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SASKATCHEWAN HIGHWAYS AND
TRANSPORTATION

STRATIGRAPHIC ANALYSIS-CONTROL
SECTION 21-12 (MUDY LAKE)

Report 0087-002 Sept. 20, 1983

E. A. Christiansen Consulting Ltd.

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September 20, 1983

Saskatchewan Highways and Transportation
P.O. Box 1750
Saskatoon, Saskatchewan
S7K 3S1

Attention: Mr. H.G. Bird

Dear Mr. Bird:

Re: Stratigraphic analysis - Control Section 21-12 (Muddy Lake)

Enclosed are three copies of Report 0087-002 on the "Stratigraphic analysis-Control Section 21-12 (Muddy Lake)" as requested in your Commission of September 29, 1982.

I found the investigation interesting and appreciated the opportunity to participate in the study of this project.

Sincerely yours,



E.A. Christiansen



MUDY LAKE DEPRESSION LOOKING SOUTHWEST FROM CONTROL SECTION
21-12, OCTOBER 18, 1982. DARK AREA IS DRY LAKE BED.



MUDY LAKE SCARP LOOKING NORTHEAST ALONG CONTROL SECTION
21-12, OCTOBER 18, 1982.

SUMMARY

Control Section 21-12 is in the north wall of the Muddy Lake depression which was formed by glacial erosion. The Control Section is in non-marine, interbedded sand, silt, clay, and coal of the Judith River Formation. Most of the alluvial fill in the Muddy Lake basin was derived from the scarp surrounding the depression. This scarp has retreated about 200 m since the last deglaciation as a result of colluvial, fluvial, and spring sapping activities or at rate of about 15 mm per year.

A major landslide 500 m long and 40 m thick resting on a slickensided silt and clay unit is thought to occur along the Control Section, and springs discharge water from the Judith River Formation at the base of the scarp on the Control Section. Flowing artesian conditions in the Ribstone Creek Tongue suggests the alluvium in the Muddy Lake depression is under-consolidated.

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1. Geologic logs along Control Section 21-12 -----

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1. INTRODUCTION

1.1 Objective

The objective of this investigation is to provide the following as set forth in the Commission Requirements for "Stratigraphic analyses - Control Section 21-12 (Muddy Lake)" of September 29, 1982 and in the extension agreement of July 15, 1983.

- (1) To examine the literature and ground conditions and to locate proposed testholes.
- (2) To supervise the drilling of two testholes representing extreme conditons.
- (3) To describe cuttings samples and compile stratigraphic logs.
- (4) To draw a cross section to show the stratigraphic model of the site.
- (5) To identify the groundwater regimes of the site.
- (6) To describe strata for engineering purposes such as brecciation, failure planes, and other physical anomalies.
- (7) To prepare three copies of a report.

1.2 Location

Control Section 21-12 is in the south - facing wall of the Muddy Lake depression (Drawing 0087-002-01; Figs. 1-5) and represents the re-routing of Highway 21 south of Unity, Saskatchewan.

1.3 Previous Work

A map of the geology and groundwater resources (Christiansen, 1967) and a paper on the history of deglaciation (Christiansen, 1979) provide the geologic framework of the Muddy Lake area.



A



B

Figure 1. Muddy Lake Control Section 21-12 looking southwest: (A) before construction, October 18, 1982 and (B) after construction of access road and granular blanket, July, 19, 1983.



A



B

Figure 2. Muddy Lake Control Section 21-12 looking northeast: (A) before construction, October 18, 1982 and (B) after construction of access road and granular blanket, July 19, 1983.



A



B

Figure 3. Location of testholes looking southwest along Muddy Lake Control Section 21-12, July 19, 1983: (A) Testhole 3 and (B) Testholes 4, 5, 9, 11, 12, and 13.



A



B

Figure 4. Groundwater discharge: (A) scarp in Judith River Formation formed by spring sapping, October 18, 1982 and (B) pipe draining groundwater from granular blanket covering springhead, July 19, 1983.



A



B

Figure 5. Landslides: (A) landslide blocks looking west from Control Section 21-12 along south-facing scarp of Muddy Lake depression, October 18, 1982 and (B) Neil Richardson standing where landslide is covered with alluvium, July 19, 1983.

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1.4 Present Study

The present study included the supervision of two testholes, examination of cutting and cores, compilation of geologic logs (Appendix 1), two field trips to examine the site with Mr. Neil Richardson, and the construction of a regional geologic cross section (Drawing 0087-002-01) and a cross section of Control Section 21-12 between Testhole Nos. 3 and 7 (Drawing 0087-002-02).

2. GEOMORPHOLOGY

Control Section 21-12 is in the south-facing scarp of the Muddy Lake depression. This depression, which is formed in bedrock, is about 8 km long, 3 km wide, and more than 70 m deep (Drawing 0087-002-01, cover photograph). Muddy Lake, which covers the floor of the depression, is saline and intermittent. The Muddy Lake depression has a closure of more than 60 m and is one of the most spectacular closed basins in the province. Hummocks of bedrock (Richardson, personal communication) flank the toe of the scarp (Fig. 5A).

3. STRATIGRAPHY

3.1 General

The Muddy Lake depression was eroded through the Judith River Formation into the Lea Park Formation (Drawing 0087-002-01). The Judith River Formation is a nonmarine, deltaic deposit which intertongues with the marine Lea Park Formation (Fig. 6). The upland is covered mainly by glacio-lacustrine silt and clay with minor amounts of till at the base of the unit.

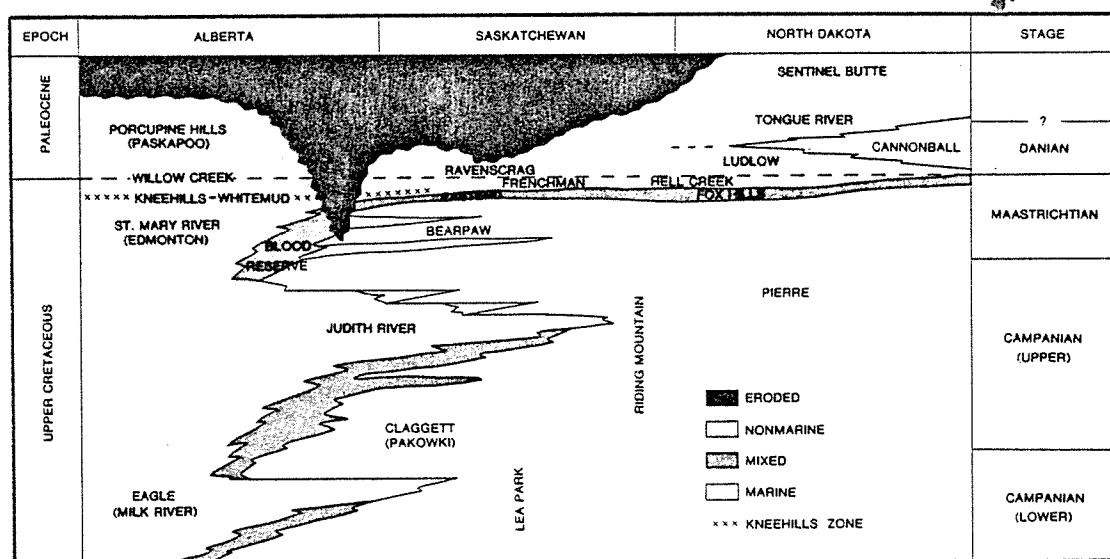


Figure 6. Schematic cross section showing intertonguing marine and nonmarine strata characteristics of the Upper Cretaceous in the Western Interior and their relationship to overlying Paleocene strata. From Whitaker et al. (1978).

The Muddy Lake alluvium, which is more than 30 m thick, is the youngest sediment and must have been derived from postglacial erosion of the walls of the depression. The total depth of the Muddy Lake depression is about 100 m (Drawing 0087-002-01).

The Ribstone Creek tongue of the Judith River Formation in the Lea Park Formation was used as a structural marker bed in this study. As can be seen in Cross Section A-A' (Drawing 0087-002-01), the depression is not a collapse structure.

3.2 Control Section 21-12

The stratigraphy of Control Section 21-12 is shown in Drawing 0087-002-02. The top of the bentonitic clay marker bed is the contact between the Lea Park and overlying Judith River Formations. The Judith River Formation is composed of a lower sand and silt bed, a slickensided silt and clay bed, and an upper sand, silt, and clay bed. Most of the failure planes examined in cores were in the silt and clay bed.

The bottom of the Muddy Lake depression is covered with alluvium which becomes coarser grained as the scarp is approached. Between Testholes 12 and 13, a buried scarp occurs which probably represents the former position of the north wall of the Muddy Lake depression. At the foot of this buried scarp are blocks of till and Judith River Formation (Drawing 0087-002-02).

4. GEOLOGIC PROCESSES

4.1 Introduction

Glacial erosion and scarp retreat by colluvial, fluvial and

spring sapping activities are the main geologic processes which have affected Control Section 21-12.

4.2 Glacial Erosion

The paucity of structure in the Ribstone Creek tongue under the Muddy Lake depression eliminates collapse as a mechanism for the origin of this feature. The missing beds attest to erosion, and the closed nature of the depression indicates glacial rather than fluvial erosion. The lack of glacio-lacustrine sediments in the depression further suggests the depression must have been filled with ice until glacial Lake Unity drained.

The northern wall of the glacially eroded depression lies between Testholes 12 and 13 (Drawing 0087-002-02) and probably emerges near the surface where Neil Richardson is standing in Figure 5B. This point marks the change from hummock landslide material to the north to a flat alluvial-colluvial plain to the south.

4.3 Scarp Retreat

4.3.1 Introduction

The present scarp (Fig. 2) is retreating as a result of colluvial, fluvial, and spring sapping activities. If the glacially eroded scarp is taken as the original scarp, then the present scarp has retreated about 200 m during the last 14000 to 13000 years (post-glacial time as defined by Christiansen, 1979 for the Unity area), or at a rate of about 15 mm per year.

4.3.2 Colluvial Activities

The appearance of bedrock blocks in the piedmont area of the south-facing scarp (Fig. 5A), the presence of colluvium in the Muddy Lake depression (Testhole 12, Drawing 0087-002-02), the presence of slickensides in the silt and clay bed in the Judith River Formation, and the bench in the scarp at Testhole 4 (Fig. 4B) suggests strongly the presence of a landslide where Control Section 21-12 intersects the scarp (Drawing 0087-002-02). The shear resistance in such a landslide would be affected by groundwater in the Judith River Formation.

4.3.3 Fluvial and Spring Sapping Activities

Because of the paucity of streams entering the Muddy Lake basin, erosion of the scarp must be the main source of the alluvium in the basin. The material was and is being derived from the scarp by fluvial erosion and spring sapping (Fig. 4). It is conceivable that colluvial activities as exemplified by Figure 7 and spring sapping are the main mechanisms of slope retreat and that the main role of fluvial activities is to deliver sediment from the scarp to the depression.

5. GEOLOGIC HISTORY

The presence of alluvium directly on bedrock and the paucity of glacio-lacustrine sediments in the Muddy Lake depression suggest that the depression was formed at least in part during the last glaciation and that ice must have stood in the depression preventing glacial Lake Unity from entering the basin.



Figure 7. Slope retreat by colluvial action in south wall of the End Lake depression (11-39-23-W3) about 4 km west of Control Section 21-12.

6. GEOTECHNICAL CONSIDERATION

From a geological point of view, landslides and groundwater are the main geotechnical considerations. In Drawing 0087-002-02 a major landslide is inferred which is being monitored during construction.

Groundwater seeps from the Judith River Formation at the base of the scarp (Fig. 4A) is being ameliorated by a granular blanket (Fig. 1B) and drain (Fig. 4B). Flowing artesian conditions from the Ribstone Creek tongue were encountered in Testhole No. 6 (Drawing 0087-002-01); consequently, under-consolidation of the alluvium should be anticipated.

7. LITERATURE CITED

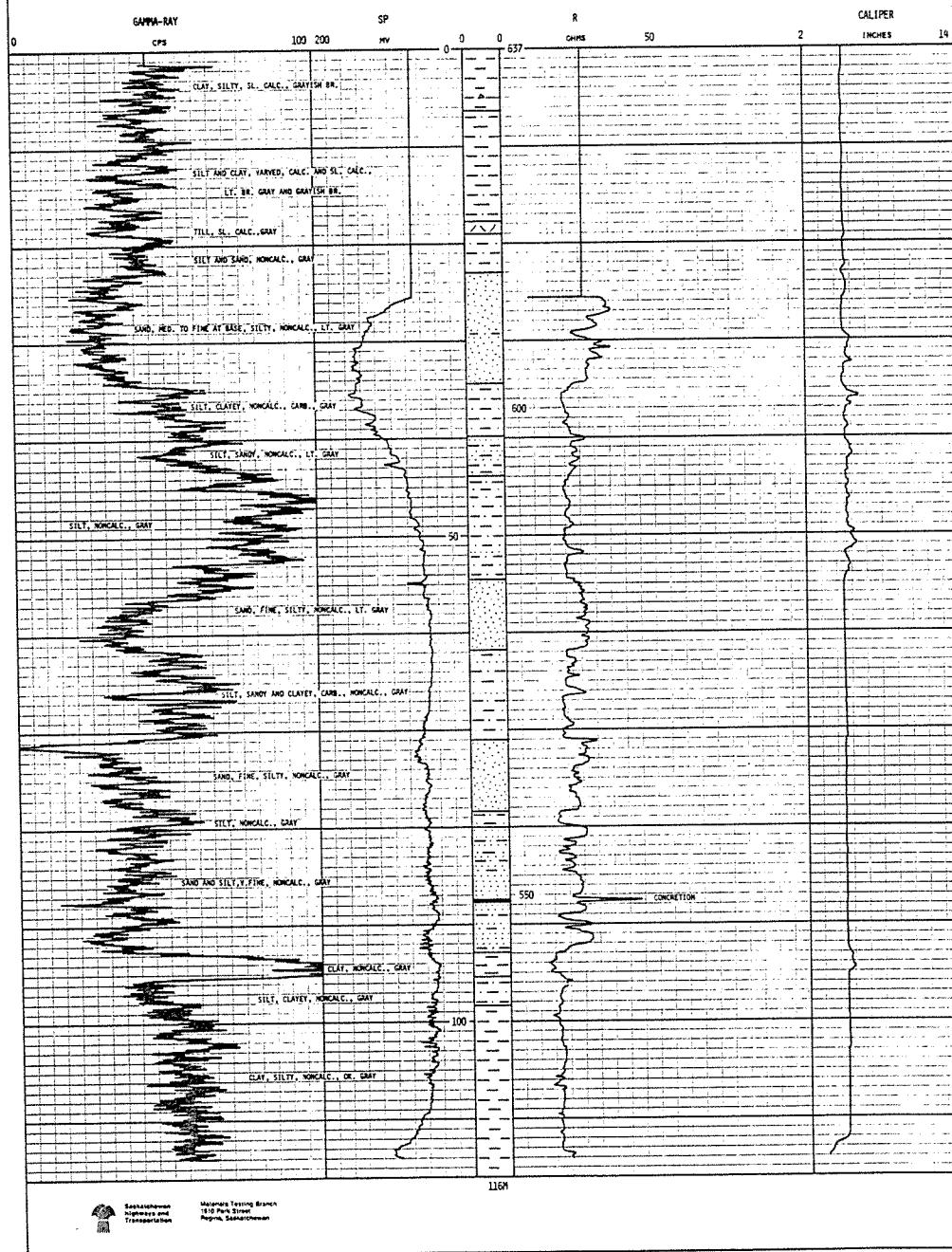
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- Christiansen, E.A. 1979. The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas. Canadian Journal of Earth Sciences, Volume 16, pages 913-936.
- Whitaker, S.H., Broughton P.L., and Irvine, J.A. 1978. Coal resources of southern Saskatchewan: a model of evaluation methodology, Saskatchewan Research Council, Report 20.

Appendix 1. Geologic logs along Control Section 21-12.

SDH 73C/6 1982
MUDDY LAKE NO.1
SE1-18-39-22.W3
12:626325E/5801175N
TESTHOLE

CONTROL SECTION 21-12 PROJECT MUDDY LAKE

BORINGHOLE No.	CUTTING SAMPLE INTERVAL
STATION 48+721	5'
STATION 48+721	OFFSET 23W 1/2E
GRID ELEV 537.49 m	DEPTH 350'
DATE DRILLED OCT 20 NOV 3 1982	CASING DEPTH
COND. WATER 2100	CASING WALL THICKNESS
COND. WAD 2150	WATER OR MUD LEVEL
SPECIFIC GRAVITY MUD 1.070	ABANDONMENT FTELEMETER
ENGINEER J. A. CHRISTIANSEN	BIT SIZE 4 3/4"
SUPERVISOR LYLE SINCLAIR	INTERVAL 0-380'
LOGGED LYLE SINCLAIR	BIT SIZE
INSTRUMENT 41000 1200	INTERVAL
PHONE ELECTRIC	TYPE OF DRILLING
PHONE CALIPER	120' TAPERING
DATE LOGGED NOV 3	LOG DEPTH
TIME OF LOGGING 1720 hrs = 1600 hrs	SCALE
DRILL OPERATOR RYLES MILLER	SPD
ASST OPERATOR JOHN BRISSE	# 114.4 50 55.5'/min
GEOLOGIST RYLE CHRISTIANSEN CONSULTING LTD.	#P 114.4 200 55.5'/min
	GAMMA 118.4 0-100 27'/min
	CALIPER 114.4 2-14" 65.5'/min
	GAMMA TO CONCRETE 1
	REMARKS SPLIT HOLE ALMOST IN CONTROL SECTION
	OF CIRCULATION NO NOTICABLE EFFECT
	ON GEOPHYSICAL LOGS



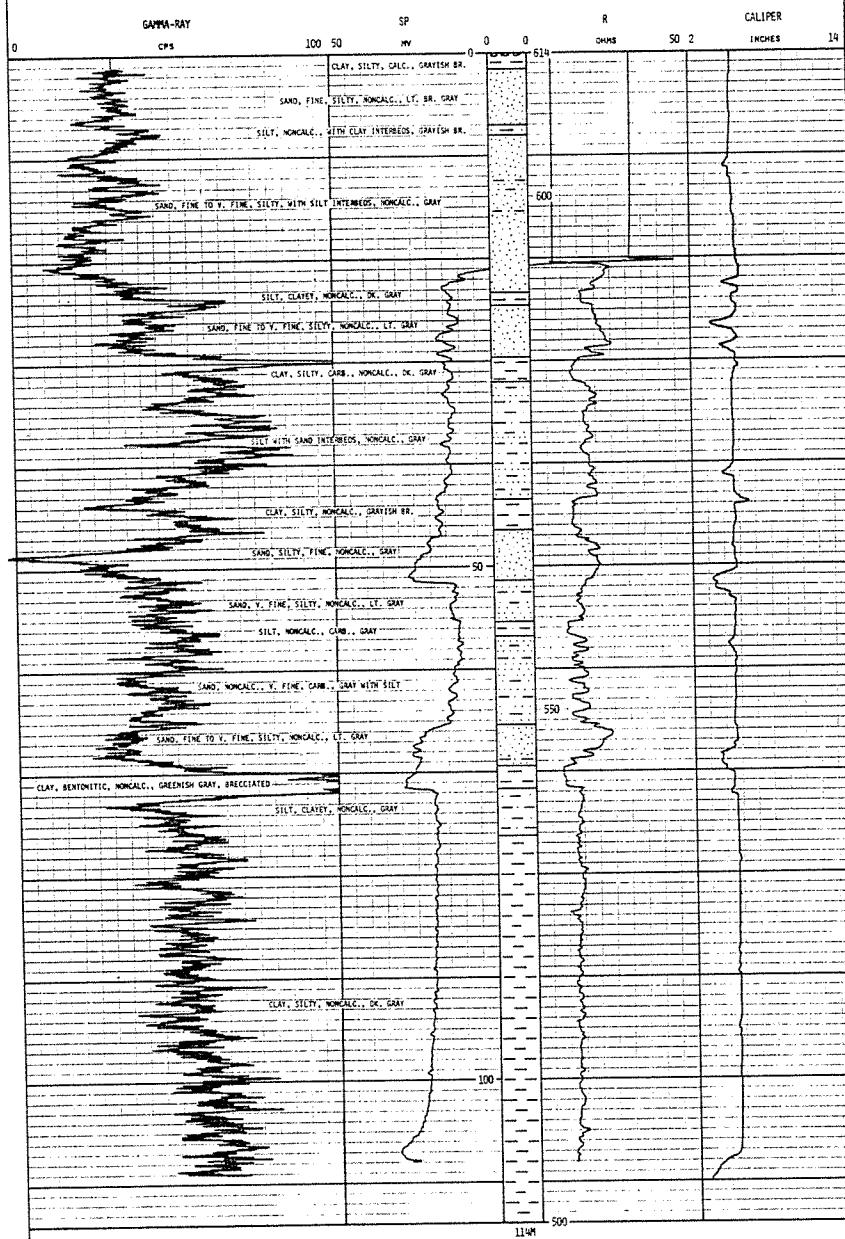
Highways and
Transportation

Materials Testing Branch
1810 Park Street
Regina, Saskatchewan

SDH Muddy Lake No. 2 not completed.

SDH 73C/6 1982
MUDDY LAKE NO.3
NW9-7-39-22-W3
12:626175E/5800600N
TESTHOLE

CONTROL SECTION	PROJECT	MUD LOG
BOROHOLE No.	3	CUTTING SAMPLE INTERVAL 5'
STATION	AD0107.3	CORE SAMPLE INTERVAL
		FROM
GRO ELEV	514.37	TO
DEPTH	112.3	CASING DEPTH 65'
DATE DRILLED	OCT 25	CASING WALL THICKNESS
COND. WATER	1200	WATER OF MUD LEVEL
COND. MUD	1550	ABANDONMENT 100' IN HOLE
SPECIFIC GRAVITY MUD	1.05	BIT SIZE 3 1/2"
ENGINEER	NEIL CHRISTENSEN	INTERNAL 0-112"
SUPERVISOR	LYLE CHRISTENSEN	BIT SIZE
LOGGED	1115' 100' AIR	INTERNAL
WEIGHT	1000 LB/FT	TYPE OF DRILL RIG 150 PILING
PHASE ELECTRIC		LOG DEPTH 1 SCALE SPEED
PHONE GAMMA		" 108 m 50 65.5/min
PHONE CALIPER		KP 108 m 50 65.5/min
DATE LOGGED	OCT 27	GAMMA 108 m 0-100 27/min
TIME OF LOGGING	1000 hrs to 0930 hrs	CALIPER 108 m 0-100 65.5/min
DRILL OPERATOR	LYLE MILLER	GAMMA TIME CONSTANT (TC) 1
ASST OPERATOR	JOHN BRITZ	REMARKS
GEOLGY BY	E. A. CHRISTENSEN CONSULTING LTD.	

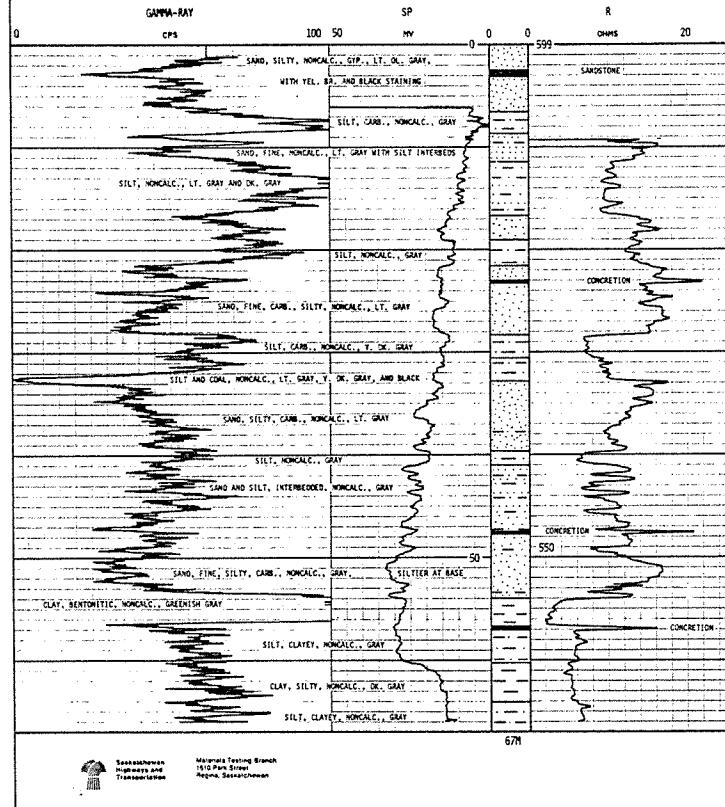


Geological Log
Geological Services and
Transcription

McLean Testing Group
1010 Park Street
Regina, Saskatchewan

SDH 73C/6 1982
MUDDY LAKE NO.4
NW3-7-39-22-W3
12:626175E/5800525N
725M TESTHOLE 725M

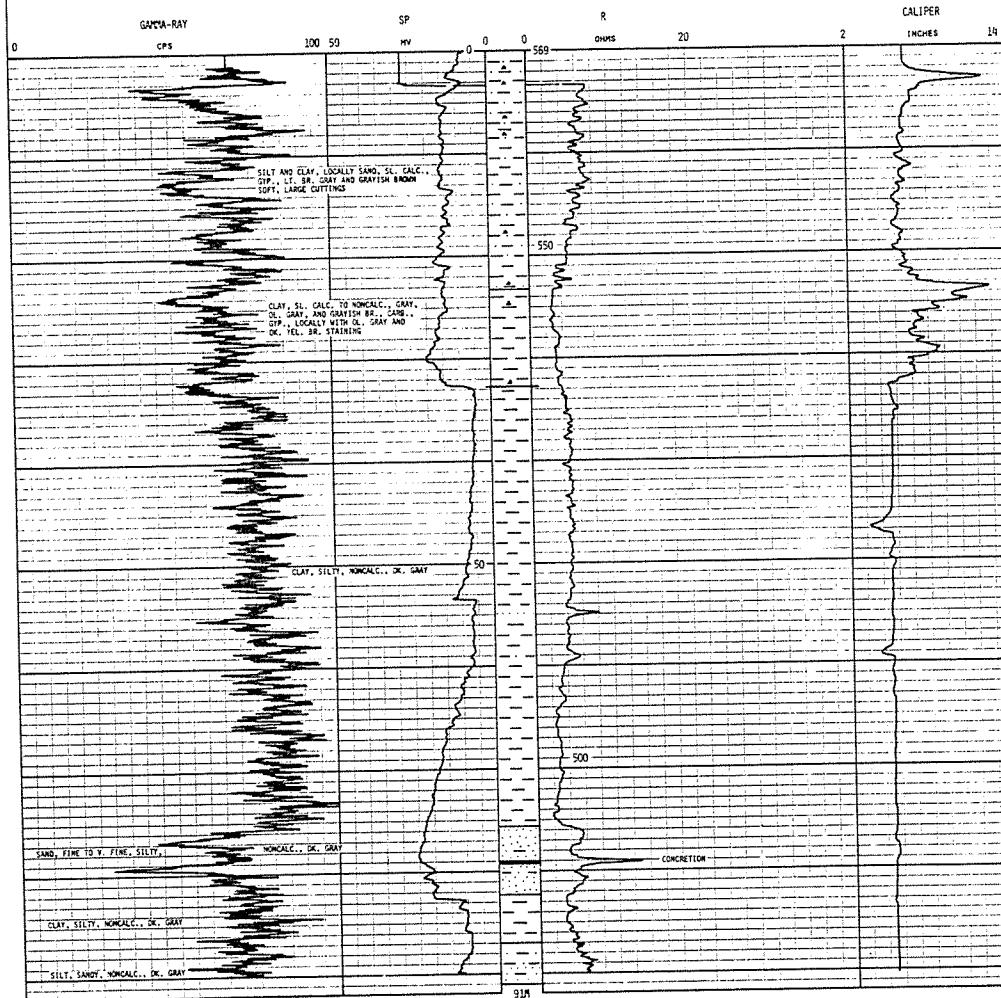
CONTROL SECTION 21-12		PROJECT MUDDY LAKE	
BORINGHOLE NO	4	CUTTING SAMPLE INTERVAL	5"
STATION	474490 m	OFFSET	346 ft (105 m)
GND ELEV.	518.50 m	DEPTH	57 m
DATE DRILLED	OCT. 20 TO OCT. 21, 1982	CASING DEPTH	
GND WATER	1200	WATERLEVEL/TEMP AT 27°C	
GND MUD	2000	WATERLEVEL/TEMP AT 29°C	
SPECIFIC GRAVITY	1.05	MATERIAL OF MUD LEVEL	
DRILLER	NEIL RICHARDSON	ABANDONMENT	POST IN HOLE
SUPERVISOR	LYLE SINGLAR	BIT SIZE	3 1/2"
LOGGED BY	LYLE SINGLAR	INTERNAL	0-220'
INSTRUMENT	WILCO 1500	BIT SIZE	INTERNAL
PROBE ELECTRIC		TYPE OF DRILL	MUD 1500 TAILING
PROBE GAMMA		LOG	DEPTH 1 SCALE SPEED
PROBE CALIPER		R	10M 20 65.5/min
DATE LOGGED	OCT. 20 AND 21, 1982	SP	60M 50 65.5/min
TIME OF LOGGED	12:00:00 AM - 2000:00:00	GAMMA	60M 0-100 277/min
DRILL OPERATOR	DALE MILLER	CONCRETE	
AST DRILLER	ZEB ARIE	GAMMA TIME CONSTANT (TC)	1 sec/min
GEOLOGY BY	C.A. CHRISTIANSEN CONSULTING LTD.	REMARKS	



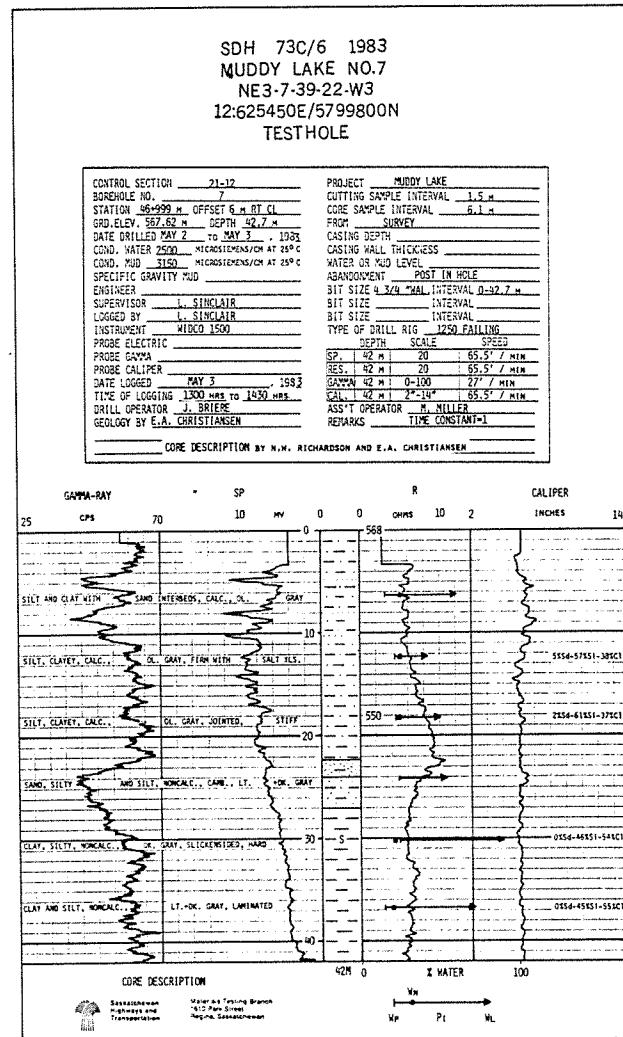
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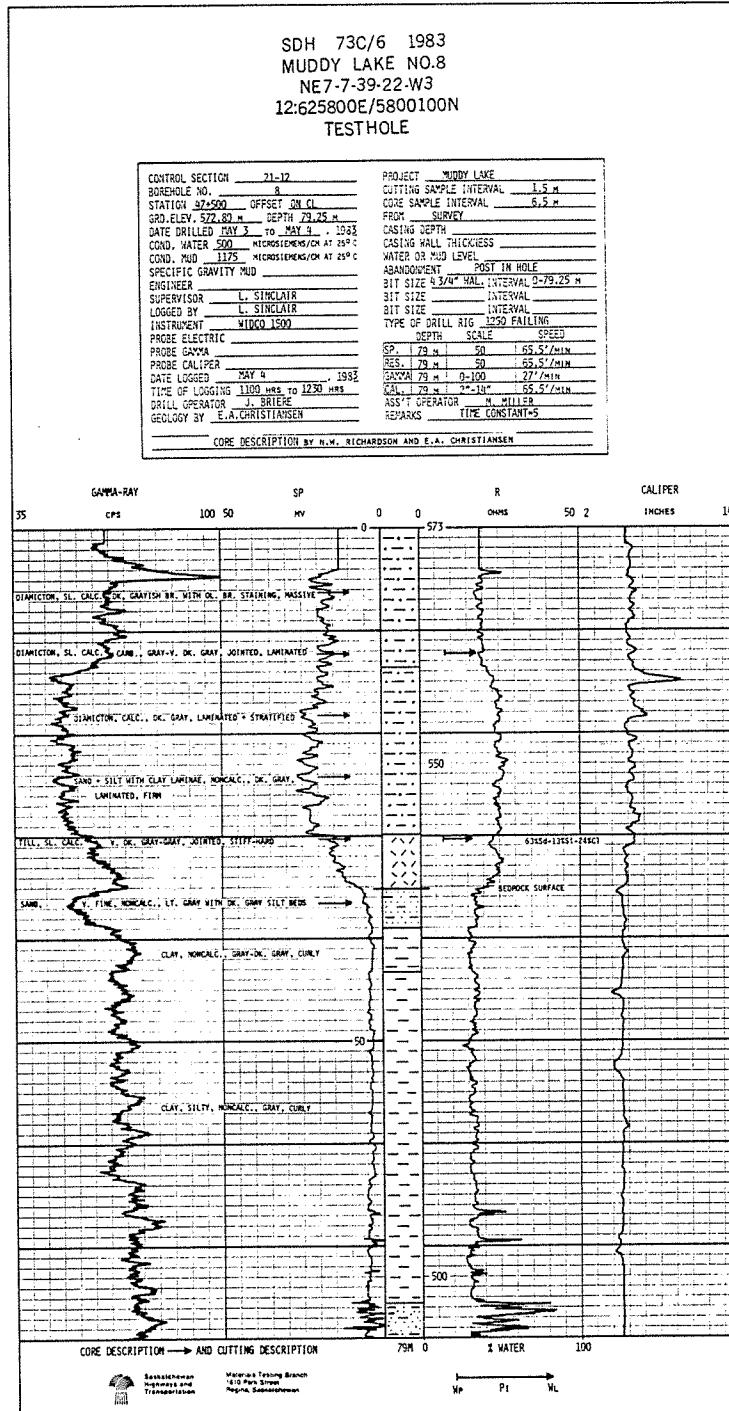
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MUDDY LAKE NO.6
NE13-6-39-22-W3
12:625025E/5799375N
TESTHOLE

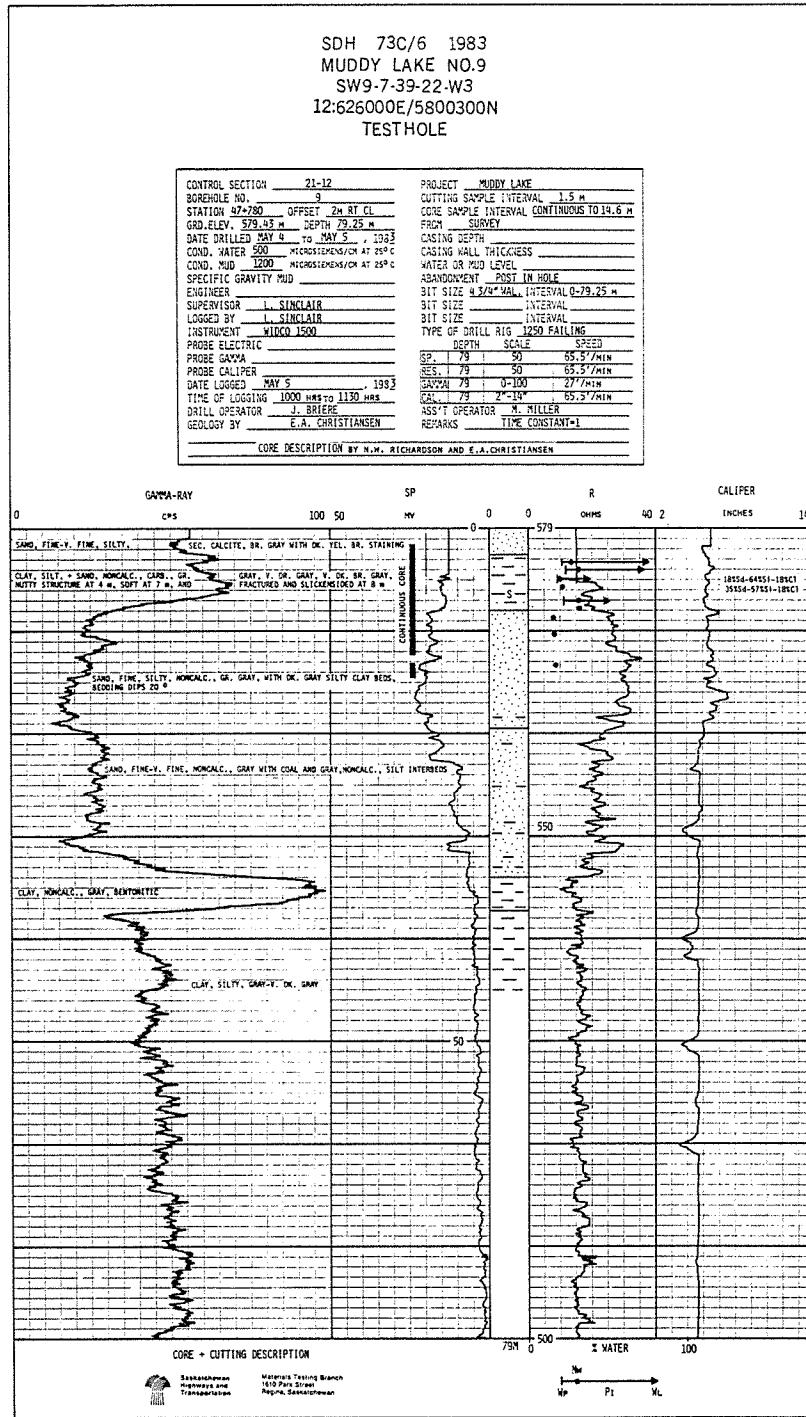
CONTROL SECTION 11-12		PROJECT MUDDY LAKE	
BORINGHOLE NO.	5	CUTTING SAMPLE INTERVAL	5'
STATION (MAGNETIC)	OFFSET 2.5m E. N.	CORE SAMPLE INTERVAL	
GRID ELEV.	649.32 m. DEPTH 31m	FROM	
DATE DRILLED	OCT. 28 to NOV. 1, 1982	CASING DEPTH	35'
CORE WATER	2100. HYDROSTATIC/WATER AT 25°C	CASING WALL THICKNESS	
CORE WDG	5000. HYDROSTATIC/WATER AT 25°C	WATER/WDG LEVEL FLINED WHEN HOLE AT 240'	
SPECIFIC GRAVITY WDG	1.05 - DEPTH 1-38	ABANDONMENT	250' WITH POST IN HOLE
ENGINEER	NEIL RICHARDSON	BIT SIZE	4 3/4"
SUPERVISOR	YLE SINCLAIR	INTERVAL	0-300'
LOGGED BY	YLE SINCLAIR	BIT SIZE	
INSTRUMENT	VERCO 1500	INTERVAL	
PROBE ELECTRIC		TYPE OF DRILL RIG	1200 TAILING
PROBE CALIPER		TYPE OF DEPTH RD.	
DATE LOGGED	NOV. 1	SCALE	SPEED
TIME OF LOGGING	0930 HRS. TO 1130 HRS.	0	65.5'/min
DRILL OPERATOR	MILES MILLER	50	65.5'/min
ASS'T OPERATOR	JOHN BRIERE	100	77.1'/min
GEOLGY BY	E.A. CHRISTIANSEN CONSULTING LTD.	200	77.1'/min
REMARKS		CALIPER	65.5'/min
		GAMMA TIME CONSTANT (TC)	1 second



Materials Testing Branch
1610 Park Street
Regina, Saskatchewan

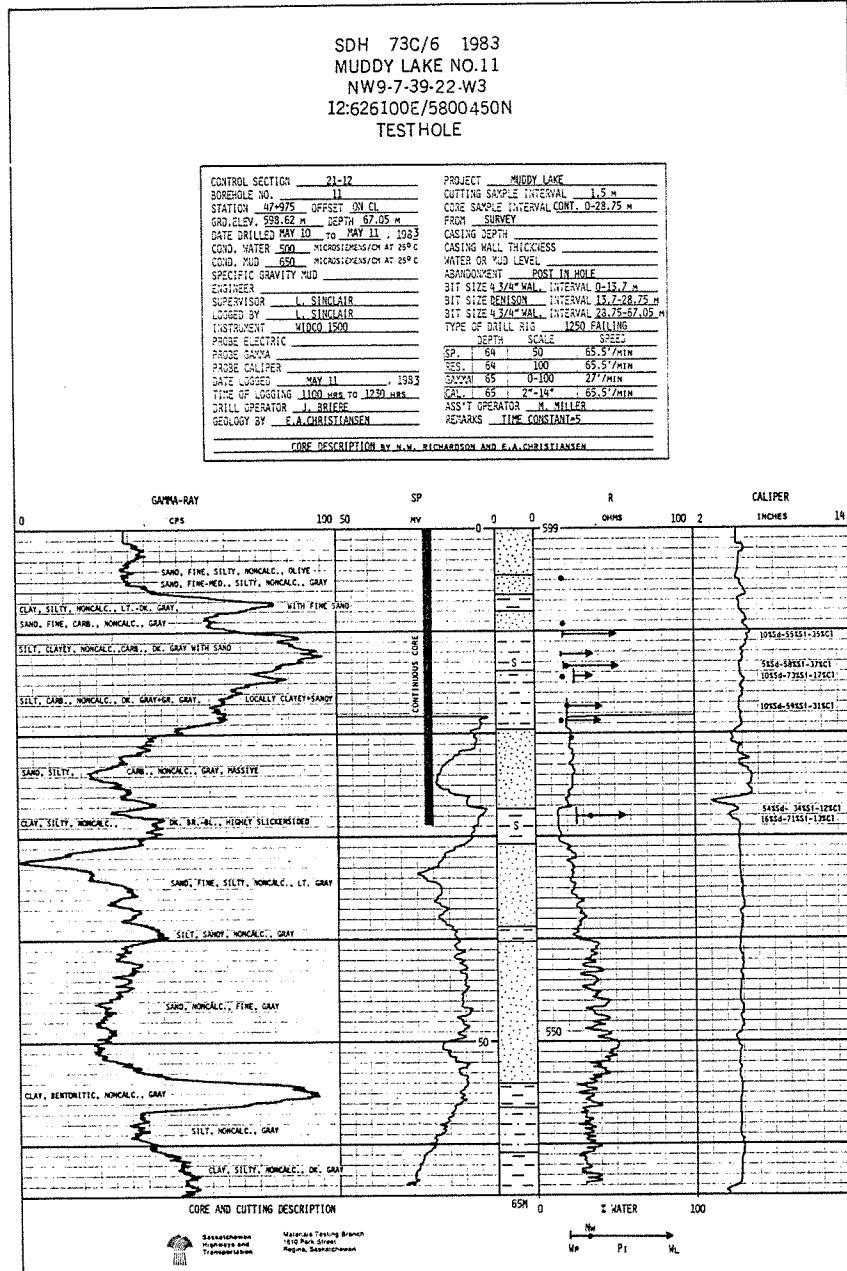


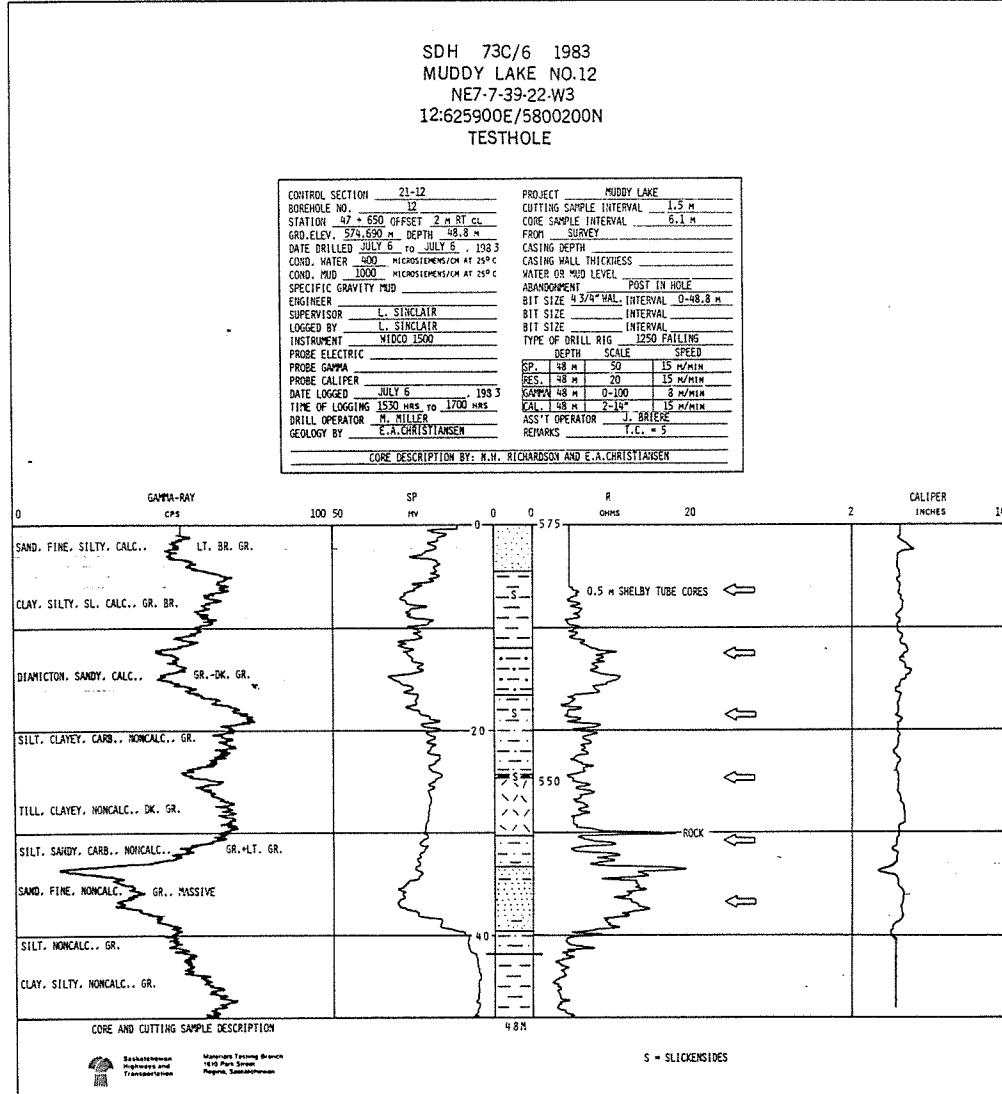




SDH 73C/6 1983
MUDDY LAKE NO.10
SW 7-7-39-22-W3
12:625650E/5799950N
TEST HOLE

E. A. Christiansen Consulting Ltd.





E. A. Christiansen Consulting Ltd.

SDH 73C/6 1983
MUDDY LAKE NO.13
SW9-7-39-22-W3
12:626000E/5800300N
TESTHOLE

CONTROL SECTION	21-12	PROJECT	MUDGY LAKE			
BOREHOLE NO.	13	CUTTING SAMPLE INTERVAL	1.5 M			
STATION	47 + 740' OFFSET	CORE SAMPLE INTERVAL	6.1 M			
GROSS ELEV.	7373.5 M DEPTH	FROM SURVEY				
DATE DRILLED	JULY 7, 1983	CASING DEPTH				
COND. WATER	400 MICROSECONDS/M at 25°C	CASING WALL THICKNESS				
COND. MUD	1000 MICROSECONDS/M at 25°C	ABRADING OR MUD LEVEL				
SPECIFIC GRAVITY MUD		ABANDONMENT	POST IN HOLE			
ENGINEER		BIT SIZE	4 3/4" M/L INTERVAL			
SUPERVISOR	L. SINCLAIR	BIT SIZE	4-1/2" INTERVAL			
LOGGED BY	L. SINCLAIR	BIT SIZE	4" INTERVAL			
INSTRUMENT	WIDCO 1500	TYPE OF DRILL RIG	1250 FAILING			
PROBE ELECTRIC		DEPTH	SCALE	SPEED		
PROBE GAMMA		SP.	48 M	50	15 MPH	
PROBE DENS.		RES.	48 M	50	15 MPH	
DATE LOGGED	JULY 7, 1983	SP.	48 M	50	8 MPH	
TIME OF LOGGING	1030 hrs to 1200 hrs	RES.	48 M	50	15 MPH	
DRILL OPERATOR	E.M. MILLER	CAV.	1-1/2" x 1"	15	15 MPH	
GEOLGY BY	E.A. CHRISTIANSEN	ASS'T OPERATOR	T.C. BRIESE			
CORE DESCRIPTION BY: N.W. RICHARDSON AND E.A. CHRISTIANSEN					REMARKS	

