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SUFFIELD TECHNICAL NOTE

NO. 335

ON THE GEOLOGIC AND HYDROLOGIC INVESTIGATIONS AT THE WASTE RADIOACTIVE MATERIAL AND CHEMICAL DISPOSAL SITES AT DRES (U)

by

H.T. Beare

PROJECT NO. 99-30-15

March 1975

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD : RALSTON : ALBERTA

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ABSTRACT

This report briefly summarizes the work done at the Defence Research Establishment Suffield during the spring and summer of 1972 by the Research Council of Alberta under contract to the Defence Research Board. The purpose of the work was to study the geologic and hydrologic features of two disposal sites; one for low level radioactive waste materials and the other for chemical wastes.

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I. INTRODUCTION

1. General. This paper briefly describes the geologic and hydrologic investigations carried out by the Research Council of Alberta (RCA) under contract to the Defence Research Board at Suffield (DRES) during the spring and summer of 1972. The investigations were carried out to evaluate two sites, one approximately seven miles north-east of the research establishment, where waste radioactive materials were buried, and the other, approximately two miles north of the establishment, where chemical wastes were buried. It is expected that in the future the waste radioactive material site will be utilized to store waste materials not only from the whole of the Department of National Defence but possibly also from other governmental agencies such as hospitals and universities in Alberta.

The work was carried out by Mr. Don Currie and Mr. Casey Waterman. Representing the Defence Research Board throughout the life of the contract and assisting in logistical and technical matters were Mr. H.T. Beare and Mr. G.K. Briosi, both employees of the Defence Research Board in the Soil Mechanics Laboratory at DRES.

2. The Contract. The Defence Research Board asked the Research Council of Alberta to "evaluate, considering the geology and groundwater hydrology as they relate to toxic liquid wastes and solid low-level radioactive wastes, the two sites for storage of such materials". The basic approach proposed by the Council was to determine the stratigraphic sequences,

thickness and lithology of the geologic deposits in and adjacent to the two sites by auger and rotary test drilling and well logging. In addition, they physically identified all geologic samples retrieved at three to five foot intervals in each drilled hole.

3. This Paper presents a summary report of the work done to fulfill the terms of the contract, which included the investigation of the field site, the drawing up of conclusions, recommendations and suggestions, and the production of the report which is listed as Reference 1 in this report. In addition, background material will be presented that relates to the geology of the two sites and the past experience of the Research Council of Alberta in the field of geologic and hydrologic studies in Alberta. It is expected that, from this discussion, the reader will better understand the reasons for the awarding of the contract to the Council and those for the Council's approach to the problem.

II. GENERAL GEOLOGY OF THE AREAS

1. General. In general, the surficial deposits in the two areas are of glacial origin and are composed of a complex sequence of glacial tills, and glacio-fluvial gravels, sands, silts and clays. The bedrock, which is of Upper Cretaceous Age, is made up of three main formations: the Foremost, the Oldman and the Bearpaw. The oldest and deepest of these is the Foremost Formation. This is overlain by the Oldman Formation which, in turn, is overlain by the Bearpaw Formation.

2. Bedrock Geology. Pre-glacial erosion in Alberta has developed a well-defined system of bedrock valleys. Beneath the waste liquid chemical disposal site, the Foremost Formation floors one of these deeply eroded valleys, the so-called Lethbridge Valley. A thick pre-glacial sand and gravel unit that overlies the bedrock in this valley forms an important regional aquifer. Because much of the groundwater in the DRES Experimental Proving Ground ultimately enters this aquifer system, there is concern that dissolved waste material could contaminate currently used drinking water supplies.

The radioactive waste storage site, underlain by the Oldman Formation, is located approximately six miles north of the deepest portion of the Lethbridge Valley. Thus, the surface of the bedrock under this site is at a greater elevation (2500 feet) than that of the waste liquid chemical disposal site (2100 feet). Test drilling indicates the presence of meltwater channels on the surface of the Oldman Formation under the waste radioactive disposal site, but these are small and, seemingly, not connected directly to the major Lethbridge channel.

It is interesting to note that, in the drilling program at this site, no Bearpaw material was encountered in any of the holes

although this formation outcrops on high sites (2600 feet elevation or greater) to the north and north-west of the site.

3. Surficial Geology. The last deglaciation in the general area was characterized by stagnant ice that thawed in place leaving surficial deposits of till composed of boulder, gravel, sand, silt and clay sized material. The physiographic term applied to this type of deposit is "moraine", and in the DRES area, the moraine is of two types, ground moraine and hummocky moraine (1). Ground moraine typically has a featureless surface. It is found in the area of the waste liquid chemical disposal site and accounts for the flat ground surface in this area. At this site, the rotary drill encountered 401 feet of a continuous till sequence with 40 feet of sand, sandy till and gravel on the bedrock surface.

In the area of the waste radioactive disposal site the terrain is extremely hilly and the moraine in this area is called "hummocky moraine". For the most part, it is a coarse textured, surface till with occasional sand and silt lenses. A sequence of well sorted, bedded, glacio-fluvial silts and sands underlies the surficial till unit which in turn, overlies a compact basal till unit. These glacio-fluvial sediments range in thickness from 0 to 70 feet with the greatest thicknesses found beneath hill sites. Besides the hummocks, the terrain is characterized by depressions that collect surface water and two meltwater channels, one to the north of the site and one to the south. Holes drilled in the meltwater channels generally encountered glacial till.

4. Groundwater Geology. At the waste chemical disposal site an augered hole drilled to a depth of 113 feet was dry until drilling fluid from a rotary drill hole some 100 feet away lost circulation and seemingly flooded it. This indicated a highly permeable zone in the till between the two holes. The investigators suspected that this zone results from fractures in the till as there was no evidence of the presence of a sand or gravel layer. Of course, the presence of this highly permeable zone combined with the fact that the site is situated over the Lethbridge bedrock channel led the investigators to recommend that the site not be used for disposal of waste chemicals.

At the waste radioactive material disposal site the drilling program revealed groundwater present in intra-till sand lenses located beneath minor topographic depressions in the hummocky moraine, in similar lenses under the meltwater channels on the surface and in bedrock sandstone aquifers. In addition, undisturbed samples of till brought up from the bore holes were fractured. Water flowing preferentially along these fracture traces has deposited iron oxide and calcium sulphate. Similar fractures at the waste liquid chemical

disposal site were blamed for the flooding of an auger hole at this site.

5. The Research Council of Alberta was chosen to do this work because of its considerable experience in carrying out geologic and hydrologic surveys in Alberta. They have produced many documents relating the occurrence and development of groundwaters, and, in particular, have published a comprehensive map of the bedrock topography in Southern Alberta (see Figure 1). Besides obtaining hydrologic and geologic data from their own studies, they collect data from other organizations such as oil well and water well drilling companies. Thus, over the past, a considerable store of knowledge concerning the bedrock and the groundwater in Alberta has been gathered.

III. THE FIELD PROGRAM

1. General. As mentioned earlier, throughout the life of the project employees of DRES soil mechanics laboratory assisted in logistic and, where necessary, in technical matters. Data available from other wells, such as water and gas wells drilled in the past around the establishment, were made available to Mr. Currie to assist him in this work. DRES employees conducted moisture content tests and provided equipment not readily available to the investigators on the site.

Work on the contract started in May 1972 and continued until early in September. During that time some 25 auger holes were drilled, cased and capped by Mobile Auger and Research, Edmonton. In addition, five deep holes were rotary drilled, logged geologically and electrically and plugged flush with the surface of the ground by Hi-Rate Drilling Company of Stettler, Alberta.

2. The Drilling Program. It was planned to drill all auger holes to depths of 100 feet or more but, because of the presence of boulders or the fact that sloughing occurred in some holes, not all reached the desired depth. However, the investigators received enough data upon which to base their conclusions. Four of the five holes drilled with the rotary rig reached depths of 400-500 feet. The fifth, because of lost circulation and poor returns, reached only 260 feet. However, once again, sufficient data were gathered.

Geologic samples were taken from all holes at least once every five feet although, at selected auger holes, samples were taken every three feet. Samples from the rotary drilled holes had to be washed clean of the drilling mud before identification could be made. All samples were lithologically described, bagged and filed in Edmonton at the Research Council of Alberta. Selected samples were analyzed to determine grain size, distributions of clay mineral and compositions of sulphate content. Typical results of these analyses are shown in Figures 2, 3 and 4.

Before leaving each site the investigators completely lined each augered hole with a 2" I.D. Magadyne Industries PVC schedule A plastic pipe slotted over the lower part of the hole to permit the entrance of groundwater. In addition, each augered hole was capped with a metal pipe on which was placed a removable metal cover to prevent the entry of foreign materials into the hole (see Figure 5).

3. The Logging Program. After the augered holes were drilled and cased, they were gamma ray logged by Data Probe Logging Ltd., Calgary and gamma ray and neutron logged by Schlumberger Ltd. Typical examples of these logs are shown in Figures 6 and 7. During the rotary drilling Hi-Rate Drilling Company's WIDCO logger provided Electric-logs of spontaneous potential and single point resistivity. In addition, the Alberta Department of Environment's side hole sampler facilitated the detailed sampling of holes at precise depths. Samples thus obtained in combination with the geologist's lithologic description, the bit penetration rates and the driller's comments provided a good basis for the geological evaluation of the rotary drilled holes.

The gamma ray neutron logs gave measurements of background radiation in the soil. These measurements can be used as a base for comparison with future measurements to monitor any migration of radionuclides.

The deeper rotary drilled holes were also E-logged and selectively sampled by means of the Alberta Department of Environment's side hole sampler. In addition, a rotary hole drilled on the radioactive waste disposal site near existing waste disposal was gamma ray logged by Data Probe Loggers. A geolograph was installed on the rotary rig to provide a bit penetration and rig operations log.

IV. THE RESEARCH COUNCIL OF ALBERTA'S REPORT

1. General. The Research Council of Alberta submitted a report on their work. This report contained many photographs, some in colour, including a stereo pair and triplet and each copy was furnished with a stereoscope. This section briefly presents the contents of the report.

2. The Body of the Report. The main body of the report contains the following in order of presentation: Index, Conclusions, Recommendations, Suggestions, Introduction, Climate, Geology, Log Interpretation and Reference List. The report covers the work thoroughly and explains, in part, how some of the logs are interpreted. The body of the report includes, also, figures showing photographs, maps of bedrock topography and an isometric drawing of the waste radioactive storage site.

3. Appendices. Three appendices are attached to the report: the first,

Appendix A, presents the field data obtained during the drilling operations. This section includes E log data, gamma ray data, geologic descriptions from all holes and moisture contents at various depths from holes #1 and #2 to depths of 108 feet and 78 feet respectively.

Appendix B presents the results of laboratory analyses. In this appendix the results of hydrometer and x-ray diffraction tests on selected samples are presented as well as the results of water analysis of samples drawn from wet holes.

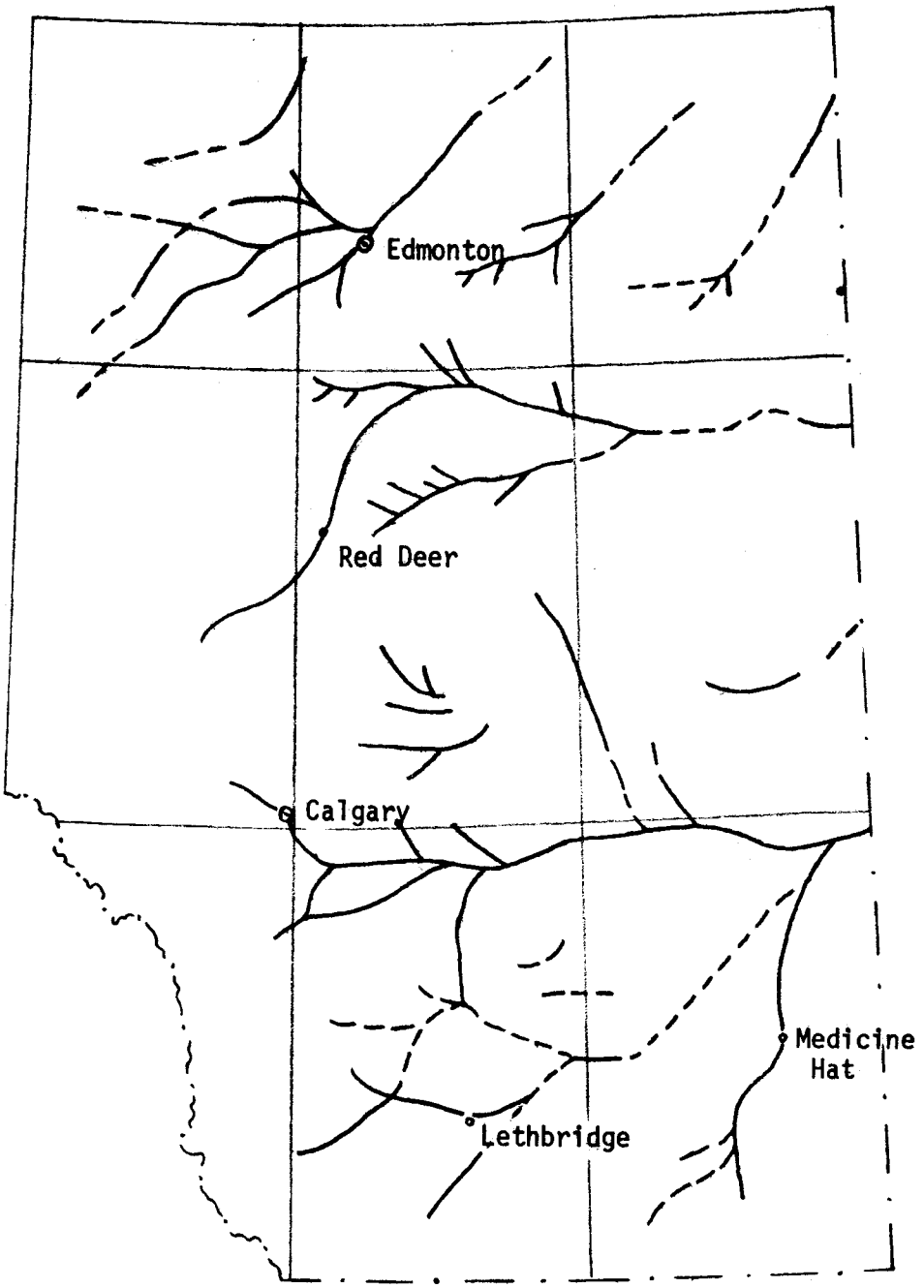
Appendix C presents data obtained during an earlier contract with the Research Council of Alberta which called for a geologic investigation of a proposed blast site some 14 miles east of the research station. As this information was pertinent to the present study, it is presented in the report under discussion. The data included soil descriptions, at various depths down to approximately 100 feet, of samples taken from some 26 augered holes.

REFERENCE

1. Royal Society of Canada, "Soils in Canada - Geological, Pedological and Engineering Studies", 1961, University of Toronto Press.

LIST OF FIGURES

FIGURE



Position of Channel Defined by Good Control ——

Position of Channel Defined by Limited Control ---

FIG. 1 BEDROCK CHANNELS OF SOUTHERN ALBERTA

GRAIN SIZE DISTRIBUTION

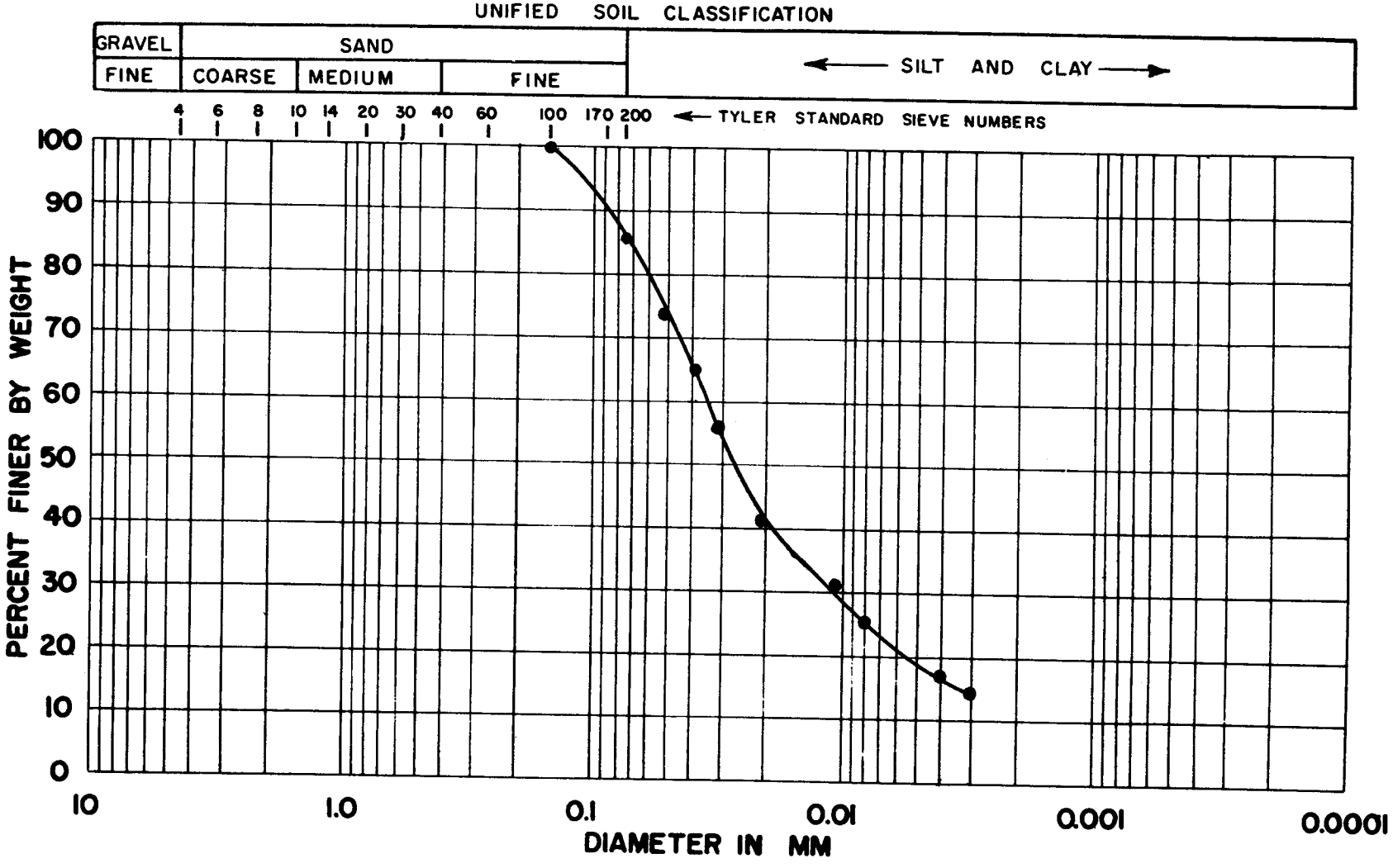


FIG. 2 GRAIN SIZE DISTRIBUTION OF EARTH SAMPLE FROM HOLE NO. 1 , DEPTH 93'-96'

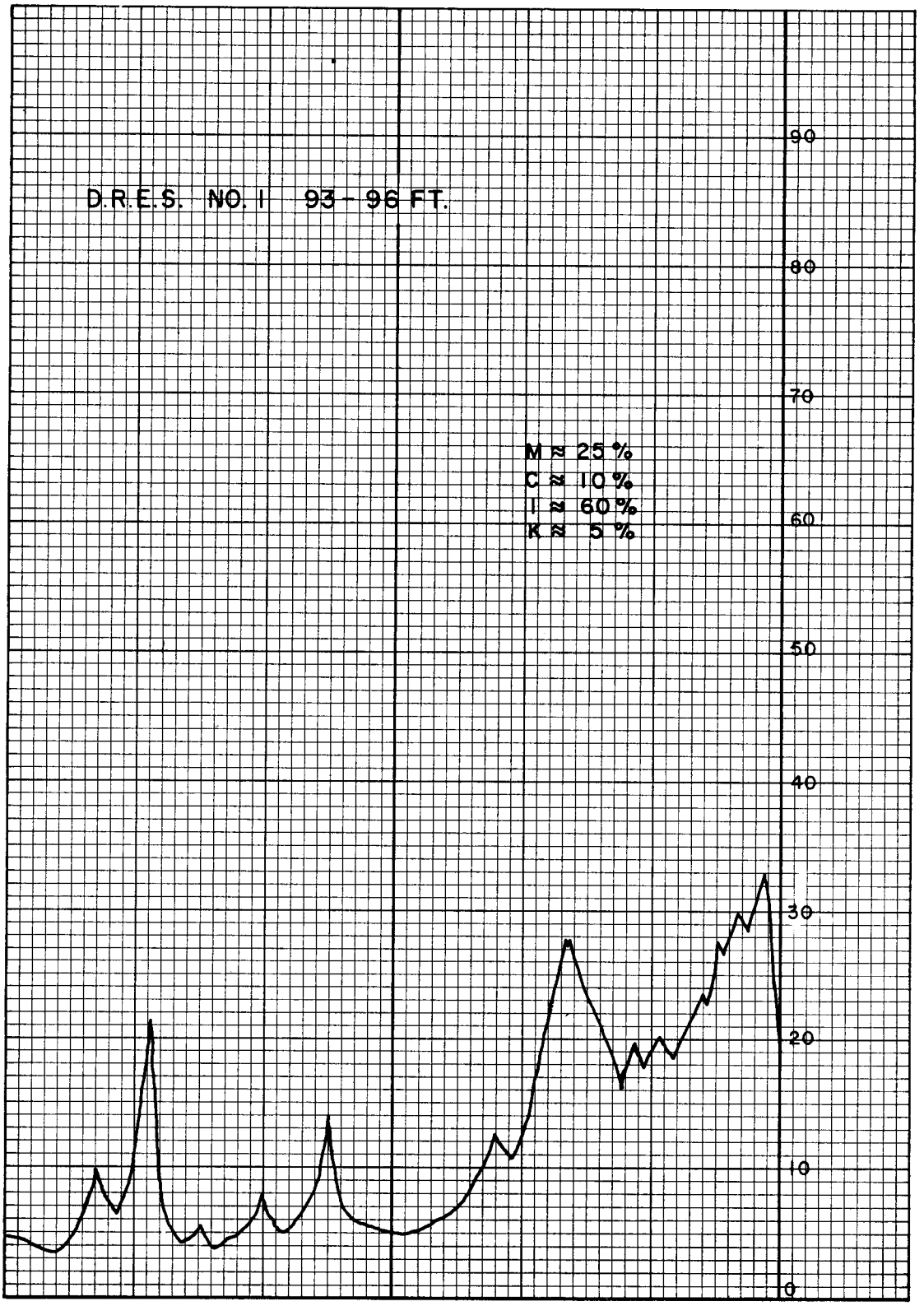


FIG. 3 MINERAL CONTENT ANALYSIS OF EARTH SAMPLE FROM HOLE NO. 1, DEPTH 93'-96'

RESEARCH COUNCIL OF ALBERTA

Identification No. 72-309
O.C.-6

Origin of Sample: DRES #2 Sp. Card 2780

Sampled by D. Currie O.C.-6

		ppm
General	Total dissolved solids	2804
	Total hardness as: $CaCO_3$	1984
	Total alkalinity	314 ($CaCO_3$)
	pH	7.7

		ppm	emp	% of total anion or cation
Major Constituents	Calcium (Ca^{++})	518.0	25.90	61.9
	Magnesium (Mg^{++})	168.0	13.78	32.9
	Sodium (Na^{+})	41.3	1.82	4.3
	Potassium (K^{+})	12.5	0.32	0.8
	Carbonate (CO_3^{--})	0.0	0.00	0.0
	Bicarbonate (HCO_3^{-})	314.0 ($CaCO_3$)	6.28	15.4
	Sulfate (SO_4^{--})	1645.0	34.54	84.5
	Chloride (Cl^{-})	2.0	0.06	0.1
	Nitrate (NO_3^{--})	0.5	0.01	0.0

		ppm
Minor Constituents	Iron (Fe) in solution	.24
	Fluorine (F)	.40

FIG. 4. WATER ANALYSIS REPORT - HOLE #2

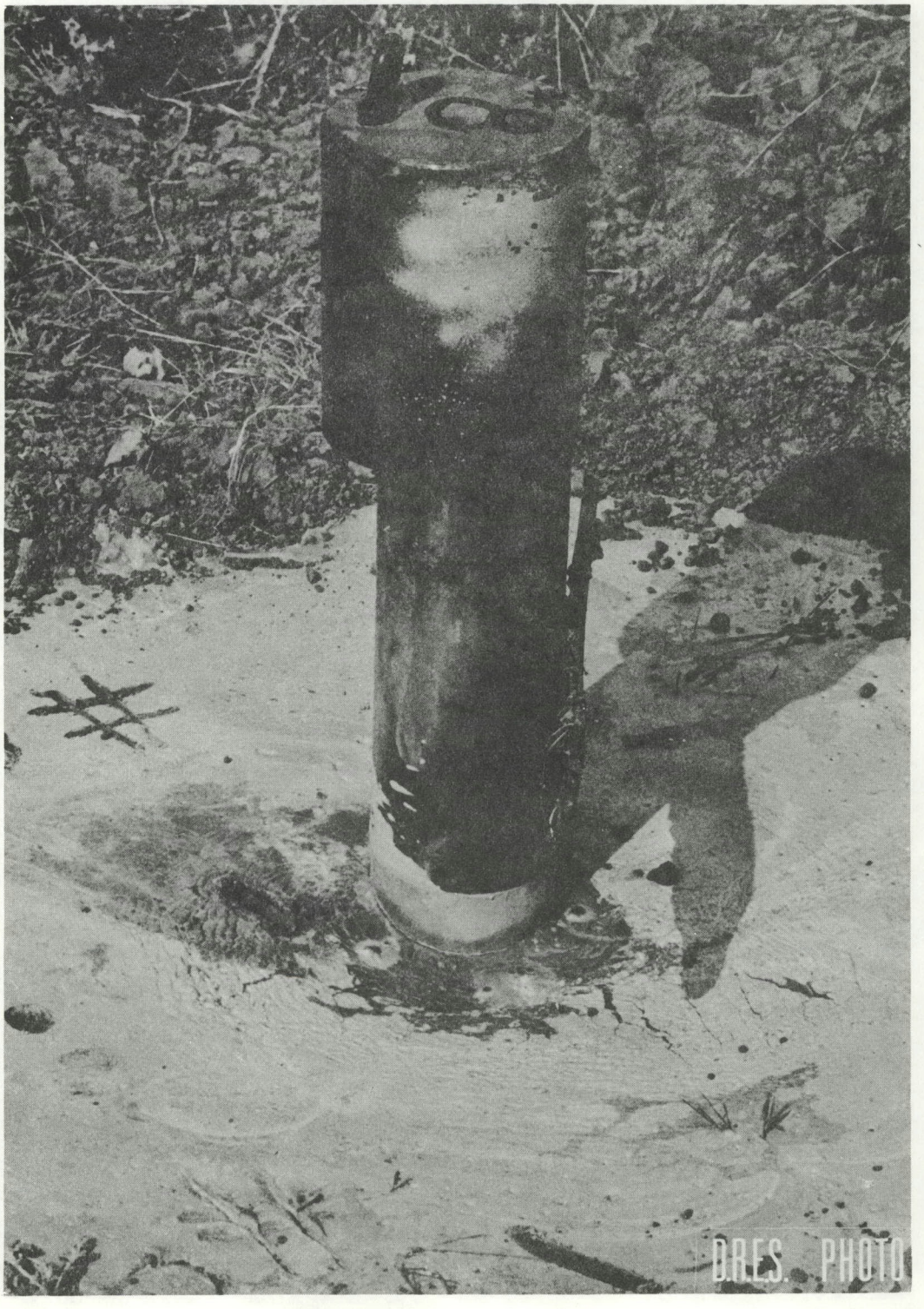
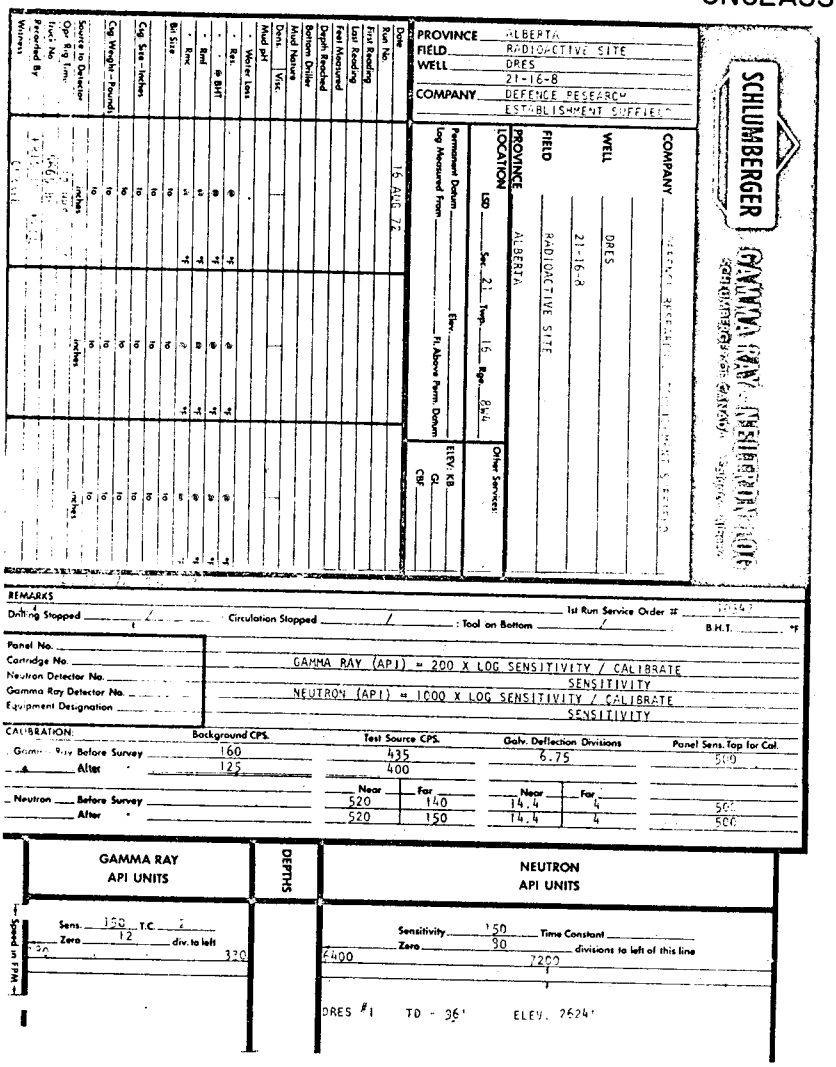


FIG. 5 COMPLETED CASED AUGER HOLE



Sample for grain size distribution I

Side-hole sample I

Till Sand Siltstone

Silt Gravel Shale

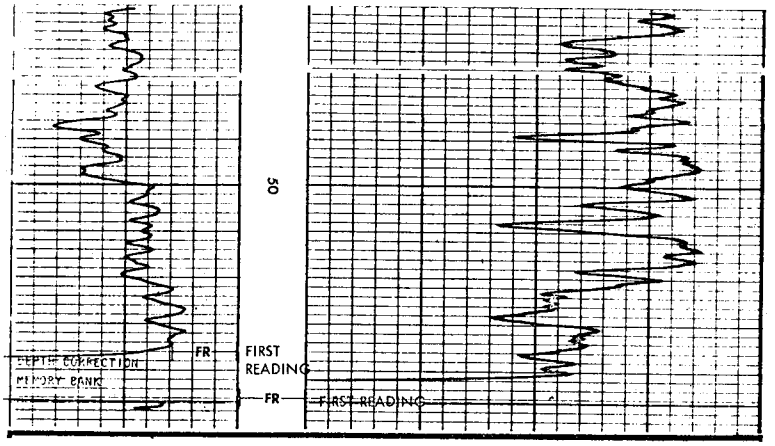


FIG. 6 SCHLUMBERGER GAMMA RAY NEUTRON LOG

STN 335

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DATA PROBE LOGGING LTD.

3610 - 15A STREET S.E., CALGARY, ALBERTA T2G 3N6

COMPANY DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

HOLE NUMBER OR NAME DRES # 1 ELEVATION 2624.19'

FIELD

COUNTY PROV ALTA

DRY

LOCATION N.E. L.SD 3 7 SECTION 21 TOWNSHIP 16 RANGE 8 W4

LOG TYPE	NATURAL GAMMA
RUN	1
DATE	MAY 17 1972
DEPTH DRILLED	108
DEPTH LOGGED	98
BOTTOM LOGGED IN	98
TOP LOGGED IN	TOP OF CASING
TIME	
TYPE HOLE FLUID	NIL
HOLE DIM	6"
CSG TBG DIA	2" P.V.C. CASING
TRUCK NO.	2
LOGGING SPEED FT/MIN	10
RECORDER DEPTH SCALE IN IN	10

RUN	
TOOL NO. AND MODEL	WELL RECON
DIAMETER INCHES	1¼"
GR DETECTOR TYPE	SCINT
SIZE CRYSTAL IN INS	¾" X 3"
K FACTOR	
DEADTIME SECONDS	
TIME CONSTANT SECONDS	3
SCALE CPS	20 C.P.S / IN.
ZERO	
WATER FACTOR	
UPHOLE ELECTRONICS	G.O.I. "NIMS"
RESISTIVITY TYPE	
SPACING INCHES	
SCALE OHM] INCH	
ZERO	
RATEMETER MODEL # RMM 204	
SP SCALE MILLIVOLTS IN	

REMARKS RUN #2
SAME SETTINGS

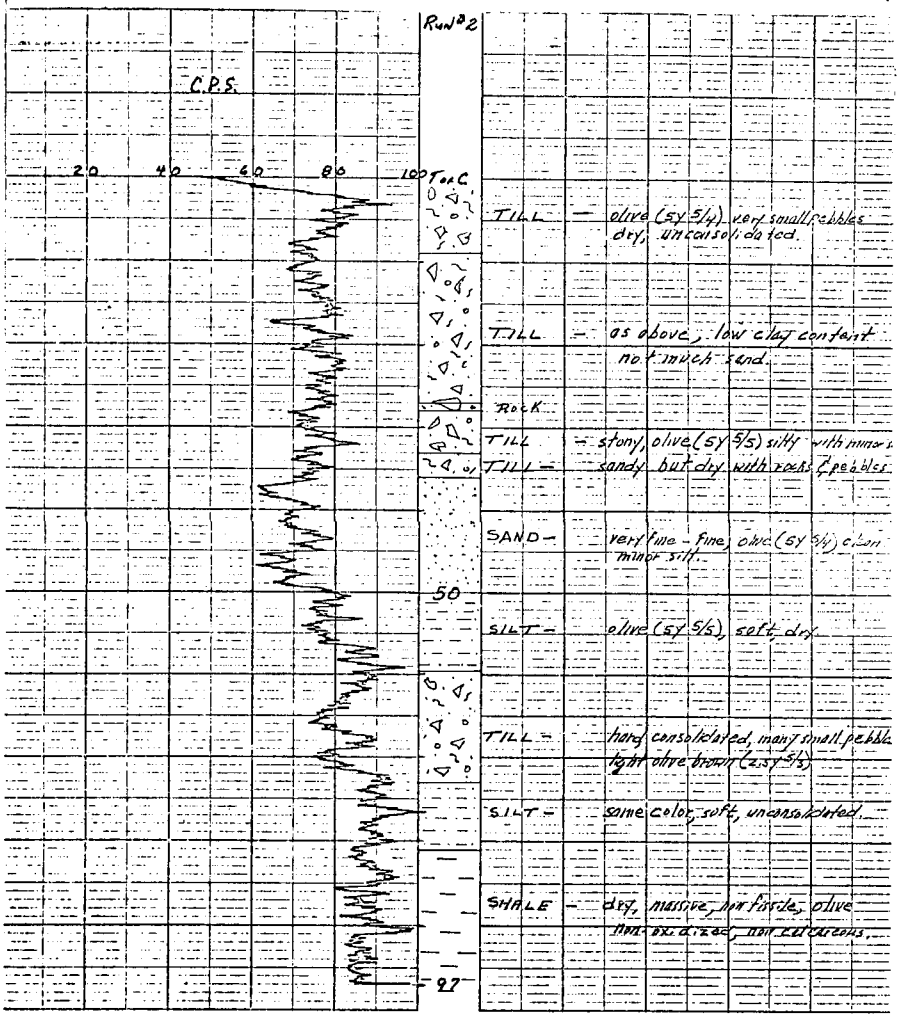

FIG. 7 DATA PROBE NATURAL GAMMA LOG

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