length of operator applied, and (iii) equalizes the power spectrum by giving a nearly constant energy level over the same frequency range to all traces over one spread and from one spread to another.

Because of the shallow geologic section encountered in the prospect area, the choice of possible deconvolution operators was severely limited. However, in order to have some measure of control over suspected periodic events, it was decided to employ a filter of 52 milliseconds length which was designed over a gate from .350 to 1.000 seconds. Each filter was designed from and applied to traces on an individual basis.

4. Zero-Phase Digital Bandpass Filtering (DCF)

Zero-phase filtering implies that there is no time shift associated with the filtering process. In this way, the deconvolved data after filtering were kept in raw record time, with none of the time shifts and phase shifts inherent in electrical filtering present.

The time-variant digital filter chosen for the prospect was determined from an examination of a harmonic analysis after deconvolution applied to two selected shot points, one shot point representing the poorest available raw data, and the other representing good raw data.

The filter used had an initial bandpass of 28-60 Hz applied from a time of 0.00 seconds to a time of .300 seconds. At .300 seconds the first filter began to taper off, and a



second filter of bandpass 20-60 Hz began to taper on. This second filter was fully on at a time of .400 seconds, and remained this way to the end of the record.

5. Time-Variant Scaling (T.V.S.)

Time-variant scaling usually functions as a multi-gated trace equalization process, and is used to remodulate the digital tape either uniformly or according to an input schedule of relative amplitudes versus time. For this survey scaling was done on an individual trace and record basis in order to modulate each shot point to nearly the same level on tape.

6. Flattening Statics

Subsequent to normal moveout and prior to stacking, each single-fold record was staticed to .400 seconds by picking and timing each trace on a consistent reflecting event in the Cambrian zone. Once picked, the time of the event was adjusted by applying a bulk time shift, or static, to place the event at the correct time. Where the record quality was good, the data were stacked immediately after statics, but where the record quality was poorer, a paper display was made after statics application, trim statics were applied if necessary, and then the data were stacked.

The horizon that was flattened was always consistent within any one of the four quadrants. However, the flattened event often differed from quadrant to quadrant.



7. Common Depth Point Stack (D.P.S.)

Two traces or three traces (for two-fold and three-fold coverage respectively) from a common subsurface point were summed to produce one output trace per subsurface point. The long offset traces were scaled according to the spread geometry, using first break suppression to eliminate: (i) surface noise, (ii) distortion related to first arrival energy, and (iii) NMO problems associated with the far traces on the shallow data. A stacking technique with space equalization over a specified time gate was used in conjunction with dead trace detection and amplitude recovery procedures to ensure proper modulation on the stacked output.

8. Structural Computations

a. Method

The approach taken on the picking and plotting of refraction breaks varied slightly in each quadrant. The S.W. quadrant, the first area in which weathering computations were made, had every third shot point plotted unless the weathering depth changed rapidly. In such cases, every shot point was plotted providing there was a 10,000 ft. per second breakover observed on the split shots.

In the N.E. quadrant every shot point was plotted if the split shots exhibited a breakover into the 10,000 ft. per second layer. If only the endover shots had a 10000'/s velocity breakover, then every third shot point was plotted



and the intercepts of intermediate shot points were interpolated between endover control points. It should be emphasized that where the weathering depths varied rapidly and radically, the endovers that were shot approximately once per mile were often the only weathering control available, and that while interpolating intercepts between endover control was not a very satisfactory method, it was as accurate as any other method that could have been employed. Lines 1, 2 and 4 in the S.E. quadrant had every shot point plotted and every third shot point interpreted, whereas about one-half of Line 5 had every third shot point plotted and the other half had each shot point done. Lines 3, 6, and A had every shot point plotted.

Interpretation consisted of using a two layer case with the subweathering layer velocity of 10,000 ft. per second assumed constant. This velocity was used on previous work in the prospect area and while it proved to be a reasonably good fit throughout most of the area, it was found to be too slow by about 2000 ft. per second in some regions. The velocity in the drift was drawn on the plots as would best fit the first break picks. Hence, drift velocities varied considerably throughout the prospect.

The two most difficult areas of weathering interpretation were the N.E. and S.E. quadrants. In both areas the drift was generally deep and often varied rapidly. Difficulties were sometimes encountered in tying lines together



(e.g. tie of Line B to Line 11) possibly because the first break arrivals emanating from the deep, narrow drift channels originated from a third-dimensional point source. In such instances the line which exhibited the best weathering control was taken as being most correct, and the tie line was interpreted to fit the first line. Structural sections which exhibit sudden synclinal features should be checked carefully by referring to the weathering plots to see if all the weathering was removed. In many instances inadequate weathering control between endover shots forced the use of interpolated intercepts, and prevented time variations due to drift problems from being adequately resolved.

b. Computations

The following formulae illustrate the approach taken to structurally correct the data to a flat datum plane 500 feet above sea level using a replacement velocity of 10,000 ft. per second. The Cambrian horizon was used as the reference marker.

$$\text{U.H. Corr} = 2 \left(\frac{\text{Esp} - \text{Ds} - \text{Ed}}{V_d} \right) + T_{uh}$$

$$H = (\text{Int } T - T_{uh}) \frac{V_1}{2 \cos \theta}$$

$$Z = H + \text{Ds}$$

$$D_c = 2H \left(\frac{1}{V_1} - \frac{1}{V_d} \right)$$

$$T_c = \text{UH Corr} + D_c$$



where:

U.H. Corr	=	Elevation correction to datum (seconds)
Esp	=	Elevation of Shot Point (feet)
Ds	=	Depth of shot (feet)
Ed	=	Elevation of datum plane (500 feet)
V _d	=	Replacement velocity to datum (10000 ft/sec.)
T _{uh}	=	Uphole time (seconds)
H	=	Depth of weathering below shot (feet)
Int T	=	Intercept time of subweathering layer plot slope (seconds)
V ₁	=	Velocity in the drift (ft./sec.)
V ₂	=	Subweathering velocity (ft./sec.)
sin θ	=	$\frac{V_1}{V_2}$
Z	=	Depth of weathering below surface (feet)
D _c	=	Drift correction (seconds)
T _c	=	Total correction (seconds)

c. Application

When the total correction, T_c, to structurally correct the Cambrian event to a 500 foot reference plane had been calculated, it was applied to the flattened stack sections. However, since the flattened stack had static shifts applied, the data traces were not in raw time, and thus had to be adjusted to raw time before the total correction was applied.

The following formula indicates the method of determining the structure time on the Cambrian event:



$$S.T. = T_F - C_S + T_C$$

where S.T. = Structure Time (Cambrian event)

T_F = Cambrian Time on flattened sections (.400 sec.)

C_S = Static correction at the shot point

T_C = Total structure correction

The structure times thus determined were located at the shot points. Structure times for depth points located between the shot points were manually interpolated.



PROGRAM LOCATION MAP

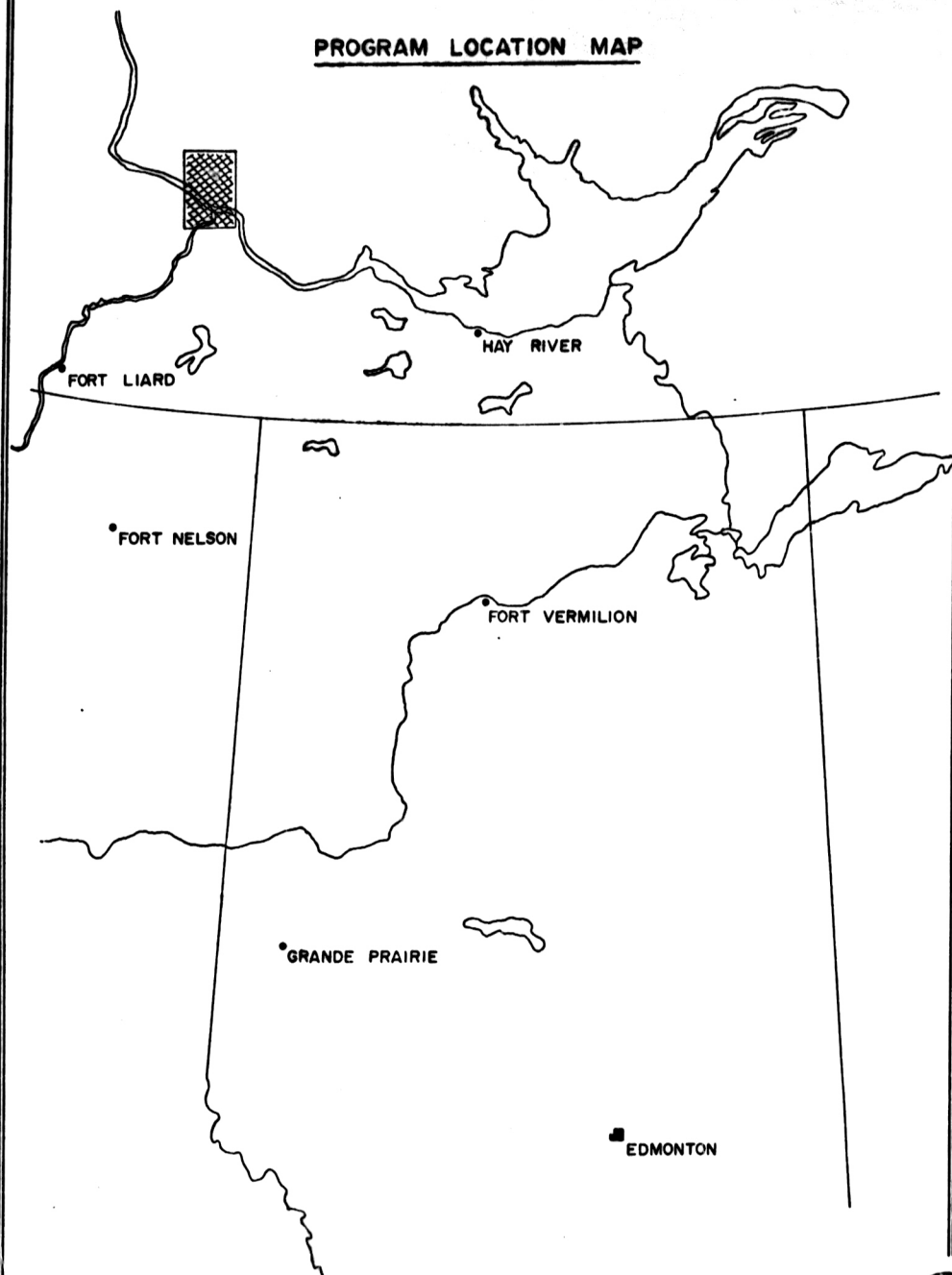
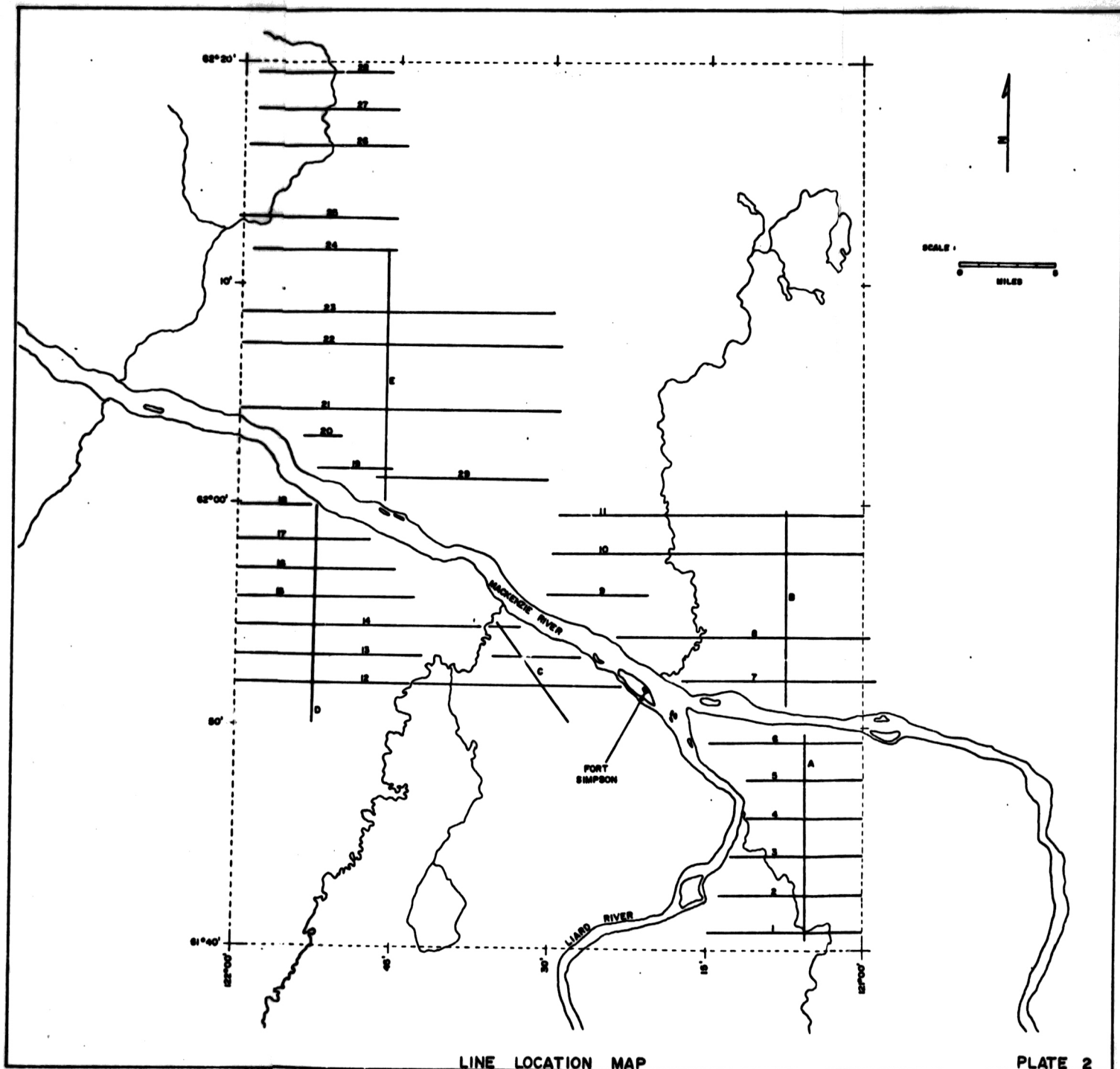


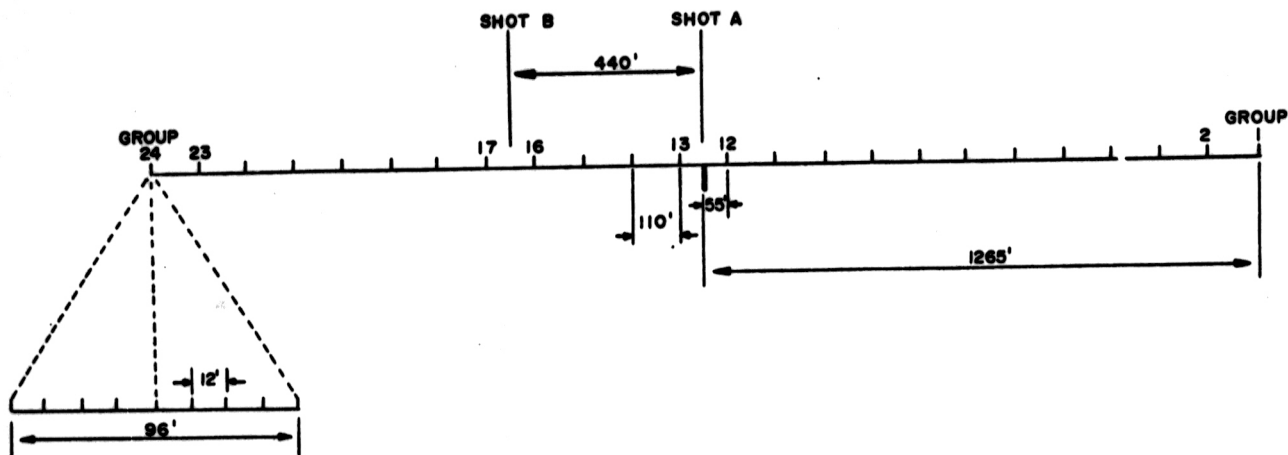
PLATE I





SPREAD CONFIGURATION

3 - FOLD



SPREAD CONFIGURATION

2- FOLD

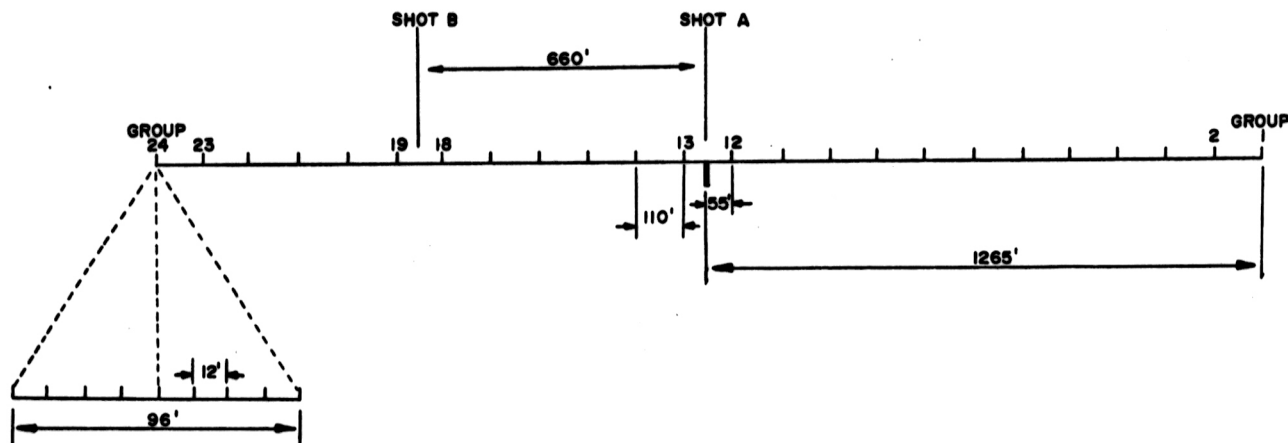
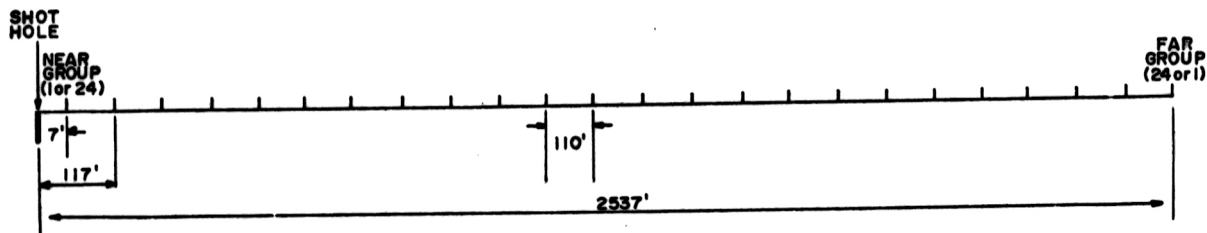


PLATE 3b



REFRACTION SPREAD CONFIGURATION

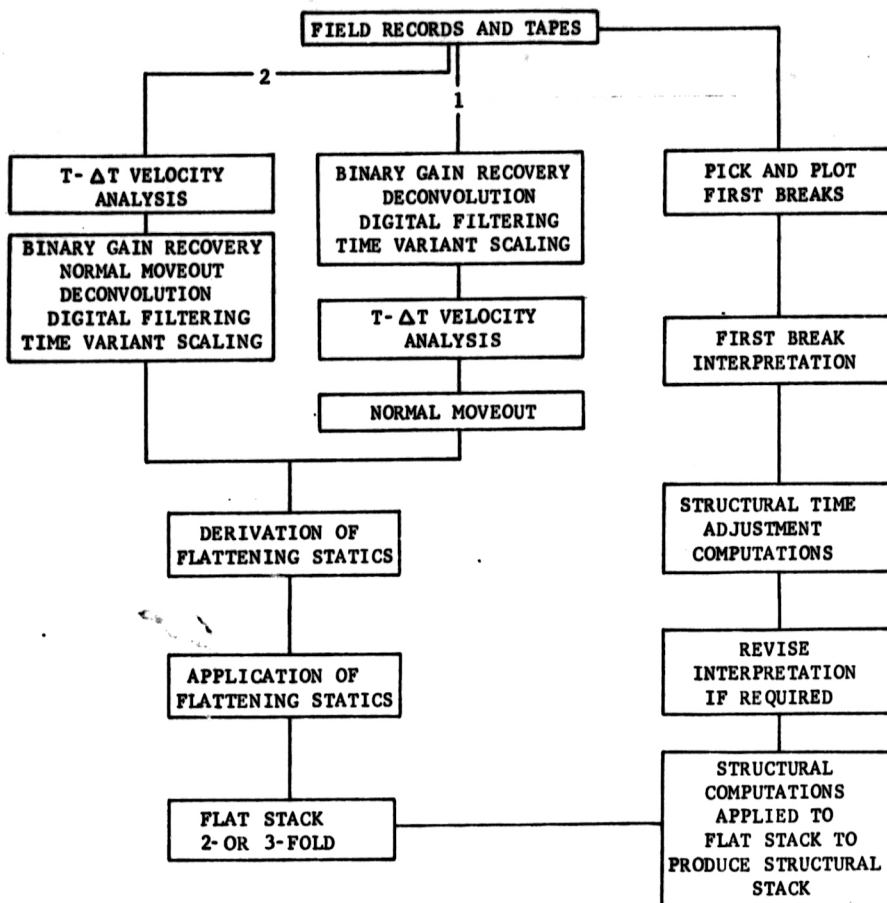
(NORMAL DISTANCES TO NEAREST PHONE OF EACH GROUP)

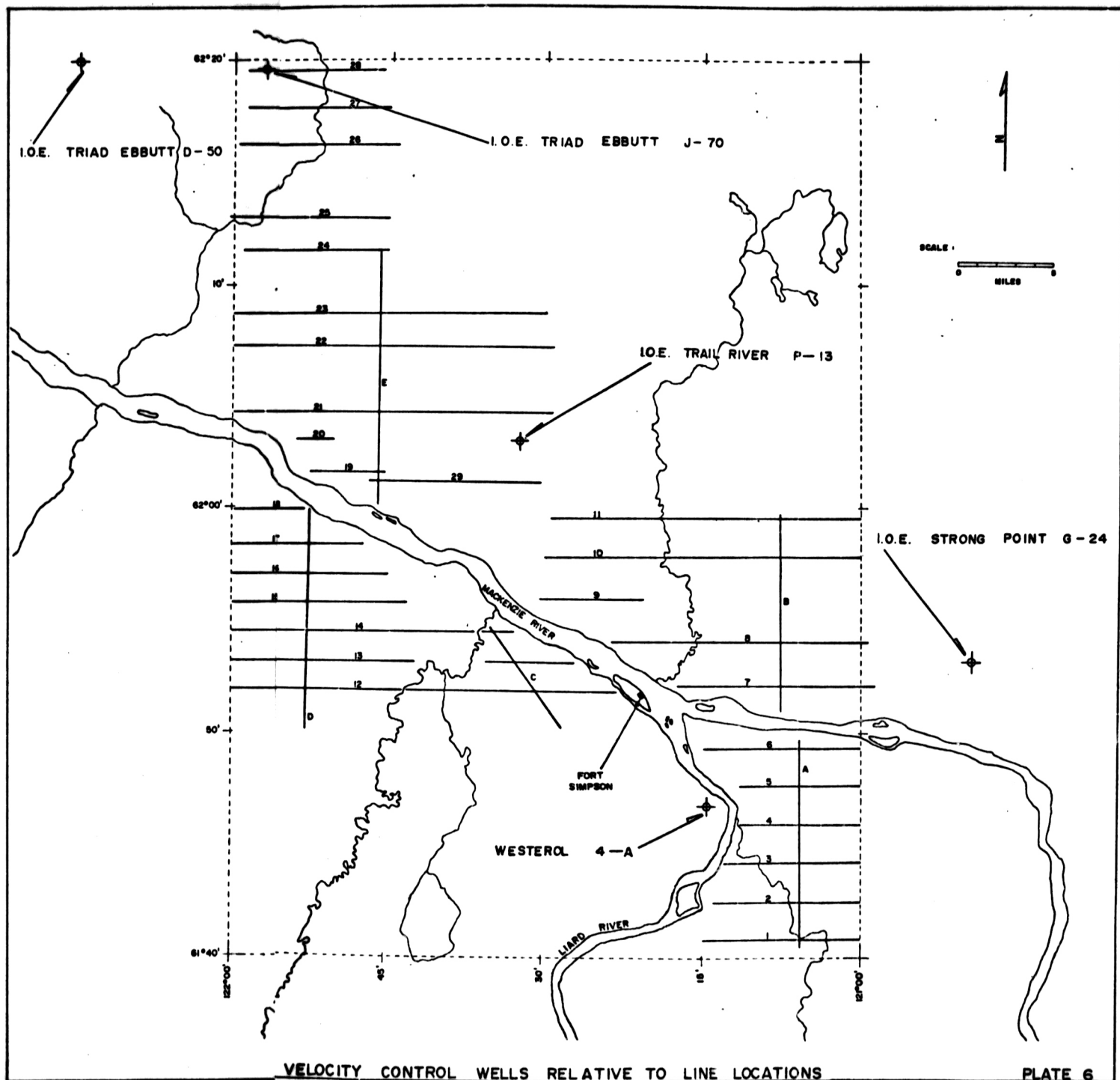


*ABNORMAL REFRACTION SPREADS :

1. SHOT MORE THAN 1 GROUP OFFEND
2. SHOT FROM ONE HOLE OF A TWO-HOLE PATTERN SHOTPOINT







Canadian Fina Oil Limited

FINAL REPORT

Willow Lake/Ebbutt Area - Permit No's. 4375, 4376, 4377,

4355, 4354, 4353, 4352, 4348 & 4360

Seismic Program: January - March, 1970

By: E. W. Redmond

July, 1970

This report covers work done for Canadian Fina Oil Limited (Operator) and Canadian Superior Oil Ltd. by Geophysical Service Incorporated between January and March (inclusive) 1970.

* For specific details on shooting, computing and playback procedures, see G.S.I. survey report for this area.

The purpose of this survey was to delineate possible reefal buildups on top of the Hume formation. Establish configuration of the lower Elk Point Salt Edge. Determine both regional and/or anomalous structure on top of the Hume and Basement:

For ease of reference or program identification, the area was divided into quadrants with the MacKenzie River acting as a dividing line between the North and South.

Field Parameters employed over the majority of the prospect were as follows:

Seismometers	H.S.J. 14 C.P.S.
Seises per group	9
No. of groups	24
Group intervals	110'
Type spread	Split
C.D.P.	300% to 200%
Pattern Holes (2) for the majority of the shooting;	
Single Holes in the N.W.	
Average Hole Depth	45'
Average Charge Size	1.72 lbs. per profile

Recording results were poor in the S.E. quadrant. This can be attributed to a thick layer of surface sand encountered throughout the immediate area. The N.E. quadrant was good in quality but the erratic depths of the "Pleistocene" was difficult

to correct and therefore the structure sections in this vicinity are not to be considered reliable. The balance of the area in the N.W. and S.W. quadrants are considered good with isolated areas of N.R. returns near the MacKenzie and Martin Rivers.

The following maps accompany this report:

1. Hume Structure
2. Cambrian Structure
3. Hume to Cambrian Isochron
4. Spence River to Hume Isochron
5. Hume to Cold Lake Salt Isochron
6. Cold Lake Salt to Cambrian Isochron

A consideration of the features shown on the maps lead to the following conclusions:

1. Hume Structure:

A structural high trend extends north from the middle west of Permit No. 4355 through the N.W. of Permit No. 4377. Closures along this high trend are shown in red. Line 23 west between S. Pts. 47 & 53 indicates the best structural high features on this map. Further seismic to the West of Permit No. 4355 would be advisable to determine the extent and/or limits of the structure as noted between Lines 12 and 14 West. The remaining portion of this map to the N.E. and S.E. cannot be considered too reliable because of the near surface problems and difficulty in correcting them.

Data not plotted in Permit No. 4353 was lacking proper L.V.L. correction. No reefal buildup on top of the Hume was observed on any of the lines.

2. Cambrian Structure:

This map conforms closely to the Hume (as is evidenced by the features mentioned on the Hume Structure). The quality or consistency of this reflection was better overall than the other horizons. However, a character change at the Basement level occurs in the lower part of Permit No. 4360 and upper portion of Permit No. 4353. This resulted in misties on the flattener. Further corrections were successful in correlating between Line 29 and Imperial Line 9, although there still seems to be a discrepancy between these two lines and the west end of Line 11.

3. Hume to Basement Isochron:

An overall regional thickening of 0.080 secs. from the S.E. quadrant to the N.W. quadrant may be noted on this map. The similarity between the Hume and Basement structure is exemplified by the lack of time difference over the anomalies of these structure maps.

4. Spence River to Hume Isochron:

The Spence River was difficult to follow over large areas of the program. The contour interval of 0.040 secs. is prevalent over the majority of the data with a 0.050 sec. interval shown in the N.E. quadrant.

5. Hume to Cold Lake Salt Isochron:

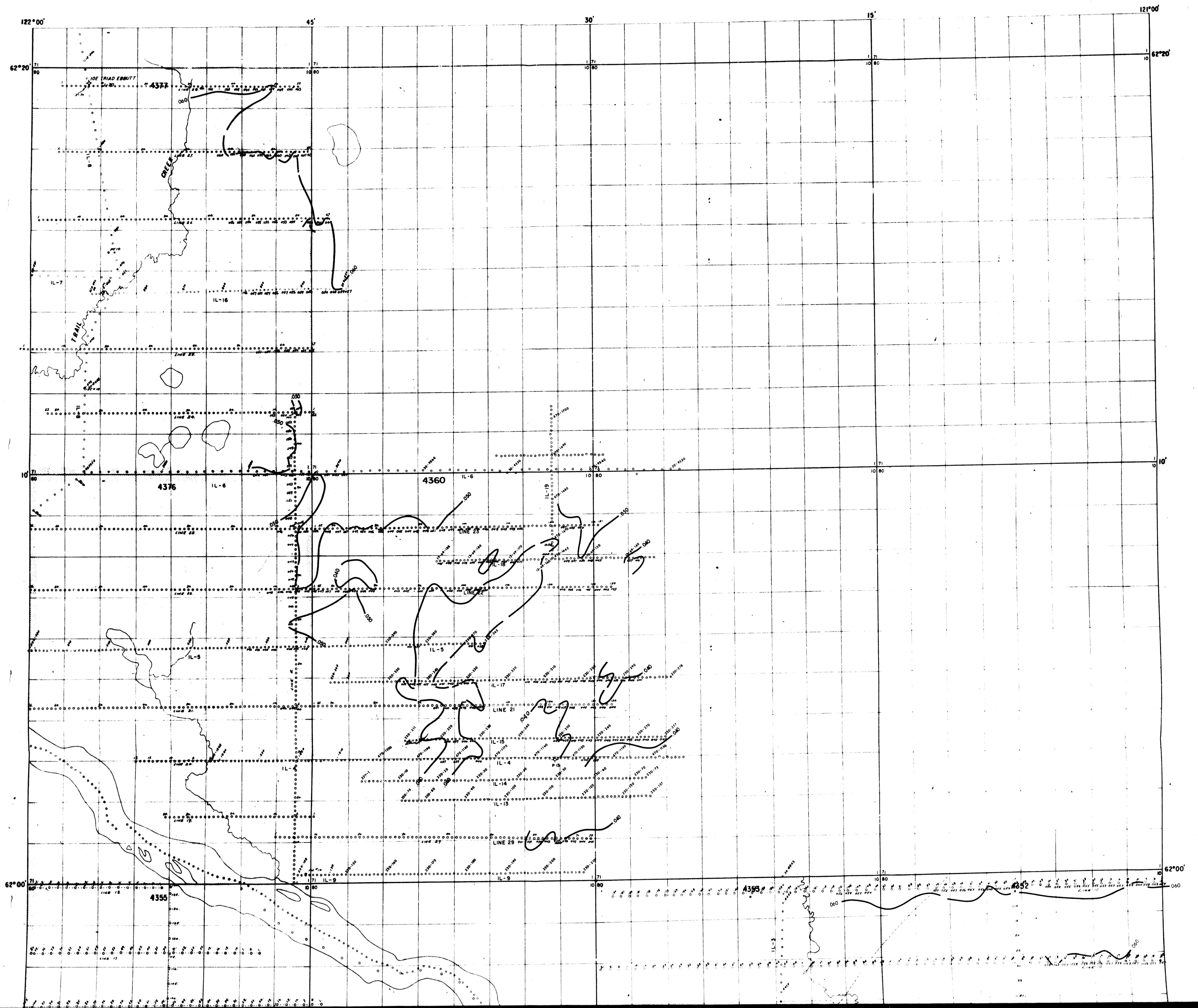
This interval indicates minimal thickening to the N.W. (0.020 secs.). The salt reflector is quite strong and consistent in the N.W. quadrant. The quality deteriorates to the S.E. thus making the salt boundaries in Permits Nos. 4352 and 4353 somewhat speculative. A map of the interpretive salt boundaries outlined in green is included with this report.

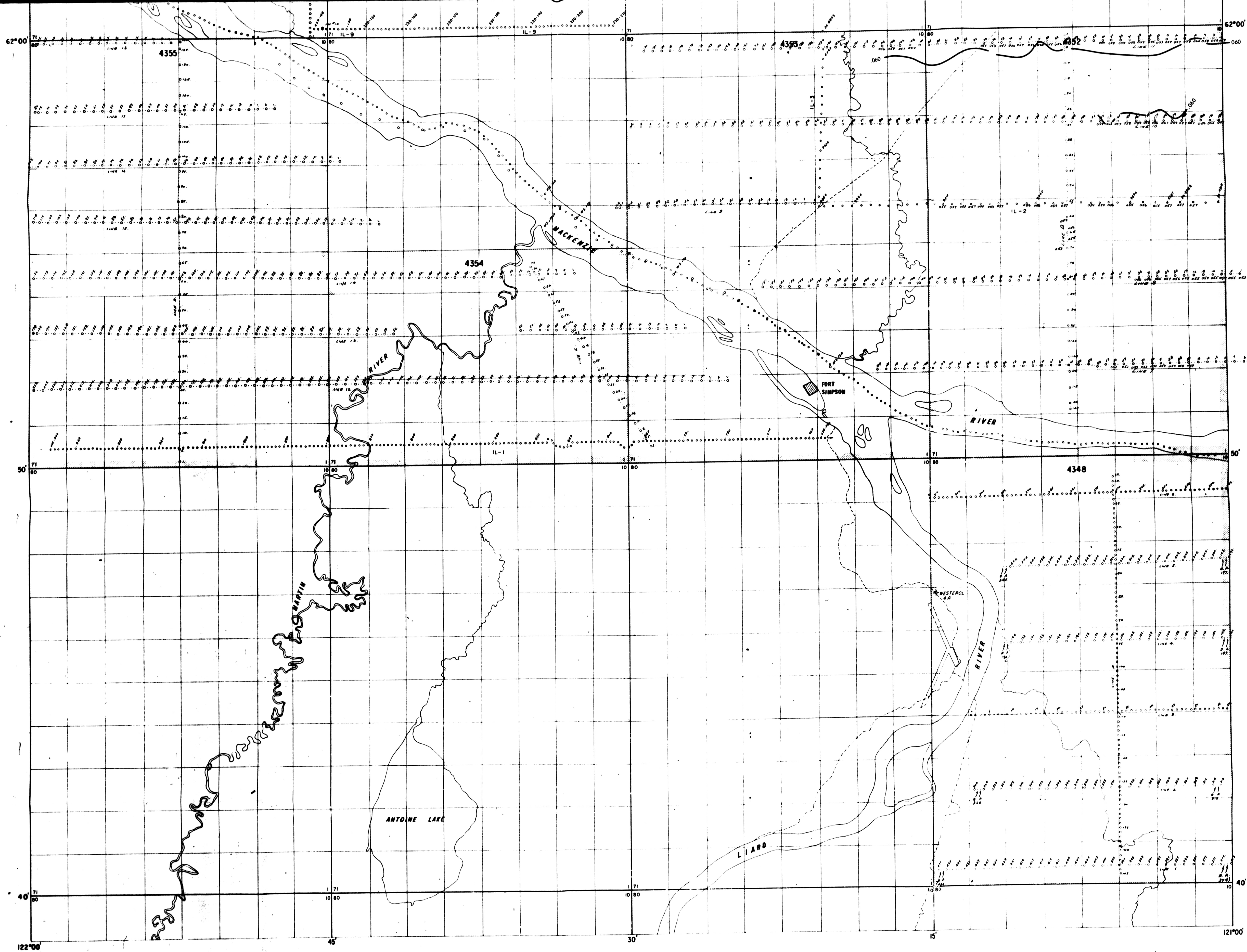
6. Cold Lake Salt to Cambrian Isochron:

There is very little overall time difference, but 0.010 sec. east thinning is noted in Permit No. 4360. The Hume to Salt interval remains relatively constant therefore the thin zones between the Salt and the Basement probably indicates Basement highs.

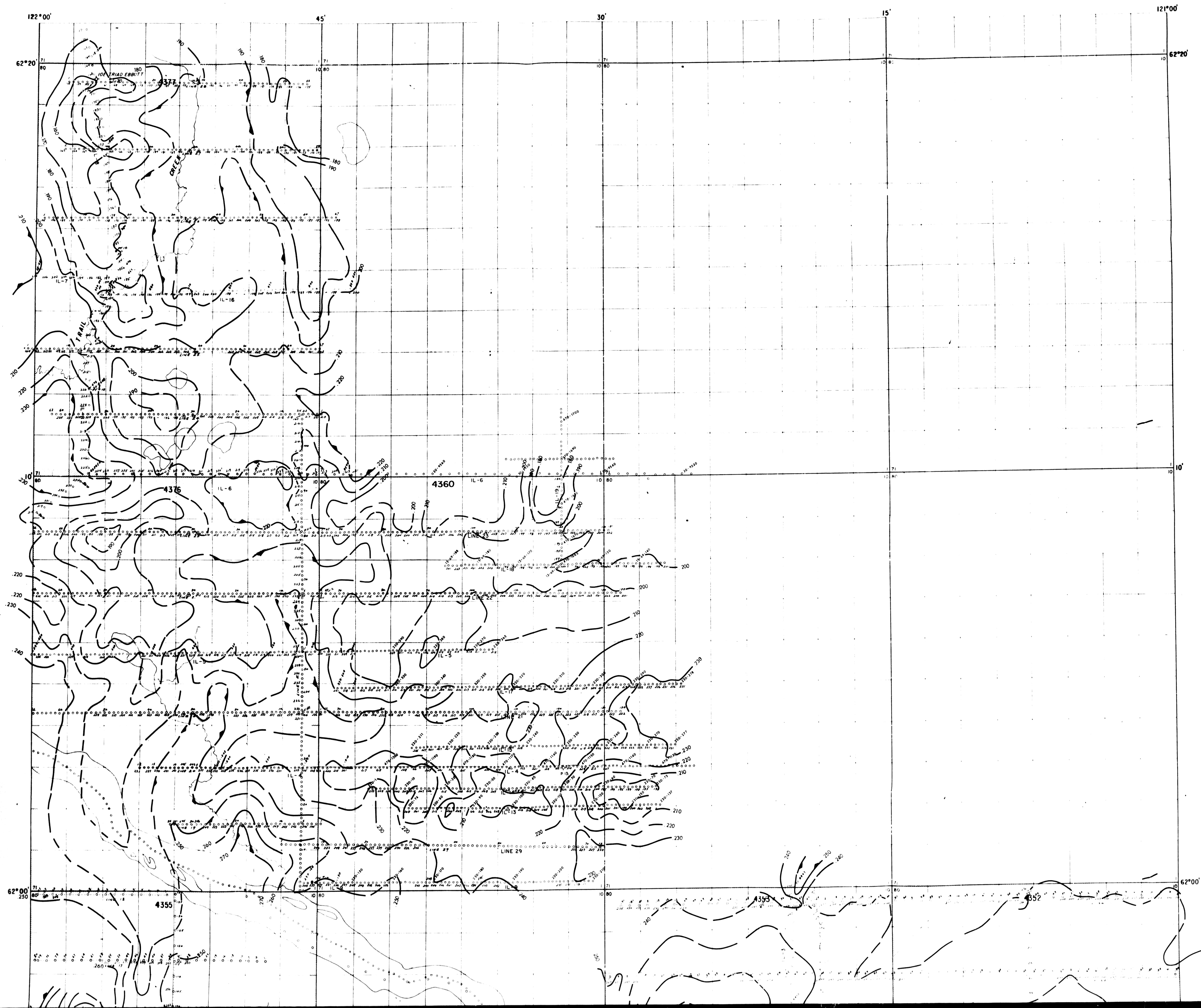
CONCLUSIONS AND RECOMMENDATIONS:

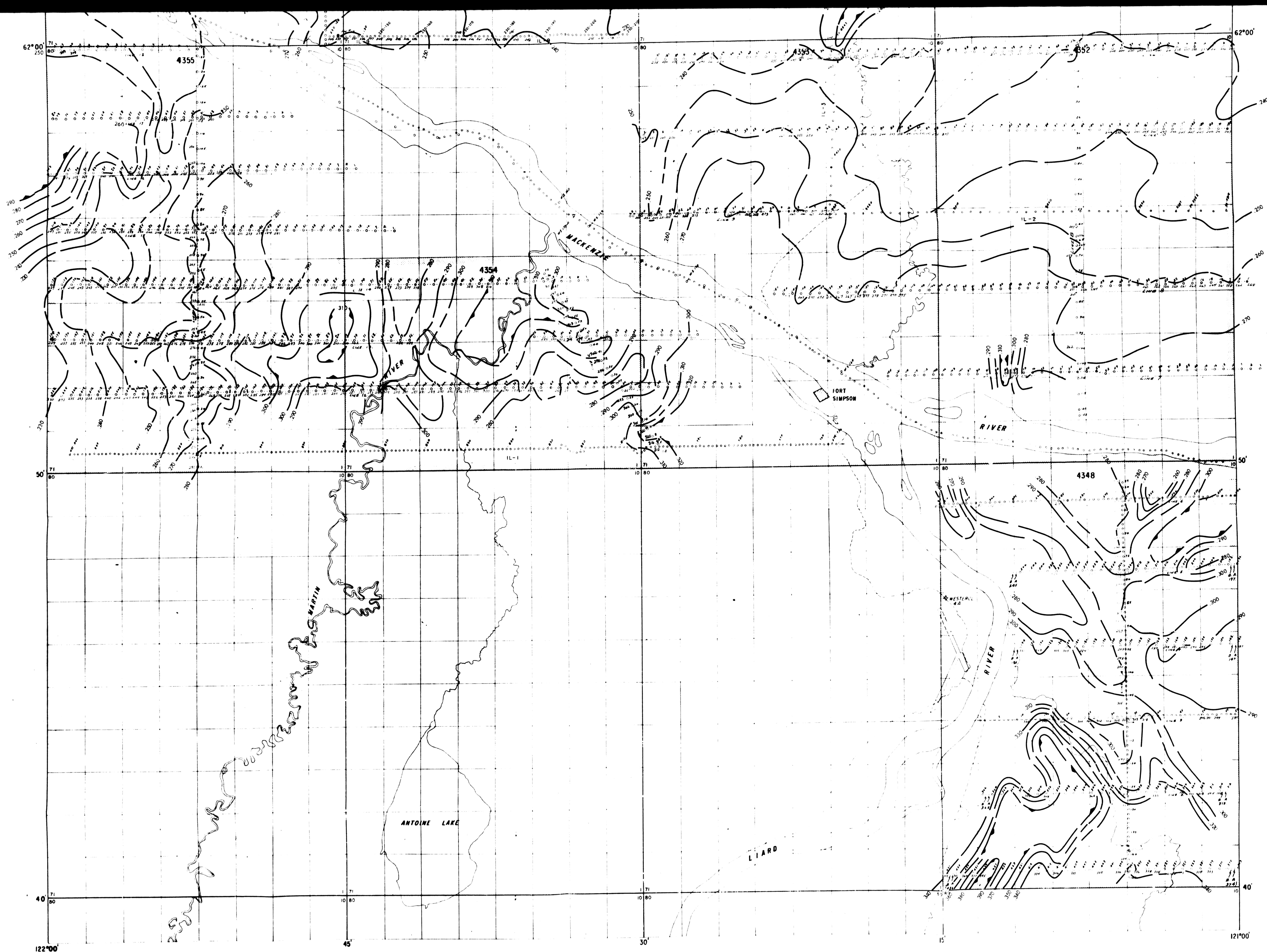
The quality of the record sections was good on the majority of the work. Field parameters and data processing were deemed adequate. A recommended location for a test is on the west end of Line 23 on S. Pt. 49, Permit 4355. Whereas no specific location can be recommended, it is to be noted that the extreme west end of Lines 12, 13 and 14 are all structurally high at the Hume marker and a test in this vicinity would be warranted in lieu of further seismic.



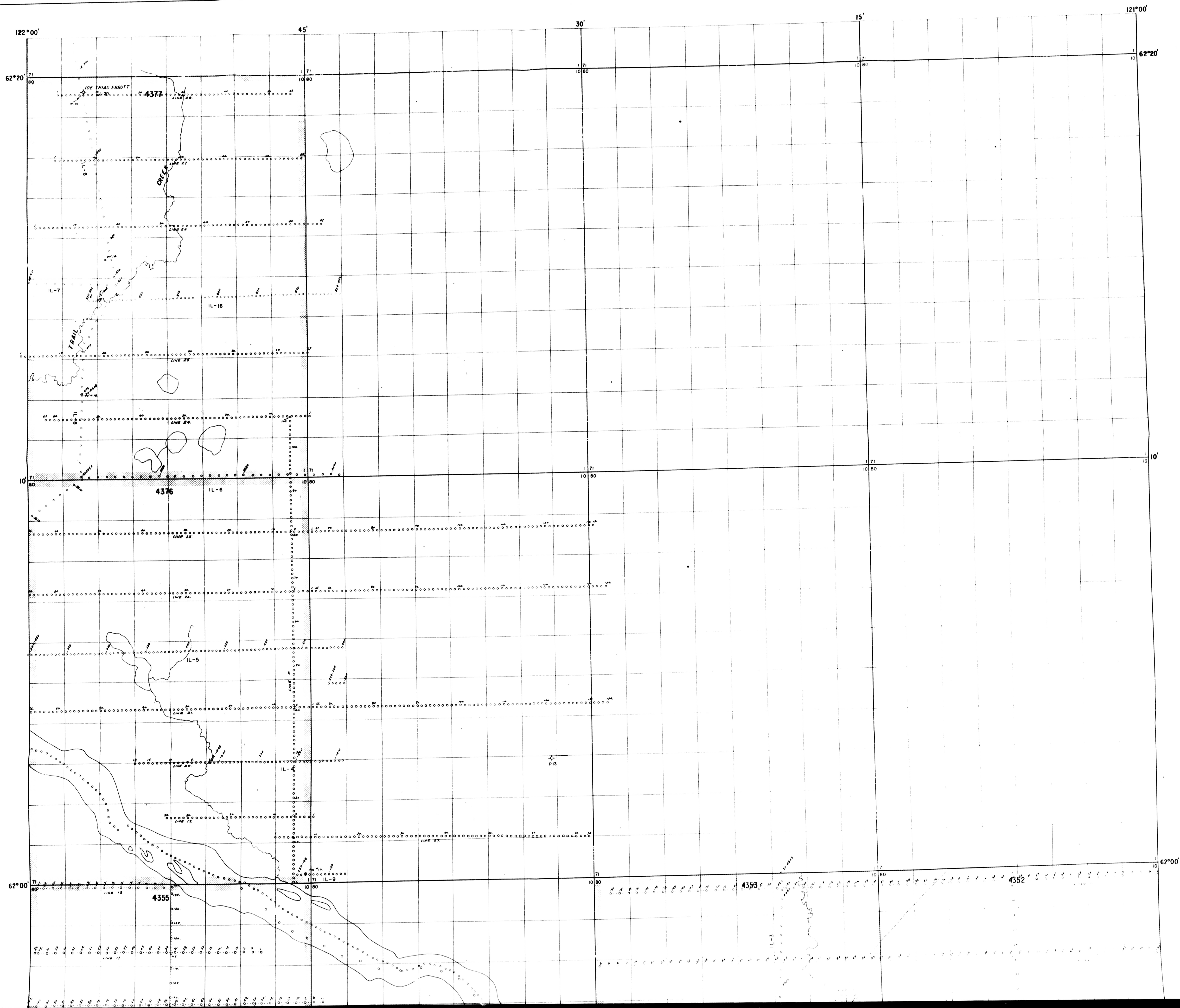


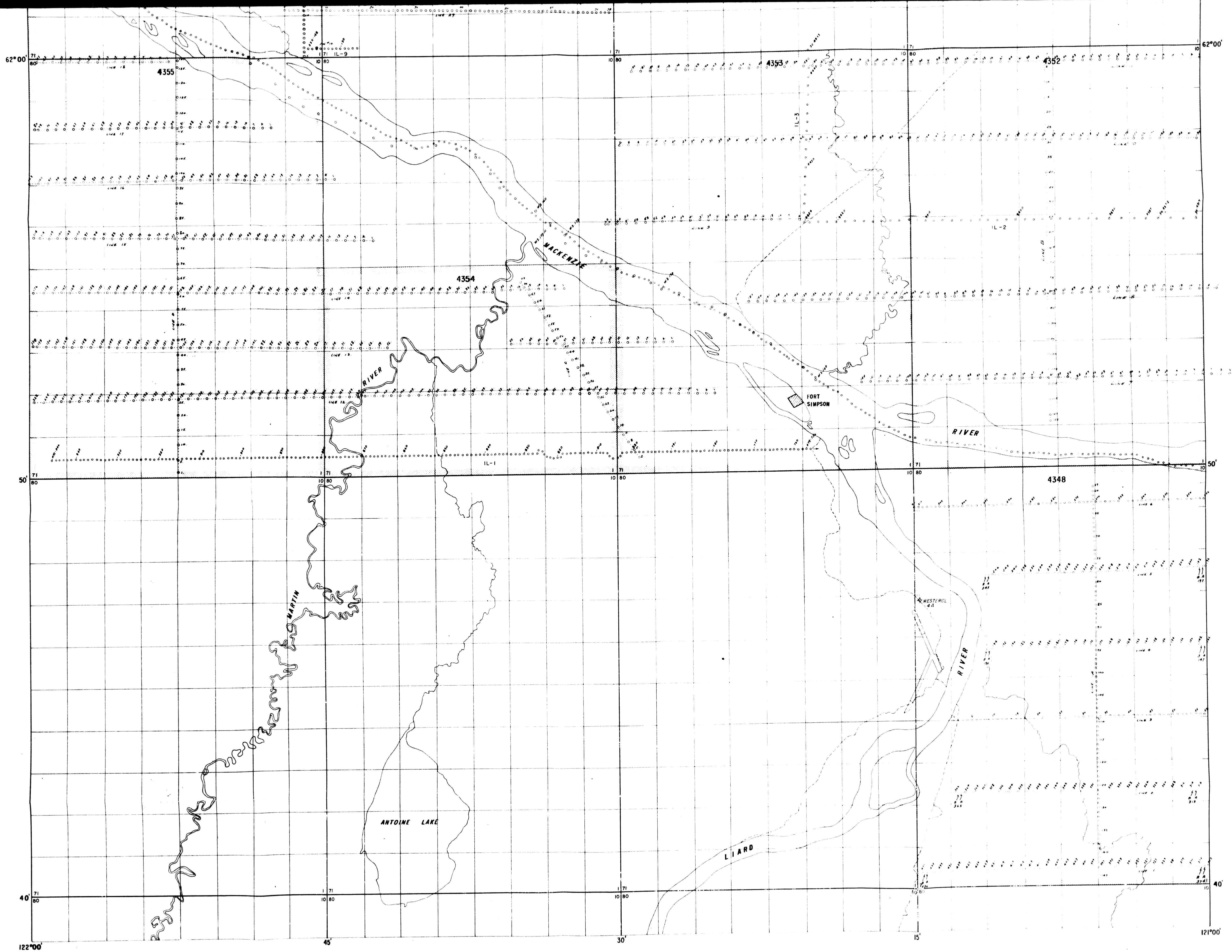
REFLECTION SEISMIC SURVEY of the	
WILLOW LAKE / EBBUTT AREA for	
CANADIAN FINA OIL LIMITED	
COLD LAKE SALT TO CAMBRIAN	
CONTOUR INTERVAL: 0.010 Sec	SCALE: 1" = 1 Mile
DATUM ELEVATION:	DATE: July, 1970
DATUM VELOCITY:	BY: E. W. Redmond





REFLECTION SEISMIC SURVEY of the	
WILLOW LAKE / EBBUTT AREA for	
CANADIAN FINA OIL LIMITED	
HUME STRUCTURE	
CONTOUR INTERVAL 500 Sec	SCALE: 1" = 1 Mile
DATUM ELEVATION 500'	DATE: July, 1970
DATUM VELOCITY 10,000'/Sec	INTERPRETED BY: E.W. Reidmond



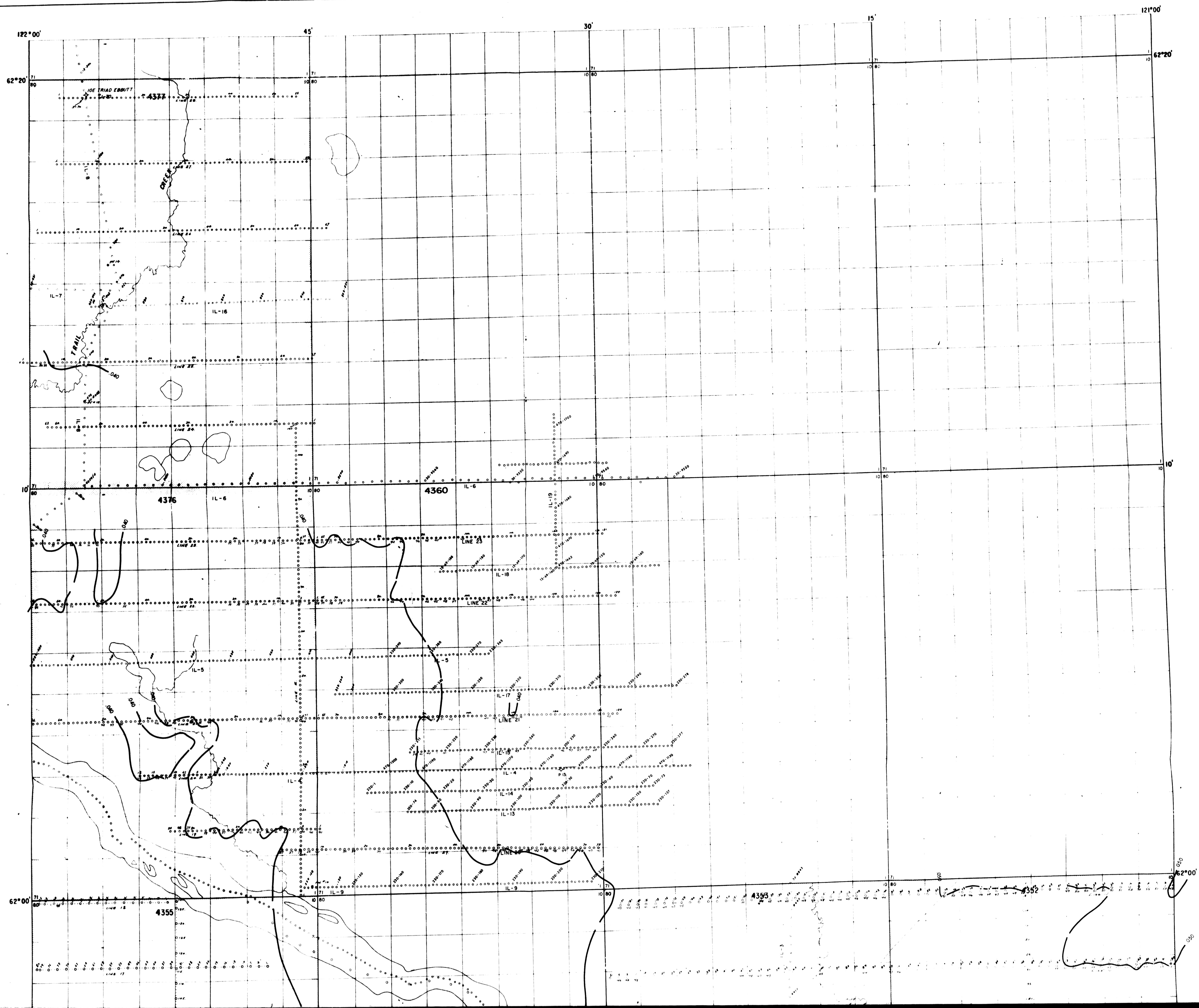


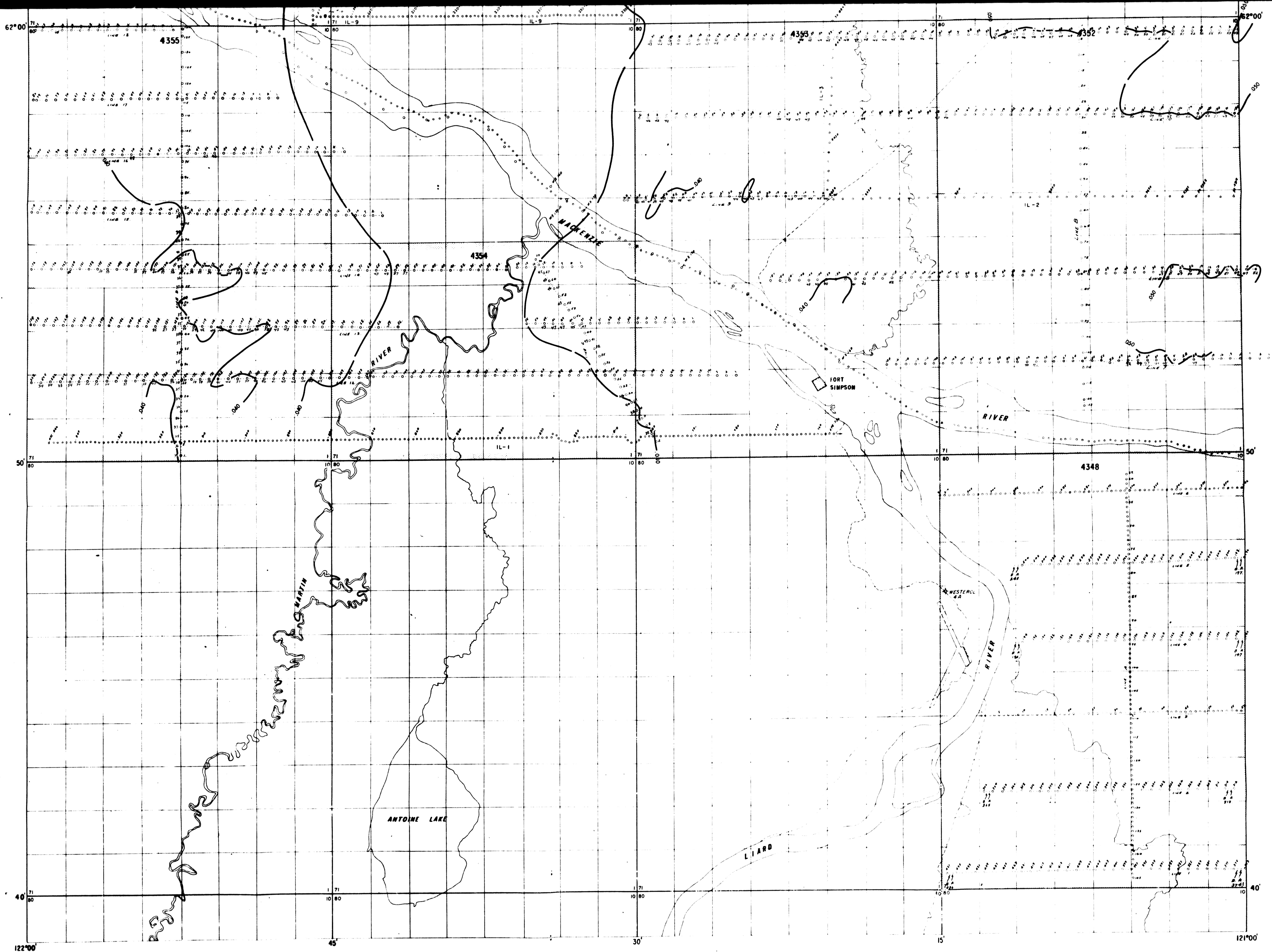
REFLECTION SEISMIC SURVEY
of the
WILLOW LAKE / EBBUTT AREA
for
CANADIAN FINA OIL LIMITED

SHOT POINT LOCATION MAP

CONTOUR INTERVAL
DATUM ELEVATION
DATUM VELOCITY

SCALE
DATE
INTERPRETED BY



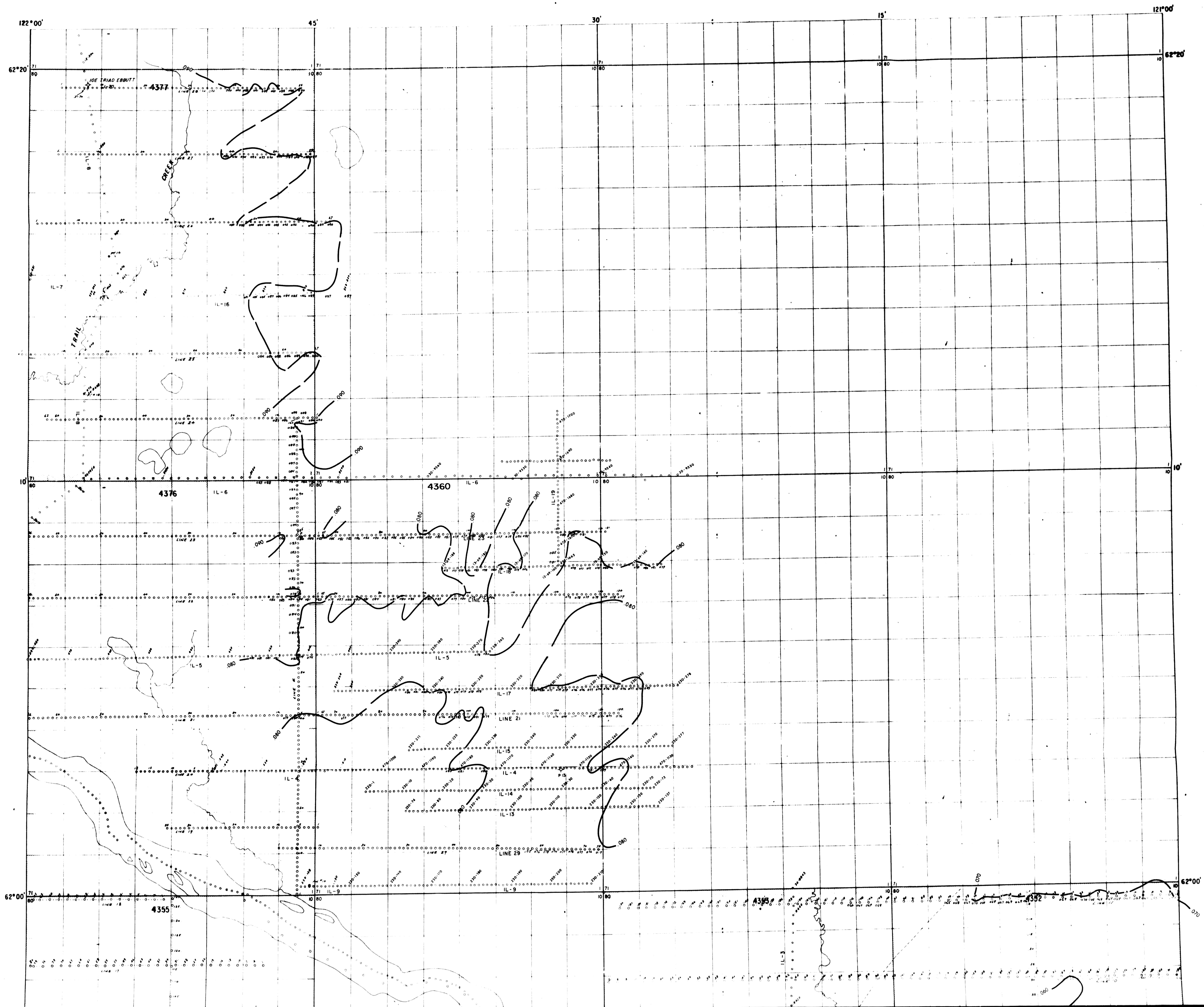


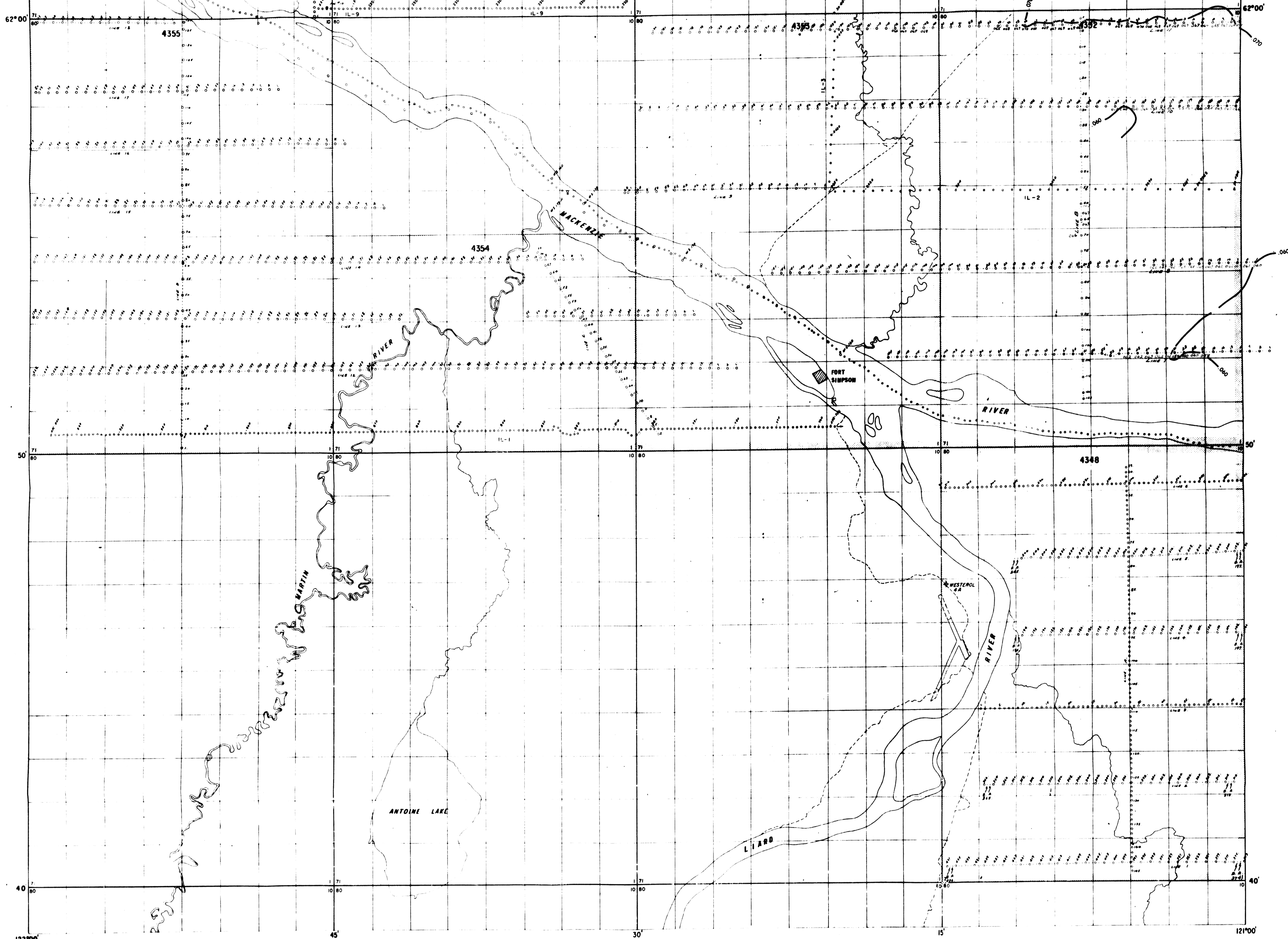
REFLECTION SEISMIC SURVEY
of the
WILLOW LAKE / EBBUTT AREA
for
CANADIAN FINA OIL LIMITED

SPENCE RIVER TO HUME

CONTOUR INTERVAL: 0.010 Sec.
DATUM ELEVATION:
DATUM VELOCITY:

SCALE: 1" = 1 Mile
DATE: July, 1970
INTERPRETED BY: E.W. Redmond



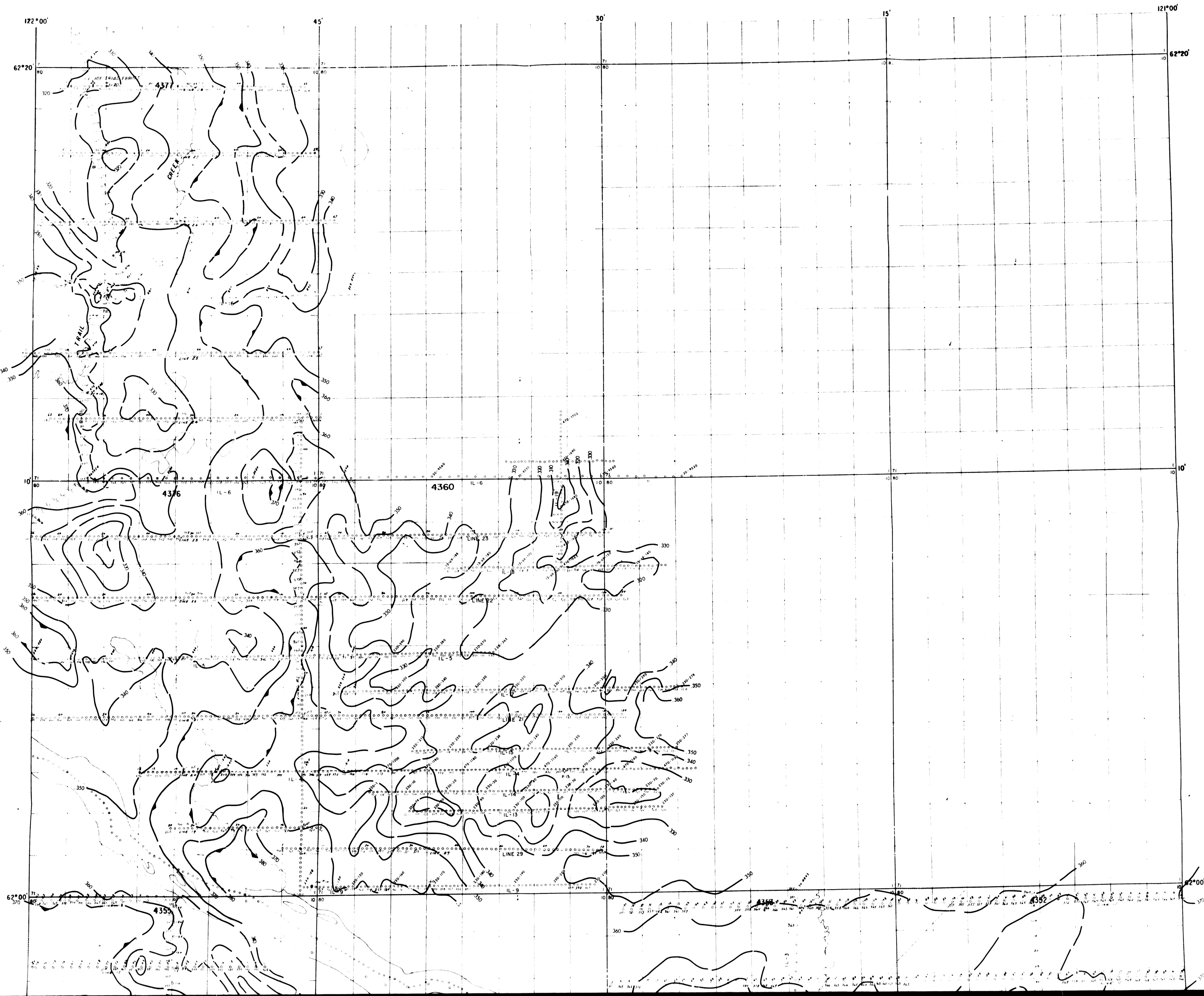


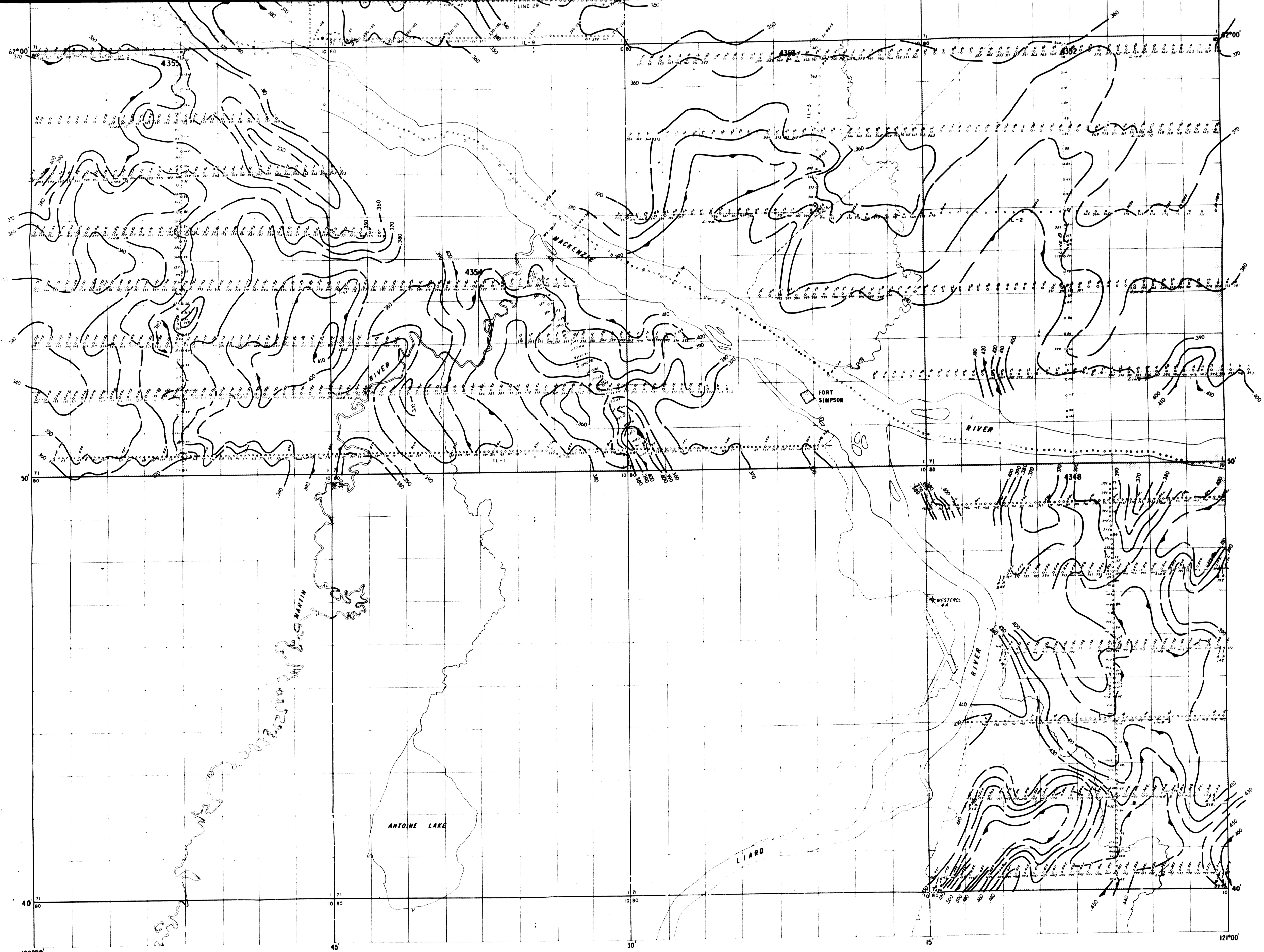
REFLECTION SEISMIC SURVEY
of the
WILLOW LAKE/EBBUTT AREA
for
CANADIAN FINA OIL LIMITED

HUME TO COLD LAKE SALT

CONTOUR INTERVAL: 0.010 Sec.
DATUM ELEVATION:
DATUM VELOCITY:

SCALE: 1" = 1 Mile
DATE: July, 1970
INTERPRETED BY: E.W. Redmond

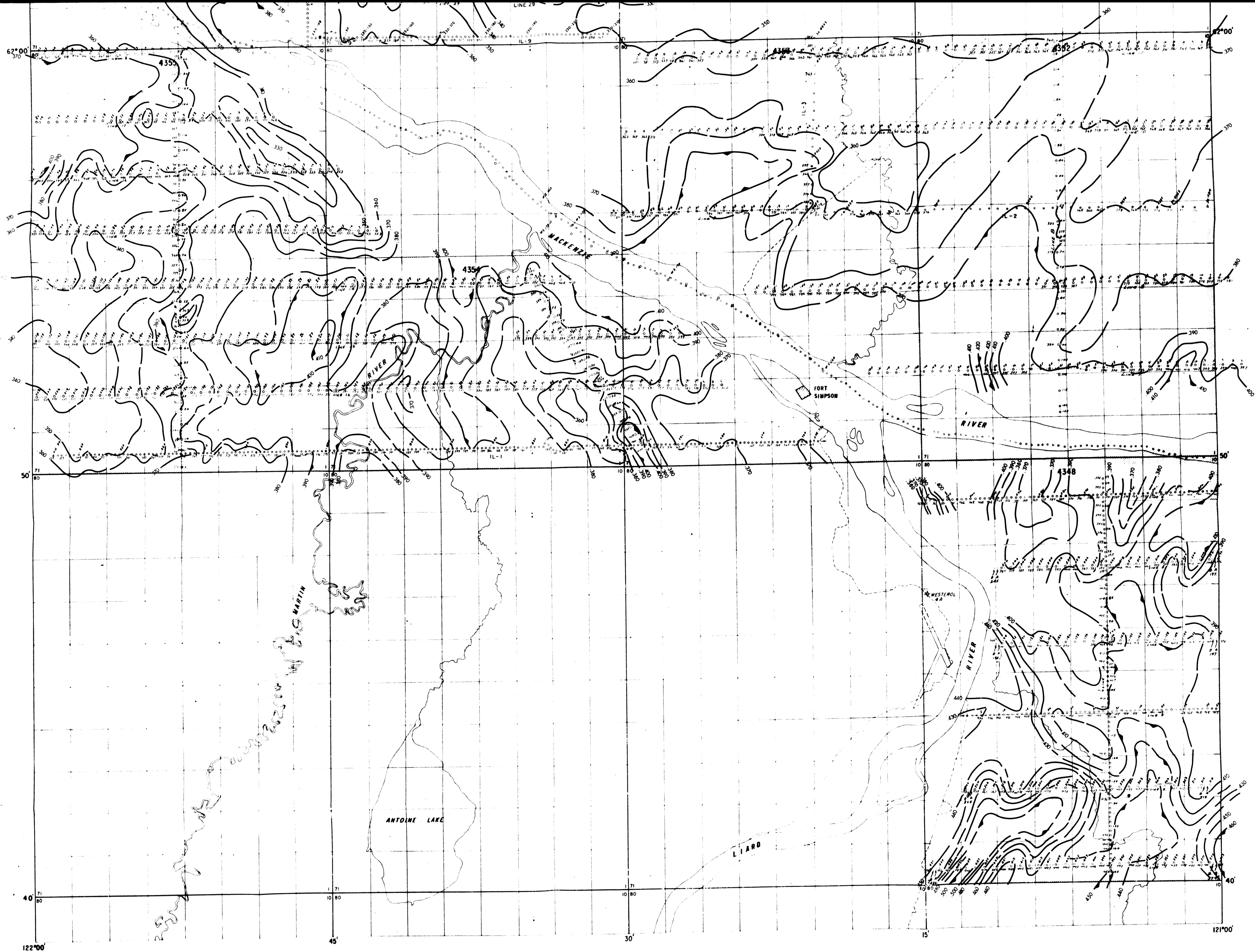




REFLECTION SEISMIC SURVEY
of the
WILLOW LAKE/EBBUTT AREA
for
CANADIAN FINA OIL LIMITED
CAMBRIAN STRUCTURE

CONTOUR INTERVAL: 100 Feet
DATUM ELEVATION: 500 Feet
DATUM VELOCITY: 10,000' / Sec

SCALE: 1" = 1 Mile
DATE: June, 1970
INTERPRETED BY: E.W. Redmond



REFLECTION SEISMIC SURVEY
of the
WILLOW LAKE / EBBUTT AREA
for
CANADIAN FINA OIL LIMITED

CAMBRIAN STRUCTURE

CONTOUR INTERVAL: 500 Feet
DATUM ELEVATION: 500 Feet
DATUM VELOCITY: 10,000'/Sec

SCALE: 1" = 1 Mile
DATE: June, 1970
BY: G. W. Redmond

