

CRIPPEN ACRES
GEOLOGICAL STUDY OF THE NIPAWIN
HYDROELECTRIC PROJECT
LETTER REPORTS
0093
AUGUST 5, 1983-FEBRUARY 15, 1984

E. A. Christiansen Consulting Ltd.

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

August 4, 1983

Crippen Acres
Sixth Floor - 500 Portage Avenue
Winnipeg, Manitoba
R3C 3Y8

Attention: Mr. D.A. Pashniak, P. Eng., Design Manager

DRAFT - DCP

Dear Mr. Pashniak:

In reply to your letter of July 25, 1983 (5151.18.02) requesting a geologic review of the Nipawin Hydroelectric Project, I am submitting the following final letter report.

A geologic review of the Nipawin Hydroelectric Project was requested by Mr. D.S. Matheson during telephone conversations on July 24 and 25, 1983 and in Mr. D.A. Pashniak's letter of July 25, 1983. This review includes the following work:

- (a) review exposures in the field in the wraparound and basin of the Main Dam Core Trench,
- (b) review geologic profiles, mapping, and logs provided by Crippen Acres staff, and,
- (c) provide views on probable causes of the above noted features in letter form by August 4, 1983.

To expedite this work, discussions were held with Messrs. R. Dick and M. Reyes at the dam site on July 25, 1983, and the Main Dam Core Trench was examined briefly the same day and again on July 26, 1983 with Mr. Reyes. During the second examination of the core trench, brief field notes and photographs were taken (Figs. 1-6). On July 26, 1983, logs, cross sections, and sketches of the Main Dam Core Trench were provided by Mr. Reyes who was most helpful in the field and during telephone conversations on July 27, 1983 and again on August 3 when The Draft Letter Report was reviewed and further information on the Main Dam Core Trench and the Downstream Principle Structures Excavation was obtained.

To relate the stratigraphy of the Main Dam Core Trench and the Downstream Principle Structures Excavation to the stratigraphy of the dam site, a location map and three cross sections were constructed (Drawing 0093-001-01-04). The cross sections show the stratigraphy of the bedrock and the drift in which the excavations are being constructed. The nomenclature of the tills developed by Crippen Acres was used, and except for a few contacts in several logs, the writer agrees with the separation made by them. Regional geology (E.A. Christiansen Consulting Ltd. 1982, Drawing 0075-002-09, Testhole 321)* suggests the Upper Till of Crippen Acres is composed of a lower hard, gray till and an upper, soft, light gray till (Drawing 0093-001-04, Testhole 198).

In ascending order, the drift is composed of: Lower Till, Middle Till, Upper Till, Lake Agassiz Deposits, Terrace Deposits, and Point Bar Deposits.

Lower Till According to SPC logs, the Lower Till is sandy and light gray in color. Locally, sand beds occur between this till and bedrock (Drawing 0093-001-04, Testhole 198) and between it and the overlying Middle Till (Testholes 167, 171).

* E.A. Christiansen Consulting Ltd. 1982. Quaternary geology of the Nipawin area, Saskatchewan. Consulting Report 0075-002 for SPC through SRC.

Middle Till The Middle Till is composed of a lower till unit, a middle interbedded till and sand and gravel unit, and an upper till unit. The till units are dark gray and clayey (Figs. 1,6). The intertill stratified units are composed of sands (Figs. 3A, 4,5) and gravels (Fig. 3B). Although these sand and gravel units appear to be discontinuous in the Main Dam Core Trench, they appear to be continuous for hundreds of metres in cross sections (Drawings 0093-001-02-04).

Upper Till The Upper Till is composed of a lower hard, gray till and an upper, soft, light gray till (Drawing 0093-001-04, Testhole 198). This till is not present at the main dam site.

Lake Agassiz Deposits The Lake Agassiz deposits are composed in ascending order of lacustrine bottomset clays, deltaic foreset sands, and topset sands and silts (Drawing 0093-001-04, Testhole 198). These topset beds are covered with cliff-top, wind-blown sands near the valley (E.A. Christiansen Consulting Ltd. 1982, Figs. 16,18).

Terrace Deposits These deposits are composed in ascending order of gravel, sand, and silt. This terrace was formed when Lake Agassiz stood in the region.

Point Bar Deposits These deposits, which in ascending order are composed of gravel, sand, and silt, were laid down as the Saskatchewan River slipped-off southeastward across the present dam site toward the southeast cutbank. These deposits were covered by about a metre of wind-blown, cliff-top sands near the valley (E.A. Christiansen Consulting Ltd., 1982, Fig. 15).

Geotechnical Considerations of Intertill Sands and Gravels The lensy nature of the white sand (Fig. 3A), the high angle of dip of the sands and gravels (Fig. 3B), and the poor sorting of some of the sediments seen

in the Main Dam Core Trench (Figs. 5, 6B) suggest these are ice-contact deposits. Such disturbed sediments were deposited either by glacial thrusting or by collapse of ablation sediments as the glacier melted. The stratigraphy of the Middle Till (Drawing 0093-001-02-04) suggests a fluctuating ice margin. In such a model, the till units represent lodgment deposition at the base of the glacier, and the intertill sands and gravels probably represent a combination of ablation and proglacial sedimentation on or near the glacier.

Even though the geologic continuity shown in the cross sections may be accepted, the problem of the degree of hydraulic continuity still exists. If the ablation - proglacial model is accepted for the intertill sands and gravels in the Middle Till, then the permeability could range from till to clean gravel; consequently, any permeable paths would be expected to follow tortuous courses. To prove whether a hydraulic continuity of the sand and gravel units in the Middle Till exists as suggested in the cross sections would require more test drilling and pump testing. During such pump tests, the pumping and observation wells must be in the same sand and gravel unit.

During construction of the tunnel, vertical drains were installed up to 300 \pm and 303 \pm m (Table 1, Drawing 0093-001-05). Testholes 171, 172, 187, 189, 194, and 211 are near the tunnel and presumably the geology is similar. Vertical drain 571 probably drains the sand and gravel unit between the Lower and Middle Tills as shown in Testhole 171 (Drawing 0093-001-04). It is unlikely, however, that this drain or others in the vicinity would affect the piezometric surface in the Middle Till sand and gravel units.

The top of vertical drain 120Y is probably in the sand and gravel unit as shown in testhole 172 (Drawings 0093-001-03,04). Vertical drain 557 should drain the lowermost sand and gravel unit as shown in Testhole 187 (Drawing 0093-001-02). Presumably the geology changes between the test-

hole and the drain accounting for the lack of flow. Vertical drains 505 and 532 near Testholes 194 and 189 (Drawing 0093-001-03,04) are in till beneath the sand and gravel units; consequently, these drains are dry. Vertical drain 544 near Testhole 211 (Drawing 0093-001-02) probably drains the lowermost sand and gravel unit.

From the above sample of testholes near the tunnel, it appears the vertical drains were not extended high enough above the tunnel to effectively drain the intertill sand and gravel units.

This study has shown that the stratigraphy of the dam site can be deciphered from a combination of geologic and electric logs. Although such information is adequate in the trench areas, it is not adequate to the north, south, and east to provide a credible interpretation of the geology of the dam site area.

Sincerely yours,



E.A. Christiansen

cc P.C. Hensman
H.S. Rupprecht



A



B

Figure 1. Southwest headwall of core trench. (A) In descending order the sediments are: brown alluvial gravel, gray Middle Till, and Middle Till and sand with gravel at base. (B) Gray Middle Till exhibiting horizontal joints (see right side of (A) for location).



A



B

Figure 2. Northwest headwall of core trench. (A) In descending order the sediments are: brown alluvial gravel, gray Middle Till, Middle Till interbedded with lensy white sand and gray gravel. (B) Close-up showing above sediments and hole from which gravel was derived to an altitude of at least 303 m.



A



B

Figure 3. Northwest headwall of core trench. (A) Close-up of 2(B) showing in descending order: brown alluvial gravel, gray Middle Till, a lens of white sand, and gravel. (B) Close-up of gravel being de-watered. Notice the angular nature and high angled dip of the gravel.



A



B

Figure 4. Looking west at "nose" of core trench. Mainly sand with dirty gravel zones, cross bedded with vertically bedded blocks.(B) is a close-up of (A).



A



B

Figure 5. Looking south at "nose" of core trench. (A) Upper right same as 4 A and B. Gray Middle Till overlying pebbly sand. (B) Pebby sand, which is interbedded with gray pebbly till, dips to the west.



A



B

Figure 6. Looking east at "nose" of core trench. (A) Gray Middle Till overlying gravel with a gradational contact. (B) Notice the till layers in the dirty gravel.

Table 1. Relationship between elevation of the top of vertical drains and stratigraphy in electric logged testholes near tunnel.

Hole No.	Cross Section No.	Elev. Top of Vert. Drain	Closest Drain Nos.	Flow L/Min.	Date	Comments
171	0093-001-04	300±m	570 571	0.00 0.7	02/08 02/08	Probably drains sand and gravel unit between Lower and Middle Tills.
172	03,04	300±m	120Y	0.03	02/08	Top of drain is probably in sand and gravel unit.
187	02	303±m	557	Dry		Should drain lower-most sand & gravel unit may be change in geology between test hole & tunnel.
189	03	303±m	532	Dry	29/07	Drain is in till below sand & gravel units.
194	04	300±m	505	Dry	29/07	Drain in till below sand and gravel unit.
211	02	303±m	544 545	0.2 Dry	29/07 29/07	Probably drains lowermost sand & gravel unit.



A



B

Excavating gravel from terrace south of nose of core trench.



A



B

Equipment working in core trench.

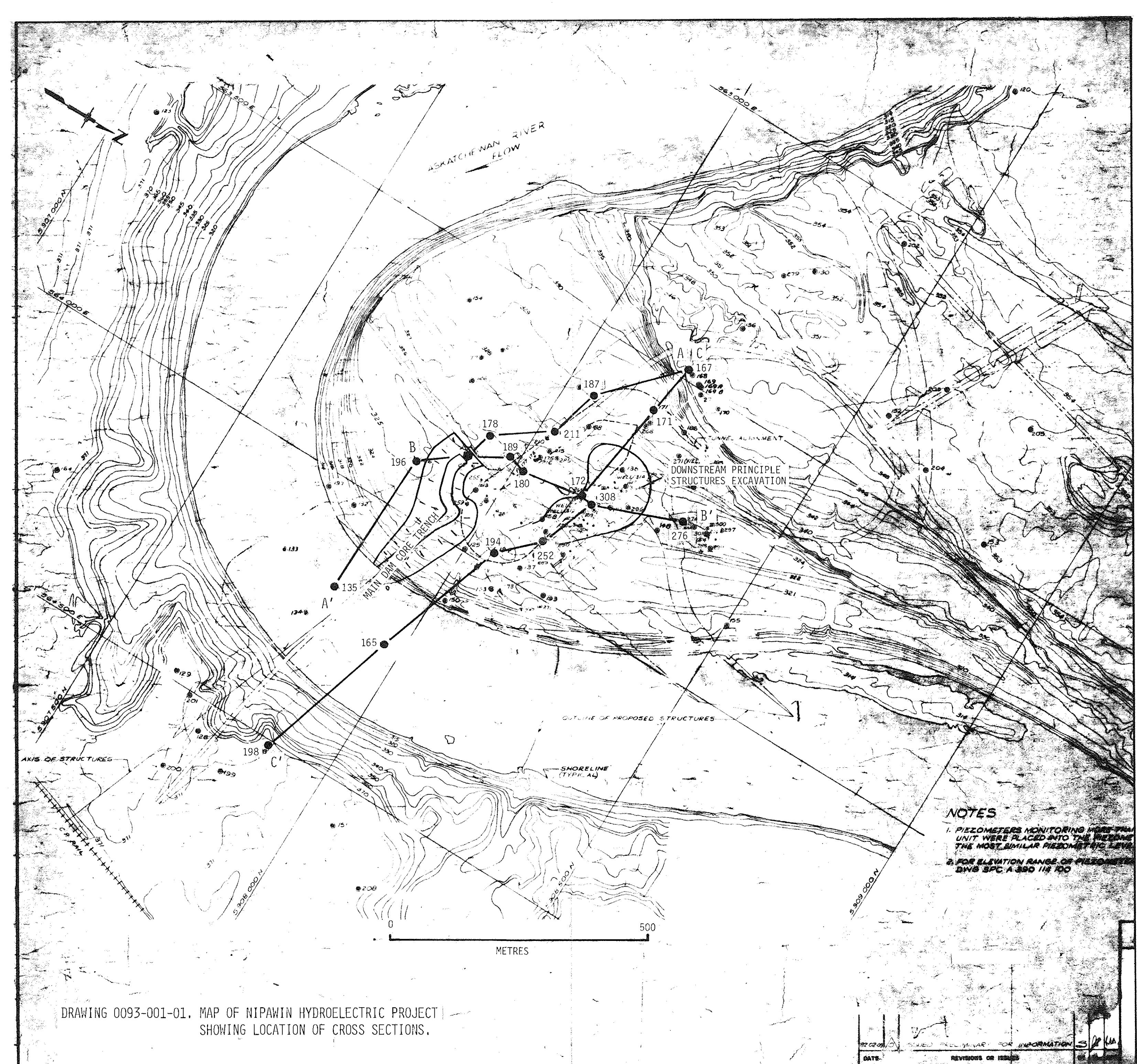


A



B

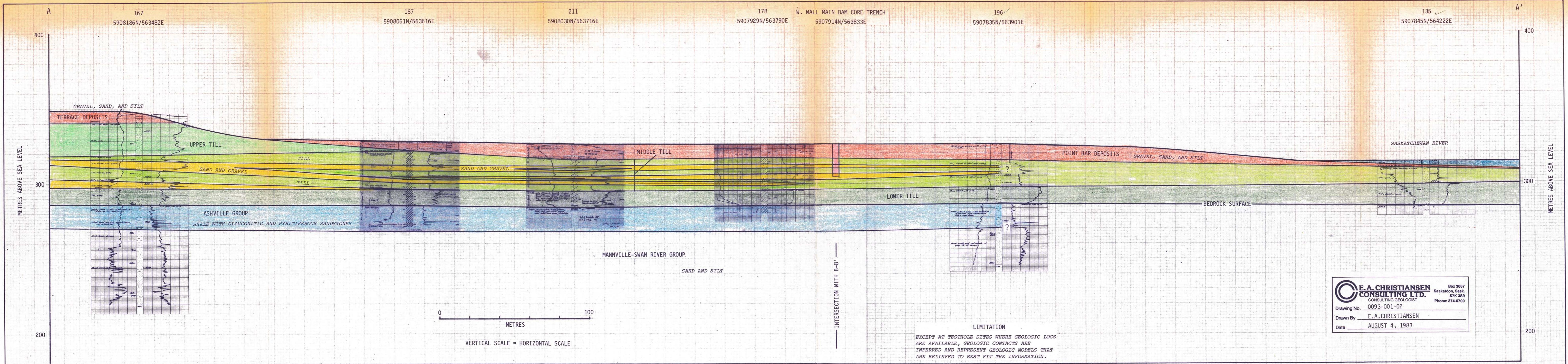
Equipment working in core trench.



DRAWING 0093-001-01. MAP OF NIPAWIN HYDROELECTRIC PROJECT
SHOWING LOCATION OF CROSS SECTIONS.

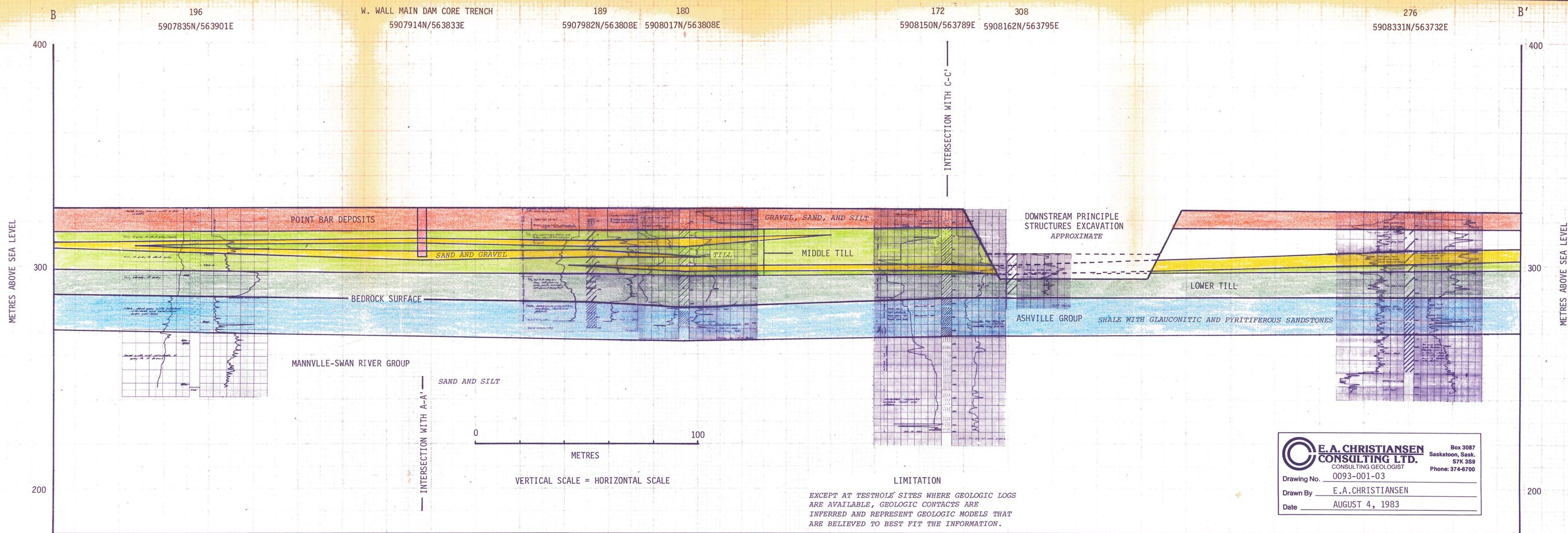
NOTES

1. PIEZOMETERS MONITORING MORE THAN UNIT WERE PLACED INTO THE PILE AND THE MOST SIMILAR PIEZOMETRIC LEVEL
 2. FOR ELEVATION RANGE OF PILE 100 FT DIV SPC A 300 1/8 100



DRAWING 0093-001-02. GEOLOGIC CROSS SECTION A-A', NIPAWIN HYDROELECTRIC PROJECT. SEE DRAWING 0093-001-01 FOR LOCATION.

NOTE: TILL NOMENCLATURE TAKEN FROM CRIPPEN ACRES AND BEDROCK NOMENCLATURE AND CONTACTS FROM EAC.

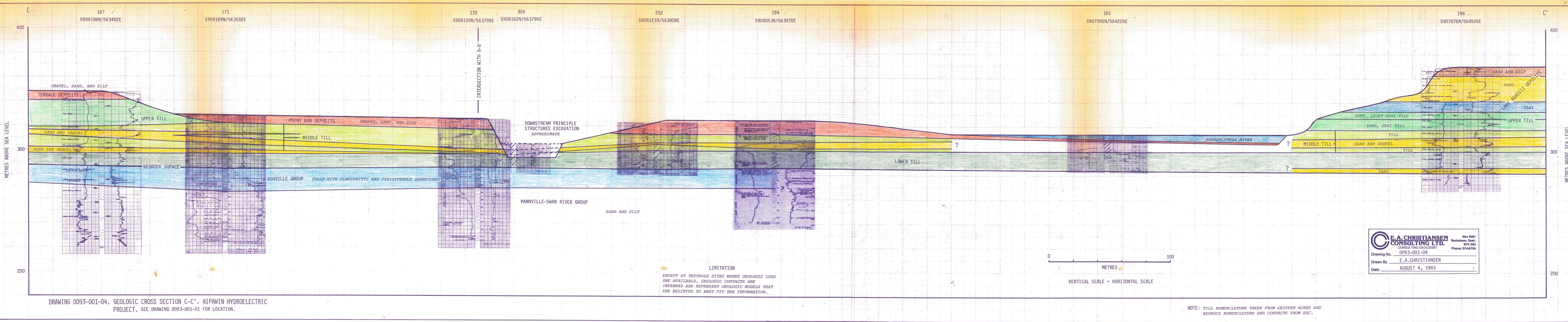


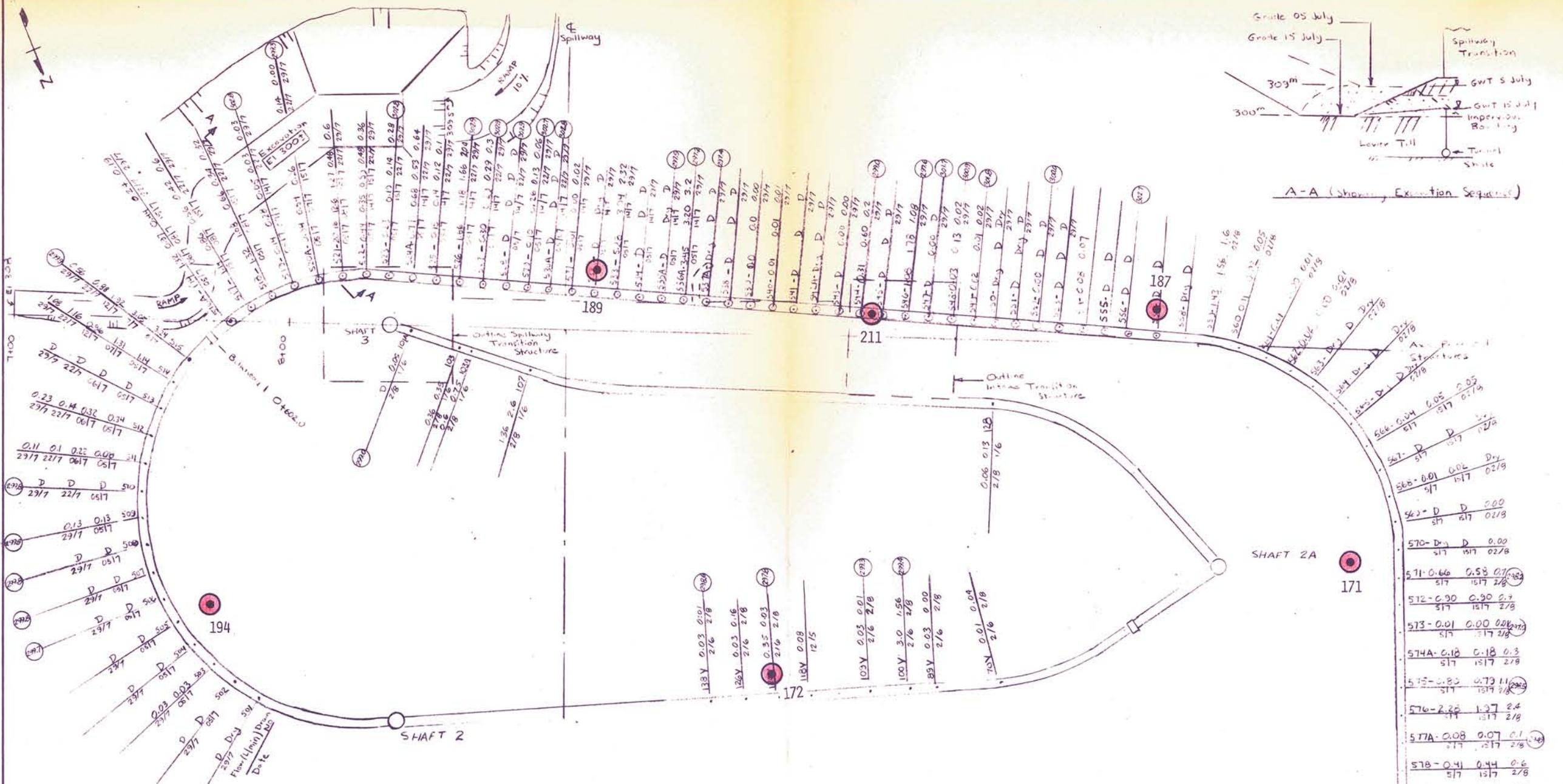
DRAWING 0093-001-03. GEOLOGIC CROSS SECTION B-B', NIPAWIN HYDROELECTRIC PROJECT. SEE DRAWING 0093-001-01 FOR LOCATION.

NOTE: TILL NOMENCLATURE TAKEN FROM CRIPPEN ACRES AND BEDROCK NOMENCLATURE AND CONTACTS FROM EAC.

E.A. CHRISTIANSEN CONSULTING LTD.
 CONSULTING GEOLOGIST
 Drawing No. 0093-001-03
 Drawn By E.A.CHRISTIANSEN
 Date AUGUST 4, 1983

Box 3087
Saskatoon, Sask.
S7K 3S9
Phone: 374-6700





194 ELECTRIC LOGGED TESTHOLE IN GEOLOGIC CROSS SECTIONS.

LEGEND

D - Damp
 ① - Vertical Drain to El 303m ↑
 - Vertical Drain to El 300m ↓

 Date 5 July 183
 ② - Drains terminating below design elevation
 (300,303m); Elevation of top of casin

- NOTES: 1. All flows from drains in Llmin.
2. Between Shafts 3 and 2 only drains discharging are shown. All others are dry.

DRAWING 0093-001-05. LOCATION OF ELECTRIC LOGGED TESTHOLES ON CROSS-
SECTIONS A-A', B-B', AND C-C' (DRAWINGS 0093-
001-02-04) NEAR TUNNEL EAC - AUGUST 5, 1983

EAC - AUGUST 5, 1981

Calculation of K from Drain Flow

Drain	R (ft.)	K (cm/s)
522 532 (1)	< 130	$< 2 \times 10^{-4}$
533 (1)	300	1.1×10^{-3}
521 (2)	660	1.1×10^{-2}
521 (3)	100	8×10^{-3}

- (1) Utilize Surchant's Formulae
 $R = C'(H-hw)\sqrt{K}$ where $C' = 30$
 $H - hw \text{ in ft} = 30 \text{ ft}$
 $\sqrt{K} \text{ in } 10^{-9} \text{ units units}$

$$\therefore K = \left(\frac{R}{30(H-hw)} \right)^2$$

(2) For drainage to drain 521 assuming
 for 5 July a 200m flowpath and $H = 9m$
 for homogeneous material at $300-308 \text{ m.s.e.m}$

(3) As per (2) for 15 July with $H = 1m$,
 $1 = \text{mft}$

Scale

CRIPPEN ACRES REGINA, SASKATCHEWAN		SASKATCHEWAN POWER CORPORATION		
DESIGN BY _____ CHECK _____ DRAWN BY <u>DSM</u> CHECK _____ SUBMITTED DEPT _____ PROJ. _____ APPROVED DEPT _____ PROJ. _____ DATE <u>2 August, 1983</u>		NIPAWIN HYDROELECTRIC PROJECT TUNNEL VERTICAL DRAINS FLOW VS. CORE TRENCH DEPTH <u>JULY 1983</u>		
SCALE <u>1:1000</u>	DWG NO. <u>SK</u>	CA 5151-A2- SHEET OF <u>1</u>		

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

November 14, 1983.

Crippen Acres,
Sixth Floor - 500 Portage Avenue,
Winnipeg, Manitoba,
R3C 3Y8

Attention: Mr. D.S. Matheson

Dear Mr. Matheson:

In response to your telephone call, I travelled to Nipawin November 1, 1983, to examine the core from DH 363 (R-5). I obtained samples of core from R-2,4,5,6 and submitted 6 till samples for carbonate analyses and 4 till samples and 1 bedrock sample for textural analyses from R-5. (Fig. 1). I also examined the core samples from R-2,4, and 6 to determine the stratigraphy in the vicinity of R-5.

The information obtained from R-5 is incomplete for the following reasons: (1) the cased interval was not gamma-ray logged; (2) the Inspector's log does not agree with the electric log between 26 and 40 feet; (3) the cutting samples (66 to 103 feet) were bagged wet and, consequently, the nature of the sediment could not be determined; and (4) a definite bedrock marker bed was not penetrated.

To identify the lithology of the till in R-5 (Fig. 1), 6 carbonate and 4 textural analyses were determined. The Lower Till has a calcite content of about 2%, whereas the Middle Till has more than 4%. The Lower Till is sandy, whereas the Middle Till has about an equal proportion of sand, silt, and clay. In hand specimens the Lower Till is more sandy and is light

brownish gray in color, whereas the Middle Till is dark gray.

To complete cross section CC' (Drawing 0093-001-04, letter report of July 30, 1983), I propose to draw a cross section from DH 194 through R-3,2,1, 4,5,6, LA1, DH 198, to UA 2. I would also recommend a testhole be drilled in the vicinity of the east end of TR1. LA1 should be drilled into the Swan River Formation to make up for R-5 which did not penetrate a definite bedrock marker.

I shall await your decision on this proposal.

Sincerely yours,



E.A. Christiansen

cc P.C. Hensman
H.S. Rupprecht

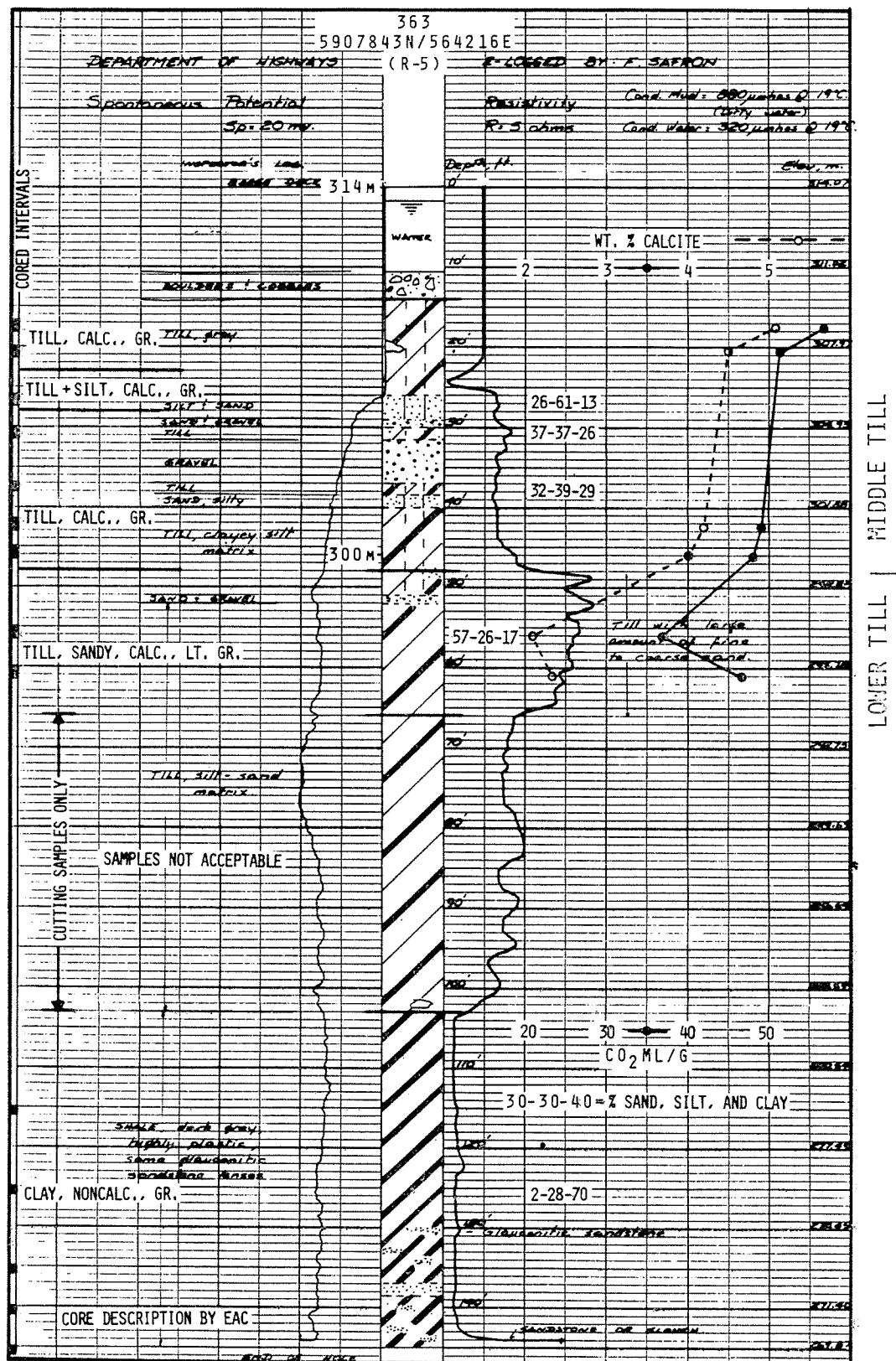


Figure 1. Drill hole log 363 (R-5) showing carbonate and textural analyses.

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

December 8, 1983

Crippen Acres
Sixth Floor - 500 Portage Avenue
Winnipeg, Manitoba
R3C 3Y8

Attention: Dr. D.S. Matheson

Nipawin Hydroelectric Project
Geologic Review 0093-003

Dear Dr. Matheson:

In response to your request, I travelled to Nipawin November 30, 1983 to demonstrate my cutting sampling technique. After a conference with Mr. Reyes and preparing Telex No. 650 for you, we examined TR-1 and the overlying exposure in the deltaic deposit. After this brief field trip, I demonstrated the technique of sampling cuttings to Mr. Reyes, two of his inspectors, and one of Hayter's drillers. I provided Crippen Acres with a complete set of sampling equipment which I was unable to demonstrate under actual drillings conditions because the rig was not operating.

With reference to my continuing geologic review of the Nipawin Hydroelectric Project, I have the following requests and suggestions.

- 1) I request that Mr. Reyes compile geologic cross sections $1\text{cm} = 10\text{m}$: (a) east-west direction through the Main Dam Core Trench including the west extension, (b) north-south section through the west wall of the west extension of the Main Dam Core Trench, (c) east-west section along the Downstream Principle Structures Excavation, and (d) north-south section throught about DH-308 in the Downstream Principle Structures Excavation. I would like to insert these cross sections into my geologic cross sections of the site. Mr. Reyes has mapped the

the excavations and is in the best position to draw such sections. I have discussed this topic with Mr. Reyes who is aware of my requirements.

- 2) I recommend that you consider establishing about three continuously recording observation wells, one in the Swan River Group, one in the Middle Till where the sands and gravels have the best continuity and the best development, and one in the deltaic sand east of the dam site. Enclosed is a brochure showing the Tessier obervation well hydrograph. I am also enclosing two continuously recording hydrographs and their completion record from wells in the Swan River Group at Armley and Smoky Burn, Saskatchewan.

Continuously recording observation wells are important for calibrating piezometers and for providing the unique signature of the hydrologic system. Such hydrographs are also important in determining the date and magnitude of recharge into or discharge from the system whether it be natural or artificial.

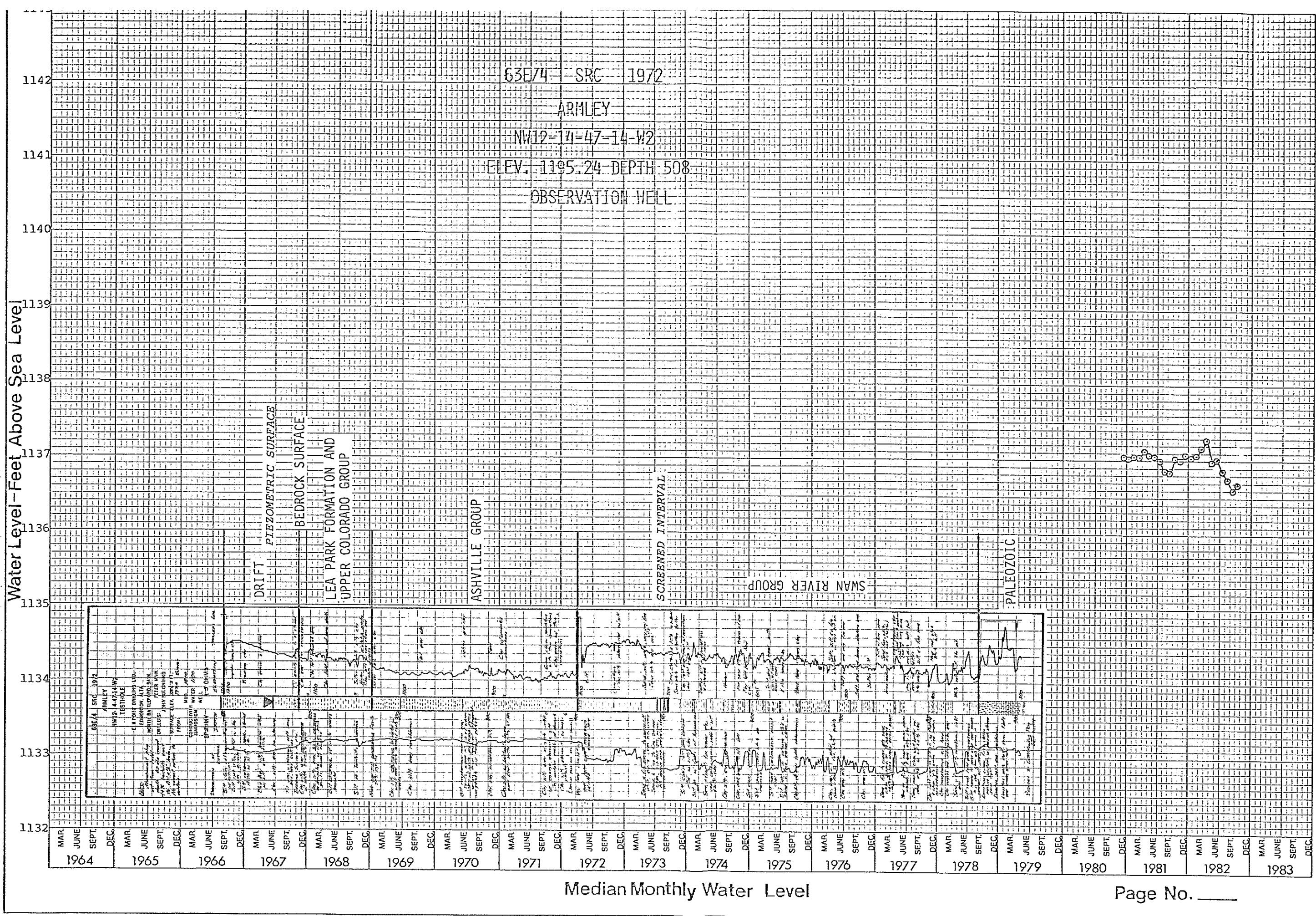
If you should decide to proceed with my recommendation, you might approach SRC who have the necessary skills to pump test, install recorders, and monitor the wells as part of their observation well network in Saskatchewan.

Sincerely yours,

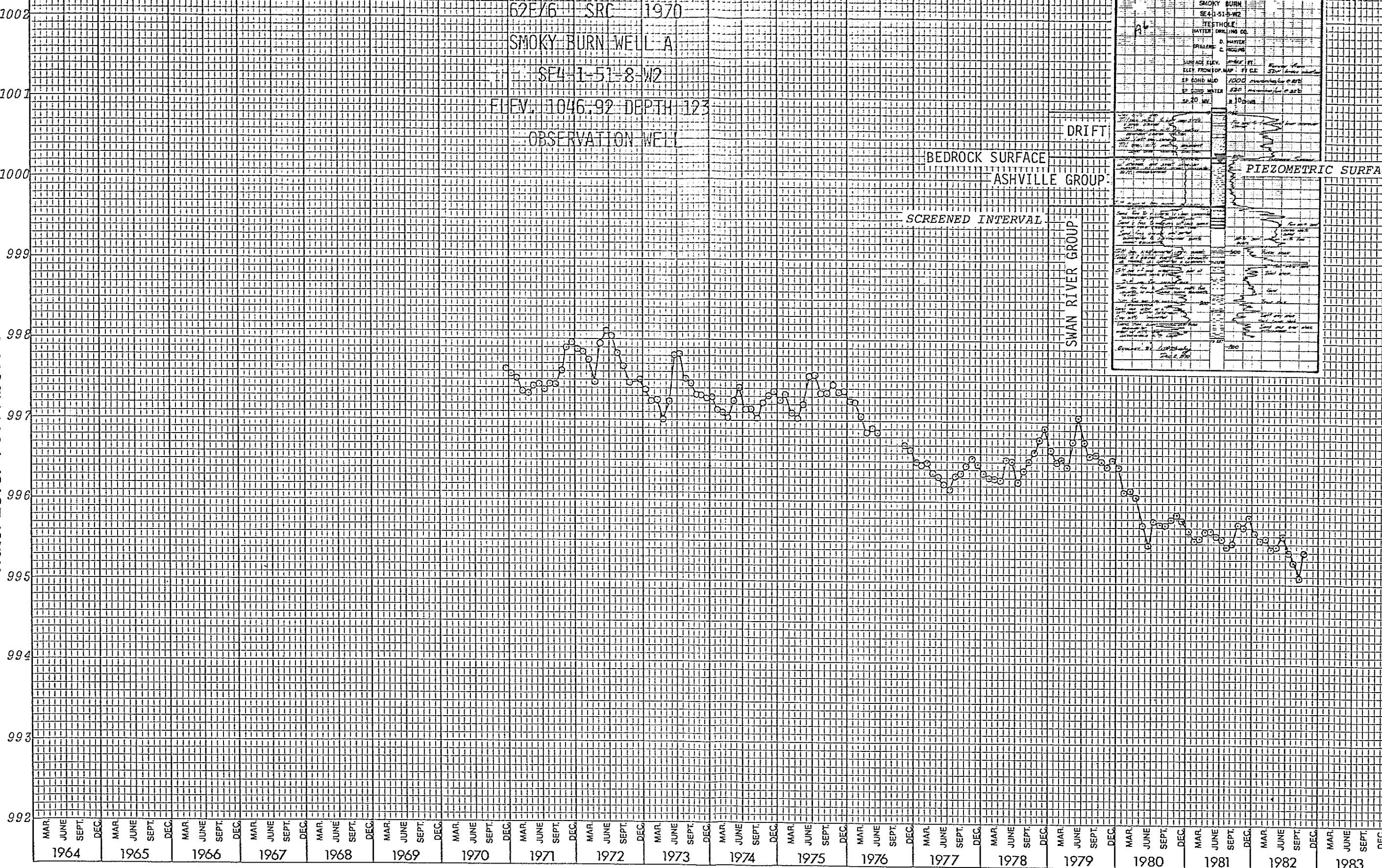


E.A. Christiansen

cc P.C. Hensman
H.S. Rupprecht

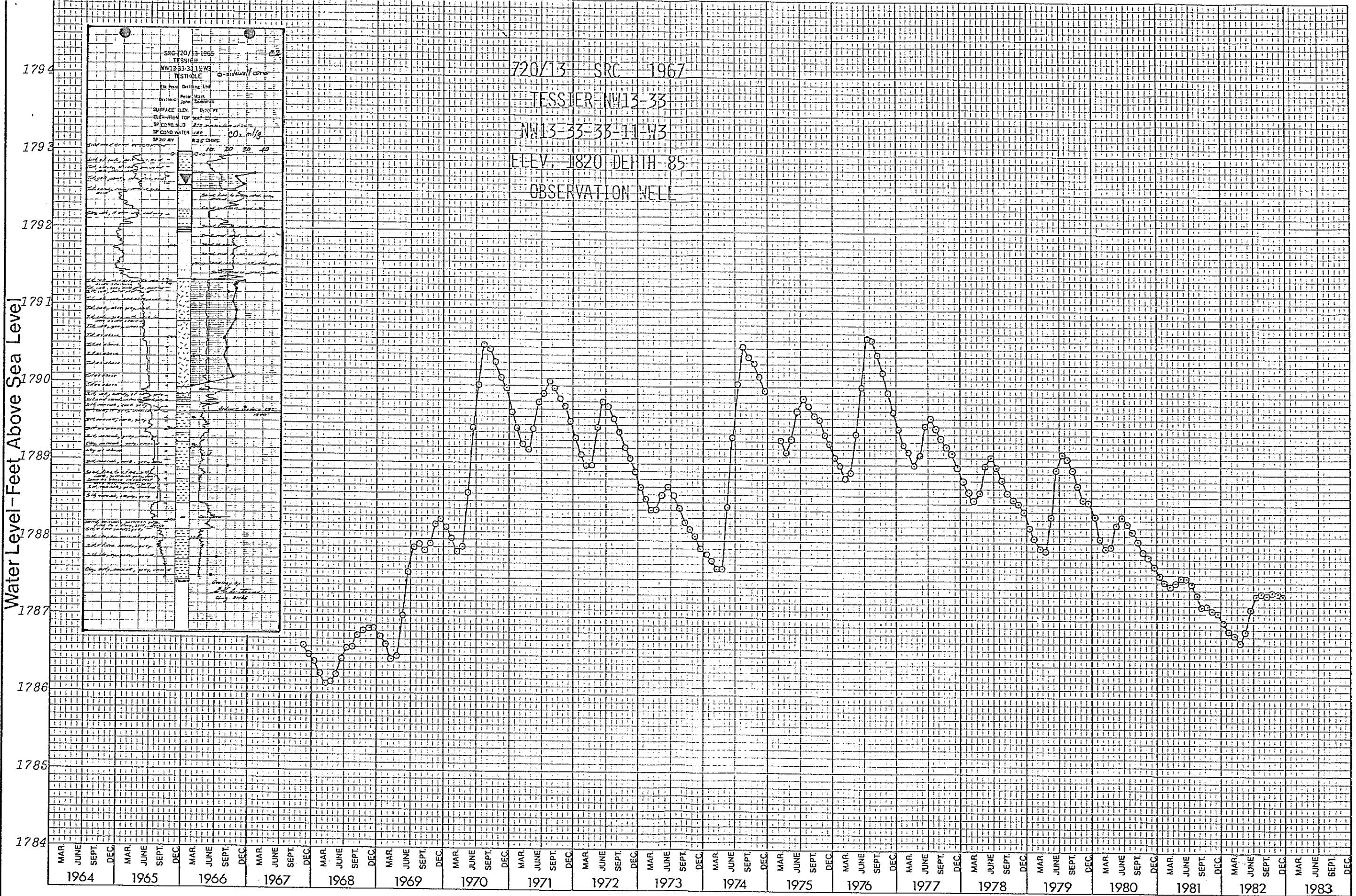


Water Level-Feet Above Sea Level



Median Monthly Water Level

Page No. _____



Median Monthly Water Level

Page No. _____

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

February 15, 1984

Crippen Acres
Sixth Floor - 500 Portage Avenue
Winnipeg, Manitoba
R3C 3Y8

Attention: Dr. D.S. Matheson

Nipawin Hydroelectric Project
Geologic Review 0093-004

Dear Dr. Matheson

In response to your request for a geologic evaluation of DH 369(UA2) and for a cross section along the centerline across the Saskatchewan River and right bank, I am enclosing copies of Drawings 0093-004-01-03. In addition to this information, carbonate and grain size analyses were conducted on numerous samples of till and bedrock from UA2, and the results are plotted on Drawing 0093-004-03. X-ray diffraction patterns were determined on the Upper, Middle, and Lower tills as well as the Ashville and Mannville - Swan River groups (Figs. 1-5).

The Upper and Middle tills in UA2 (Drawing 0093-004-03) can be readily separated on carbonate content and texture. The Upper till has a lower carbonate content and is more sandy and less silty than the Middle till. Although the Middle and Lower tills have similar carbonate content, the Middle till is more silty and less sandy than the Lower till. All tills have a similar mineral content (Figs. 1-3).

The Ashville and Mannville - Swan River Groups can be readily separated on color, texture, and clay mineral content. The Ashville Group is composed of

dark gray, highly montmorillonitic clay and shale (Drawing 0093-004-03, Fig. 4), whereas the Mannville - Swan River Group is composed mainly of light gray, kaolinitic silt and siltstone (Drawing 0093-004-03, Fig. 5).

With reference to Cross Section D-D' (Drawing 0093-004-02), the following observations are noteworthy.

1. A major sand, silt, and gravel unit occurs in the lower part of DH 368 and 370. Although the occurrence of till between this stratified unit and bedrock in DH 368 suggests the sand, silt, and gravel unit lies in the Lower till as shown, it is possible that it belongs to the Empress Group.
2. The sand and gravel unit occurs in all testholes in Cross Section D-D' except DH 363. At testhole DH 371, the sand and gravel unit thickens downward and probably represents a channel fill. It is conceivable that thicker channel fills may occur in this intertill deposit in the Middle till.
3. A FSL of 348 m intersects the deltaic sand and silt unit about 4 m above the base of the unit.

Under separate cover, I shall send you a map showing the location of proposed testholes along with the reasons for requesting them. After our meeting in Saskatoon when the location of these proposed testholes is finalized, I will proceed with the proposal.

Sincerely yours,



E.A. Christiansen

cc: P.C. Hensman
H.S. Rupprecht

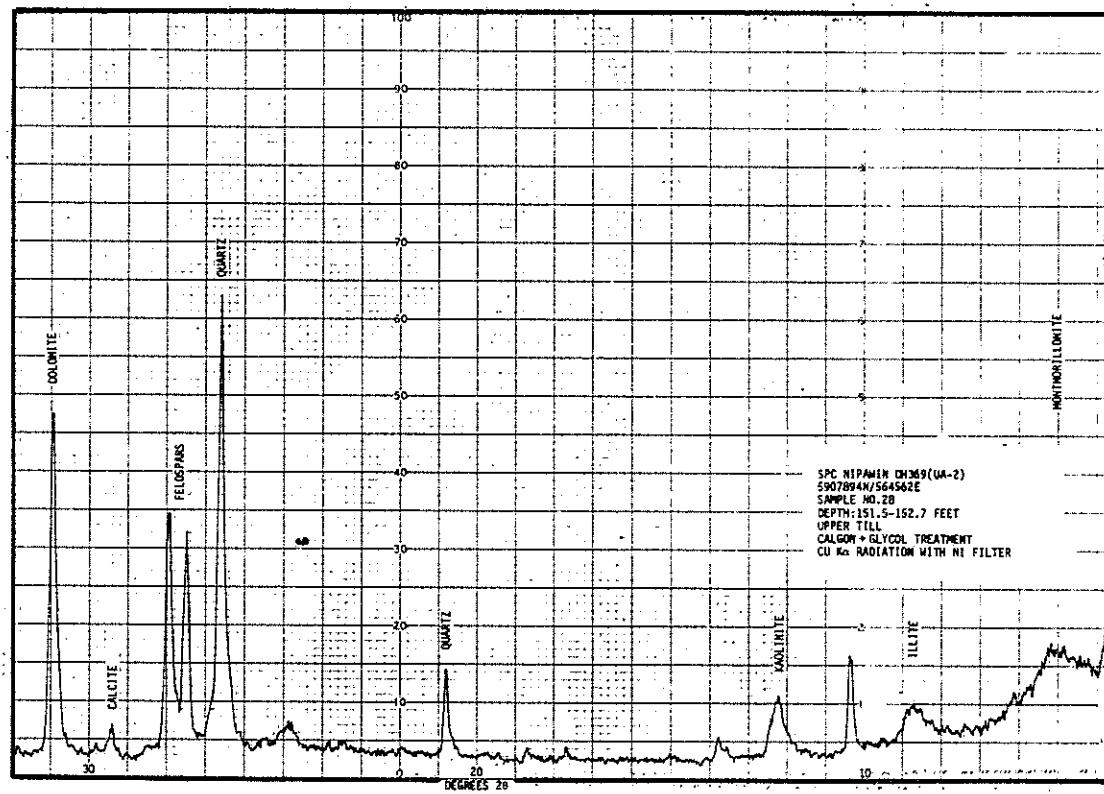


Figure 1. X-ray diffraction pattern of Upper till.

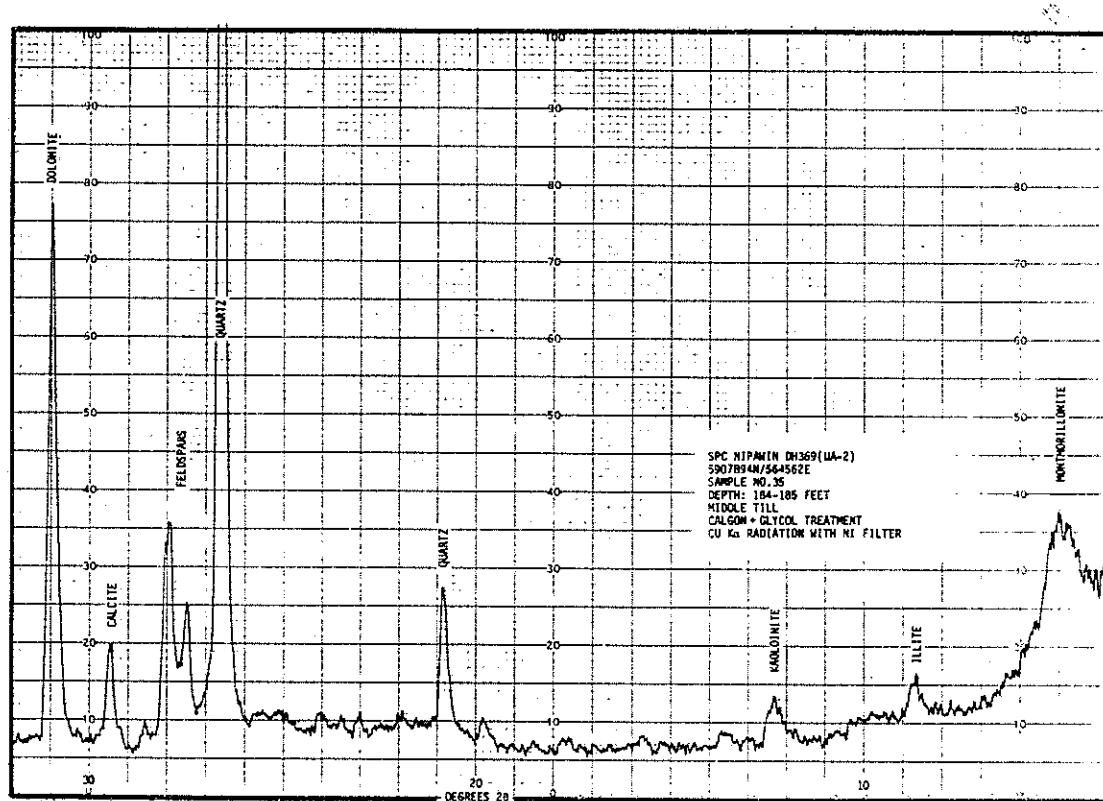


Figure 2. X-ray diffraction pattern of Middle till.

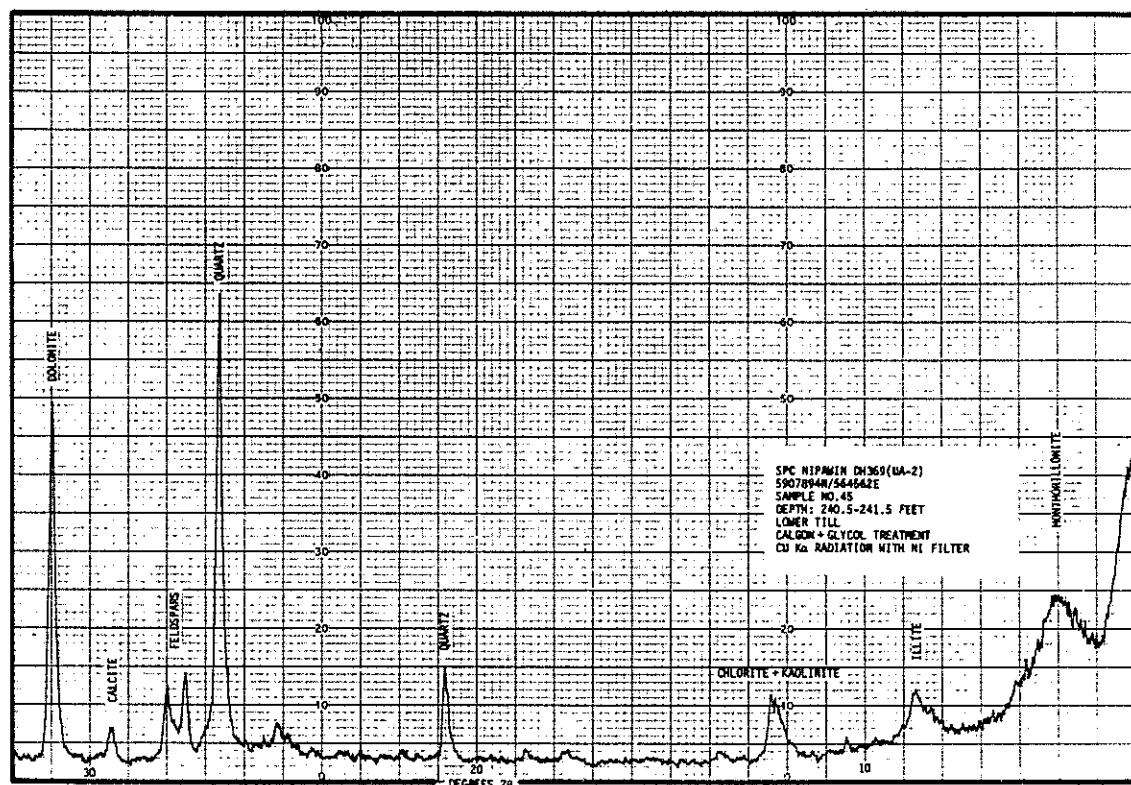


Figure 3. X-ray diffraction pattern of Lower till.

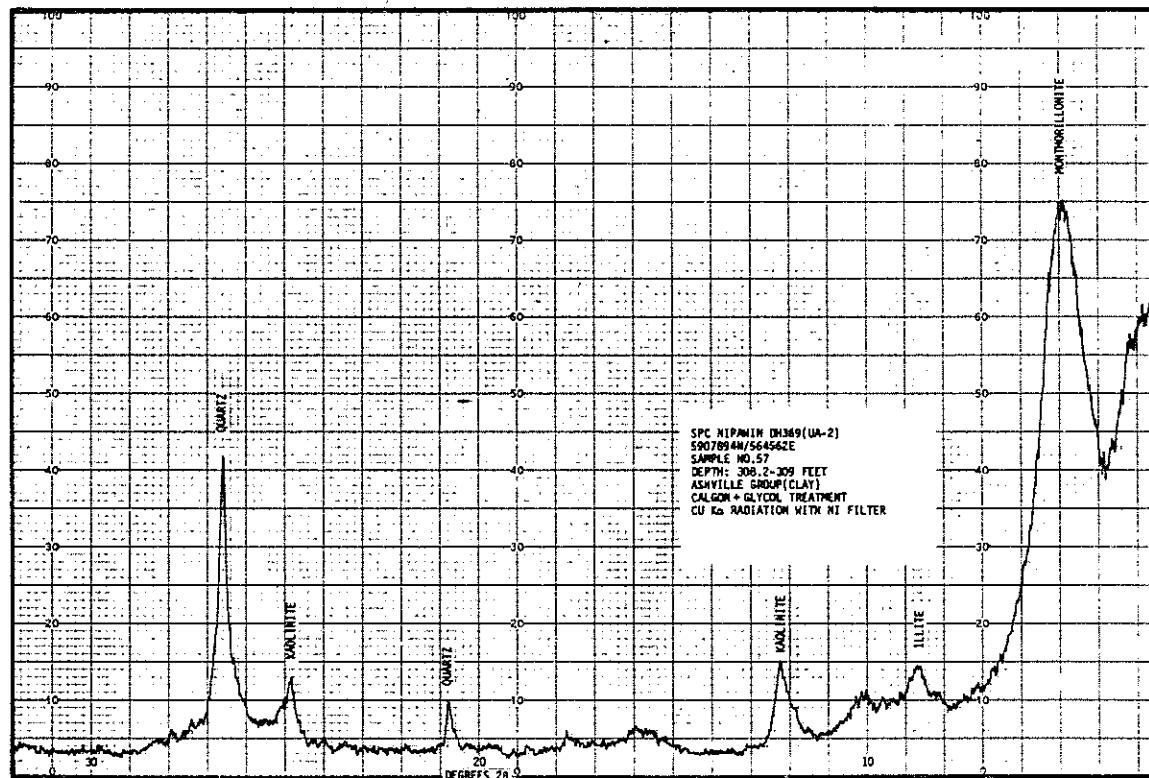


Figure 4. X-ray diffraction pattern of Ashville Group.

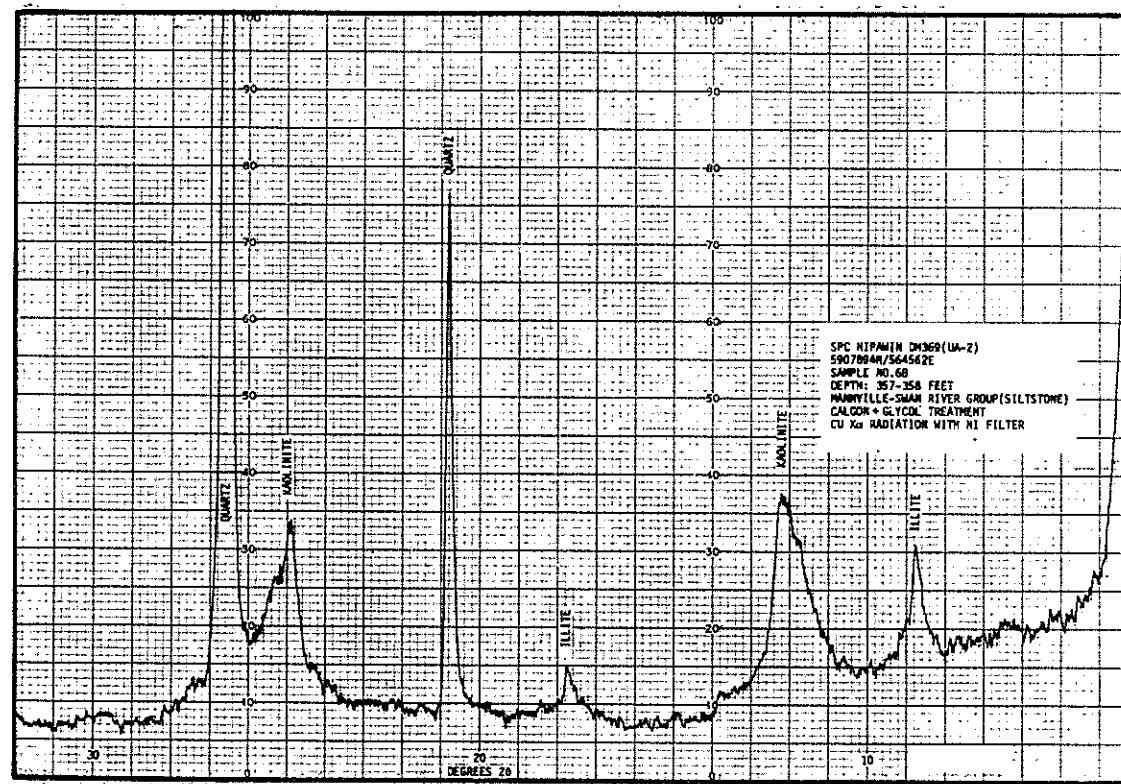


Figure 5. X-ray diffraction pattern of Mannville-Swan River Group.

SPC 73H/8 1983

NIPAWIN DH-369

SW16-18-50-14-W2

13,564562E/5907894N

TESTHOLE UA-2

CONTROL SECTION
 BOREHOLE NO. DH369(UA-2)
 STATION 5907894N/584562E
 GRD.ELEV. 370.82 M DEPTH 125.9 M
 DATE DRILLED NOV. 29 TO DEC. 11, 1983
 COND. WATER 700 MICROSIEMENS/CM AT 25°C
 COND. MUD 840 MICROSIEMENS/CM AT 25°C
 SPECIFIC GRAVITY MUD
 ENGINEER M.S. REYES
 SUPERVISOR INSPECTORS
 LOGGED BY P. MACHIBRODA ENGINEERING LTD.
 INSTRUMENT WIDCO 1500
 PROBE ELECTRIC
 PROBE GAMMA
 PROBE CALIPER
 DATE LOGGED DEC. 11, 1983
 TIME OF LOGGING TO
 DRILL CONTRACTOR: HAYTER DRILLING LTD.
 GEOLOGY BY E.A.CHRISTIANSEN CONSULTING LTD. BASED ON CORE DESCRIPTIONS.
 INSPECTORS' LOGS, DRILLERS' LOGS, AND COMPILATION BY M.S. REYES
 FOR CRIPPEN ACRES

PROJECT NIPAWIN HYDROELECTRIC

CUTTING SAMPLE INTERVAL

CORE SAMPLE INTERVAL

FROM SURVEY

CASING DEPTH 71 M

CASING WALL THICKNESS

WATER OR MUD LEVEL

ABANDONMENT CEMENT

BIT SIZE INTERVAL

BIT SIZE INTERVAL

BIT SIZE INTERVAL

TYPE OF DRILL RIG

DEPTH SCALE SPEED

SP. 124M 100

RES. 124M 100

GAMMA 127M 0-100 84/MIN

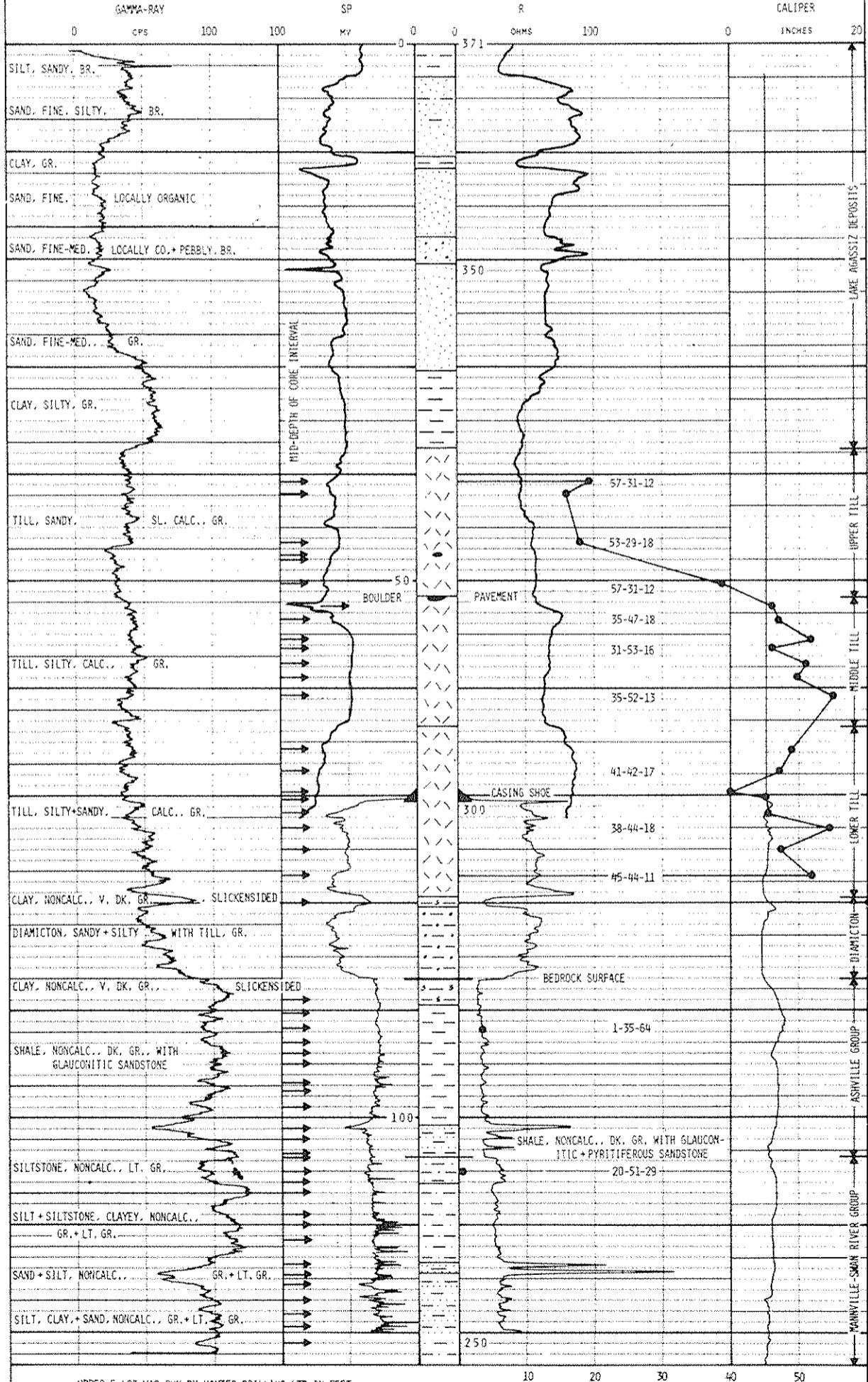
CAL.

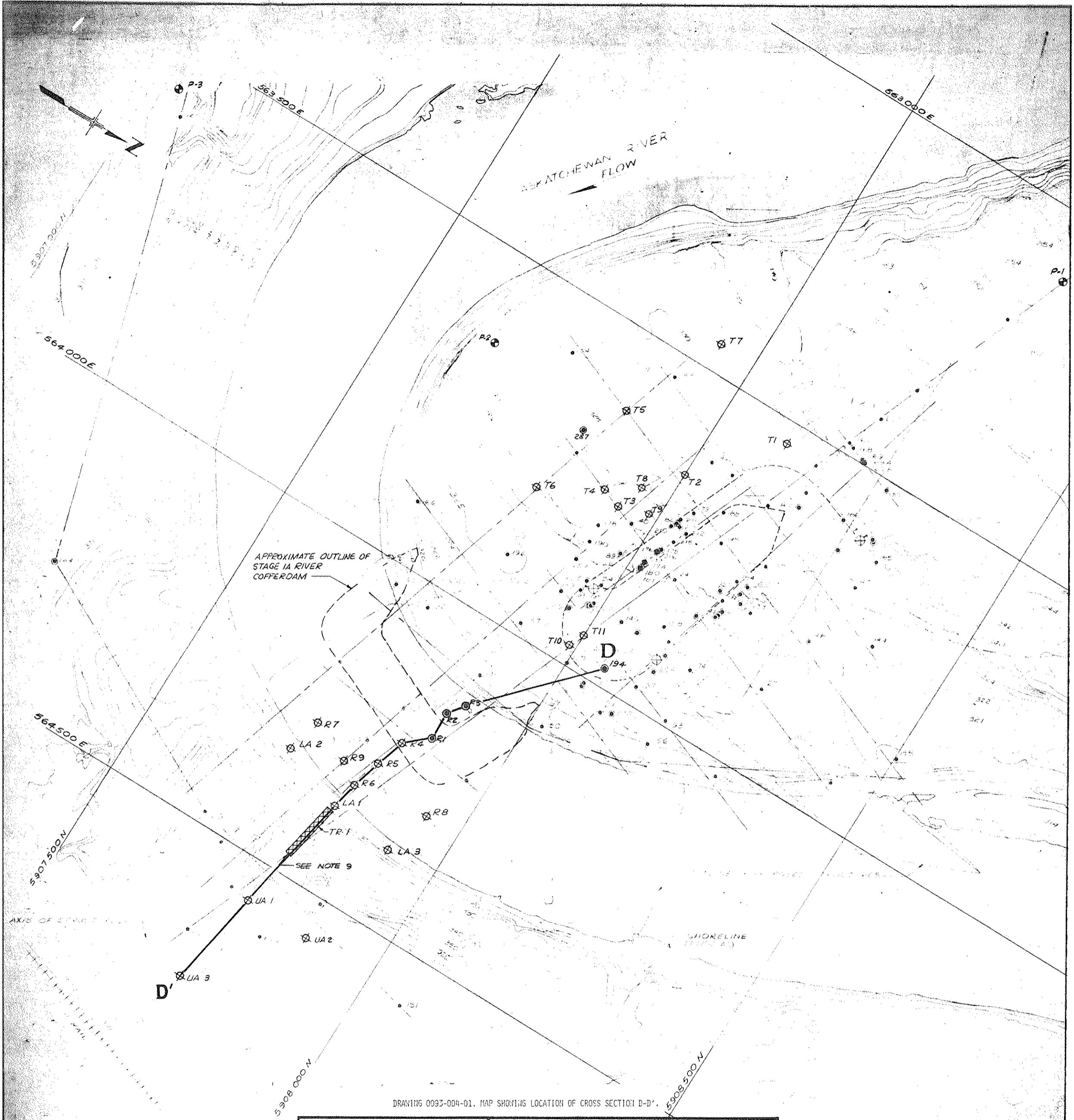
T.C. GAMMA-RAY = 3 T.C. CALIPER = 1

GEOLGY BY E.A.CHRISTIANSEN CONSULTING LTD. BASED ON CORE DESCRIPTIONS.

INSPECTORS' LOGS, DRILLERS' LOGS, AND COMPILATION BY M.S. REYES

FOR CRIPPEN ACRES





DRAWING 0093-004-01. MAP SHOWING LOCATION OF CROSS SECTION D-D'.

CRIPPEN ACRES REGINA, SASKATCHEWAN		SASKATCHEWAN POWER CORPORATION		
DESIGN BY	<i>DRM</i>	NIPAWIN HYDROELECTRIC PROJECT		
CHECK	<i>JBS</i>	1983 EXPLORATORY PROGRAM		
DRAWN BY	<i>ET</i>	TERRACE, RIVER, RIGHT BANK		
CHECK	<i>S</i>			
SUBMITTED DEPT.	<i>Brown</i> <i>Q.E. Int'l</i>			
PROJ.				
APPROVED DEPT.	<i>DRM</i> <i>Hallam</i>			
PROJ.				
DATE	1983-08-03	SCALE 1:2500	SKETCH NO. CA SISI-AO-400	REV. Sheet / of /

