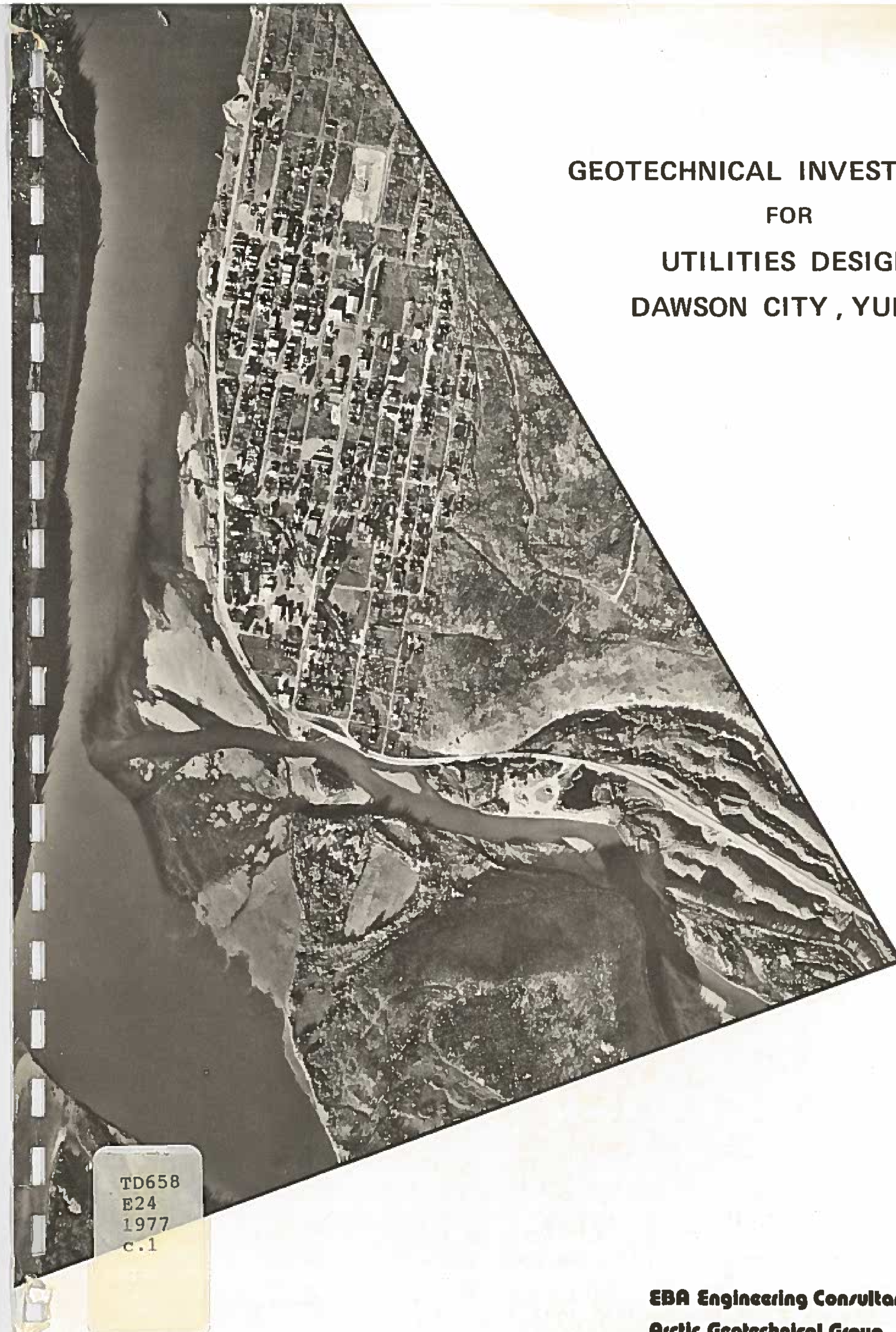

GEOTECHNICAL INVESTIGATION
FOR
UTILITIES DESIGN
DAWSON CITY, YUKON

EBA Engineering Consultants Ltd.
Arctic Geotechnical Group

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A REPORT SUBMITTED TO

STANLEY ASSOCIATES ENGINEERING LTD.

OCTOBER, 1977

EBA Engineering Consultants Ltd.

ABSTRACT

Geotechnical data and design recommendations for the Dawson City utilities reconstruction are presented in this report. The geotechnical data obtained in a field program conducted in June, 1977, have been combined with the data collected by EBA in two previous drilling programs in Dawson City. The combined data is presented graphically in a series of plans and stratigraphic cross sections.

The site conditions consist of permafrost, ice rich, organic silt overlying gravel or bedrock at a depth of approximately 15 feet. Permafrost is not present at the south end of the city. The city is poorly drained in the permafrost sections.

Foundation recommendations are presented for a sewage treatment plant. The caisson method of installing a wet well in the treatment plant is discussed along with several alternative methods of resisting hydrostatic uplift forces on the well. Foundation recommendations are also presented for two alternative lift station locations.

Trench designs for water and sewer lines buried up to 4.5 feet below the ground surface are presented. Frost heave and thaw-induced settlement of the permafrost soils were considered in the design.

The major construction problems anticipated at various times of the year were delineated and discussed. Those problems are related to groundwater and excavation of frozen soil.

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1.0 INTRODUCTION

1.1 General

Dawson City, Yukon has had a long and colourful history since gold was discovered along tributaries to the Klondike River in 1896. The community of Dawson City was established at the point of confluence of the Klondike and Yukon Rivers to service up to 50,000 people attracted by the gold field. The first water and sewer system, constructed of wood stave piping was installed in 1904. Little regard was paid to the ice rich permafrost material (appropriately described by the miners as "muck") which underlies most of the town. The flexible nature of the wood stave system has withstood settlement and frost heave for the past 73 years. The maintenance, however, has become increasingly costly in recent years. Stanley Associates Engineering Ltd. (SAEL) was retained by the Yukon Territorial Government to design and construct a new water and sewage system. SAEL retained EBA Engineering Consultants Ltd. to supply geotechnical input for their redesign.

Previous experience by EBA in Dawson City has been utilized to the benefit of this study. An extensive drilling program was conducted in 1972 for Parks Canada in conjunction with restoration of several historic buildings. A drilling program was also conducted in 1974 in conjunction with an addition to the Robert Service School.

1.2 Objectives and Scope

From the previous experience in Dawson City, three problems with respect to water and sewer systems were identified at the outset of this program:

1. Ground subsidence resulting from thawing of the ice-rich permafrost soil.

2. Seasonal frost heave of buried foundations and utility pipes.

3. Groundwater conditions which can adversely affect excavation in the townsite.

The objectives of the program were to obtain site data in areas of proposed construction and to make recommendations regarding the aforementioned design and construction problems. In addition, foundation recommendations were required for a sewage treatment plant and lift station.

1.3 Authorization

The project was authorized by Mr. N.J. Nuttall of Stanley and Associates Engineering Ltd. in a letter of May 26, 1977.

2.0 SITE INVESTIGATION

2.1 General

The data which EBA had obtained from two previous site investigations in Dawson City was drawn upon freely in both the planning and reporting segments of this project (EBA, 1972; EBA, 1974).

The field investigation was carried out from June 6 to June 13, 1977. The investigation consisted of a reconnaissance segment to evaluate groundwater conditions and a drilling segment to evaluate subsurface conditions.

2.2 Field Drilling Program

The drill rig used was a truck mounted Failing 1000 drill equipped to drill with both air and mud as a circulating fluid. Provision was also made to sample with an auger type core barrel capable of coring in frozen silt and sand. The core barrel provided a frozen, undisturbed core 7.5 centimetres (3 ins.) in diameter.

In permafrost areas the boreholes were advanced using air until frozen material was encountered. The hole was then advanced using the core barrel until further penetration was halted by a gravel strata. The boreholes were logged in detail and a sample of each core returned in a thawed condition to the EBA Edmonton laboratory for testing. In addition, select sections of core were returned to the laboratory in a frozen condition. In non-permafrost areas grab samples were obtained and conventional split spoon drive sampling was used for down-hole testing and sampling.

The elevation survey was performed by SAEL. The borehole elevations are referenced to a geodetic bench mark. A re-survey of some of the 1972 borehole locations indicated that the reference elevation in the 1972 EBA report was approximately three feet to high by the currently accepted standard. Thus, the 1972 borehole elevations have been reduced accordingly in this presentation.

2.3 Reconnaissance

A block-by-block reconnaissance was conducted over most of the town. The purpose of the reconnaissance was mainly to observe seepage zones and other indicators of groundwater conditions.

2.4 Laboratory Testing

The laboratory test results are presented in Appendix D. Water content determinations were performed on all of the samples and textural analyses were performed on select samples. Frozen bulk density tests were carried out on a few of the frozen samples. In addition, tests for soluble sulphates were performed on samples from the lift station and treatment plant areas to determine if the soils are potentially reactive with subsurface concrete.

2.5 Ground Temperature

A series of ground temperature profiles, from EBA (1972) are reproduced in Appendix E. In addition, two thermistor strings were installed in this program and the temperature profiles obtained are also presented in Appendix E. Temperature of the frozen core was obtained as soon as possible after the core had been removed from the borehole. These data are presented on the borehole logs.

3.0 SITE DESCRIPTION

3.1 General

The townsite is situated on an inactive flood plain at the confluence of the Klondike and Yukon Rivers (Drawing B.1). The town is bounded on the west by the Yukon River, the east by steeply-rising mountains and on the south by the Klondike River.

The central position of the townsite (floodplain) is quite level but the housing district to the east is situated on a moderately steep slope. A gully, known locally as the "slough", traverses the south edge of town. In Drawing B.1, which is enlarged from aerial photographs taken in 1970, most of the gully is in the natural state. In recent years, however, much of the gully has been infilled. Front Street has been raised approximately 12 feet above the surrounding terrain to serve as a dyke during spring floods on the Yukon River.

3.2 Site Geology

Several events have shaped the geomorphology of the townsite. During valley deglaciation, flows in the Yukon were much greater than at present and the Yukon River occupied its entire valley, scouring the surface and infilling depressions with a coarse granular alluvium. With reducing flows, and advance of the Klondike River Delta into the Yukon River Valley, the river abandoned its east channels except during periods of flood. A thick deposit of silt was subsequently deposited downstream from the Klondike Delta during successive flood stages to form the river terrace which the townsite now occupies. Exploration borings have verified that a sharp contact is present at the base of the organic silt. Often, a layer of cobbles, identifying the former riverbed, is encountered at the contact with alluvial gravel and in some places the alluvial material may consist of a single layer of cobbles and boulders resting on the underlying bedrock.

The south end of the townsite, occupies a portion of the Klondike River Delta. Here, coarser grained sand and occasionally gravel has been built up contemporaneously with the river terrace. Along the toe of the slope that borders the townsite on its east side, coarse grained colluvium from the bedrock exposures above overlies and is interlayered with the fluvial deposits. The limit of this colluvial deposit, interpreted from aerial photographs is presented in Drawing B-1.

3.3 Permafrost

Permafrost has subsequently developed in the soils underlying the river terrace. The approximate boundary between permafrost and non-permafrost areas is presented in Drawing B.2. This boundary has been inferred from the nearest boreholes and is approximately coincidental with the boundary between the fluvial deltaic sediments of the Klondike River and the fine grained terrace deposits of the Yukon River. The distribution of the permafrost will vary locally depending on specific surface and subsurface conditions. Temperature profiles from thermistor strings installed in select boreholes are presented in Appendix E. In addition, temperatures at the core as it was taken from the boreholes are presented on the borehole logs.

The thickness of the active layer could not be determined directly from any of the drilling programs because of the time of year when the drilling was carried out. The active layer depth could, however, be inferred from either a thin layer of thawed ground between the seasonal frost and the permafrost or by detecting a concentration of ice at the base of the active layer. The average depth of the active layer beneath the roads is believed to be 6 ft. and beneath the predominately organic-covered lots is 5 feet.

The depth of seasonal frost in the non-permafrost snow covered areas varies from 6 to 8 feet with one isolated case of 12 feet reported. Somewhat greater depths of frost can be anticipated beneath roadways.

3.4 Soil Conditions

3.4.1 General

The stratigraphy has been determined from drilling programs conducted in

1972, 1974 and 1977. The borehole locations are presented in Drawing B.2 and the borehole logs in Appendix C. The borehole data from this project, as well as EBA (1972) and EBA (1974) are presented. The laboratory test data from each of the programs is presented in Appendix D.

Stratigraphic cross sections along several of the major streets are presented in Drawings B.3 through B.8. The cross section locations are presented in Drawing B.2. Since the cross sections were located along the streets, many of the boreholes, especially those from previous programs were not directly on the cross-section. The stratigraphic data from these "off-line" boreholes has been shifted laterally by as much as 250 feet. In addition, the boreholes from the previous programs were drilled on building lots rather than the street, which results in surface elevation discrepancies between the borehole surface and street centre line for those boreholes. The centre line profiles and stationing on the cross-sections are from an SAEL survey.

Simplified textural borehole logs are presented on the cross sections. The average ice content expressed as a percentage of the total volume of ice and soil is presented beside each of the simplified logs.

Three stratigraphic units have been identified. The surficial strata is organic soil or fill over organic soil. These two materials were lumped together as one stratigraphic unit since the occurrance of the fill is too erratic to correlate. Underlying the organic soil is a silt or sand stratum which is in turn underlain by a gravel stratum. Each of these units is discussed in the following sections.

3.3.2 Fill and Organic Soil

The average depth of fill beneath the streets is 2 feet. Over the remainder of the town the occurrance and thickness of fill is extremely erratic. The fill beneath the streets is a medium brown, very silty gravel and sand. In most cases, the fill has been placed directly over the initial organic surface. The organic soil consists of peat and mineral soil with an organic content in excess of 30 percent. The average thickness of the organic soil is 1.6 feet while the maximum thickness is 5 feet identified at Borehole 72-7. The organic soil tends to be thickest in the northeast section of town, decreasing in thickness to the south. South of the "slough" and in elevated regions, such as Borehole 77-8, the organic soil is not present.

3.4.3 Organic Silt

From an engineering viewpoint, the most important soil unit underlying the townsite is the organic silt. The silt, which has been deposited in a floodplain environment, extends from beneath the surficial organic soil to the underlying gravel stratum. The average thickness is 9.5 feet. The silt unit is present under most of the town grading into a silty sand and silt toward the south end of the townsite. The change in texture roughly corresponds to the location of the "slough".

The silt is a dark grey to black, non-plastic soil. Organics are distributed throughout the silt and are also present as organic laminations. The silt contains up to 20 percent sand and approximately 3 percent clay size particles. The organic content presented in EBA (1972) ranged from 8 to 15 percent by weight as determined from 4 tests.

Permafrost has developed in the silt. The excess ice is generally stratified in nature within the permafrost silt. The excess ice content was normally 10 to 25 percent of the total soil volume with a few instances of 100 percent ice observed. The ice contents are reported in detail on the borehole logs. Photographs of cores of permafrost silt are shown in Plates A.1 through A.3.

Approximate contours of the cumulative thickness of ice from the base of the active layer to the surface of the gravel stratum are presented in Drawing B.9. This represents the approximate surface settlement potential if the permafrost were to thaw. The distribution of the ice is extremely variable and, at any one location, may differ from that indicated on the contour plan by 200 percent or more. The plan does, however, show the trend for increasing frozen soil ice content towards the northeast section of town.

3.4.4 Sand (Deltaic)

Near the south end of town, the soils which have been deposited in a fluvial deltaic environment at the mouth of the Klondike River, consist of a silty sand and sand with a trace of gravel. The sand is fine-grained, and uniform in size, with a widely varying silt content. Silt contents ranging from 3 to 76 percent have been observed. Organic laminations, similar to those in the silt stratum, were encountered. The sand is predominantly in the non-permafrost area. None to very little visible ice has been noticed in seasonally frozen sand material.

3.4.5 Gravel (Alluvium)

The alluvial gravel is very dense and composed of hard rock minerals. Consequently, this strata has consistantly proven to be difficult to drill and sample. The gravel is believed to be clean, coarse-grained and, in areas underlain by permafrost, to contain no excess ice. In footing foundation excavations for the Robert Service School addition, a cobble layer was observed on the surface of the gravel. The gravel overlies bedrock which is believed to be the serpentine schist which outcrops in the hills surrounding the townsite. In many places, the gravel may be less than 1 foot thick and boreholes terminated at the gravel contact may actually have encountered bedrock.

Contours of the gravel surface along with spot elevations of the surface are presented on Drawing B.10. The gravel or bedrock surface rises approximately 10 feet from the west to east side of the town.

3.5 Groundwater

The low relief of most of the townsite provides rather poor surface drainage. The streets are generally higher than the lots where thaw-settlement has been commonplace compounding the drainage problems. Some areas have surface drainage facilities consisting of ditches, culverts and old sewer mains, however, these facilities are all, of necessity, quite shallow and serve mainly to carry the spring runoff.

Front Street has been elevated up to 10 feet above the surrounding terrain but it does not appear to substantially impede surface drainage since it is composed of coarse, permeable tailings.

A major surface drainage feature is the "slough". Although it has been largely filled in recent years, it still serves to collect the surface water and direct it toward the river since the fill is composed of coarse gravel and cobble tailings.

Artesian conditions, encountered in BH 72-13 were not observed in the June 1977 drilling program. It is believed that the artesian conditions observed in BH 72-13 were a seasonal phenomena resulting from a surficial confining layer of frozen soil overlying unfrozen permeable soil. During other times of the year, artesian conditions could, however, exist at locations bordering the valley slope.

The generalized groundwater conditions throughout the town are presented on Drawing B.11. The groundwater conditions were assessed from the boreholes as well as a reconnaissance program. The severity of groundwater as a construction problem has been categorized into three divisions which are described below:

(1) Undrained: This section of town is essentially undrained. Water levels in June throughout this area were two feet or less below the surface. Ponded water in closed, organic filled depressions are common. Subsurface drainage is prevented by the underlying permafrost and surface drainage is restricted by the raised streets and generally flat topographic conditions. An example of ground water conditions in this area is illustrated in Plate A.4.

(2) Poorly Drained: This section includes those areas which have subsurface drainage restricted by permafrost but have moderate topographic relief resulting in an improvement to surface drainage. Ponded water is infrequent but may occur in isolated areas. Evidence of seepage in road cuts and on natural and embankment slopes was noted. An example of ground water conditions in this area is illustrated in Plate A.5.

(3) Well-Drained: This section includes the non-permafrost sections of town which have well developed subsurface drainage through the underlying, unfrozen gravel. The gravel stratum is hydraulically connected to the Yukon river, so that in times of flood the groundwater table in this section will be essentially at river elevation. A standpipe installed in Borehole 72-9, was dry at the time of drilling (April, 1972) however the water level was reported to be 13 inches below the surface when the Yukon River was at its flood stage (June 4, 1972).

The groundwater conditions reported are those present at the time of the field exploration program (June, 1977). Seasonal and year-to-year variations in the conditions are certain to occur.

4.0 FOUNDATION RECOMMENDATIONS

4.1 Sewage Treatment Plant

4.1.1 Site Conditions

The proposed location of the sewage treatment plant is adjacent to the Government of the Yukon Territory (YTG) Highways Department yard. Boreholes 77-1 and 77-2 were located on the proposed site: The borehole logs are presented in Appendix C and the borehole locations shown in Drawing B.2.

It is understood that the proposed structure is approximately 30 feet square and will house light screening machinery and a 6 foot diameter by 15 foot deep intake well and pump.

The site is quite level and well drained. It is bounded on the west by the "slough" which, in this area, has been filled with coarse tailings. Borehole 77-2 was located on the coarse tailings. The borehole could not be drilled in the coarse rock, however, a shallow test pit was excavated which exposed boulders up to 1.5 feet in diameter. A photograph of the test pit is shown in Plate A.6. The boundary of the "slough" can be inferred from Drawing B.1.

The subsurface conditions consist of a medium brown, loose, silty sand extending from the surface to a depth of 11 feet. Underlying the sand is a medium dense sand and gravel stratum which grades into a sandy gravel at approximately 14 feet below surface. The gravel is medium coarse grained and contains a trace of silt.

The static water level on June 14, 1977, 5 days after the borehole was drilled was 8 feet below the surface.

4.1.2 Recommendations

Structure Foundation

The surfical sand stratum is an acceptable foundation strata for light loads. The material is quite loose and contains sufficient silt to make it succeptible to frost heave. For a lightly loaded foundation, such as that anticipated for the screening machinery and the structure, spread footings are recommended. The allowable bearing pressure is one thousand (1000) pounds per square foot which will result in differential settlements of less than 0.75 inches. The location of the plant should be selected so as to avoid placing footings on the fill material in the "slough". Negligible amounts of sulphate were found in the soil, thus from a soil-water standpoint Type I Normal Portland cement is satisfactory for foundation elements.

The surficial 1.5 feet of soil which is rich in organics, should be stripped and wasted. The recommended minimum depth of conventional footings is 6 feet below the final exterior grade to provide adequate protection against frost heave. An acceptable alternative foundation system is a slab-on-grade with thickened perimeter footings founded 1.5 feet below final exterior grade. A system of insulation is required with this type of foundation to prevent frost from penetrating below the footings. The recommended insulation arrangement is presented in Drawing B.12. A two inch thickness of insulation extending 6 feet horizontally from the footing is recommended. The insulation thickness should be increased to 3 inches around the corners as shown in the corner detail. The insulation should be a closed cell polystyrene suitable for below ground application such as the Dow HI series. The insulation should be bedded in approximately 3 inches of sand and covered with a minimum of one foot of fill. The interior building temperature must be maintained at 18°C or greater during the winter, including the first winter after construction of the footings, for this system to operate effectively.

Fill material used for grading beneath the floor slab should be clean granular material compacted to 100 percent of Standard Proctor dry density.

Intake Well

It is understood that the sewage intake well will be six feet in diameter and up to 15 feet deep. A light weight archimedes screw pump will lift the effluent from the well into the screening machinery. The ground water conditions present some serious design and construction problems for the intake well.

Since the underlying gravel stratum is continuous with the river, the ground water table will be dependent upon the river stage. For this reason, construction would best be performed later in the summer when the river stage is lowest. River stage records should be investigated to determine an optimum construction timing. The yield of the groundwater in an excavation is expected to be quite high as recurrent loss of circulation problems encountered while drilling borehole 77-1 indicate a high permeability.

Two alternative methods of construction are suggested. The first method is to dewater the site and construct the intake well in a dry excavation. The practicality of dewatering is uncertain as a result of the high permeability of the gravel stratum. A pumping test would be required to determine if dewatering is practical and to design the dewatering system. A permanent reaction against hydrostatic uplift on the well must be provided. For a well 6 feet in diameter and 15 feet deep approximately 26.5 kips of uplift must be provided for a design water table at the ground surface. A footing protruding 2 feet from the outside circumference of the well is sufficient to resist the uplift forces.

The backfill surrounding the well should be a clean granular material compacted to 98 percent of Standard Proctor dry density and compacted in lifts not exceeding 6 inches in thickness. The compactive effort should be reduced slightly for the two feet surrounding the well so as not to introduce high soil pressures on the well. The foundation recommendations for footings placed on this fill are unchanged from those presented previously with the exception that frost protection measures are not required within the heated building area.

The second method is to install the well as a wet caisson. A caisson of corrugated metal with a cutting shoe 1 to 2 inches larger in radius that the caisson is recommended. The caisson can be advanced by applying a load to the top of the caisson and excavating the interior material under water with a crane and clamshell. The load required to advance the caisson is uncertain, however, it is estimated that approximately 20 kips may be required as the caisson approaches a depth of 15 feet. The base concrete can be placed under water using the tremme method.

Permanent reaction against hydrostatic uplift can be provided by installing sufficient dead weight in the base or a surficial concrete collar. The possibility of tying the well into the floor slab to mobilize the weight of the floor should also be investigated. The skin friction which can be relied upon to resist uplift is strongly dependent on the depth of the well. For a 10 foot well, 200 pounds per foot of circumference can be relied upon however, up to one inch of vertical displacement will be required to mobilize the friction.

Pressure grounting of the annulus between the caisson and the soil to sufficiently increase the skin friction is an alternative method to resist uplift forces. This method, however, requires dewatering the caisson to provide access for the grouting operation. If the water table is sufficiently low at the time of construction that normal skin friction will resist the temporary bouyant force, this method would be practical. The procedure is not straight forward and would require the services of a grouting contractor working under the supervision of a geotechnical engineer. For these reasons, this method is somewhat less practical than the dead weight system and should be considered only if serious difficulties with the dead weight system arise.

4.2 Lift Station Princess Street and Second Avenue

4.2.1 Site Conditions

Borehole 77-3 was drilled at one of the alternative lift station locations at the corner of Princess Street and Second Avenue. The subsurface conditions are summarized as follows:

0 - 3 feet	Organic Soil
3 - 5 feet	Silt and Organics
5 - 10 feet	Silt
10 - 13.5 feet	Sand and Silt
13.5 - 15.5 feet+	Gravel

Although the borehole is located in the section of town which is generally permafrost, only one foot of seasonally frozen soil was encountered. It is believed that the thick surficial organic strata in conjunction with the probable thick snow cover at this location results in the absence of permafrost. The groundwater table on June 14, 5 days after the borehole was drilled, was 4 feet below the ground surface.

It is understood that the lift station is to be a prefabricated structure, 6 feet in diameter and 15 feet deep. The top of the structure will be at Princess Street elevation which is approximately 6 feet above the surface elevation at the site. The site will be filled to street elevation.

4.2.2 Recommendations

The recommendations are essentially the same as for the treatment plant intake well. For an excavation and backfill construction method, excavation to the gravel stratum would be required which would involve dewatering. Since the gravel strata is thawed at this location, the same uncertainty regarding a drainage system as that encountered at the treatment plant exists at this site. The backfill should be a clean granular material to reduce frost heave forces on the well. The backfill should be compacted to 97 percent of Standard Proctor dry density.

A caisson method of installing the well is practical, however, the pressure grouting system of restraining the uplift forces is not recommended in the compressible silt soils. The caisson should be advanced to the gravel strata. It is understood that fill would be placed to bring the site up to street elevation. The surficial organic soils should be excavated (approximately 5 feet) to prevent excessive settlements of the fill. Some settlement of the fill will still occur under the weight of the fill and thus the caisson should be designed to resist downdrag soil forces of 1500 pounds per foot of circumference. An alternate uplift resistance system consists of a concrete collar installed at the base of the organic soil excavation. The collar should extend 2 feet beyond the circumference of the well and the bond between the collar and the well designed to resist full uplift force. A minimum of 10 feet of fill is required over the collar.

4.3 Lift Station, King Street and Second Avenue

4.3.1 Site Conditions

This alternative lift station location was proposed after the drilling program was completed and thus no site specific data is available. Boreholes 77-2 and 77-15 are the closest boreholes to the site. These boreholes indicated varying amounts of fill overlying permafrost silt with ice contents of up to 20 percent. The gravel surface elevation dips quite steeply in this area varying from 1035.6 in Borehole 72-2 to 1028.8 in Borehole 77-15 which is approximately 15 feet below the ground surface. During the summer season, the groundwater table is approximately 2 feet below the ground surface.

It is understood that the lift station structure proposed is a pre-fabricated structure 6 feet in diameter and 15 feet deep.

4.3.2 Recommendations

The excavation and backfill method of construction is recommended. The structure should be founded on or in the gravel strata.

Although the surrounding soils are presently frozen, consideration must be given to their eventual thaw, and the base designed to resist the hydrostatic uplift pressure resulting from the water table at the ground surface. A circular base protruding 2 feet from the circumference of the structure will develop sufficient soil resistance to withstand the uplift forces. The backfill should be a clean, granular material compacted to 97 percent of Standard Proctor dry density.

Groundwater entering the excavation from the active layer will be the predominant construction problem. This problem can be largely avoided if construction is carried out in winter or early spring. The second problem will be excavation of the frozen soil. In spite of these problems, construction conditions are more favourable than at the Princess Street and Second Avenue location where major groundwater problems are anticipated.

5.0 PIPELINE DESIGN

5.1 Pipe Burial

5.1.1 General

It is understood that the configuration of the proposed pipeline is a 10 to 12 inch diameter, insulated polyethelene pipe. The pipe burial conditions must be chosen so that deflections of the pipeline are maintained within tolerable limits. The potential sources of pipe deflection are frost heave of seasonally frozen material beneath the pipe and thaw-induced settlement of ice rich permafrost material beneath the pipe. The methods available to control displacements are:

(1) Specify trench backfill materials

(2) Specify pipe insulation.

(3) Specify the depth of pipe burial.

The trench design in permafrost and non-permafrost sections of town along with ground water control methods are discussed in the following subsections.

5.1.2 Permafrost Areas

The majority of Dawson City is underlain by permafrost silt where seasonal thaw develops to a depth of approximately 6 feet (Drawing B.1). The frozen silt typically has an excess ice content of 20 percent by volume. Generally, the ice contents increase from the south to the northeast of the city (Drawing B.10). The texture of the soil in conjunction with the generally wet conditions results in an extremely frost susceptible environment within the depth of seasonal freezing and thawing.

In order to prevent large pipe displacements resulting from frost heave, soil which seasonnaly freezes and thaws beneath the pipe must be excavated and replaced with non-frost-susceptible granular backfill wherever practical. Since the presence of the backfill will increase the thickness of the active layer, some trenching into the permafrost will be required.

The construction of a buried water or sewer line, with fluid at 40°F may cause thaw of the permafrost and resulting settlement of the pipe. At shallow depths of burial, the effects of the pipe are overshadowed by the natural freezing and thawing of the active layer. As the depth of burial increases, the proportion of the heat flux from the pipe contributing to thaw of the permafrost increases. (Hwang, 1977)

Increasing the insulation thickness surrounding the pipe will reduce the heat flux from the pipe and thus reduce the tendency for permafrost thaw. In addition to the heat flux from the pipe, the change in thermal properties of the trench backfill caused by replacing the natural soil with gravel will increase the thickness of the active layer slightly.

A two dimentional numerical analysis of the geothermal interaction between the soil and a shallow buried pipeline has been performed. The case analyzed is summarized as follows:

depth of of burial of 4.5 feet to top of pipe
12 inch diameter pipe
2 and 3.875 inches of polyurethane insulation
fluid temperature of 40°F (4.4°C)

A check analysis was carried out to simulate the natural thermal conditions. An active layer thickness of 7 feet was predicted which is in reasonable agreement with that observed in the field.

The cross section analyzed and depth of thaw penetration beneath the pipe centerline versus time for 2 and 3.875 inches of insulation is presented in Drawing B.13. Drawing B.14 shows the thaw front beneath the road. The numerical model was run for a period of five years. Complete freezeback was observed for each winter season and no cumulative thaw of the permafrost material was predicted. The amount of thaw predicted for 2 inches of insulation is 2.5 feet below the base of the pipe. Increasing the insulation thickness to 3.875 inches reduces the depth of thaw to 2 feet below the base of the pipe. Not all of the thaw, however, is a result of the warm pipe. The maximum seasonal thaw depth without the pipe corresponds to 1.5 feet of thaw beneath the pipe base. Thus, the effect of the warm pipe and the backfill has resulted in an increase in the depth of thaw of only 1 foot. Moreover, a portion of this increase in thaw depth can be attributed to substitution of high water content silt by lower water content granular backfill to simulate the trench configuration. The higher thermal conductivity and lower volumetric latent heat of the granular backfill causes an increase in the depth of thaw in the trench irregardless of heat loss from the pipe.

Based on frost heave and thaw settlement considerations, the trench cross section presented in Drawing B.15 is recommended for pipe burial depths of 4.5 feet or less to the top of the pipe. Two inches of polyurethane insulation surrounding the pipe is sufficient to prevent excessive thaw settlement. The trench must be excavated to a minimum of 7 feet below ground surface and 3.0 feet below the base of the pipe and backfilled to 6 inches above the pipe with a granular material containing no more than 5 percent by weight finer than the #200 U.S. Sieve (silt sizes). The backfill should be compacted to 97 percent of Standard Proctor dry density.

The trench design for depths of burial greater than 4.5 feet requires additional thermal design work. It is believed that designs with burial depths of 12 feet or more are possible using additional insulation and overexcavation. If the trench is excavated to the gravel strata (Drawings B.3 through B.8 and B.10), all of the high ice content silt is removed and thaw-settlement is not a concern for pipe stability.

From Drawing B.14, it is evident that some thaw of the permafrost silt adjacent to the trench will occur. This will result in surface settlement of the roadway which may require periodic maintenance.

Surface infiltration and groundwater may be intercepted by the trench and the water flow concentrated along the permeable trench backfill. This is detrimental for several reasons. The first and most important is that flowing water will provide a heat load on the permafrost and upset the thermal balance. This heat input has not been considered in the thermal analysis presented. As well, in areas of relief, drainage through the backfill may initiate frost action in the roadbed and in extreme cases springs could result causing loss of trafficability.

Impermeable cutoffs are recommended at selected intervals along the pipe. The cutoffs should be spaced at a minimum of 100 foot intervals in level terrain and spaced so that adjacent cutoffs overlap vertically by at least 50% in sloping terrain. In addition, cutoffs should be placed immediately up-slope of every road intersection in sloping terrain. As a result of the raised nature of the streets, ponded water may develop in the lots adjacent to the streets at these locations. The backfill placed above the pipe should be similar to that used throughout the townsite for roadway construction. This material has sufficient fines to reduce surface infiltration. Compaction of the trench backfill above the pipe to 95% Standard Proctor dry density is recommended to limit surface settlement of the ditch line.

5.1.3 Non-Permafrost Areas

The non-permafrost areas of the townsite are approximately delineated in Drawing B.1. The surficial soils are generally silty sands, however, silt contents of up to 76 percent have been observed. The materials are frost susceptible; however, the underlying gravel provides excellent drainage during the late summer and fall when the river stage is low. Thus, the soils are normally well drained when the frost begins to penetrate. During the spring when the river is in flood, however, groundwater levels one foot below the surface (elevation 1042.7) have been observed. (EBA, 1972) The depth of seasonal frost observed generally varies from 6 to 8 feet, but may be up to 12 feet under plowed roads.

In spite of the generally good drainage, sufficient moisture will be present in localized areas to result in some frost heave. For example, the natural moisture content present in Borehole 77-11 may produce a heave of approximately 2 inches under a pipe buried 3 feet below the surface due to in situ freezing of the pore water alone. Any segregational frost heave will result in larger displacements. For this reason, the minimum depth of burial or overexcavation recommended to protect against frost heave is 6 feet. The frost will certainly penetrate below 6 feet, however the heave is anticipated to be within tolerable limits. The risk of frost heave will gradually increase as the depth of burial (or over-excavation decreases.

Shallower depths of excavation are acceptable if a greater risk of frost heave displacements can be accepted. Nominal pipe insulation is required to prevent freeze-up of water lines. The backfill material below the pipe extending to 6 inches above the pipe should be a clean granular material compacted to 97 percent of Standard Proctor dry density.

5.2 Appurtenances

5.2.1 Hydrants and Valve Risers

Frost jacking of the hydrants and valve risers is a potential problem. The magnitude of frost jacking that can occur in the silt material is illustrated in Photograph A.7. This pipe was installed in 1974 with the paint line initially at ground surface. The approximate one foot of upward displacement is largely a result of frost jacking.

Two alternate methods of preventing frost jacking are recommended. The first is to use a non-frost susceptible backfill surrounding the risers. The backfill should extend at least 3.5 feet from the riser to reduce the risk that frost heave forces can be transmitted through shear from the surrounding silty soils to the riser. Steel pipe risers may also be wrapped with polyethelyene tape to reduce the adfreeze bond. The method is recommended for water line depths up to 4 feet.

For water lines deeper than 4 feet, an anchored riser is recommended. The steel riser should be restrained with a circular plate approximately 2.5 feet in diameter welded to its base. The excavation should be backfilled with non-frost susceptible material compacted to a density of 97 percent of Standard Proctor dry density.

5.2.2 Manholes

Manholes are also susceptible to frost heave forces. The base of the manholes should protrude 2 feet from the outside diameter of the manhole. The manhole segments should then be tied into the base. The ties should be designed to withstand a shear stress of 4000 pounds per square foot acting on the manhole segments from the surface to a depth of 7 feet. The excavation for the manhole must extend to a minimum of 7 feet and 3.0 feet below the base. The excavation should be backfilled to the proper grade with non-frost susceptible backfill compacted to a density of 97 percent of Standard Proctor density. In order to reduce the rate of thaw of permafrost, the base of the manhole should be insulated with twice the thickness of insulation provided for the pipes entering the manhole. If the manhole extends into the permafrost, insulation should also extend up the sides of the excavation to the top of the permafrost.

6.0 CONSTRUCTION

6.1 Scheduling

The major problem associated with construction in the permafrost areas is the high groundwater table during the spring, summer and fall seasons. During the winter, the seasonal frost extends to the permafrost under roadways and groundwater seepage will not be a problem. The groundwater conditions could be most severe in the fall in areas of some relief. At this time, the surficial frost layer will confine the groundwater in the peat and lead to artesian conditions. The increased head available to cause flow could result in a significant increase in flows to an open trench. The locations where artesian conditions can be expected are along the slopes and at the base of the slopes at the north and east edges of the city.

Summer construction in permafrost areas will degrade the permafrost at the base of the trench by exposure to sunlight and warm air as well as infiltrating water. Thus, placement of the backfill must follow very quickly upon excavation of the trench to prevent undue thaw of the permafrost soil.

6.2 Excavation

Excavation of varying amounts of permafrost will be required depending upon the pipe burial depth. In addition, winter and spring construction will require excavation of seasonally frozen ground. During the summer and fall, the excavated material will be thawed and sidewall slumping is anticipated. Shoring or sloping trench walls will probably be required. Additional difficulties are anticipated for deep trenches which must be excavated into the gravel stratum. This material is very dense and hard and a layer of cobbles has been observed at the surface of the gravel stratum. In addition, the gravel may consist of a thin stratum overlying bedrock at some locations.

For those sections of trench in the non-permafrost areas which must be excavated below the groundwater table, dewatering of the trench will be required. It may be feasible to pump from within the trench, however if caving sides are encountered either a series of well points or shoring will be required. This can only be effectively assessed after trial excavation. There appears to be no obvious advantage to winter construction for control of groundwater in the non permafrost area of town.

Respectfully submitted,

EBA Engineering Consultants Ltd.

David D. Kent, P. Eng.

D.W. Hayley, P. Eng.

DDK/cmk

LIST OF REFERENCES

EBA, 1972; "Subsurface Conditions, Dawson, Yukon", A report submitted by EBA to the Department of Indian Affairs and Northern Development.

EBA, 1974; "Site Investigation for Robert Service School, Dawson, Yukon", A report submitted by EBA to the Government of the Yukon Territory, Department of Highways and Public Works.

Hwang, C.T., 1977; "On Quasi-Static Solutions for Buried Pipes in Permafrost", Canadian Geotechnical Journal, Vol. 14, NO. 2, pp. 180-192.

APPENDIX A

PHOTOGRAPHS

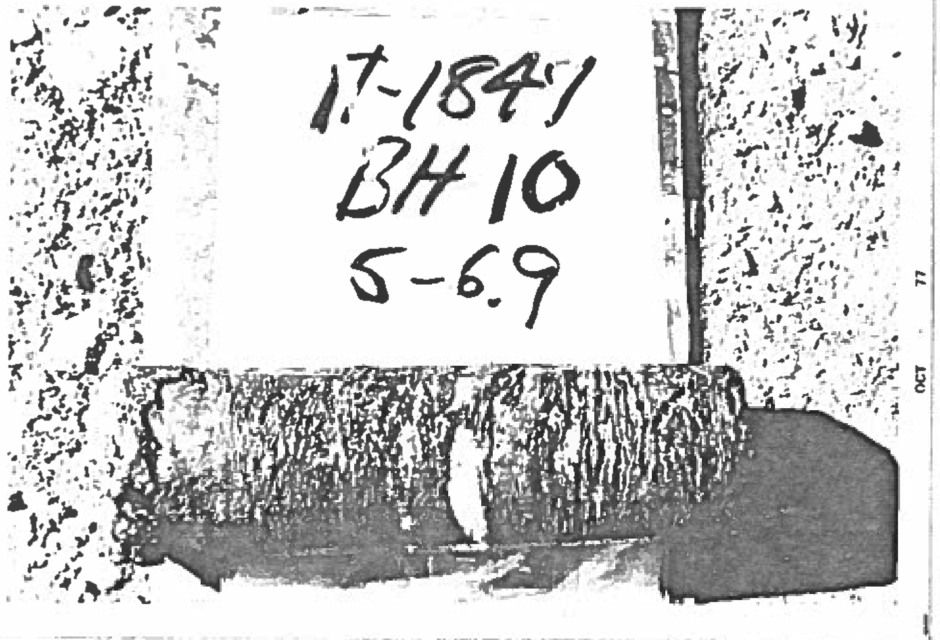


PLATE A.1 Core from BH 77-10, 5 to 6.9 feet
Ice Classification Vs 40-50%

PLATE A.2 Core from BH 77-10, 7.9 to 8.4 feet
Ice Classification Vs 50-60%

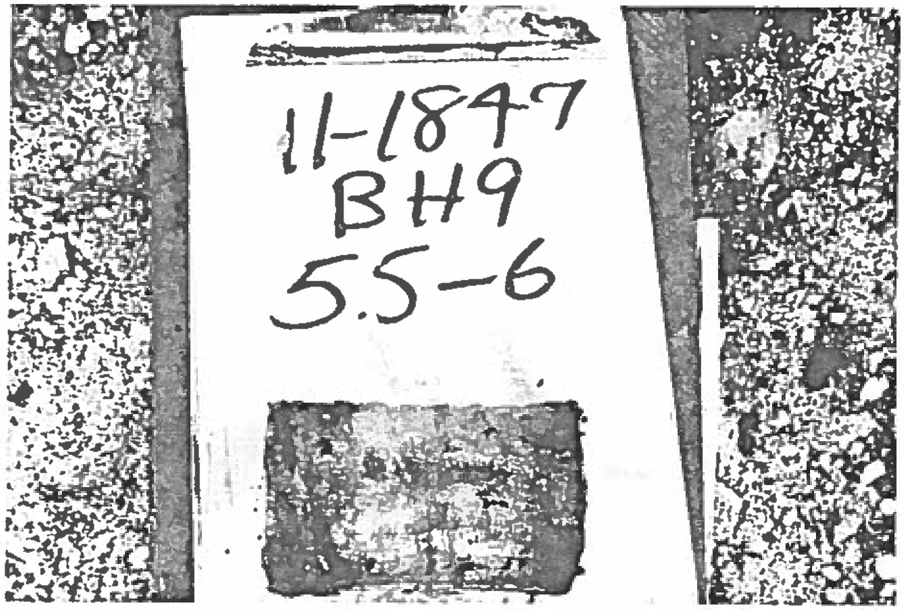


PLATE A.3 Core from BH 77-9, 5.5 to 6 feet
Ice Classification ICE

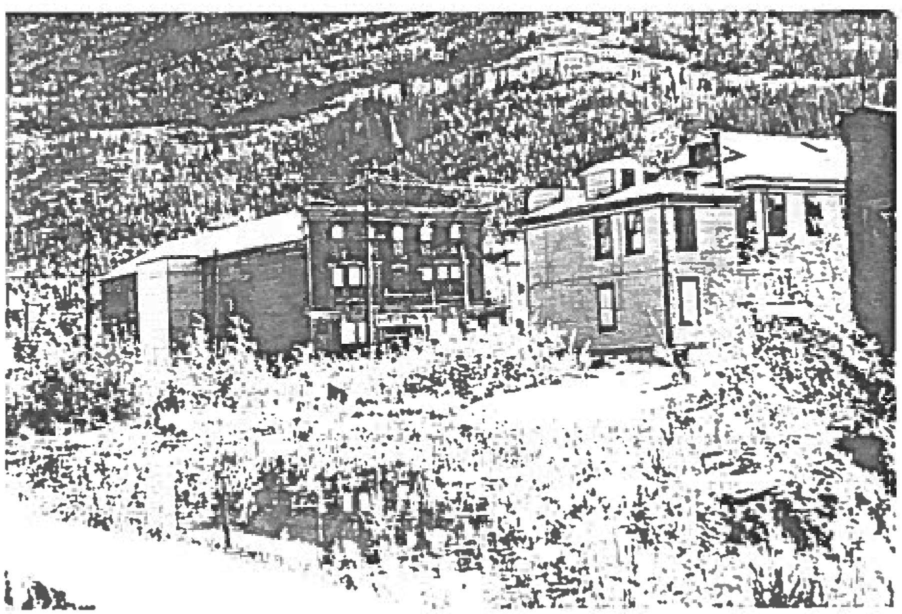


PLATE A.4 Groundwater conditions in lot adjacent to Second Avenue between King and Queen Streets. Note ponded water.

PLATE A.5 Groundwater conditions along 8th Avenue between Harper and Church.

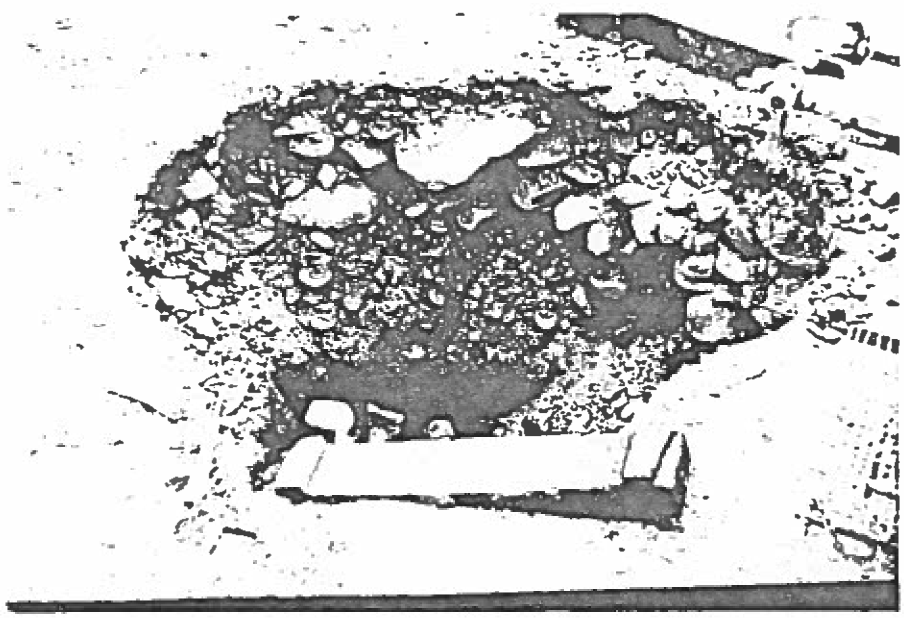
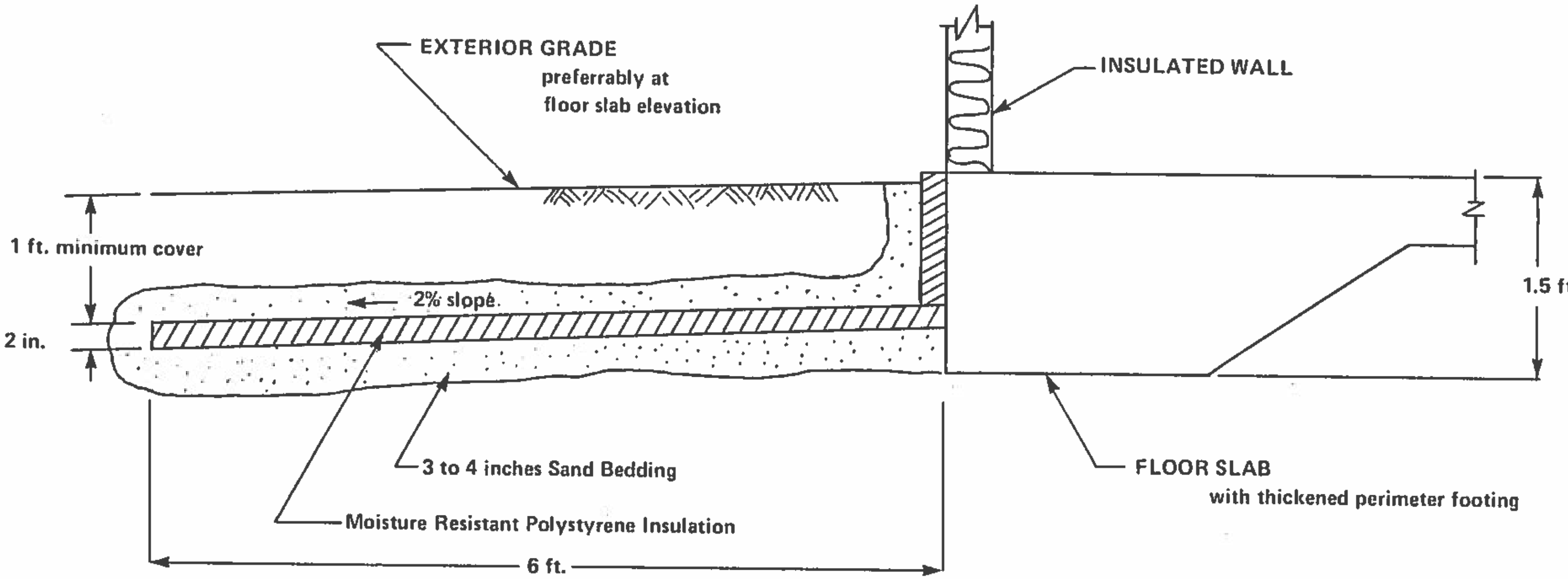
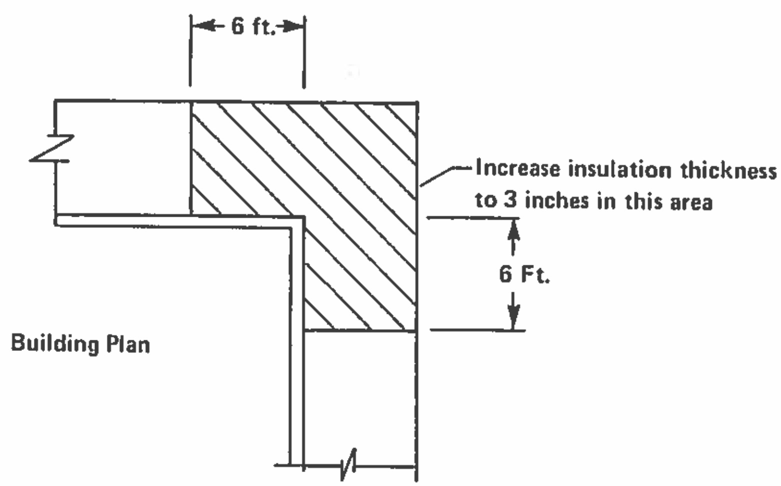


PLATE A.6 BH 77-2. Note large cobble sized material. Two by four for scale.

PLATE A.7 Illustration of frost jacking. Paint line was at ground surface in 1974.



CROSS SECTION



CORNER DETAIL

DAWSON CITY	
INSULATED FOOTING	
EBA Engineering Consultants Ltd.	
JOB No.: 11 - 1847	DATE: 13/10/77
DRAWN BY: DFC	DRAWING No.:
REVIEWED BY:	B - 12

APPENDIX B

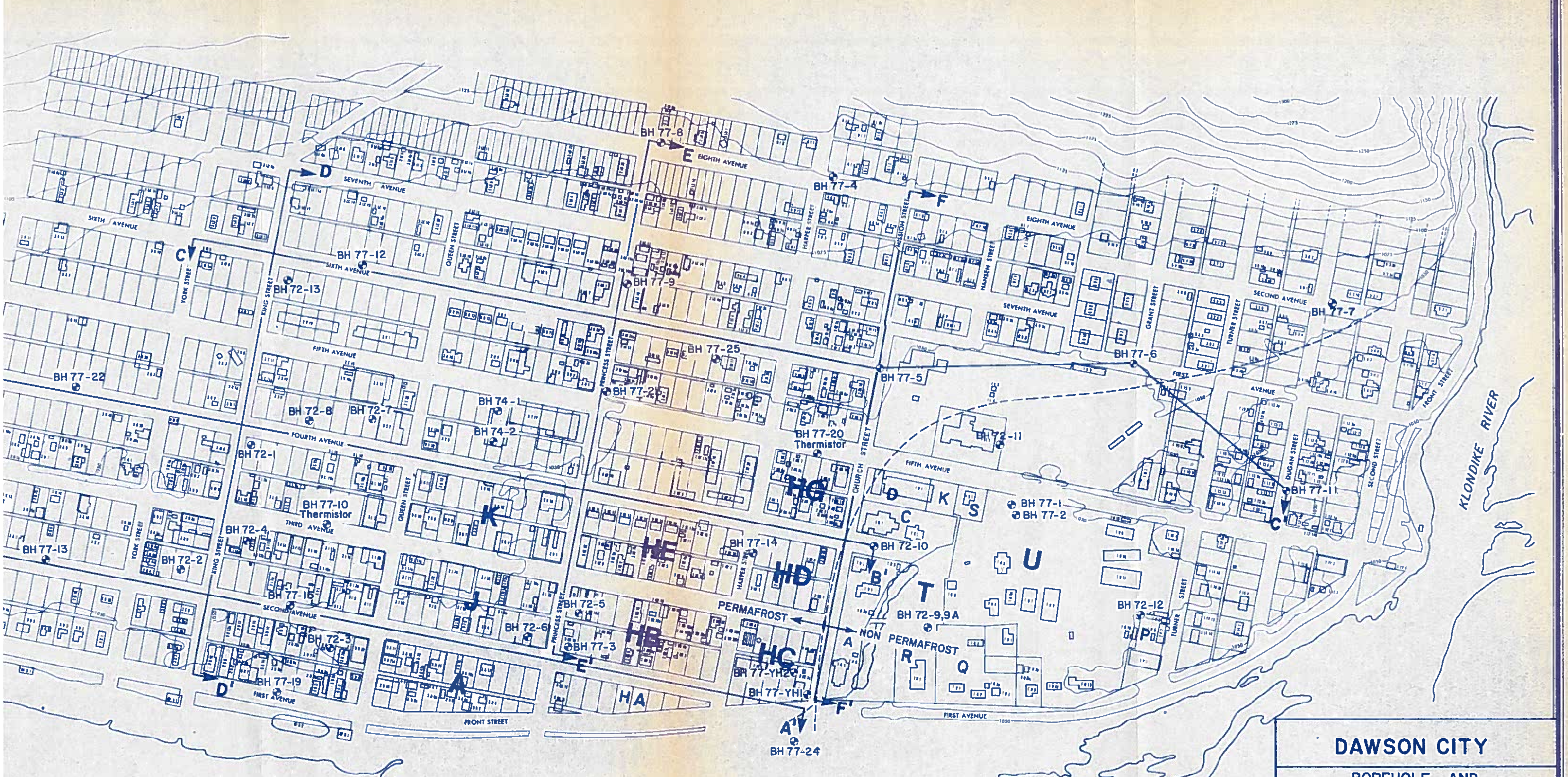
DRAWINGS

DAWSON CITY

LOCATION PLAN

EBA Engineering Consultants Ltd.

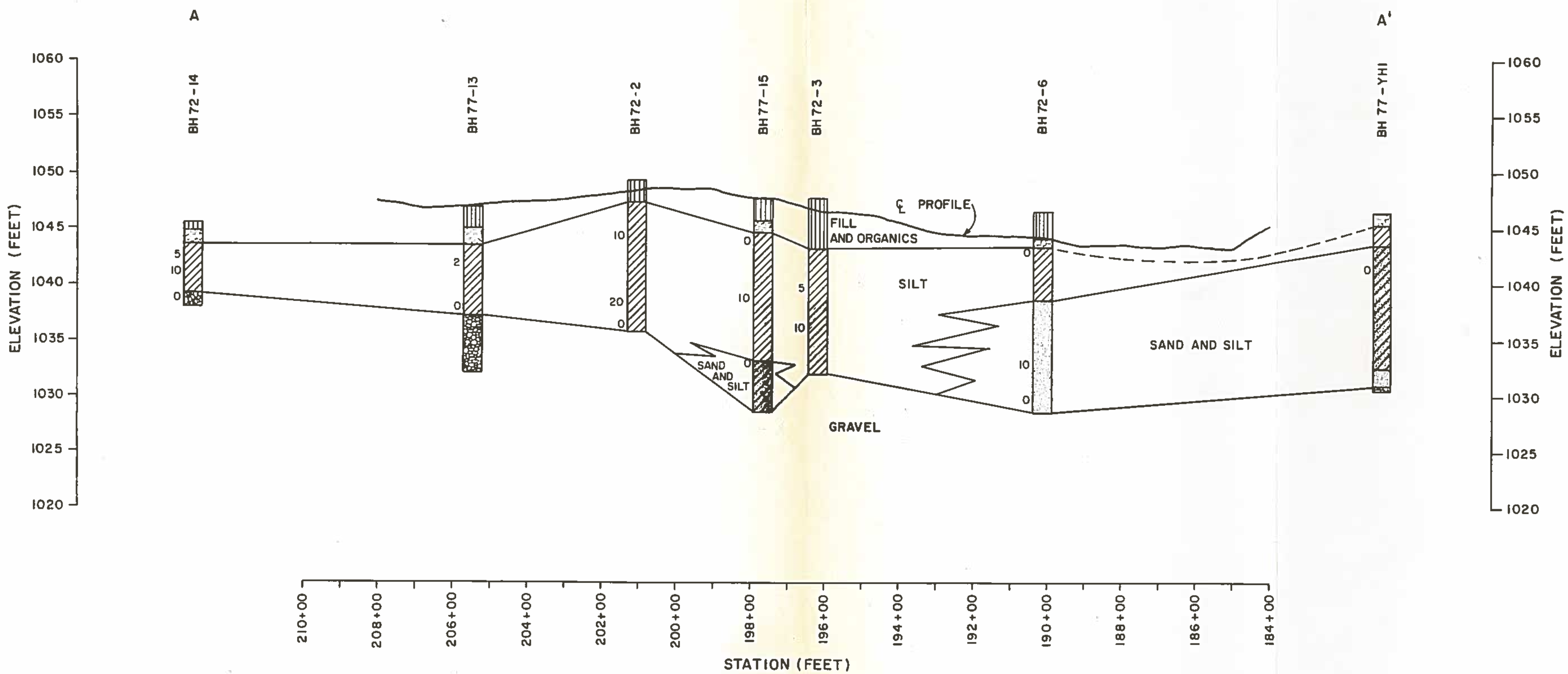
JOB NO. 11-1847	DATE: 27/09/77
DRAWN BY: MKN	DRAWING NO.:
REVIEWED BY:	B.1



NOTE:
BH 72-XX Boreholes from EBA (1972)
BH 74-XX Boreholes from EBA (1974)
BH 77-XX Boreholes drilled June, 1977

Base map from Dawson City Site Plan, Parks Canada, August 1975.

DAWSON CITY	
BOREHOLE AND CROSS SECTION LOCATIONS	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: MKN	DRAWING NO.:
REVIEWED BY:	B.2



NOTES

a) All stratigraphy between boreholes has been assumed

b) Centre line profile from SAEL survey; June; 1977

c) Elevations of 1972 boreholes have been adjusted down 3 feet because of survey inconsistencies

d) Not all boreholes have been located directly on the profile which results in elevation inconsistencies

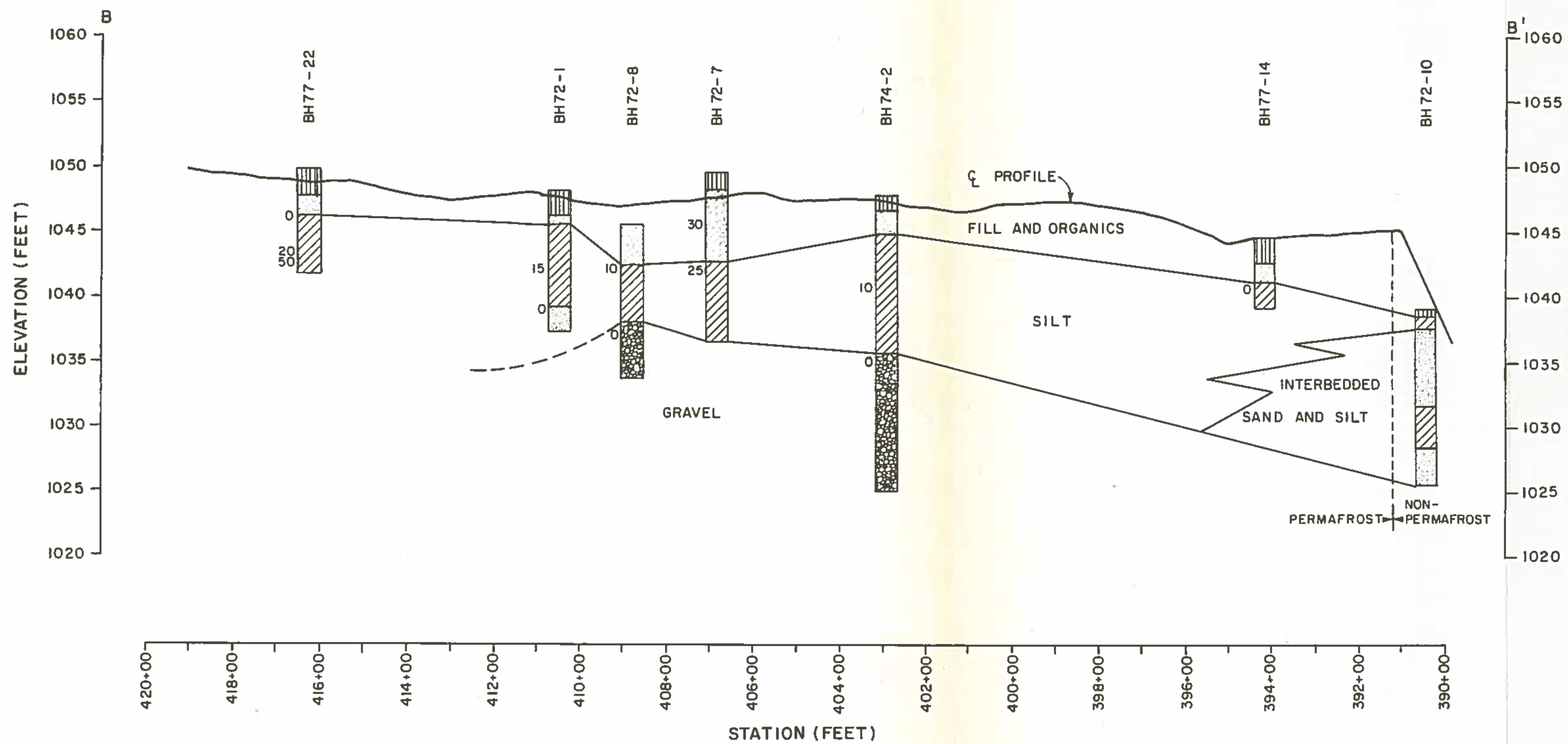
e) Vertical exaggeration = 30: 1

LEGEND

- FILL
- ORGANICS
- SILT
- SAND AND SILT
- SAND
- GRAVEL
- ICE

Numbers beside boreholes refer to percentage of excess ice

DAWSON CITY	
STRATIGRAPHIC CROSS SECTION A-A' SECOND AVENUE	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: DFC	DRAWING NO.:
REVIEWED BY:	B.3



NOTES

a) All stratigraphy between boreholes has been assumed

b) Centre line profile from SAEL survey; June; 1977

c) Elevations of 1972 boreholes have been adjusted down 3 feet because of survey inconsistencies

d) Not all boreholes have been located directly on the profile which results in elevation inconsistencies

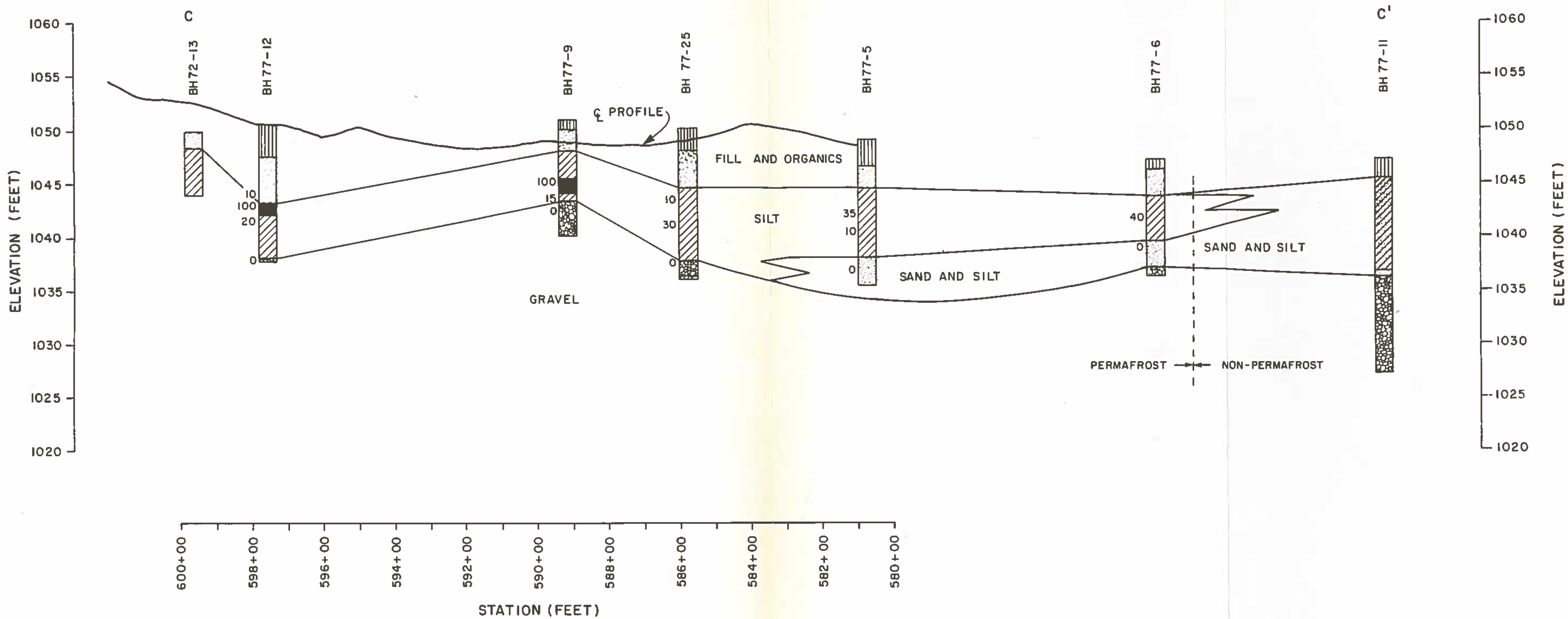
e) Vertical exaggeration = 30:1

LEGEND

FILL
ORGANICS
SILT
SAND AND SILT
SAND
GRAVEL
ICE

Numbers beside boreholes refer to percentage of excess ice

DAWSON CITY	
STRATIGRAPHIC CROSS SECTION B-B' FOURTH AVENUE	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: DFC	DRAWING NO.:
REVIEWED BY:	B.4



NOTES

a) All stratigraphy between boreholes has been assumed

b) Centre line profile from SAEL survey; June; 1977

c) Elevations of 1972 boreholes have been adjusted down 3 feet because of survey inconsistencies

d) Not all boreholes have been located directly on the profile which results in elevation inconsistencies

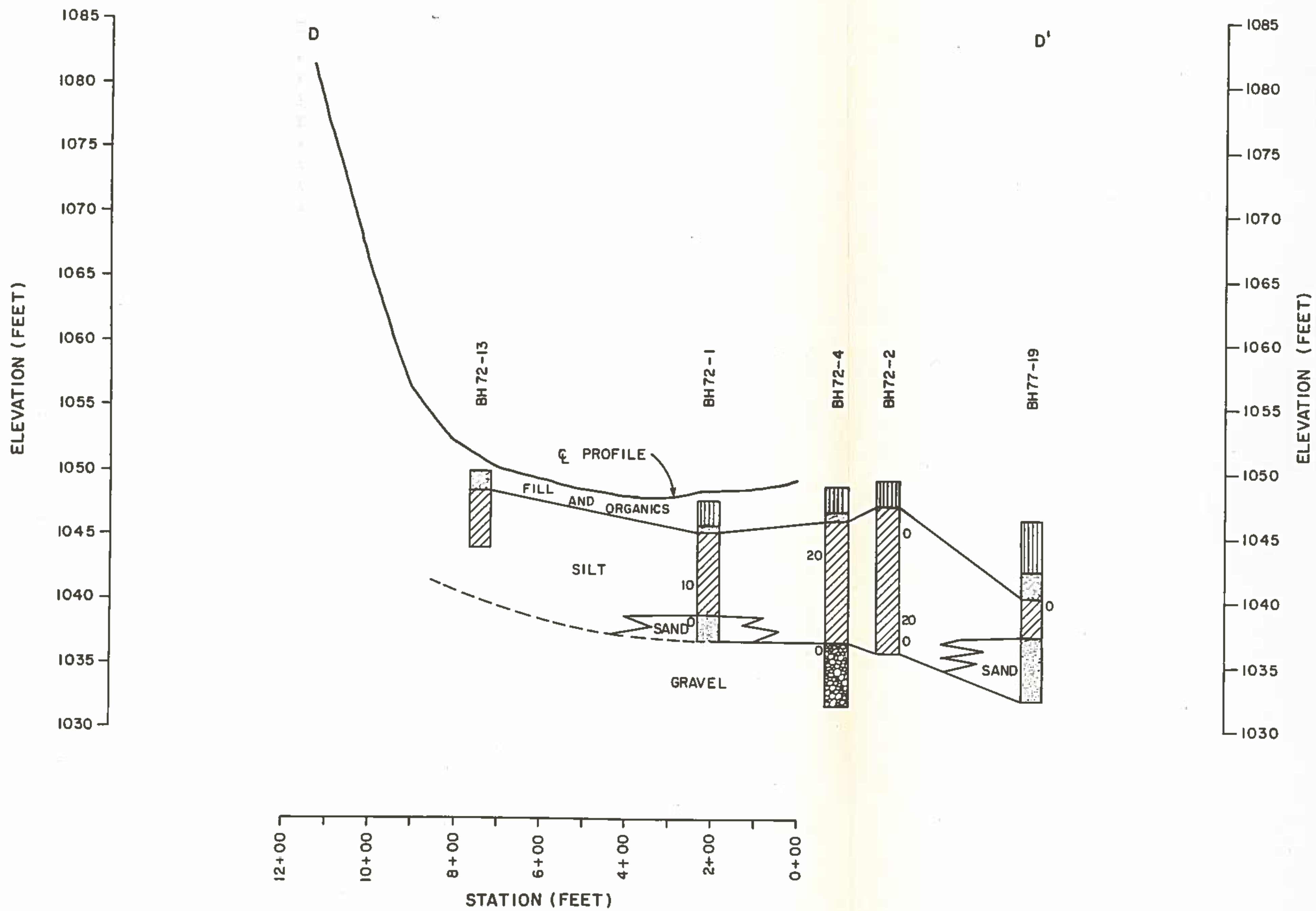
e) Vertical exaggeration = 30:1

LEGEND

FILL
ORGANICS
SILT
SAND AND SILT
SAND
GRAVEL
ICE

Numbers beside boreholes refer to percentage of excess ice

DAWSON CITY	
STRATIGRAPHIC CROSS SECTION C-C' SIXTH AVENUE	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: DFC	DRAWING NO.:
REVIEWED BY:	B.5



NOTES

a) All stratigraphy between boreholes has been assumed

b) Centre line profile from SAEL survey; June; 1977

c) Elevations of 1972 boreholes have been adjusted down 3 feet because of survey inconsistencies

d) Not all boreholes have been located directly on the profile which results in elevation inconsistencies

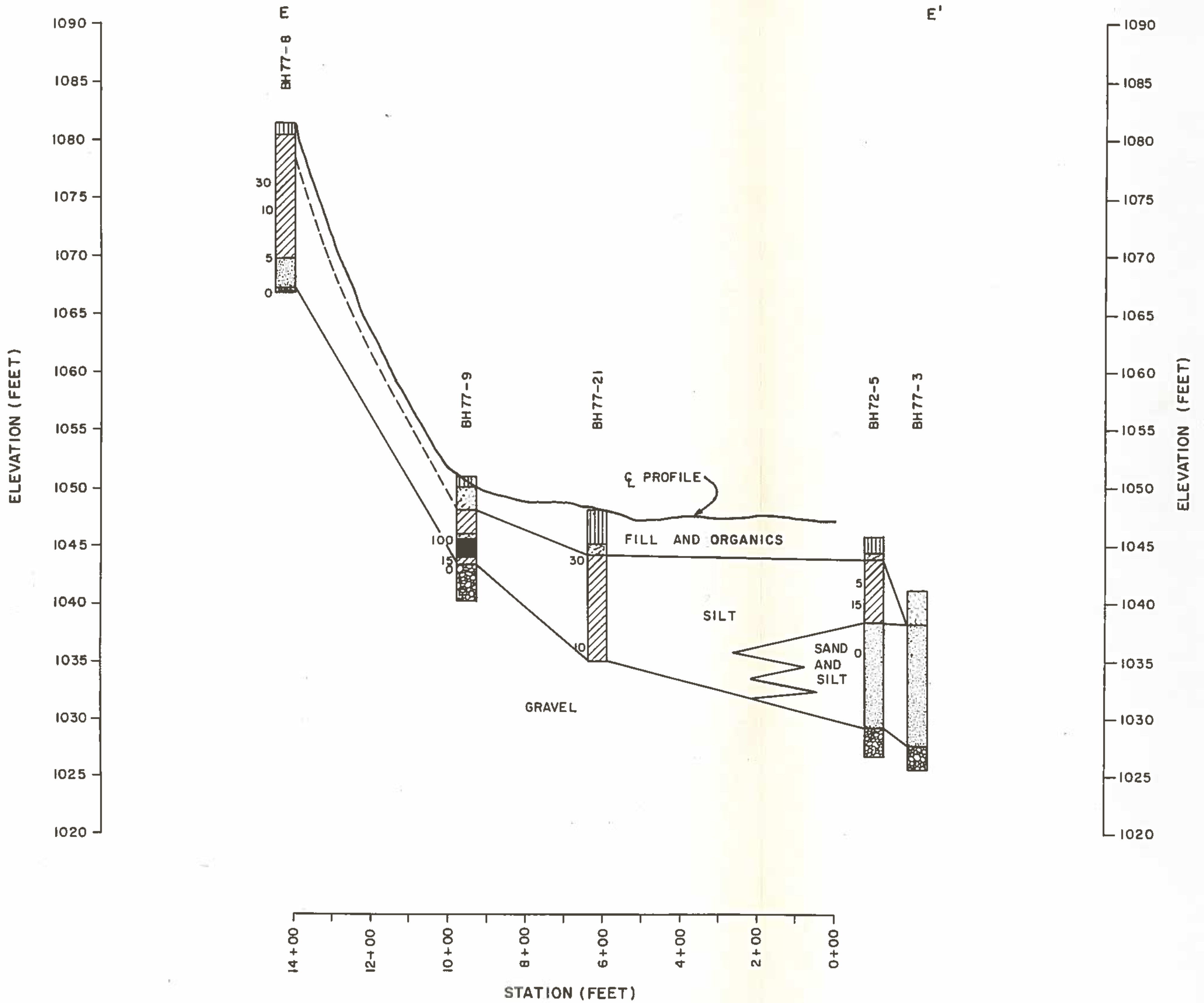
e) Vertical exaggeration = 30: 1

LEGEND

FILL
ORGANICS
SILT
SAND AND SILT
SAND
GRAVEL
ICE

Numbers beside boreholes refer to percentage of excess ice

DAWSON CITY	
STRATIGRAPHIC CROSS SECTION D-D' KING STREET	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: DFC	DRAWING NO.:
REVIEWED BY:	B.6



NOTES

a) All stratigraphy between boreholes has been assumed

b) Centre line profile from SAEL survey; June; 1977

c) Elevations of 1972 boreholes have been adjusted down 3 feet because of survey inconsistencies

d) Not all boreholes have been located directly on the profile which results in elevation inconsistencies

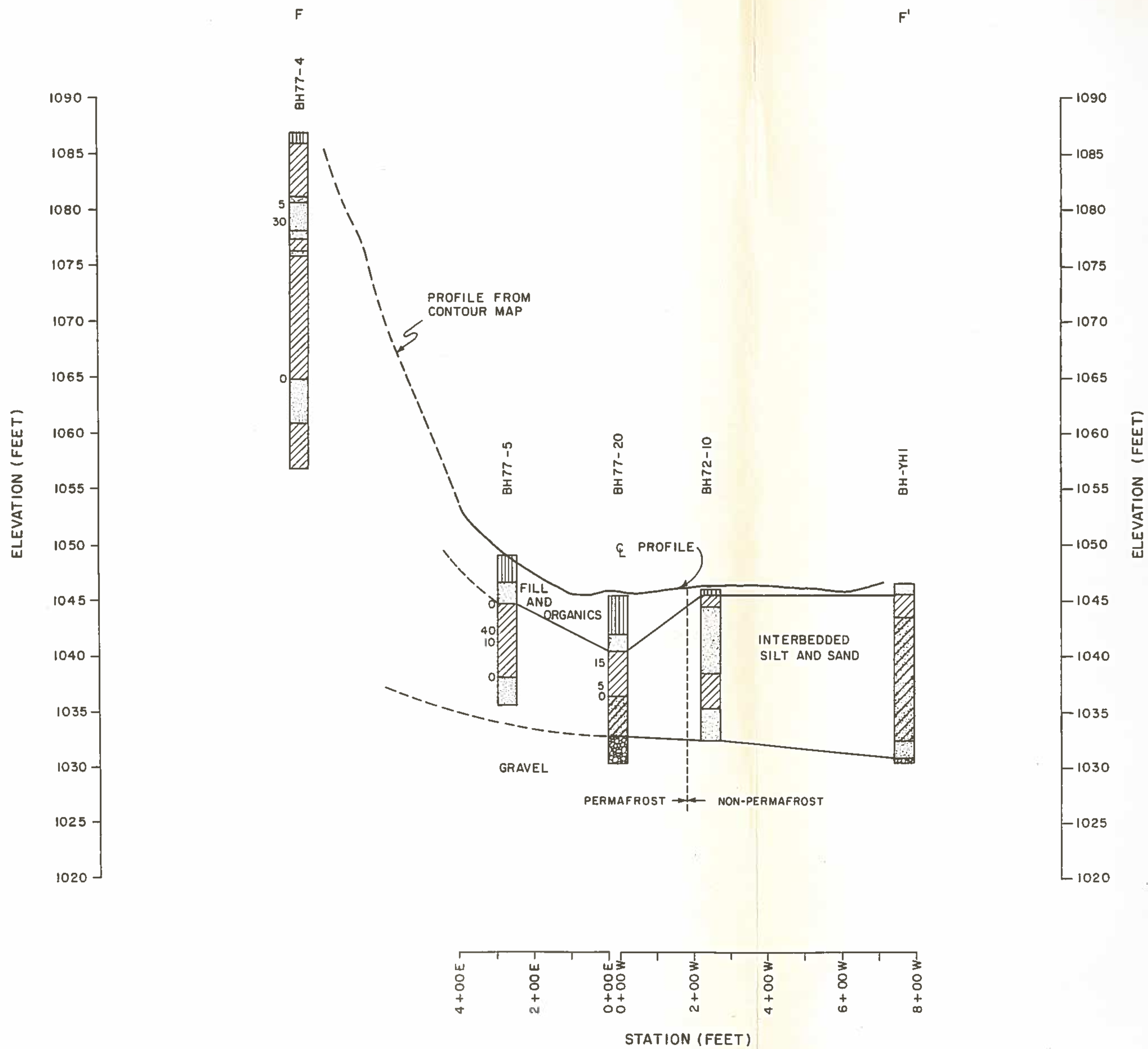
e) Vertical exaggeration = 30:1

LEGEND

- FILL
- ORGANICS
- SILT
- SAND AND SILT
- SAND
- GRAVEL
- ICE

Numbers beside boreholes refer to percentage of excess ice

DAWSON CITY	
STRATIGRAPHIC CROSS SECTION E-E' PRINCESS STREET	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: DFC	DRAWING NO.:
REVIEWED BY:	B.7



NOTES

a) All stratigraphy between boreholes has been assumed

b) Centre line profile from SAEL survey; June 1977

c) Elevations of 1972 boreholes have been adjusted down 3 feet because of survey inconsistencies

d) Not all boreholes have been located directly on the profile which results in elevation inconsistencies

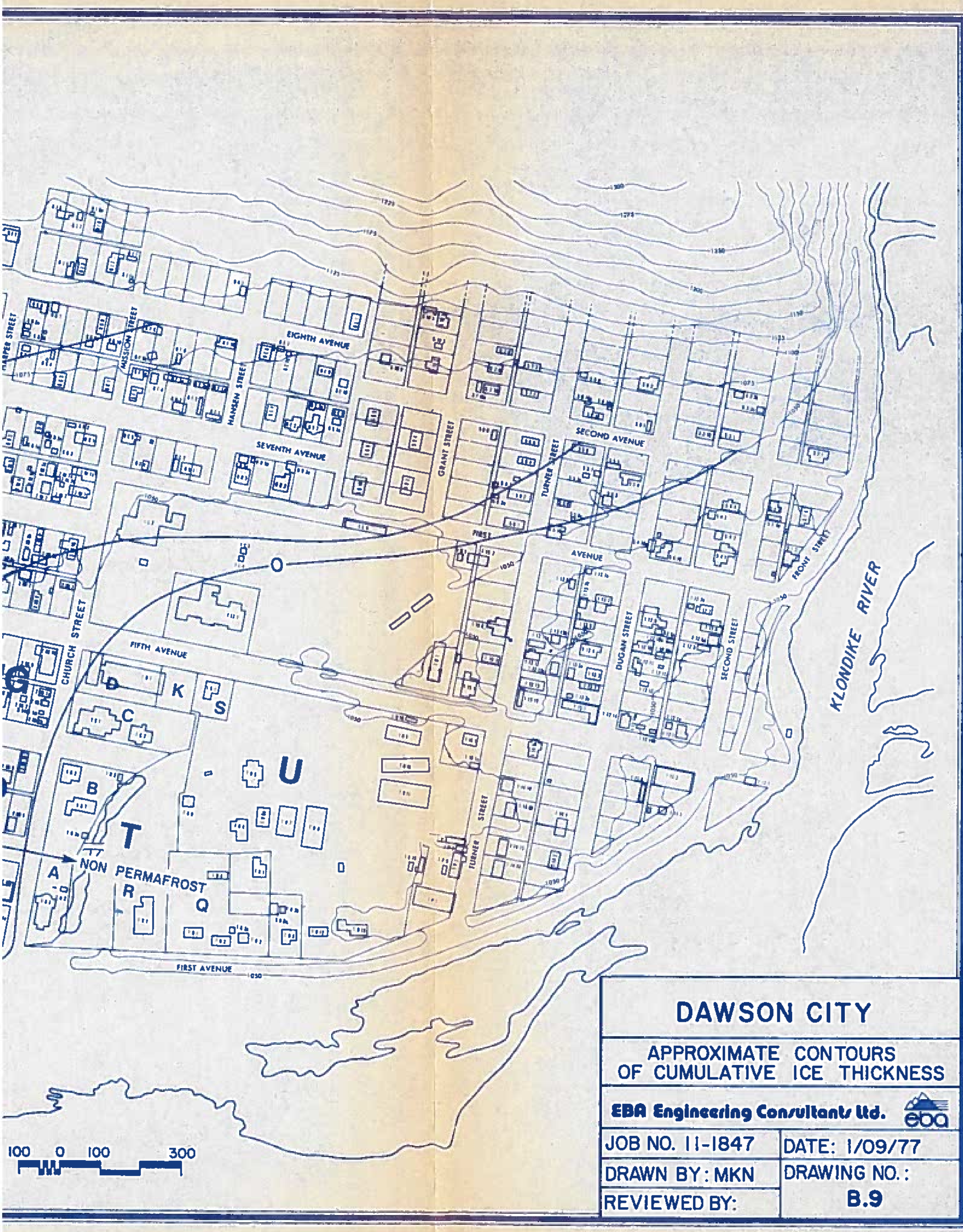
e) Vertical exaggeration = 30:1

LEGEND

FILL
ORGANICS
SILT
SAND AND SILT
SAND
GRAVEL
ICE

Numbers beside boreholes refer to percentage of excess ice

DAWSON CITY	
STRATIGRAPHIC CROSS SECTION F-F' CHURCH STREET	
EBA Engineering Consultants Ltd.	
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: DFC	DRAWING NO.:
REVIEWED BY:	B.8



DAWSON CITY	
APPROXIMATE CONTOURS OF CUMULATIVE ICE THICKNESS	
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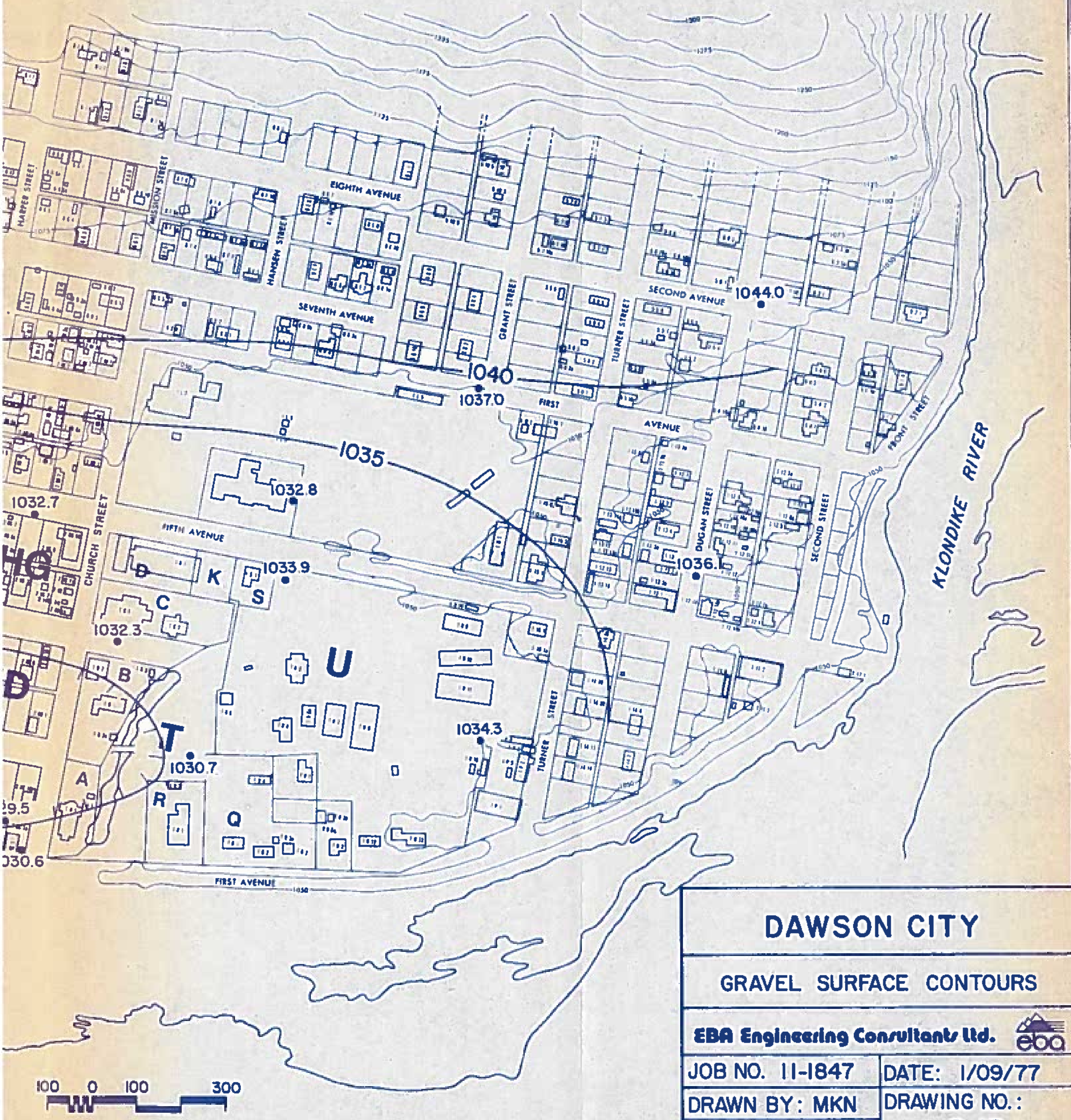
JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: MKN	DRAWING NO.:
REVIEWED BY:	B.9

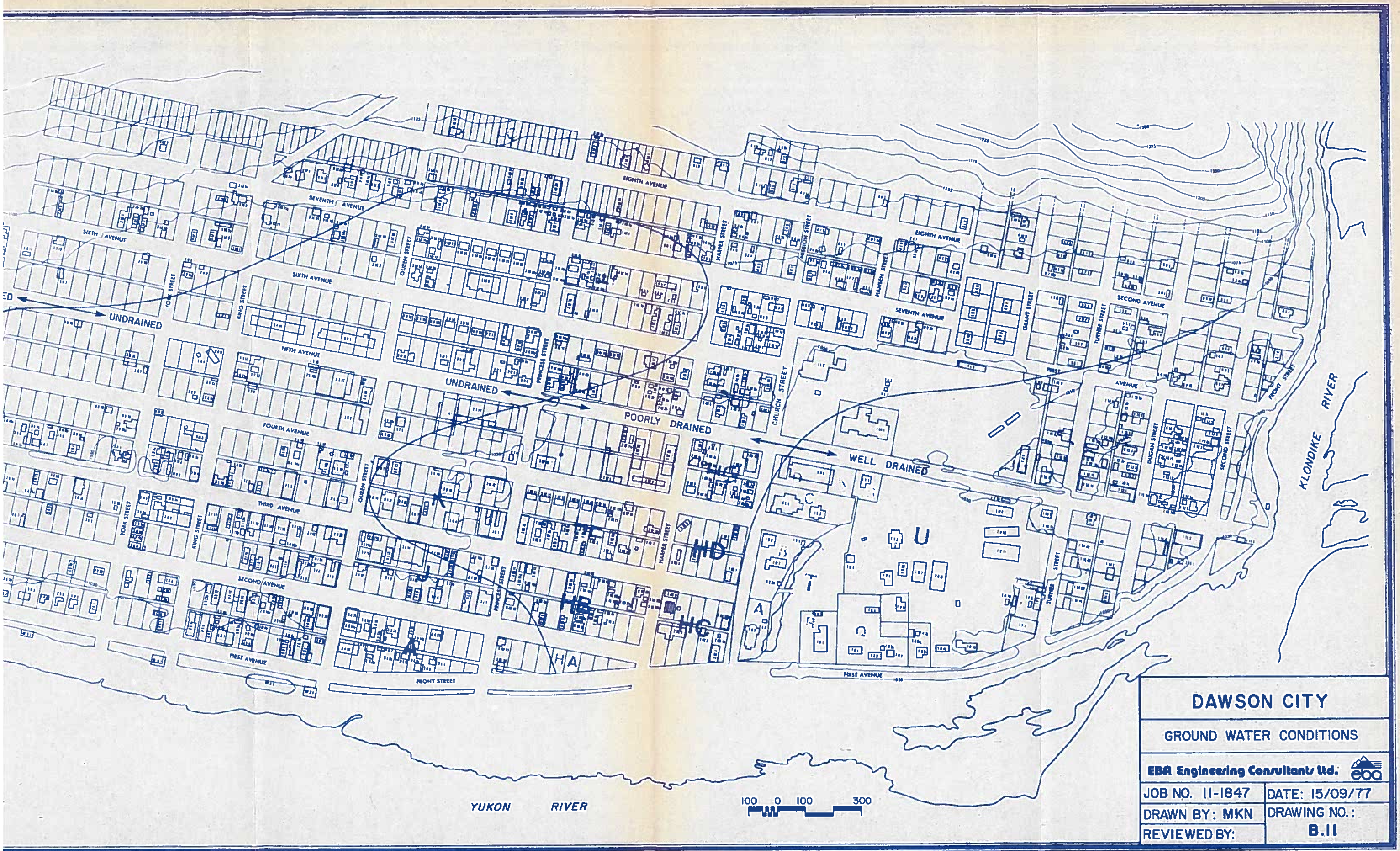


DAWSON CITY

GRAVEL SURFACE CONTOURS

EBA Engineering Consultants Ltd.

JOB NO. 11-1847	DATE: 1/09/77
DRAWN BY: MKN	DRAWING NO.: B.10
REVIEWED BY:	



DAWSON CITY
GROUND WATER CONDITIONS
EBA Engineering Consultants Ltd.
JOB NO. 11-1847
DATE: 15/09/77
DRAWN BY: MKN
DRAWING NO.:
B.11
REVIEWED BY:
UNDRAINED
POORLY DRAINED
WELL DRAINED
YUKON RIVER
KLONDIKE RIVER
100 0 100 300
FIRST AVENUE
SECOND AVENUE
THIRD AVENUE
FOURTH AVENUE
FIFTH AVENUE
SIXTH AVENUE
SEVENTH AVENUE
EIGHTH AVENUE
FRONT STREET
YORK STREET
KING STREET
QUEEN STREET
PRINCESS STREET
HARPER STREET
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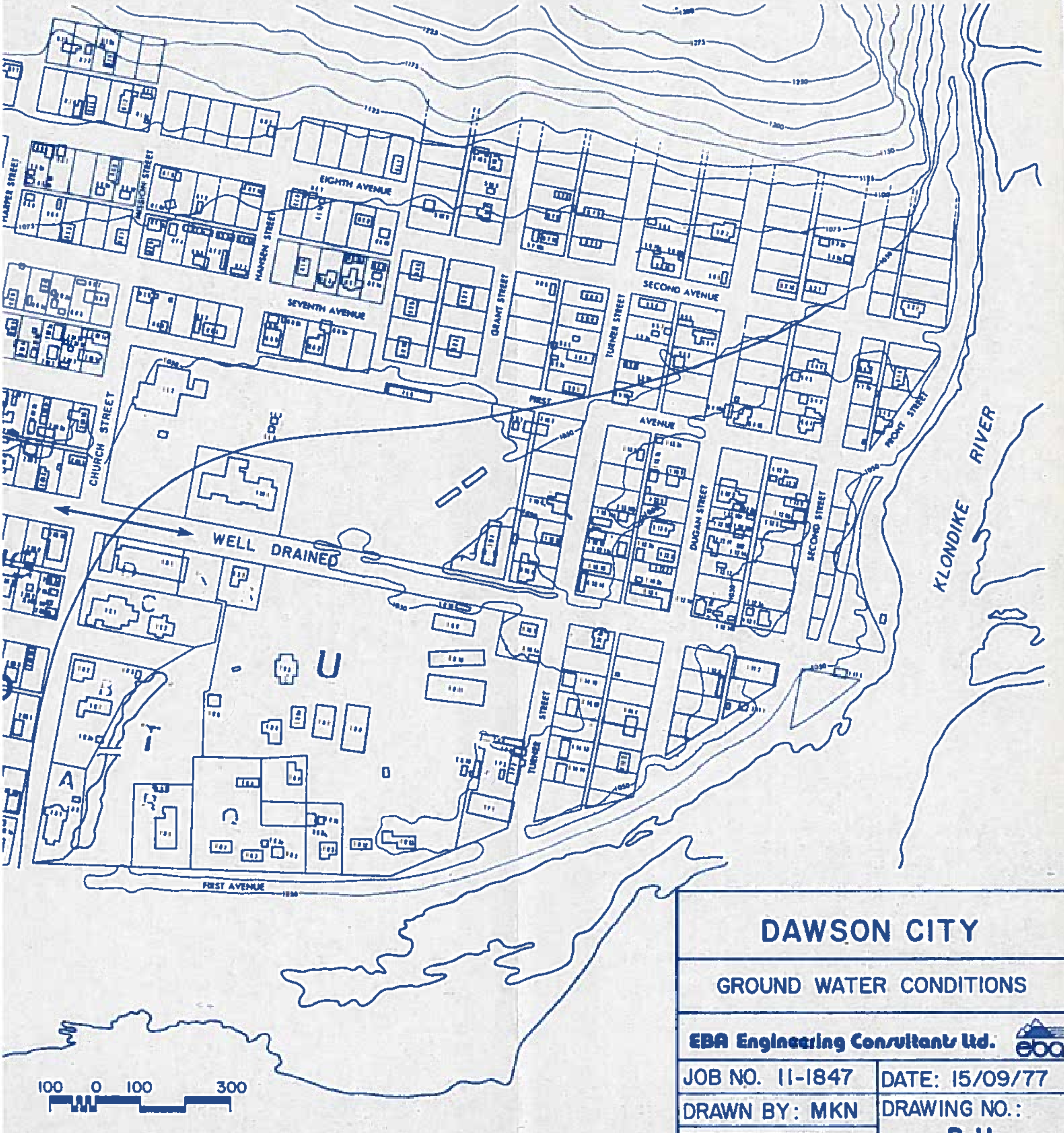
MISSION STREET
HANSEN STREET
GRANT STREET
TURNER STREET
DUGAN STREET
SECOND STREET



DAWSON CITY	
GROUND WATER CONDITIONS	
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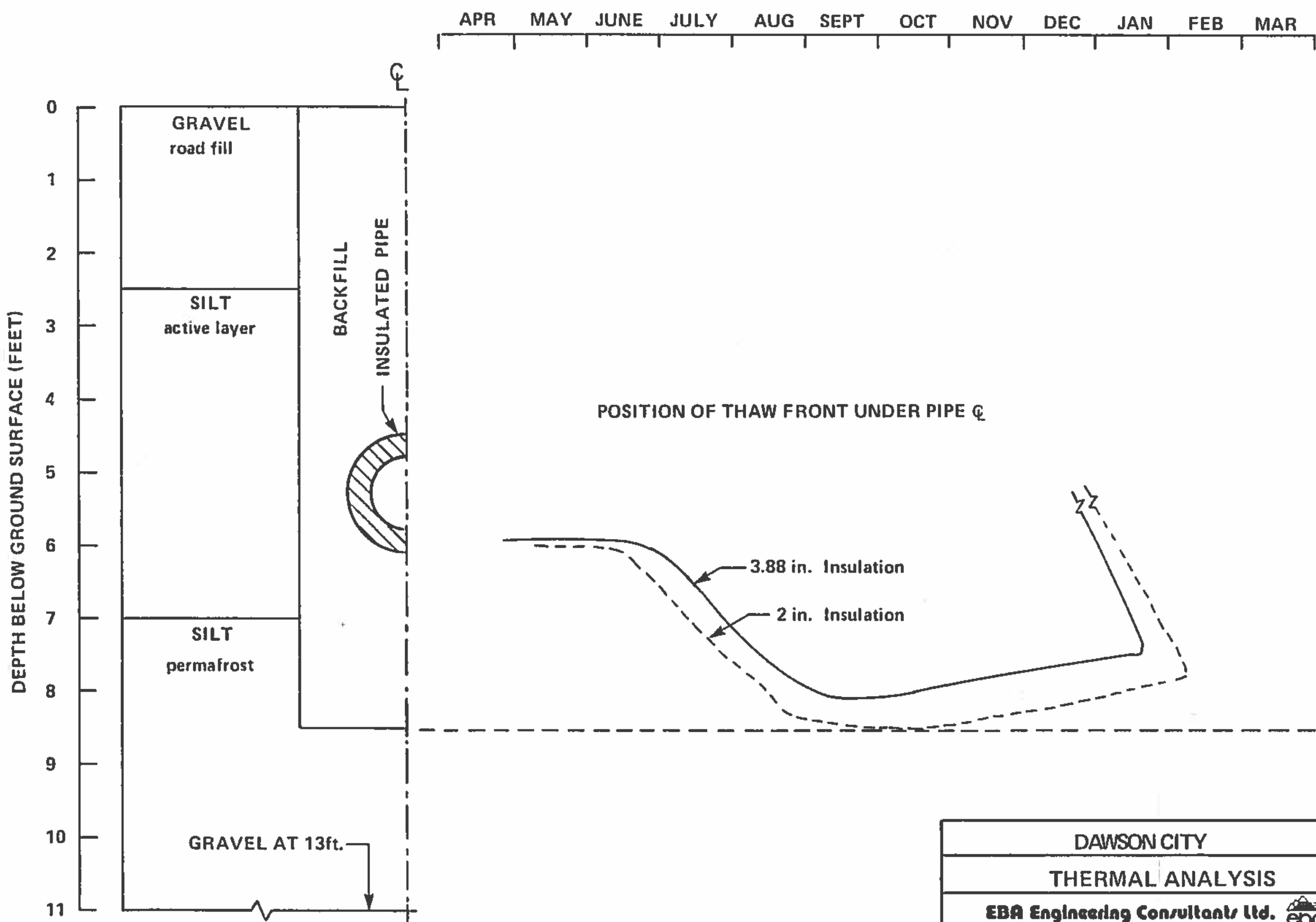
REVIEWED BY:	B.11



DAWSON CITY	
THERMAL ANALYSIS	
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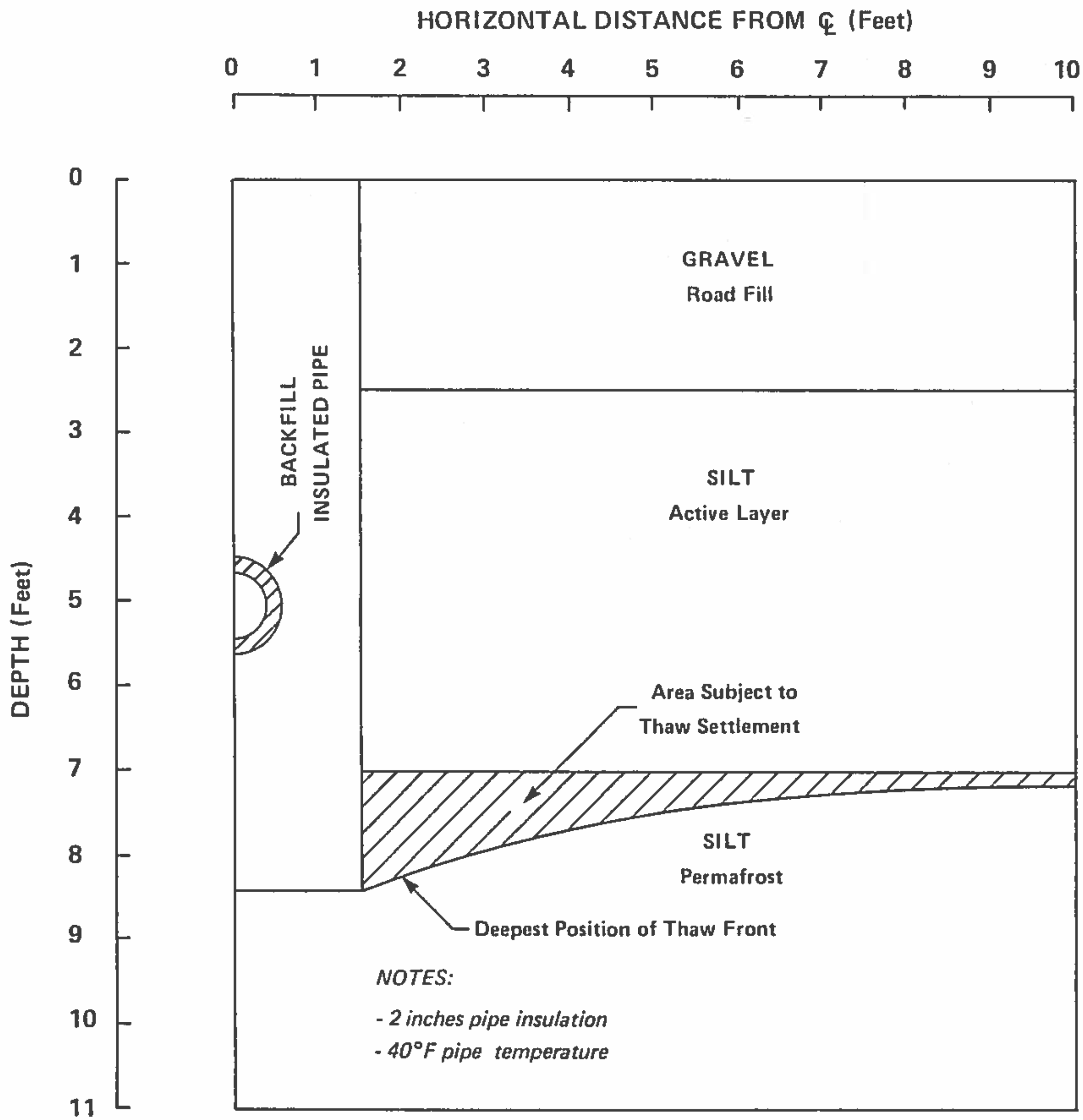
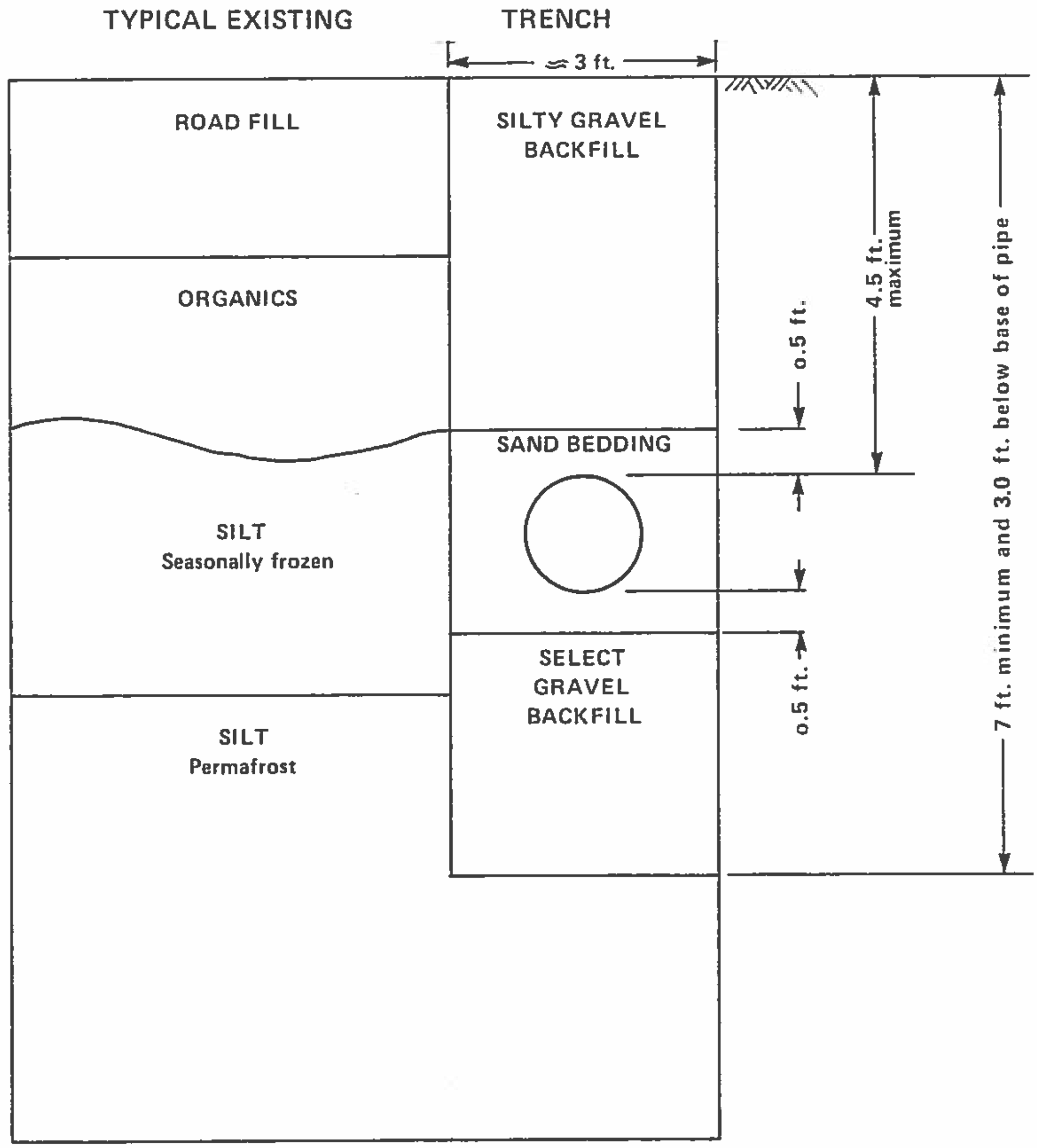
JOB No.: 11-1847	DATE: 13/10/77
DRAWN BY: DFC	DRAWING No.:
REVIEWED BY:	B-13



DAWSON CITY	
POSITION OF THAW FRONT	
EBA Engineering Consultants Ltd.	
JOB No.: 11-1847	DATE: 20/10/77
DRAWN BY: MKN	DRAWING No.: B 14
REVIEWED BY:	



NOTES:

- 2 inches pipe insulation

- all backfill compacted to 97% standard proctor

- maximum pipe temperature is 40°F.

DAWSON CITY	
TRENCH DESIGN CROSS SECTION	
EBA Engineering Consultants Ltd.	
JOB No.: 11-1847	DATE: 13/10/77
DRAWN BY: DFC	DRAWING No.: B - 15
REVIEWED BY:	

APPENDIX C

BOREHOLE LOGS

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOL	SUBGROUP SYMBOLS	SUBGROUP DESCRIPTION	
N	Nf	Poorly bonded or friable	
	Nbn	No excess ice, well bonded	
	Nbe	Excess ice, well bonded	

NOTE: 1) Dual symbols are used to indicate borderline or mixed ice classification.

2) Ice strata less than 0.2 m thick have been omitted from the summary borehole logs.

3) The above system for ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes.

LEGEND: Soil Ice

VISIBLE ICE LESS THAN 50% BY VOLUME

V	Vx	Individual ice crystals or inclusions	
	Vc	Ice coatings on particles	
	Vr	Random or irregularly oriented ice formations	
	Vs	Stratified or distinctly oriented ice formations	

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + soil type	Ice with soil inclusions	
	ICE	Ice without soil inclusions (greater than 2.5 cm (1 in.) thick)	

UNIFIED SOIL CLASSIFICATION
INCLUDING IDENTIFICATION AND DESCRIPTION

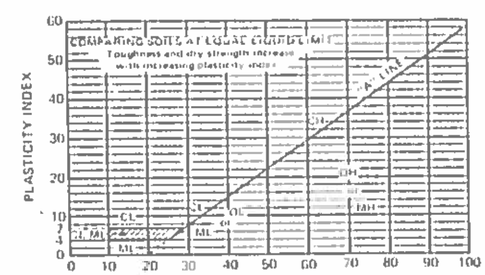
Major divisions			Field identification procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights)	Group symbols (1)	Typical names	Information required for describing soils	Laboratory classification criteria
COARSE GRAINED SOILS — More than half of material is larger than No 200 sieve size (2) (The No. 200 sieve size is about the smallest particle visible to the naked eye)	GRAVELS — More than half of coarse fraction is larger than No 4 sieve size (For visual classifications the ¼" size may be used as equivalent to the No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel sand mixtures, little or no fines.	Give typical name, indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the course grains; local or geologic name and other pertinent descriptive information, and symbol in parentheses.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		GRAVELS WITH FINES (Appreciable amount of fines)	Non plastic fines (for identification procedures see ML below)	GM	Silty gravels, poorly graded gravel sand silt mixtures.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	Atterberg limits below "A" line, or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
			Plastic fines (for identification procedures see CL below)	GC	Clayey gravels, poorly graded gravel sand clay mixtures.		Atterberg limits above "A" line with PI greater than 7
	SANDS — More than half of coarse fraction is smaller than No 4 sieve size	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	SW	Well graded sands, gravelly sands, little or no fines.	EXAMPLE — Silty sand, gravelly; about 20% hard, angular gravel particles ½ in. maximum size; rounded and subangular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM)	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		Not meeting all gradation requirements for SW
		SANDS WITH FINES (Appreciable amount of fines)	Non plastic fines (for identification procedures see ML below)	SM	Silty sands, poorly graded sand-silt mixtures.		Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
			Plastic fines (for identification procedures see CL below)	SC	Clayey sands, poorly graded sand-clay mixtures.		Atterberg limits above "A" line with PI greater than 7

Use grain size curve in identifying the fractions as given under field identification.

Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No 200 sieve size) coarse grained soils are classified as follows:
Less than 5% — GW, GP, SW, SP.
More than 12% — GM, GC, SM, SC
5% to 12% — Borderline cases requiring use of dual symbols

IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN No 40 SIEVE SIZE

Major divisions		Dry strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group symbols	Typical names	Information required for describing soils
FINE GRAINED SOILS — More than half of material is smaller than No 200 sieve size (The No 200 sieve size is about the smallest particle visible to the naked eye)	SILTS AND CLAYS — Liquid limit less than 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.
		Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	CL	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.
	SILTS AND CLAYS — Liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays.	EXAMPLE — Clayey silt, brown, slightly plastic, small percentage of fine sand; numerous vertical root holes, firm and dry in place, loess, (ML)
		Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity.	
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other highly organic soils.	



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

(1) Boundary classifications — Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW GC well graded gravel sand mixture with clay binder.
(2) All sieve sizes on this chart are U.S. standard.

UNIFIED SOIL CLASSIFICATION CHART — E B A Engineering Consultants Ltd.

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
1	SAND - med. brown - silty		UNFROZEN	
2				
3				
4				
5	- few laminations of silt	X		
6				
7				
8				
9				
10	- very silty	X		
11	SAND AND GRAVEL - some silt 58.3% GRAVEL 44.8% SAND 3.1% SILT			
12				
13				
14				
15	GRAVEL - med. brown - med. coarse - tr. white silt - sandy	X		
16				

PROJECT: DAWSON CITY

DATE: June 9/77

LOGGED BY: DK

ELEVATION: 1044.9 ft.

DEPTH: 20.5 ft.

HOLE NO.: BH 77-1

SHEET 1 of 2

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
15–19	GRAVEL (CONT.)			
19–20.5	- med. brown - sandy and silty - well graded 78.7% GRAVEL 18.1% SAND 3.2% SILT	X		● ▲
20.5	END OF HOLE - LOST CIRCULATION			

	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 9/77 LOGGED BY DK ELEVATION 1044.9 ft. DEPTH 20.5	BH 77-1 SHEET 2 of 2

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● SPT RESISTANCE ▲ 10 20 30 40 50 60 70
0–1	GRAVEL + ROCK (fill)			
1	- very coarse			
2				
3				
4				
5	END OF HOLE			
6	Note: Excavated as test pit			
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PROJECT: Dawson City

DATE: June 9, 1977

LOGGED BY: DK

ELEVATION:

DEPTH: 7

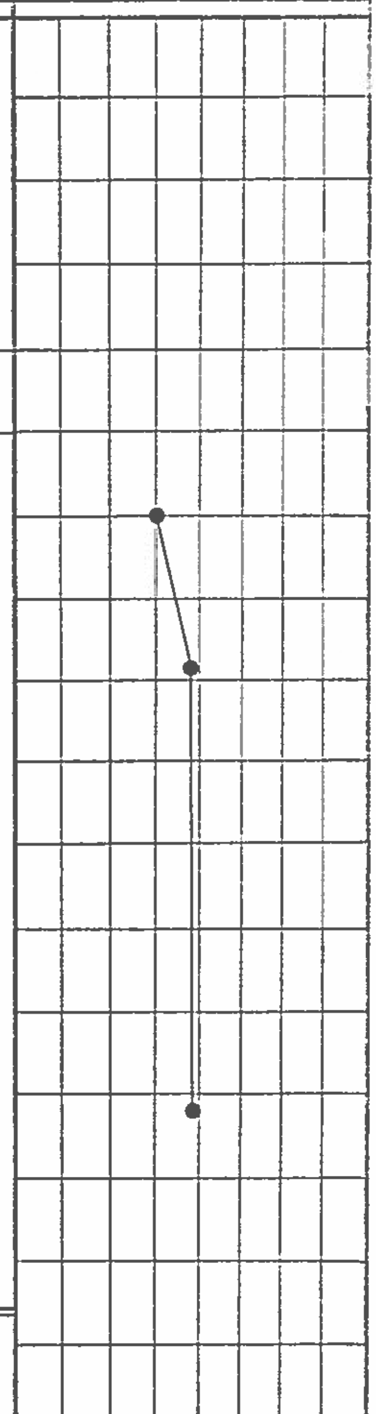
HOLE NO.: BH77-2

SHEET: 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0 – 3	ORGANICS		UNFROZEN
3 – 5	SILT AND ORGANICS W.L. June 14 (at approx. 3.7 ft)		UNFROZEN (to 4 ft) FROZEN SEASONAL (4 – 5 ft)
5 – 10.3	SILT - dk. br. grey - organic - dk. grey - sandy to some sand - sand laminations - organics Sand 17% Silt 80% Clay 3%	sampled	UNFROZEN
10.3 – 13.5	SAND and SILT - gradational contact - dk. grey - very fine, uniform grained sand - organic	sampled	
13.5 – 15.5	GRAVEL - producing approximately 5 gpm from 4 7/8" hole		
15.5	END OF HOLE - sloughing		

MOISTURE CONTENT % ⊕
SPT RESISTANCE ▲
10 20 30 40 50 60 70

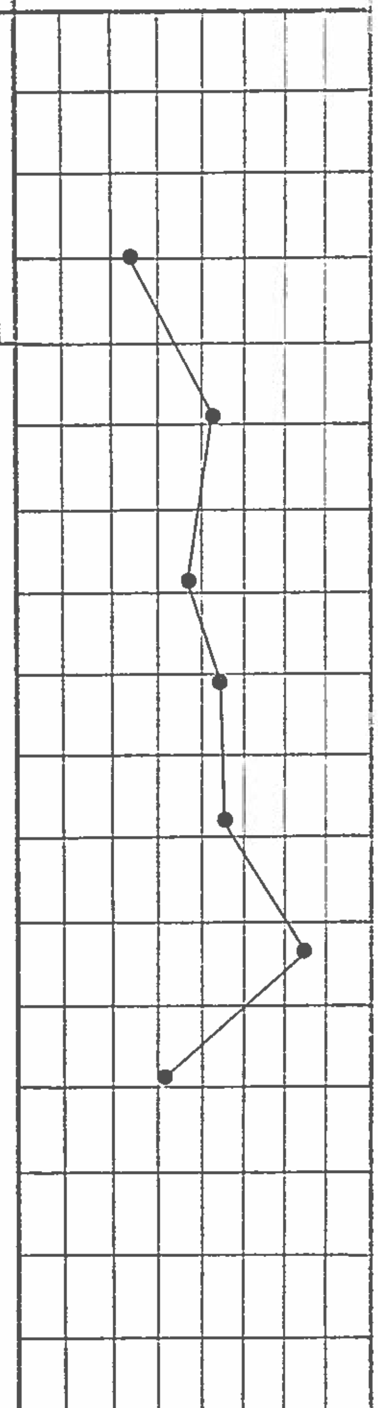


	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 9, 1977 LOGGED BY DK ELEVATION 1040.9 ft. DEPTH 15.5 ft.	BH 77-3 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–1	SAND AND GRAVEL (FILL) - very silty		UNFROZEN
1–6	SILT - med. grey brown - and sand - fine uniform sand		FROZEN (from ~4 ft) Nbn-Nf
6	ORGANICS		Nbe, Vs 0-5% Nbe, Vs 0-2%
6–9	SILT - med. grey - very fine uniform - dark grey - organic		Vs 34-45%
9	ORGANICS		Vr 35%
10	SILT - med. grey		Vs 20%
11	ORGANICS - drk. brown		Vr 25%
11–16	SILT - dark grey - very organic		Vs 25-35% Vs 25%

MOISTURE CONTENT % ○
SPT RESISTANCE △
10 20 30 40 50 60 70



eba	PROJECT DAWSON CITY	DATE June 7, 1977 LOGGED BY DK ELEVATION 1086.6 ft. DEPTH 30 ft.	HOLE NO. BH 77-4 SHEET 1 of 2

BOREHOLE LOG
PERMAFROST REGION

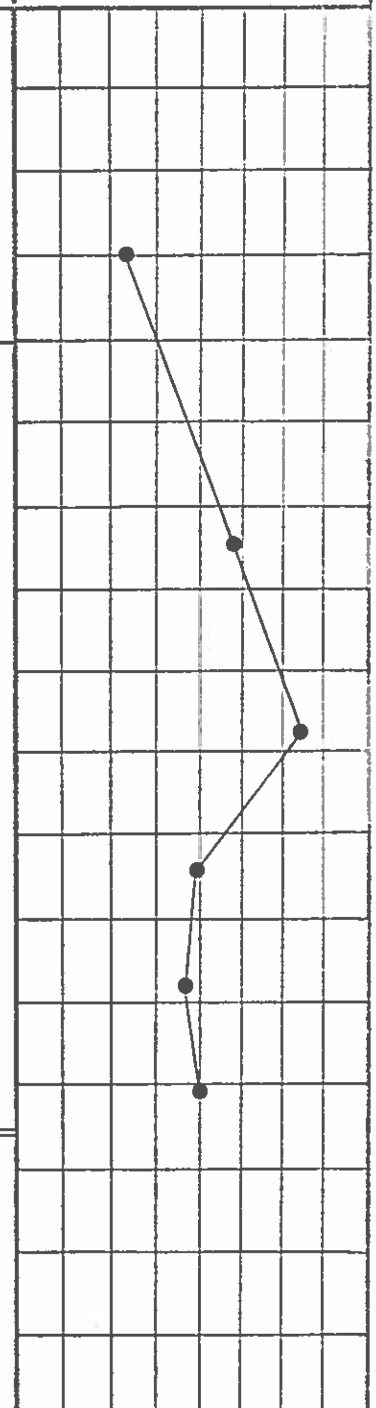
DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊖ / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
	SILT (Con't.)			
17				
18				
19				
20				
21				
22	SAND - med. brown - very fine grained - uniform		Nbn	
23				
24				
25				
26	SILT		Nbn-Nbe	
27				
28				
29				
30	END OF HOLE			

	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 7/77 LOGGED BY DK ELEVATION 1086.6 ft. DEPTH 30 ft.	BH 77-4 SHEET 2 of 2

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–3	SAND AND GRAVEL (FILL) - trace silt		UNFROZEN
3–4	SILT AND ORGANICS - black		
4	ORGANICS		FROZEN
4–7	SILT - lt. grey - mottled with lt. brown organics - some fine sand SAND 4% SILT 94% CLAY 2%		Nbn Nbn T = 29.8°F Nbn Nbe
7–8	SILT AND ORGANICS		Vr-Vs 35-45% T = 29.9°F
8–11	SILT - med. dk. brown - very organic - dk. grey - less organic		Vs 5-10% Vs 5-10%
11–13.5	SAND - med. grey - very silty - very fine grained & uniform - coarse sand lamination - organic		Nbe T = 29.4°F Vs 0-2%
13.5	END OF HOLE		

MOISTURE CONTENT % ⊙
SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT		
DAWSON CITY	DATE June 7/77 LOGGED BY DK ELEVATION 1048.8 ft. DEPTH 13.5 ft.	HOLE NO. BH 77-5 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊕ / SPT RESISTANCE △ (10 20 30 40 50 60 70)
0–1	GRAVEL & SAND (FILL) - very silty		UNFROZEN	
1–3	ORGANICS & SILT - black			
3–5	SILT - dark grey to brown - very organic		FROZEN	
5–6	γ_f=82 pcf		Vs 30 - 40%	120.2
6–8	- medium grey - very organic		Vs 45 - 55%	119 →
8–10	SAND & SILT - medium grey - organic		Vs 0 - 3% T = 30.4°F	
10–11	GRAVEL			
11	END OF HOLE			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

eba	PROJECT: DAWSON CITY	DATE: June 8, 1977 LOGGED BY: DK ELEVATION: 1047.0 ft DEPTH: 11 ft	HOLE NO.: BH 77-6 SHEET: 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE △ (10 20 30 40 50 60 70)
0–1	GRAVEL (FILL)		UNFROZEN	
1–6.5	SAND - med. lt. brown - fine - med. grained - some silt - silty - some organic laminations - lt. grey	sample 4.1–6.5	UNFROZEN (to approx. 4 ft) FROZEN Nbn	● approx. 27 at approx. 4.8 ft ● approx. 35 at approx. 5.8 ft
6.5–15	SAND AND GRAVEL - med. lt. brown - very silty		assumed frozen	● approx. 5 at approx. 12.5 ft
15	END OF HOLE			

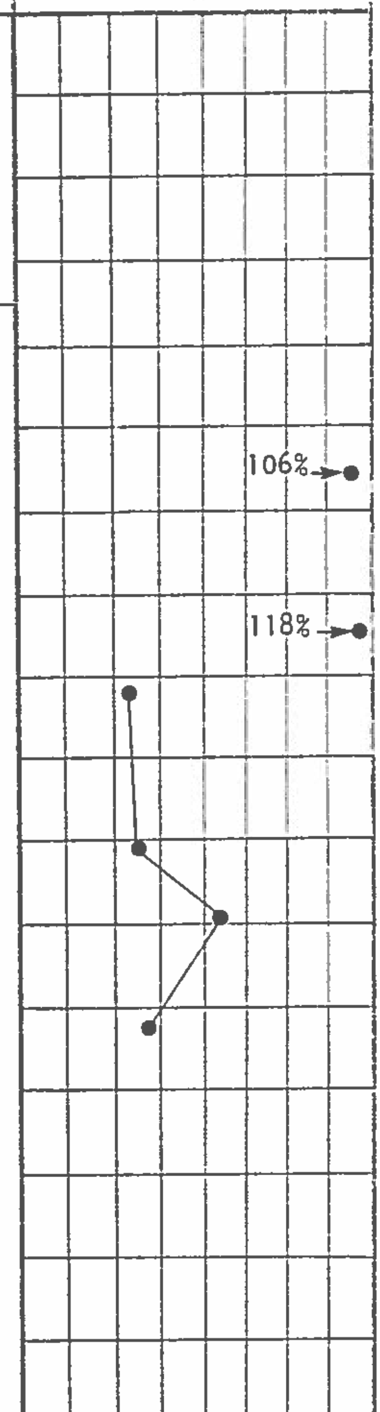
	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 7/77 LOGGED BY DK ELEVATION 1050.5 ft. DEPTH 15 ft.	BH 77-7 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–1	GRAVEL (FILL) - med. brown		UNFROZEN
1–3.5	SILT - black - very organic		
3.5–9	- dk. brown - very organic		FROZEN Nbn-Nbe
6			Vs 30%
7–8			Vs 10%
8–9			Vs 0-5% Nbe
9–11.5	- lt. grey - some sand - sand laminations - sandy - layers of brown organics		Vs 10-20%
11.5–14.5	SAND - med. grey - very silty - very fine grained, uniform		Vs 5-10%
14.5	GRAVEL		
	END OF HOLE		

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

MOISTURE CONTENT % ● SPT RESISTANCE ▲ 10 20 30 40 50 60 70



	PROJECT DAWSON CITY	DATE June 7/77 LOGGED BY DK ELEVATION 1081.1 ft DEPTH 14.5 ft	HOLE NO. BH 77-8 SHEET 1 of 1

eba

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % / SPT RESISTANCE (10 20 30 40 50 60 70)
0–1	GRAVEL & SAND (FILL) - silty		UNFROZEN	
1–3	SILT & ORGANICS - black - some wood chips			
3–5	SILT - med. grey - organics			
5–5.5	ORGANICS		FROZEN Nbn-Nbe T = 30.2°F Nbn	
5.5–7	ICE		ICE+ T = 31.2°F	
7–8.5	SILT - med. gr. brown - some organics - tr. fine gravel		Vs Vr 15-25%	
8.5–11	GRAVEL - med. brown - silty - wet returns			
11	END OF HOLE - sloughing at 11 feet			

eba	PROJECT DAWSON CITY	DATE June 8/77 LOGGED BY DK ELEVATION 1050.9 DEPTH 11 ft.	HOLE NO. BH 77-9 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % / SPT RESISTANCE (10 20 30 40 50 60 70)
0–1	SAND & GRAVEL (FILL) - very silty		UNFROZEN	
1–3	ORGANICS - some gravel; W.L. (≈2)			
3–11	SILT - dr. grey - some organics			
5–6		sample	FROZEN Vs 40-50% T = 30.4°F	151%
7		sample	Vs 50-60%	
8	- dk. grey black	sample	T = 30.6°F Vs 50-60%	254% 239%
10		sample	Vs 10-20% T = 31.2°F	97%
11–12.5	GRAVEL - fine to coarse - silty			
12.5	END OF HOLE - thermistor string installed			

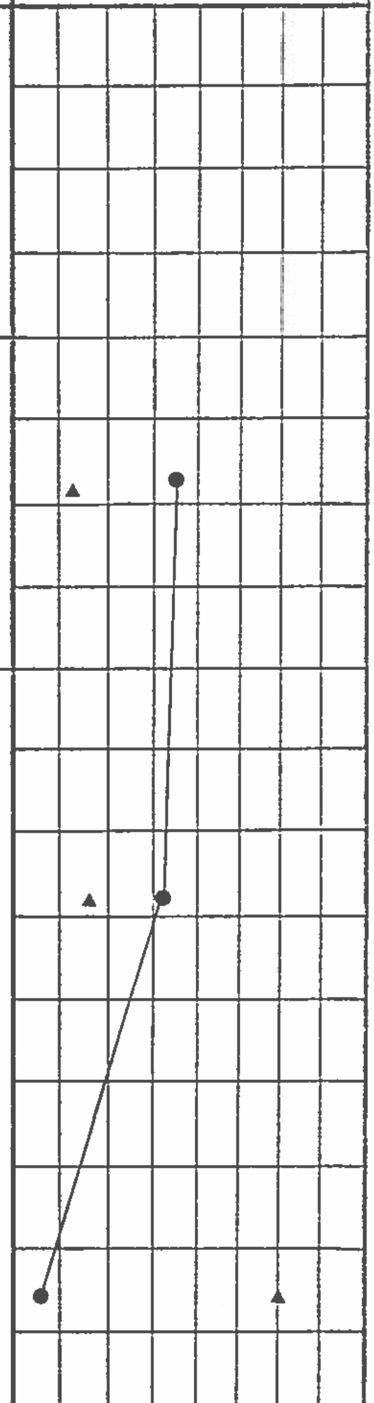
Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

eba	PROJECT DAWSON CITY	DATE June 8/77 LOGGED BY DK ELEVATION 1047.5 ft. DEPTH 12.5 ft.	HOLE NO. BH 77-10 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–2	GRAVEL (FILL) - med. brown - sandy, silty		UNFROZEN
2–10.5	SILT - dark grey - very sandy - organic - laminated SAND 21% SILT 76% CLAY 3%	X (5–6.5)	UNFROZEN (to 4); FROZEN (4–8); Nbn (at 6); UNFROZEN (8–)
10.5–12	SAND - dk. brown, silty, very organic	X (10–11.5)	
12–	GRAVEL & SAND slough level (14) - fine to med. grained gravel - coarse grained sand - some silt	X (15–16.5)	

MOISTURE CONTENT % ●
SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT		
DAWSON CITY	DATE June 9, 1977 LOGGED BY DK ELEVATION 1047.1 ft. DEPTH 20 ft.	HOLE NO. BH 77-11 SHEET 1 of 2

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % / SPT RESISTANCE (10 20 30 40 50 60 70)
	GRAVEL AND SAND (CONT)			
17	GRAVEL 55%			
	SAND 40%			
18	SILT 5%			
19				
20	END OF HOLE			

eba	PROJECT DAWSON CITY	DATE June 9, 1977 LOGGED BY DK ELEVATION 1047.1 ft. DEPTH 20 ft.	HOLE NO. BH 77-11 SHEET 2 of 2

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊕ / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
0–3	GRAVEL AND SAND (FILL) - med. brown - very silty (water level ▽ at approx. 2 ft)		UNFROZEN	
3–7	PEAT - wet - dark brown - fibrous - some silt - more silt		FROZEN Vr 30-40%	272%
7–7.5	SILT AND ORGANICS		Vr 5-10%	300%
7.5–8.7	ICE - 2" vertical wedge		T = 31.0°F	
9–11	SILT - med. lt. grey - some organics - γ_f = 89 pcf		Vs 15-25% Vs 10% Vs 25-35% T = 30.6°F	
11–12.6	SILT AND SAND - med. grey brown - sand is very fine, uniform grained		Vs 5-15%	
12.6–12.9	GRAVEL			
12.9	END OF HOLE			

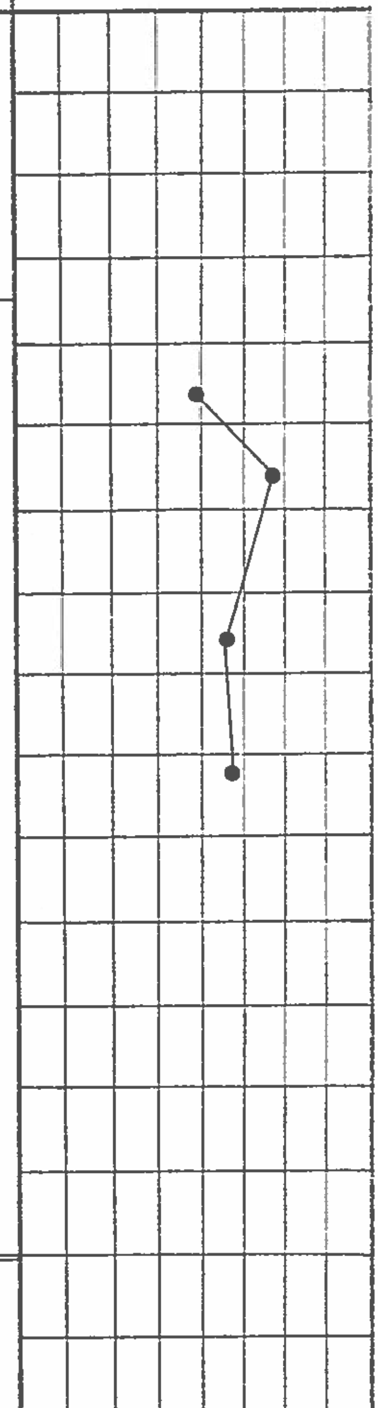
PROJECT	DATE	HOLE NO.
DAWSON CITY	June 8, 1977	BH 77-12
	LOGGED BY: DK	SHEET 1 of 1
	ELEVATION: 1050.4 ft	
	DEPTH: 12.9 ft	

eba

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–2	GRAVEL AND SAND - silty		UNFROZEN
2–2.5	SILT & ORGANICS		
2.5–3	PEAT		
3–3.4	SILT & ORGANICS		
3.4–5	SILT & SAND - med. grey - dk. brown organic laminat-ions		FROZEN Nbn T = 29.9°F
5–9.6	SILT - med. grey - some sand - some organics - γ_f = 102.4 pcf CLAY 3% SILT 83% SAND 14%		Nbe Vs 0-2% T = 29.8°F Vs 0-5% T = 29.8°F Nbe
9.6–15	GRAVEL AND SAND - very silty		Nbn-Nbe
15	END OF HOLE		

MOISTURE CONTENT % ◉
SPT RESISTANCE ▲
10 20 30 40 50 60 70



	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 8, 1977 LOGGED BY DK ELEVATION 1046.8 ft DEPTH 15 ft	BH 77-13 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
0 – 2	GRAVEL AND SAND - very silty		UNFROZEN	
2 – 3.5	PEAT - dk. brown - fibrous			
3.5 – 5.5	SILT - med. grey - some sand		FROZEN Nbe	●
5.5	END OF HOLE			

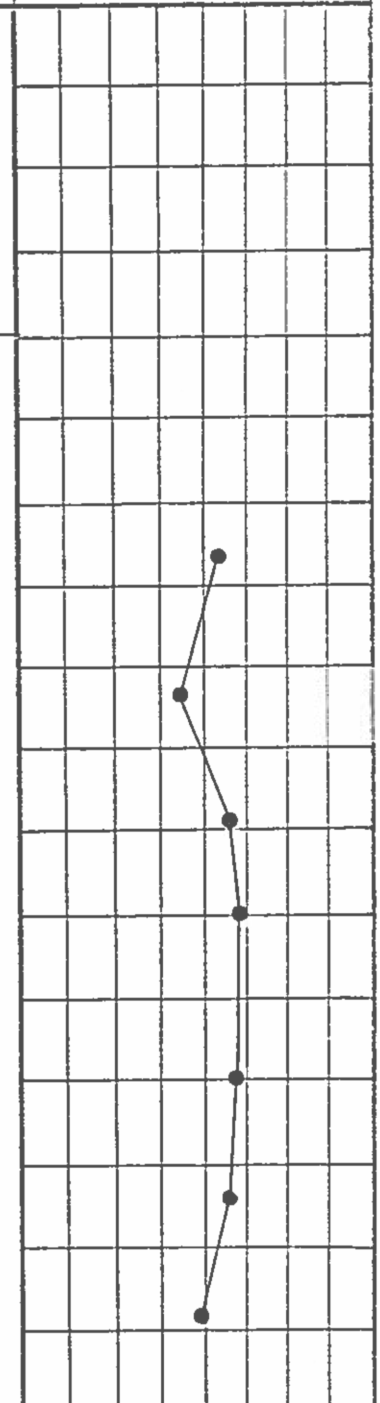
Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 9, 1977	BH 77-14
		LOGGED BY DK	SHEET
		ELEVATION 1044.5 ft.	1 of 1
		DEPTH 5.5 ft.	

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–1	GRAVEL (FILL) - silty - wet		UNFROZEN
2	ORGANICS		
3	SILT - black - organic		
4			FROZEN
5			
6	- med. grey - organic laminations		Nbn T = 29.6°F
7	- tr. fine sand		
8			
9			T = 30.8°F Vs 10-20%
10			T = 29.9°F Vs 10%
11	- γ_f = 106.7 pcf - med. brown - organics		T = 30.2°F Vs 0-10%
12	- sand		Vs 5-10% T = 29.7°F
13			
14			
14.5–15	SILT & SAND - med. grey		Nbe T = 29.7°F
16			

MOISTURE CONTENT % ⊙
SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT
DAWSON CITY

DATE June 9, 1977
LOGGED BY DK
ELEVATION 1047.4 ft.
DEPTH 19 ft.

HOLE NO.
BH 77-15

SHEET
1 of 2

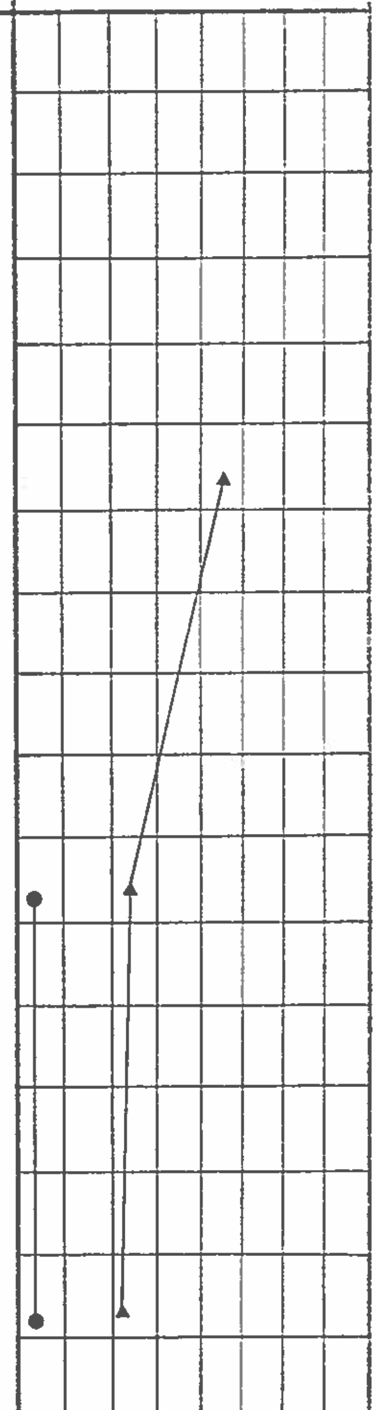
BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % / SPT RESISTANCE (10 20 30 40 50 60 70)
15–18	SILT & SAND (CONT) - dk. grey - sand laminations		Nbe	
18–19	GRAVEL			
19	END OF HOLE			
20				
21				

	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 9, 1977 LOGGED BY DK ELEVATION 1047.4 ft. DEPTH 19 ft.	BH 77-15 SHEET 2 of 2

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊖ SPT RESISTANCE ▲ 10 20 30 40 50 60 70
	GRAVEL (TALUS)		UNFROZEN	
1	- med. lt. grey - coarse grained - silty, sandy			
2				
3				
4				
5		X		
	- lt. grey	X		
6				
7				
8				
9				
10	- very silty - sandy	X		
11	GRAVEL 72.7% SAND 19.7% SILT 7.6%	X		
12				
13				
14				
15		X		
16	- sandy - silty	X		

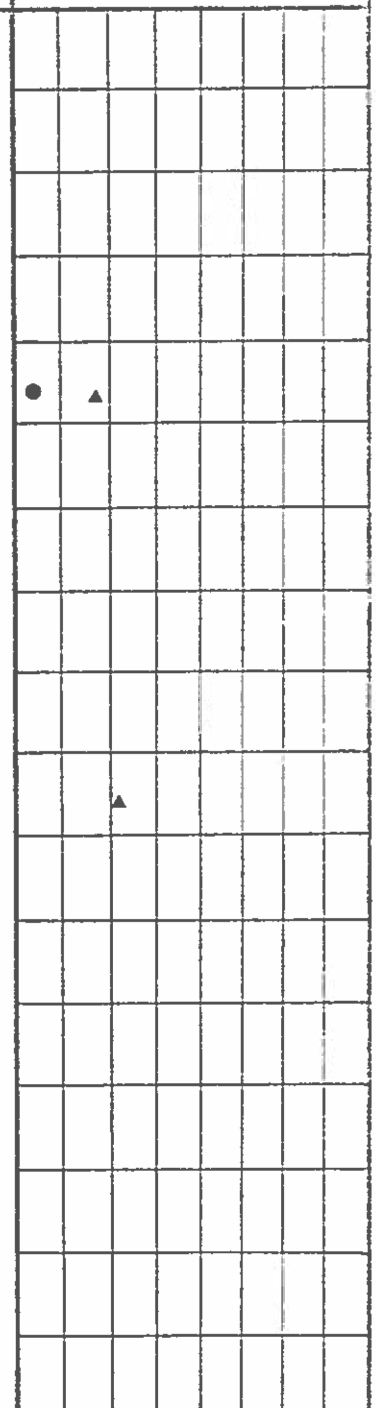


eba	PROJECT: Dawson City	DATE: June 10, 1977 LOGGED BY: DK ELEVATION: 1084.6 ft. DEPTH: 35 ft.	HOLE NO.: BH 77-18 SHEET: 1 of 3

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
	GRAVEL (CONT) - med. dk. grey - sandy, med-coarse - cobbly - rounded particles		
17			
18			
19			
	SILT - lt. grey - sandy, gravelly		
20		X	
21			
22			
23	W.l. June 14		
24			
25		X	
	- med. brown - sand, gravelly - 6" weathered schist - very soft		
26			
27			
	- tr. asbestous		
28			
29			
30			
31			
32			

MOISTURE CONTENT % ●
SPT RESISTANCE ▲
10 20 30 40 50 60 70



eba	PROJECT DAWSON CITY	DATE June 10, 1977 LOGGED BY DK ELEVATION 1084.6 ft DEPTH 35 ft	HOLE NO. BH 77-18 SHEET 2 of 3

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
33 34 35 36	SILT - med. brown grey - very gravelly - sandy - with weathered schist	X (35–36)		● ▲ (at ~35.5 ft)
	END OF HOLE			

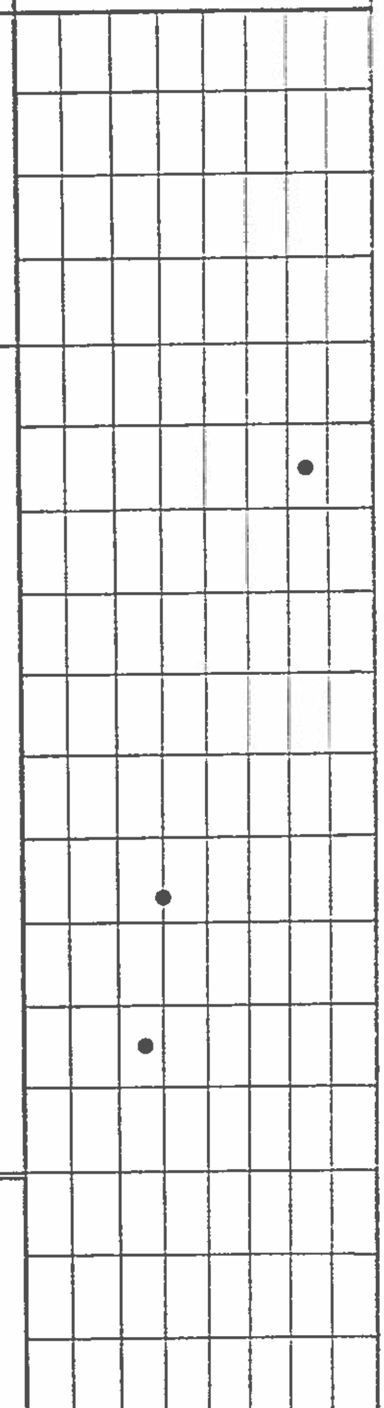
	PROJECT		HOLE NO.
eba	DAWSON CITY	DATE June 10, 1977 LOGGED BY DK ELEVATION 1084.6 ft. DEPTH 35 ft.	BH 77-18 SHEET 3 of 3

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0 – 4	GRAVEL (FILL) - med. grey - silty - sandy		UNFROZEN
4 – 6	ORGANICS - dk. brown	sample (5 – 6.5)	FROZEN
6 – 9	SILT - dk. grey to black - very organic		Nbn
9 – 14	SAND - med. brown - fine to med. grained - uniform - very silty - silt beds (6") - very organic SAND 73% SILT 27%	sample (10 – 13.4)	Nbe Nbe T = 30.8°F
14	END OF HOLE - encountered gravel		

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

MOISTURE CONTENT % ●
SPT RESISTANCE ▲
10 20 30 40 50 60 70



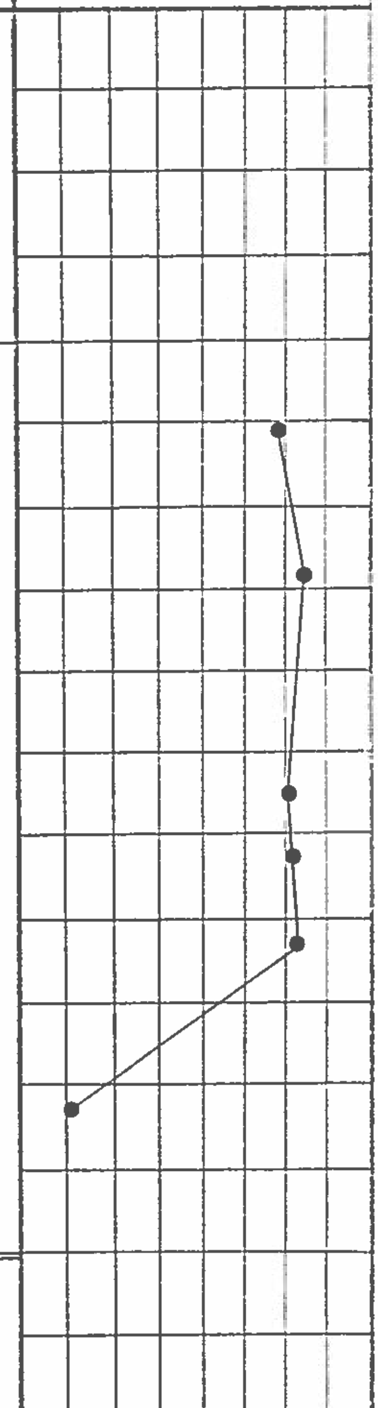
PROJECT			
DAWSON CITY	DATE: June 10, 1977 LOGGED BY: DK ELEVATION: 1046.0 ft. DEPTH: 14 ft.	HOLE NO. BH 77-19	SHEET 1 of 1

eba

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–3.5	GRAVEL (FILL) - med. brown - very silty		UNFROZEN
3.5–5	ORGANIC - black - fibrous		FROZEN
5–9	SILT - med. grey - tr. sand - very organic, laminations - dk. grey - sandy - organics		Nbn T = 29.9°F Vs 0-10% T = 30.2°F Vs 10-30% T = 29.7°F Vs 0-5%
9–10	SAND - silty		Nbe T = 30.4°F
10	SILT AND SAND		Nbn
10–12	SAND AND SILT . - coarsly bedded (6") - dk. grey		Sand - Nbe Silt Vs 0-2%
12–12.5	SILT - med. brown, organics		Vs 5-10%
12.5–15	GRAVEL - med. brown - fine to coarse grained - very silty		
15	END OF HOLE Thermistor String 242 installed		

MOISTURE CONTENT % ●
SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT		
DAWSON CITY	DATE June 10, 1977 LOGGED BY DK ELEVATION 1045.2 ft. DEPTH 15 ft.	HOLE NO. BH 77-20 SHEET 1 of 1

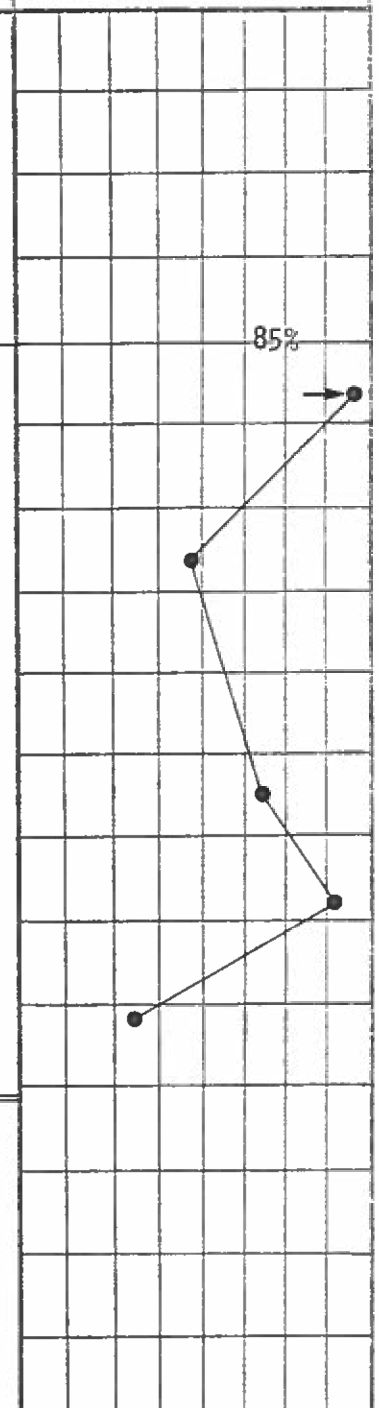
eba

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–1	GRAVEL (FILL) - silty		UNFROZEN
3	ORGANICS		
4	SILT - dk. med. grey - very organic to 4.5 ft - med. grey - tr. sand - some organics		FROZEN Vr 30% T = 30.1°F
6			Vr-Vx 50% T = 29.7°F
8			Vs 20-30%
9			Vs 20-30% T = 30.3°F
10	- med. brown - sandy - some 2" sand bedds		Vs 30% T = 30.2°F Vs 20%
11			Vs 10-20%
13	- 1" oxidized fine sand bed GRAVEL		

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

MOISTURE CONTENT % ⊖
SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT DAWSON CITY

DATE June 10, 1977
LOGGED BY DK
ELEVATION 1047.9
DEPTH 13 ft

HOLE NO. BH 77-21

SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
0–2	GRAVEL AND SAND - med. brown - very silty		UNFROZEN	
2–3.5	SILT AND ORGANICS (water level ▽)		FROZEN (from approx. 3 ft)	
3.5–4	SILT - very organic		T = 30.1°F Nbn - Nf	
4–5	SAND - very silty - tr. gravel			● approx. 4.5 ft
5–8	SILT - very organic - med. grey - med. brown		Nbe Vs 20-30% T = 29.4°F Vs 50-65% T = 30.1°F	162% → ● (approx. 5.8 ft) ● approx. 7.2 ft
8	END OF HOLE CORE BARREL FROZE IN			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

eba	PROJECT DAWSON CITY	DATE June 11, 1977 LOGGED BY DK ELEVATION 1048.9 ft. DEPTH 8 ft.

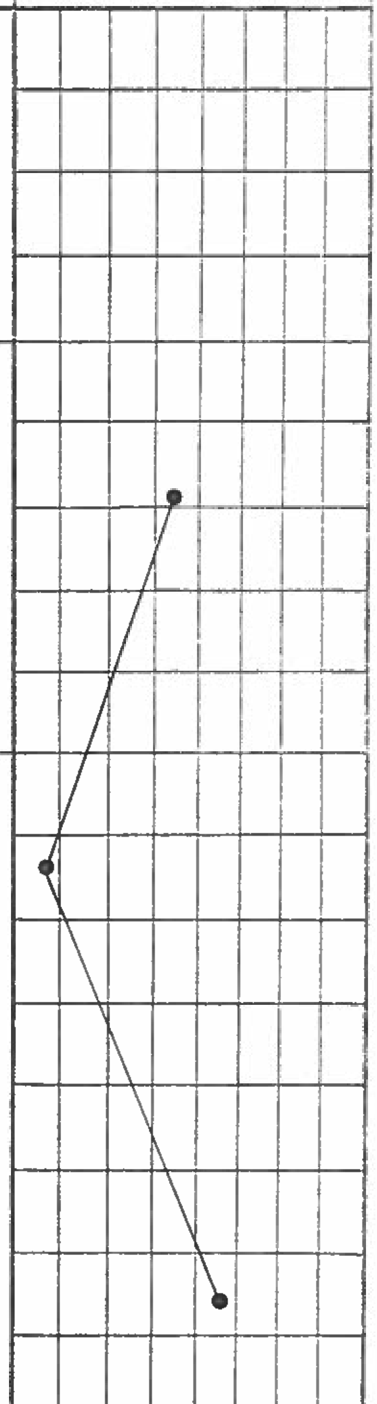
HOLE NO. BH 77-22

SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–3	GRAVEL (FILL) - silty & sandy		UNFROZEN
3–9	SILT - med. to dk. grey - organic - cobble	X (5–6.5)	FROZEN (from ~4) Nbn excess ice
9–11	GRAVEL	X (10–10.6)	Presumed frozen
11–17	SILT - interbedded silty sand and sandy silt	X (15–16.4)	Nbe

MOISTURE CONTENT % ● / SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT: DAWSON CITY

DATE: June 11, 1977
LOGGED BY: DK
ELEVATION: 1045.1 ft.
DEPTH: 24.5 ft.

HOLE NO.: BH 77-23

SHEET 1 of 2

BOREHOLE LOG
PERMAFROST REGION

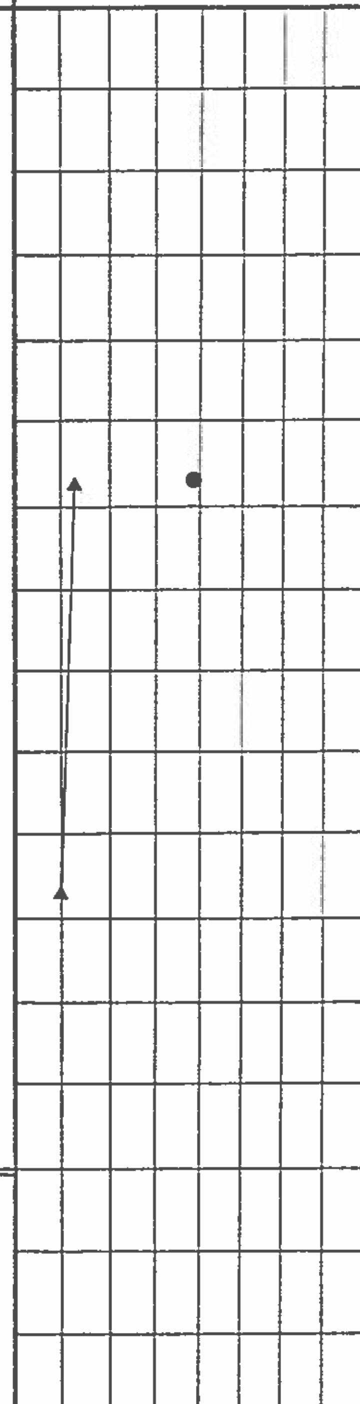
DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % / SPT RESISTANCE (10 20 30 40 50 60 70)
	SILT (CONT.)		high ice content from cuttings	
17				
18				
19				
20				
21				
22				
23				
24				
	GRAVEL			
25	END OF HOLE			

	PROJECT	DATE	HOLE NO.
eba	DAWSON CITY	June 11, 1977	BH 77-23
		LOGGED BY DK	SHEET
		ELEVATION 1045.1 ft.	2 of 2
		DEPTH 24.5 ft.	

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
0–3.5	GRAVEL AND SAND - very silty - well graded		UNFROZEN	
3.5–14	SAND W.L. June 14 - med. dk. brown - med. grained - uniform - silty with silt laminations SILT 36% SAND 64% - fine grained - tr. gravel - silty - rock	X (5–6.5) X (10–11.5)	▽ (approx. 4 ft)	
14	END OF HOLE NOTE: coarse, hard rock on surface to river side.			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16



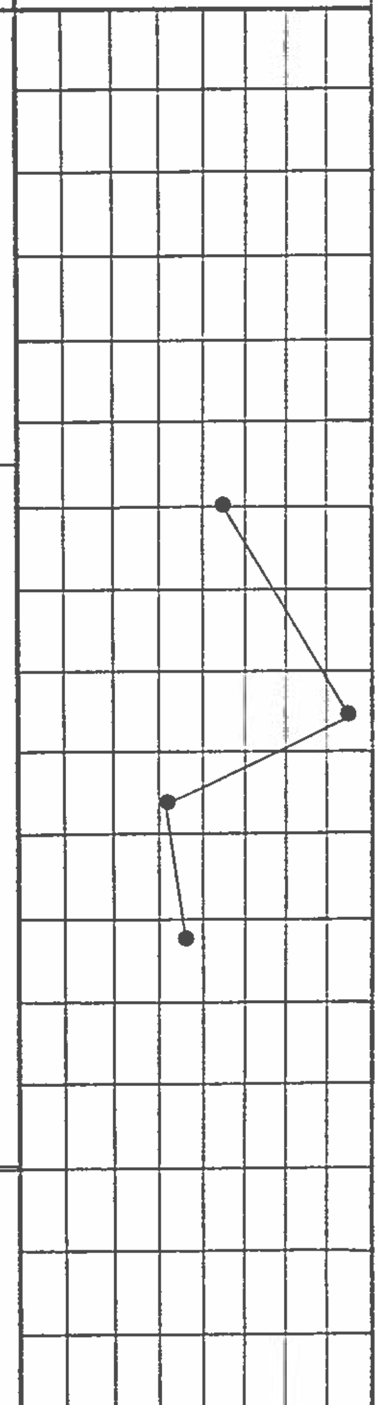
PROJECT			HOLE NO.
DAWSON CITY	DATE	June 11, 1977	BH 77-24
	LOGGED BY	DK	SHEET
	ELEVATION	1039.4 ft.	1 of 1
	DEPTH	14 ft.	

eba

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION
0–2	SAND AND SILT (FILL) - light brown		UNFROZEN
2–5	ORGANICS & SILT - black - moist		
5–5.5	ORGANICS		
5.5–12.5	SILT - med. to light grey - brown organic laminations - med. grey - 6" of fibrous peat - dk. grey CLAY 3% SILT 77% SAND 20% - some fine sand		FROZEN Nbn-Nbe Vs-Vr 10% Vs 30-40% Vs 60-80% Vs 30% Vs 30-40%
12.5–14	GRAVEL		
14	END OF HOLE		

MOISTURE CONTENT % ⊕
SPT RESISTANCE ▲
10 20 30 40 50 60 70



PROJECT	DAWSON CITY
	NCPC RESIDENCE
DATE	June 8, 1977
LOGGED BY	DK
ELEVATION	-
DEPTH	14 ft.
HOLE NO.	BH 77-25
SHEET	1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
0–1	PEAT		UNFROZEN	
1–3	SILT - medium grey brown - moist			
3–14	SAND AND SILT - medium grey - laminated	☒ (≈5–6)	FROZEN Nbn-Nbe	
	- dark grey - organics - laminated	☒ (≈10–11)	Nbe	
14–17	SAND - medium grained - very silty - trace gravel	☒ (≈15–16)	Nbn-Nbe	
17–19	GRAVEL			
19	END OF HOLE			

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32

eba	PROJECT YUKON HOTEL DAWSON CITY	DATE June 9 LOGGED BY DK ELEVATION DEPTH 16 ft.	HOLE NO. BH 1 SHEET 1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ● / SPT RESISTANCE ▲ (10 20 30 40 50 60 70)
0–2	PEAT and SILT - medium to dark brown		UNFROZEN	
2–7	SILT - dark grey - very organic - very sandy		FROZEN Nbe, Vs 0-2%	
7–10	SAND and SILT - medium grey - organic laminations		Nbe Tr. Vs	
10–16	SILT - gravelly			
16–24	GRAVEL and SAND - medium brown - silty		assumed thawed	
24	END OF HOLE			

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32

PROJECT: YUKON HOTEL, DAWSON CITY

DATE: June 11
LOGGED BY: DK
ELEVATION:
DEPTH: 24 ft.

HOLE NO.: BH 2

SHEET: 1 of 1

The following Borehole Logs

are from

EBA, 1972

The elevations shown on the logs are 3 feet too high

PROJECT	Dawson (S.W. Corner 4th Ave. & King St.)	TESTHOLE No. 1
SURFACE ELEVATION	1050.6'	JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description	Water Content % ⊖ (10 20 30 40)	Temperature °F (10 15 20 25 30 35 40)
0–2	FILL - clay rubble some gravel			
2–2.5	PEAT			
2.5–9	SILT - sandy, grey organic - peat & roots - fossil shells	Nbn (2.5–6.5) Nbe - Vs 10% (6.5–7) Permafrost Nbe - Vs 15 - 20 % (7–8) Nbe - Vs 10% (8–9)	52 (at ~6); 93 (at ~7.5)	
9–11	SAND - silty, medium brown - cohesive, some gravel	Nbn		
11	GRAVEL			

Completion Depth 11.0'

Date Apr. 18/72

Depth to Water in Boring: Dry

Page 1 of 1

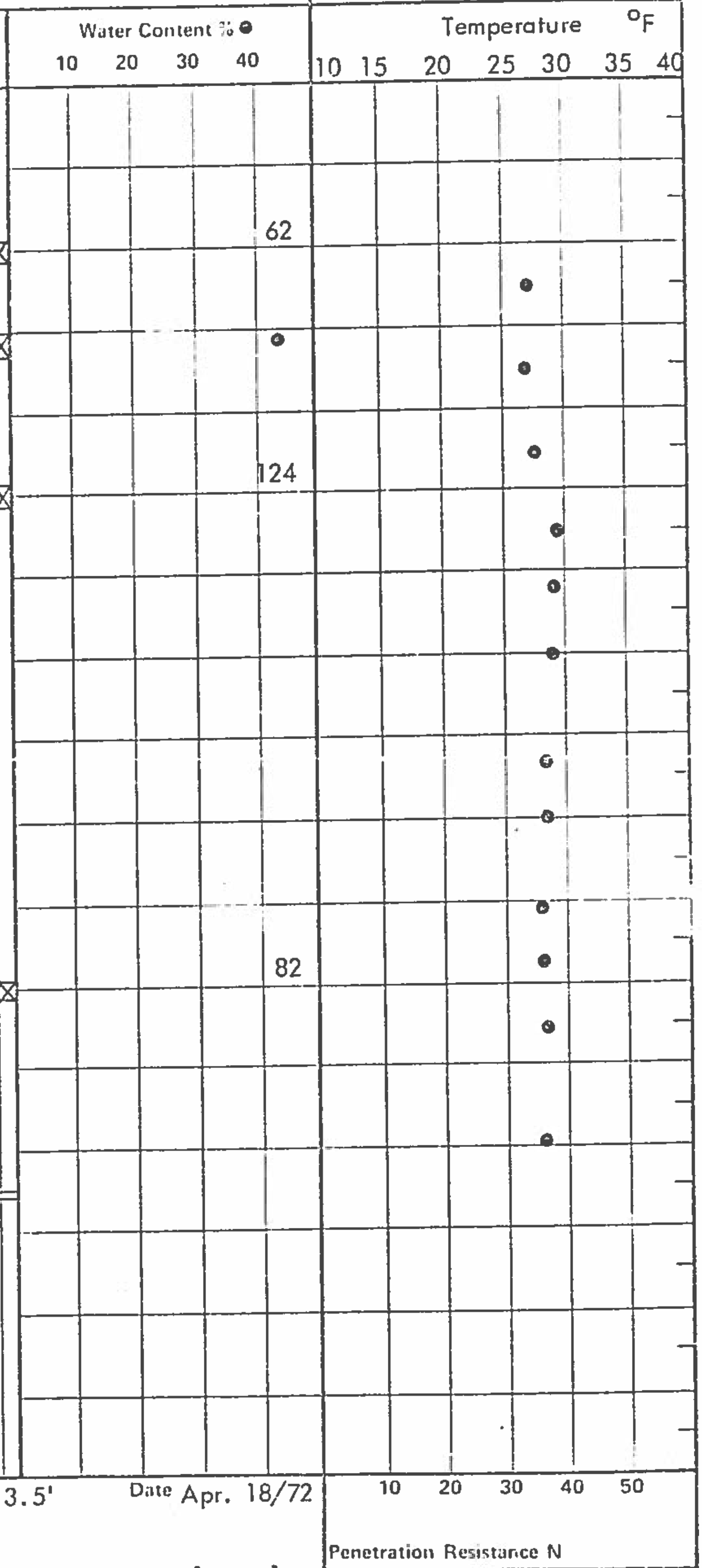
Penetration Resistance N (10 20 30 40 50)

Dwg. No.

BROOKER & ASSOCIATES

PROJECT	Dawson (Old Bonanza Hotel)	TESTHOLE No.	2
SURFACE ELEVATION	1052.1'	JOB No.	E - 383 - C

Depth ft.	Soil Description	Ice Description
0–2	FILL - clay, gravel roots & sawdust	frozen Nbn
2–3.5	SILT - sandy, organic grey - some peat	
3.5–5		Vs 5-10% hairline ice
5	O.C. = 13.9%	Vs 10 - 15 %
9.5–10.5		Vs 15%
10.5–12.2	25 % sand 70 % silt 5 % clay	Vs 20 - 25 % hairline ice
12.2–13.5		Nbe
13.5	GRAVEL	



Completion Depth 13.5'

Date Apr. 18/72

Depth to Water in Boring Dry

Page 1 of 1

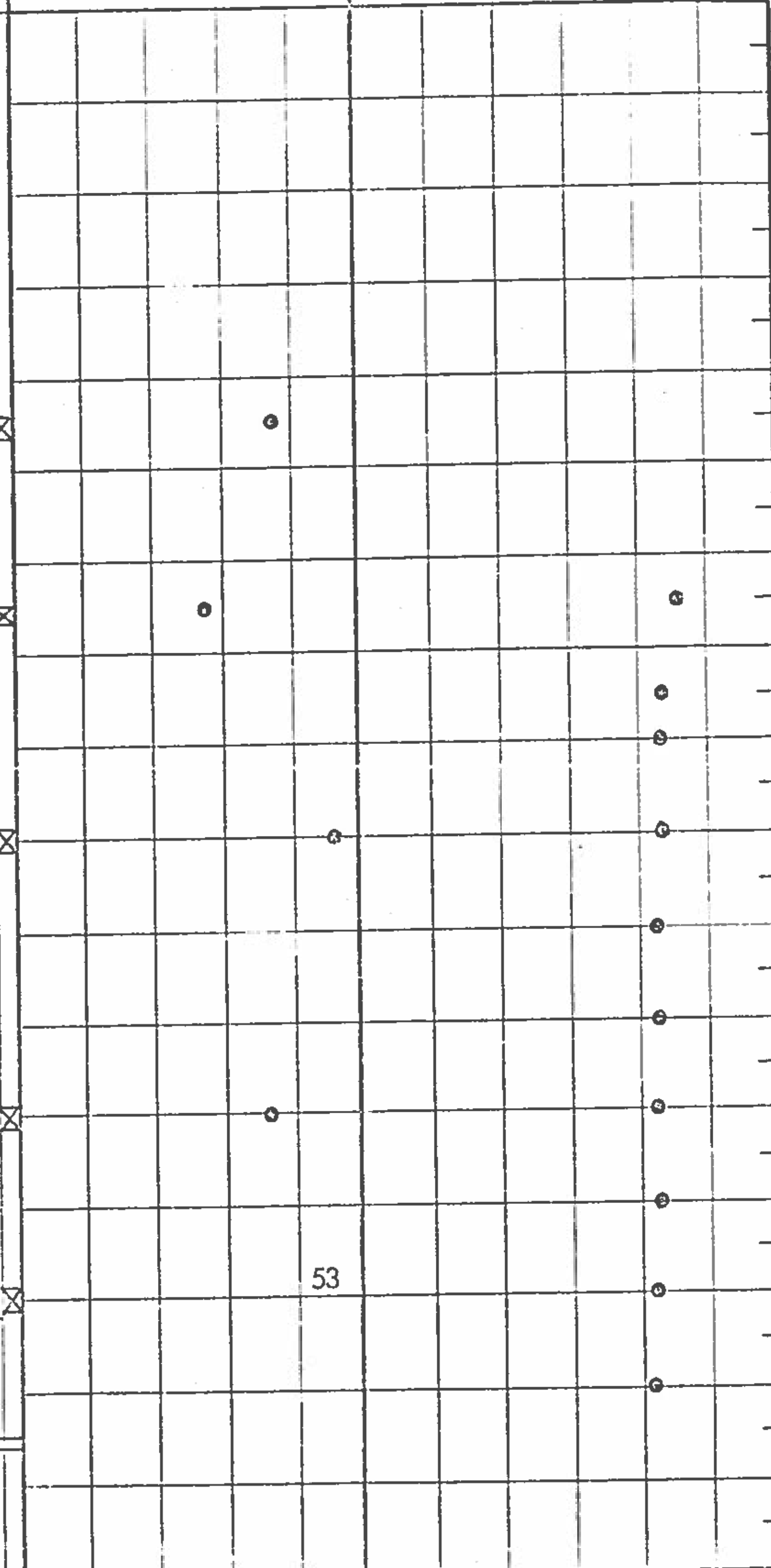
Dwg. No.

BROOKER & ASSOCIATES

PROJECT	Dawson (Old Winault's Store)	TESTHOLE No.	3
SURFACE ELEVATION	1050.6'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
1 – 4	FILL - clay, sandy cobbles, roots & wood, light brown - silty, medium brown	
5 – 7	SILT - sandy, pebbles roots, peat & shells, medium brown	
8 – 11	- medium grey - 1/4" gravel lens	Vc 5%
12 – 13	sand layers in silt	Vc 5 - 10 %
13 – 14		Vr 5 - 10 %
14 – 15.5		Vc 5 %
15.5	GRAVEL OR SAND	

Water Content % ● 10 20 30 40 | Temperature °F 10 15 20 25 30 35



10 20 30 40 50

Penetration Resistance N

Completion Depth 15.5' | Date Apr. 19/72

Depth to Water in Boring Dry | Page 1 of 1

Dwg. No.

BROCKER & ASSOCIATES

PROJECT	Dawson (Old Post Office)	TESTHOLE No.	4
SURFACE ELEVATION	1051.6'	JOB No.	E - 381 C

Depth ft.	Soil Description	Ice Description	Water Content % ● (10 20 30 40)
0 – 2	FILL - clay, bricks, roots, wood, pebbles, sawdust medium brown	frozen Nbn (seasonal)	
2 – 2.3	PEAT - medium brown		
2.3 – 12	SILT - organic, some peat, medium brown, nonplastic OC=15.3% 18% sand 77% silt 5% clay -some fine sand, shells grey O.C.=11.1% non plastic no recovery (10 – 12)	3.4 – 4.4: thawed 4.4 – 5: frozen Nbn (permafrost) 5 – 5.8: Vx - Vs 5 - 10 % 5.8 – 7.9: Vs 25% 7.9 – 9.8: Vs 20% some Vx + Vc	4.8: 80 5.8: 67 6.8: 86 7.8: 72 8.8: 64 13.4: ●
12 – 17	GRAVEL - sandy, some silt, grey (hole sloughed to 12.5')	frozen Nbn	

Temperature °F: 10 15 20 25 30 35

Penetration Resistance N: 10 20 30 40 50

△ Sensor Readings April 30/72

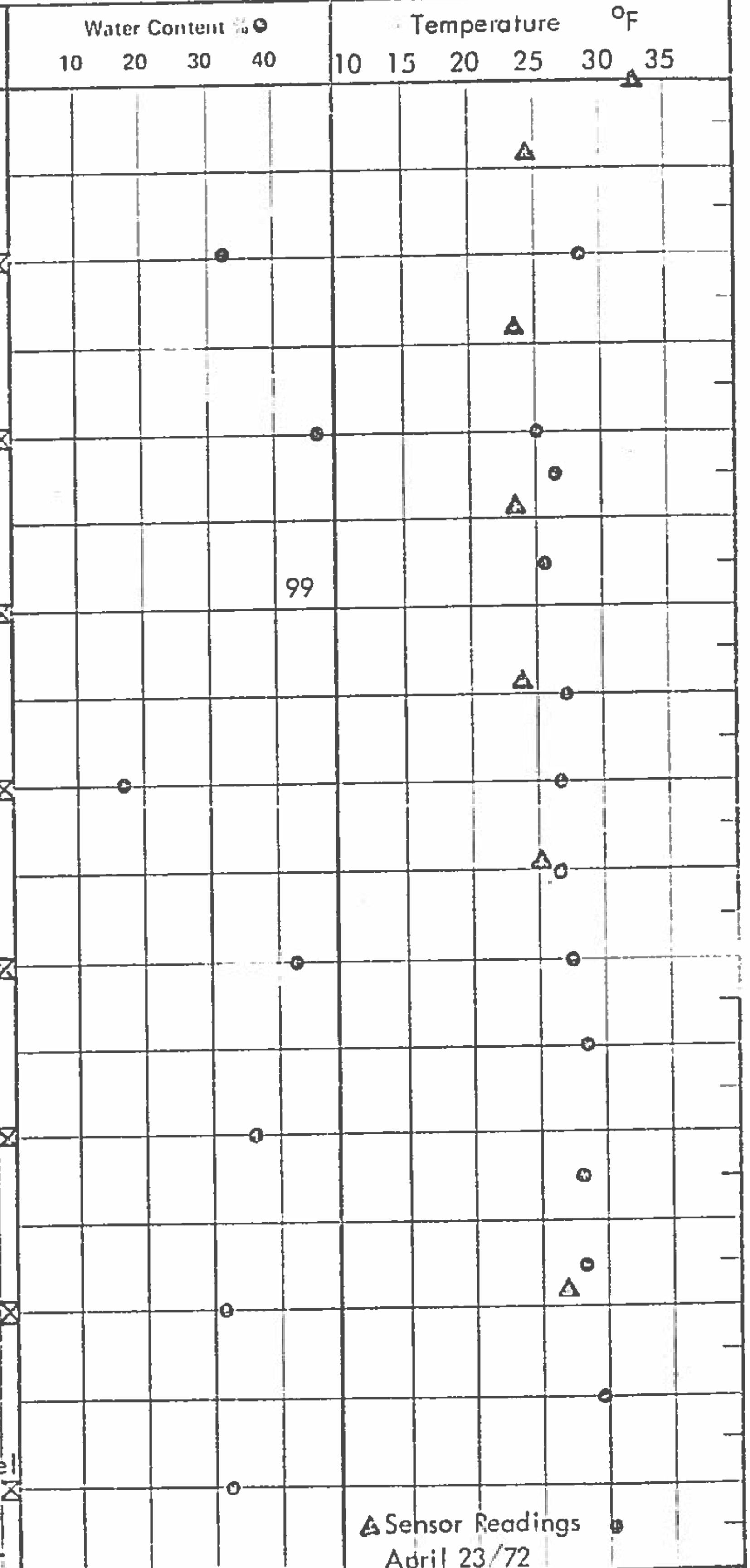
● Soil Sample Temperature April 19/72

BROOKER & ASSOCIATES	Completion Depth 17.0'	Date April 19/72	Penetration Resistance N
	Depth to Water in Boring Dry	Page 1 of 1	Dwg. No.

PROJECT	Dawson (Red Feather Saloon)	TESTHOLE No. 5
SURFACE ELEVATION	1048.5'	JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
0–1.5	FILL - clay rubble, wood & steel	frozen
1.5–1.9	PEAT - some cobbles & rubble	
1.9–7.6	SILT - organic, grey some peat	Nbn (2–4); Vs 5 % ... 20 % (4–6); Vs 10 - 15 % (6–7.6)
7.6–7.9	SAND - silty grey	Vc 10% some Vx
7.9–8.3	SILT - sandy, grey	
8.3–17	SAND - silty, grey - peat & sand lenses - interbedded peat O.C. = 5.9% [52 % sand 40 % silt 8 % clay] - 3" tree root - medium brown some silt - medium brown to grey, fine sand - medium - coarse, medium brown, occ. pebble	Vx 15% (8.3–9.8); Nbn (9.8–17); 2 % gravel 98 % sand
17	GRAVEL	

Depth: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17



BROOKER & ASSOCIATES	Completion Depth 19.0'	Date Apr. 20/72	
	Depth to Water in Boring Dry	Page 1 of 2	Dwg. No.

PROJECT	Dawson (Red Feather Saloon)	TESTHOLE No. 5
SURFACE ELEVATION	1048.5'	JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description	Water Content % (10 20 30 40)	Temperature °F (10 15 20 25 30 35)
18	GRAVEL (no core)			
19				⚠
	Hole sloughed to 17.0'			

⚠ Sensor Readings April 23/72

Penetration Resistance N: 10 20 30 40 50

BROOKER & ASSOCIATES

Completion Depth 19.0' Date Apr. 20/72

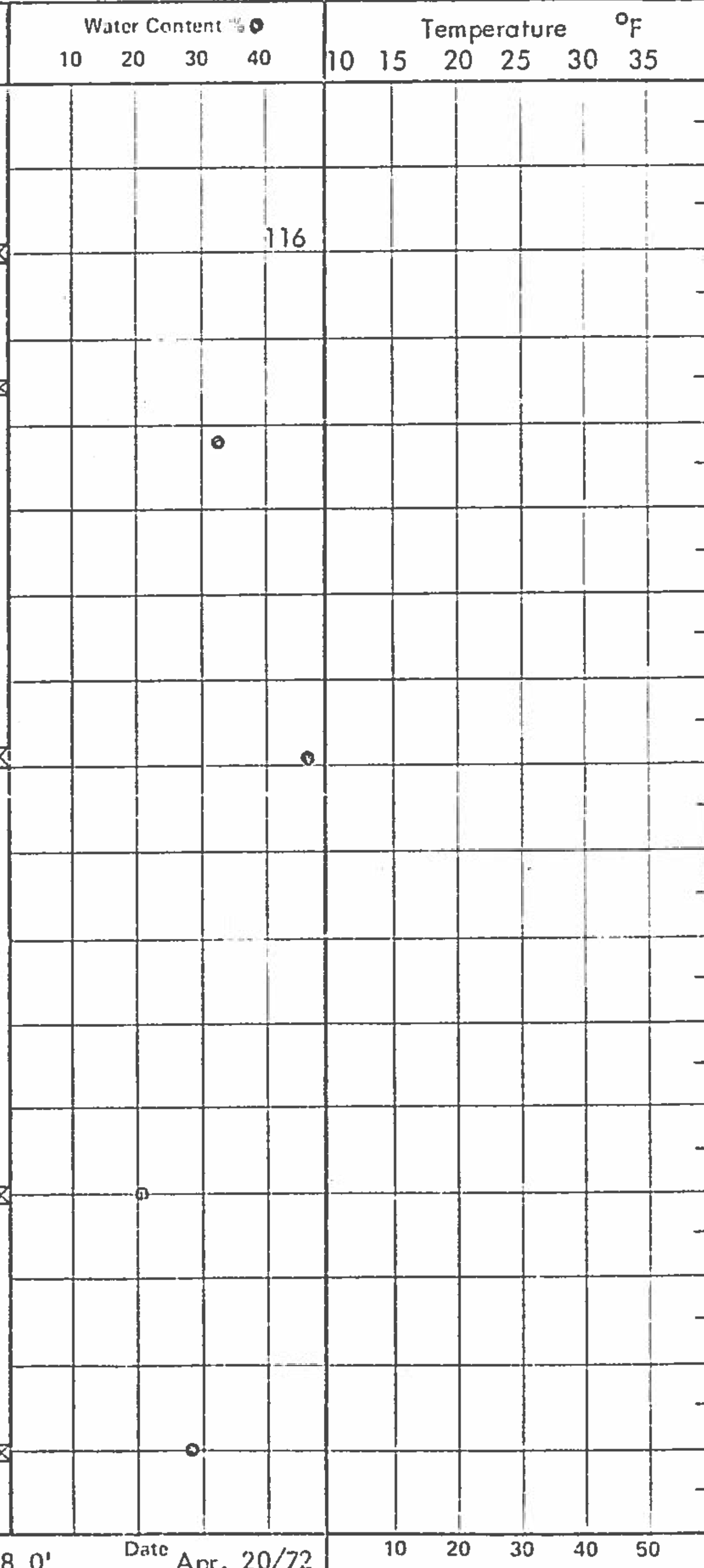
Depth to Water in Boring Dry

Page 2 of 2

Dwg. No.

PROJECT	Dawson (Ruby's Place)	TESTHOLE No. 6
SURFACE ELEVATION	1049.4'	JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
0 – 2.3	FILL - clay, rubble gravel, ashes wood	
2.3 – 2.6	PEAT - dark brown	
2.6 – 3.2	NO RECOVERY	
3.2 – 7.8	SILT - sandy, some peat, grey - laminated peat O.C. = 7.7 %	Nbn (3.2 – 6.1) Nbn to Vr 5 % (6.1 – 7.8)
7.8 – 10.0	SAND - silty, grey laminated peat - medium brown	Nbn (7.8 – 8.2)
10.0 – 10.5	SILT - some sand & peat	Vc 0-5%
10.5 – 12.1	SAND - silty, laminated with peat, grey	Nbn
12.1 – 12.5	GRAVEL	
12.5 – 18.0	SAND - silty, grey, some gravel - tree roots - some pebbles & occ. rock	Vc 10 - 15 % (13.4 – 14.6) Vc 5 - 10 % (14.6 – 16.5) Nbn (16.5 – 17)



BROOKER & ASSOCIATES	Completion Depth 18.0'	Date Apr. 20/72	
	Depth to Water in Boring Dry	Page 1 of 2	Dwg. No.

PROJECT	Dawson (Ruby's Place)	TESTHOLE No.	6
SURFACE ELEVATION	1049.4'	JOB No.	E - 381 - C

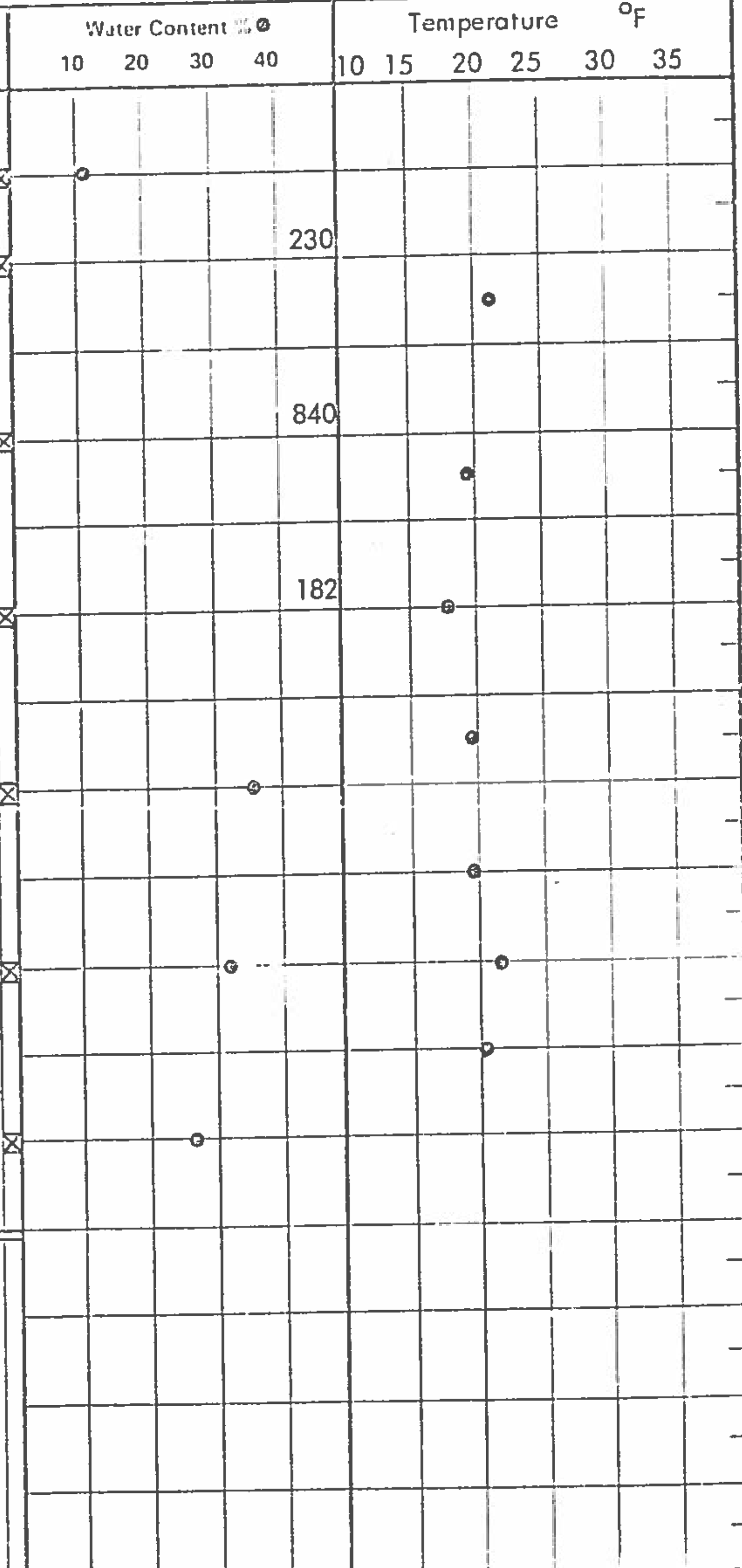
Depth ft.	Soil Description	Ice Description	Water Content % (10 20 30 40)	Temperature °F (10 15 20 25 30 35)
	SAND - grey silty some gravel	Nbn		
18	GRAVEL			

Completion Depth	18.0'	Date Apr. 20/72	Penetration Resistance N (10 20 30 40 50)
Depth to Water in Boring	Dry	Page 2 of 2	Dwg. No.

BROOKER & ASSOCIATES

PROJECT	Dawson (Proposed Arena)	TESTHOLE No.	7
SURFACE ELEVATION	1052.5'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
0 – 1.4	FILL - sand & gravel	frozen Nbn
1.4 – 3.5	PEAT - dark to medium brown	Nbn
3.5 – 4.8	PEAT	Vx 30 - 35 %
4.8 – 7.1	PEAT	Vr to Vx 30 - 35 %
7.1 – 8.1	SILT - grey	Vs to Vr 25 %
8.1 – 9.4	SILT [9 % sand 85 % silt 6 % clay]	Vr 25%
9.4 – 11.3	- occ. pebbles - some interbedded peat	Vr 20%
11.3 – 13.2	- sandy, some gravel	
13.2 –	GRAVEL	



Completion Depth	13' 2"	Date	Apr. 20/72
Depth to Water in Boring	Dry	Page 1 of 1	

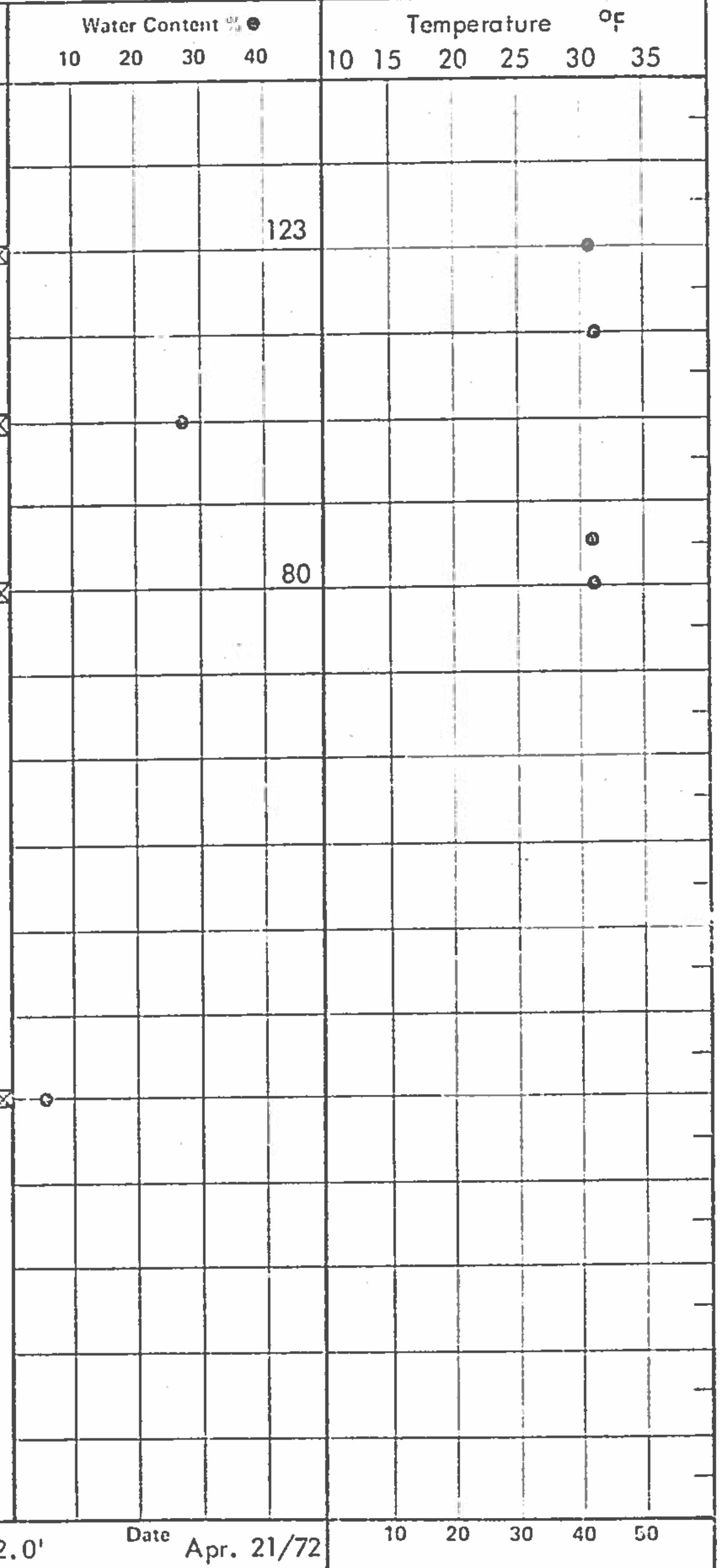
Penetration Resistance N: 10 20 30 40 50

Dwg. No.

BROOKER & ASSOCIATES

PROJECT	Dawson (Proposed Arena)	TESTHOLE No.	8
SURFACE ELEVATION	1048.4'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
0–3	PEAT - sand & pebbles - medium to dark brown - some gravel & glass	frozen Nbn; Vx 5%
3–7.5	SILT - sandy, brown to grey; NO RECOVERY (approx. 6.3–7.7)	Vr 10%
7.5–12	GRAVEL - silty sandy grey	
12	Hole sloughed to 9.0'	



Completion Depth	12.0'	Date	Apr. 21/72
Depth to Water in Boring	Dry	Page	1 of 1

BROOKER & ASSOCIATES

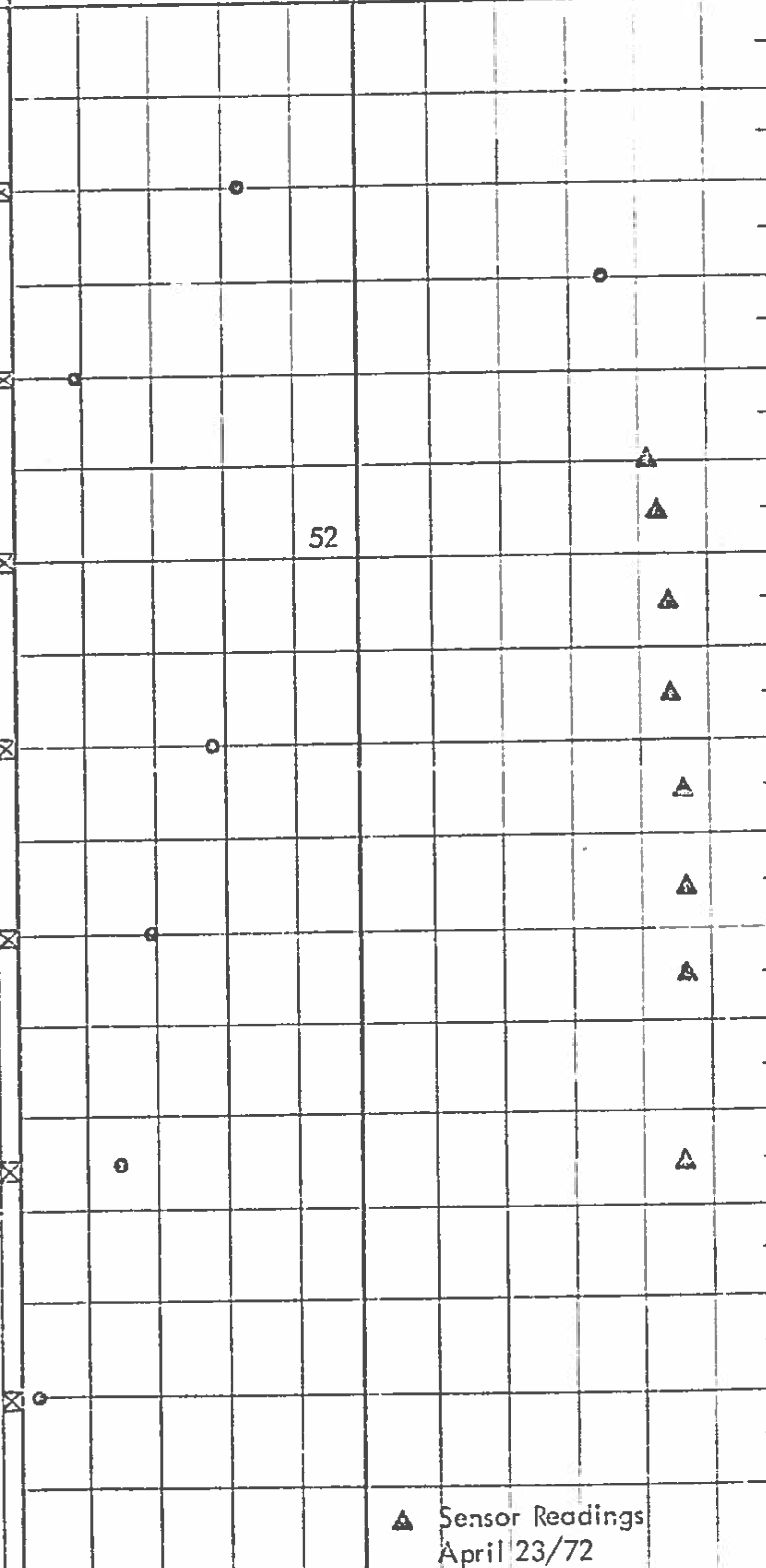
Dwg. No.

PROJECT	Dawson (Commissioner's Residence)	TESTHOLE No.	9 & 9A
SURFACE ELEVATION	1046.7'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
0–2	SILT - organic, medium brown, roots	frozen Nbn
2–4	- medium brown to grey, sandy laminated peat	Nbn some ice coatings on peat particles
4–6	SAND - silty, dry medium brown 62 % sand & gravel 32 % silt 6 % clay	Nf
6–6.8	SILT - sandy, grey interbedded peat	
6.8–13	SAND - silty, medium brown - some peat - some gravel	unfrozen
13–17	GRAVEL - no penetration TH 9 TH 9A drilled to 19.75' hole sloughed to 12.5' 19 % gravel 67 % sand 14 % silt	

Water Content % ● : 10 20 30 40

Temperature °F : 10 15 20 25 30 35



Penetration Resistance N : 10 20 30 40 50

Completion Depth	#9 = 13.0' #9A = 19.75'	Date	Apr. 21/72
Depth to Water in Boring	Dry	Page	1 of 2

Dwg. No.

BROOKER & ASSOCIATES

PROJECT Dawson (Commissioner's Residence)				TESTHOLE No. 9A
SURFACE ELEVATION 1046.7'				JOB No. E - 381 - C
Depth ft.	Soil Description	Ice Description	Water Content % 10 20 30 40	Temperature °F 10 15 20 25 30 35
18	GRAVEL			
19				
20	END OF HOLE TH 9A Note: Plastic pipe, slotted bottom 18" installed to 13.5'. Backfill with sand filter around slotted portion, 12" of bentonite (drilling mud) seal and random backfill placed above.			

BROOKER & ASSOCIATES

Completion Depth 19.75'

Date Apr. 22/72

Depth to Water in Boring Dry

Page 2 of 2

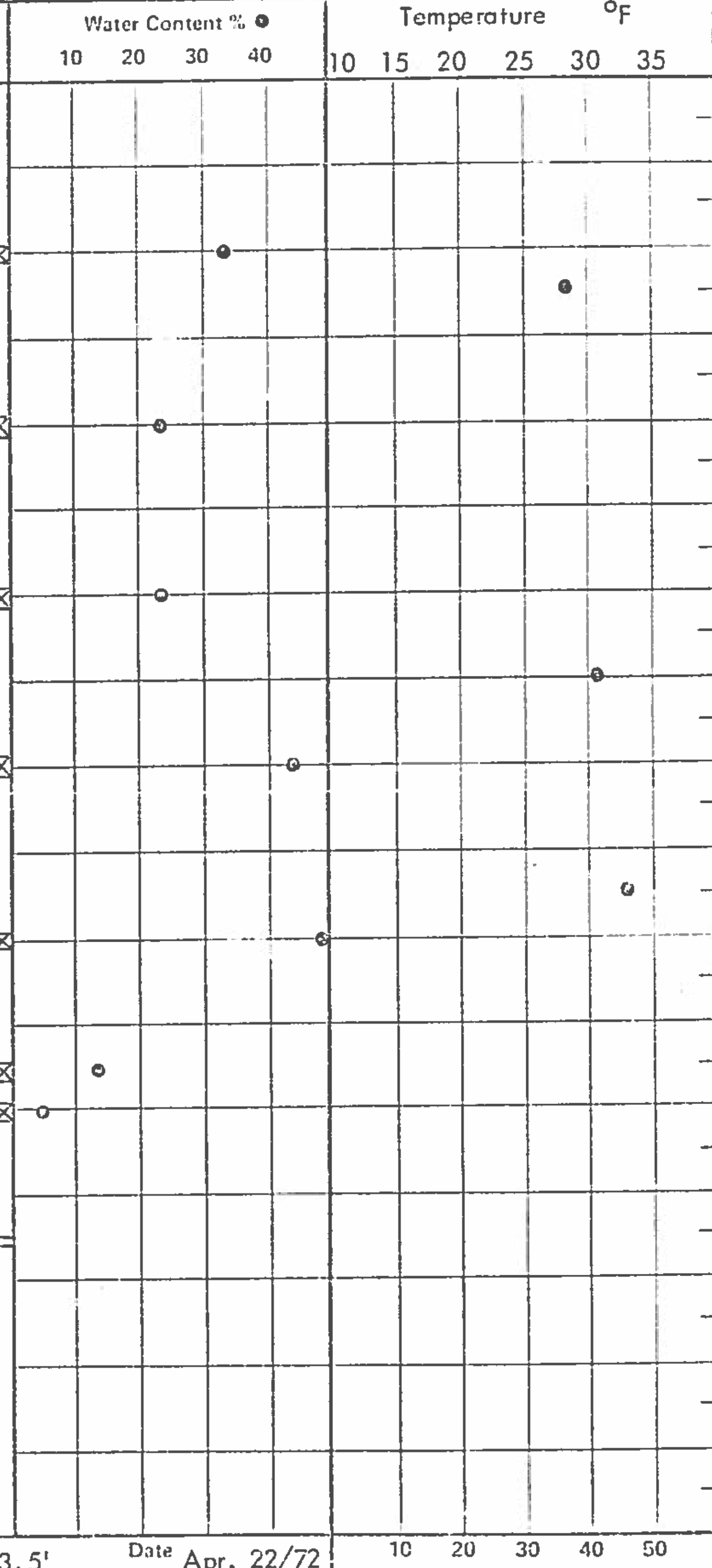
10 20 30 40 50

Penetration Resistance N

Dwg. No.

PROJECT	Dawson (St. Andrews Church)	TESTHOLE No. 10
SURFACE ELEVATION	1048.8'	JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
0–1.6	FILL - silt, organic sand, gravelly medium brown SILT - med. to dark brown	
1.6–7.7	SAND - silty, medium brown, peat laminations - silt laminations	Nf
7.7–10.8	SILT - grey, some peat	unfrozen
10.8–13.5	SAND - silty, medium brown to grey - medium brown some gravel	
13.5–	GRAVEL	



BROOKER & ASSOCIATES

Completion Depth 13.5'

Date Apr. 22/72

Depth to Water in Boring Dry

Page 1 of 1

Dwg. No.

PROJECT	Dawson (Old Administration Building)	TESTHOLE No. 11
SURFACE ELEVATION	1047.8'	JOB No. E - 381 - C

Depth ft.	Soil Description	Ice Description
0–2.3	FILL - silt, pebbles wood, roots	
	- silt, sand, peat medium brown	Nf
	- burnt wood, metal	
5.5	SILT - peat, grey	
6	SAND - silty peat medium brown	unfrozen
	- peat & silt laminations	
	42 % sand 54 % silt 4 % clay O.C. = 16 %	
	- occ. pebble	
	- dark brown, some gravel	
12	GRAVEL - some sand 69 % gravel 31 % sand	
14.5	Hole sloughed to 12.9'	

Water Content % ● (10, 20, 30, 40) — value noted: 57

Temperature °F (10, 15, 20, 25, 30, 35)

Penetration Resistance N (10, 20, 30, 40, 50)

Completion Depth	14.5'	Date	Apr. 23/72
Depth to Water in Boring	Dry	Page 1 of 1	Dwg. No.

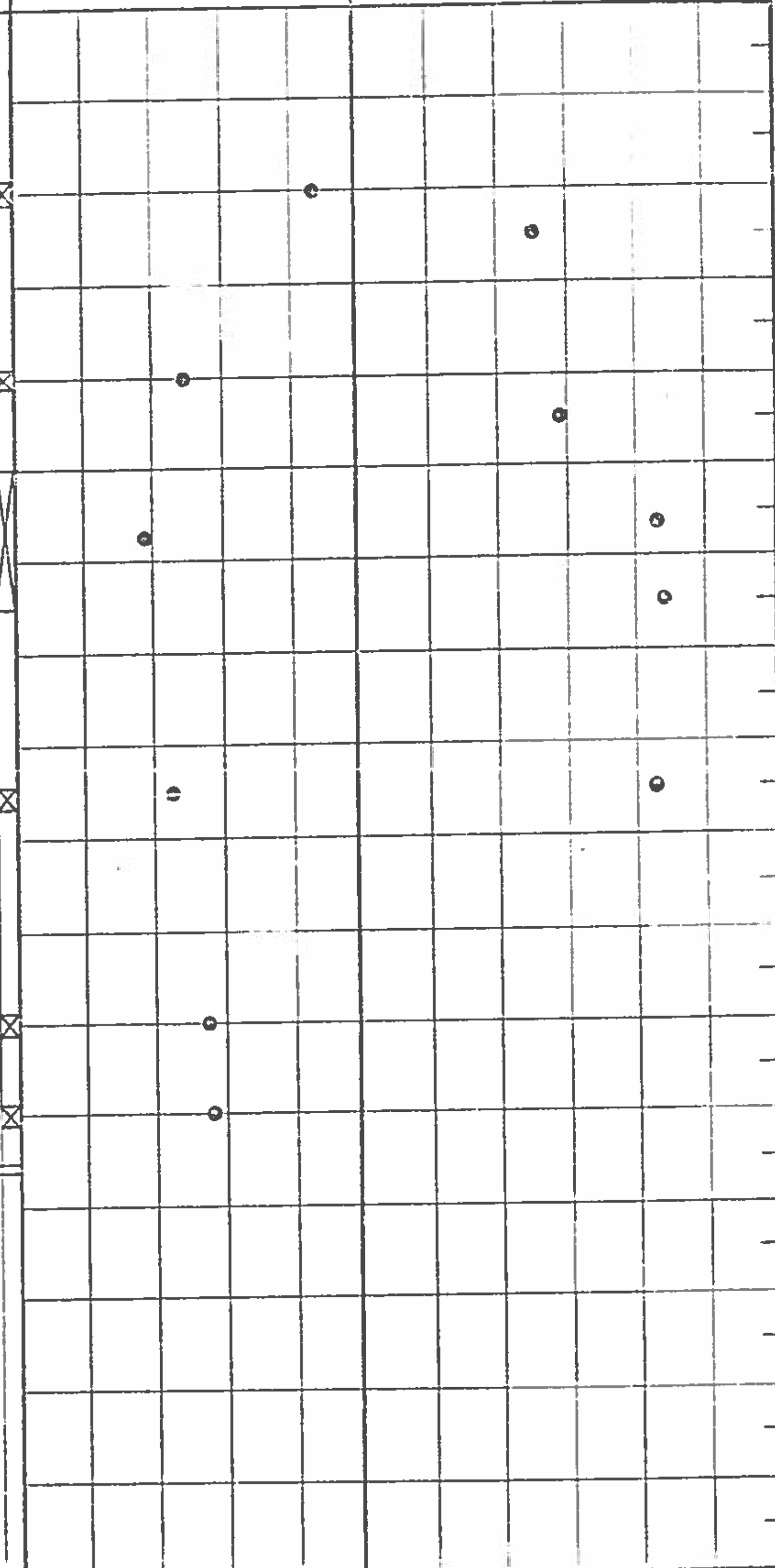
BROOKER & ASSOCIATES

PROJECT	Dawson (Historic Sites Building)	TESTHOLE No.	12
SURFACE ELEVATION	1049.8'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
0–2	FILL - gravel - silt & gravel mixed, some peat	
2–6.4	SILT - peat & sand laminations brown to grey - peat laminations [32 % sand 62 % silt 4 % clay]	Nbn Ice coating on peat Nf Nbn Ice coating on peat & some Nf Nf
6.4–12.5	SAND - fine clean - medium - coarse - silty, peat laminations - coarse, silty fine sand laminations - medium to coarse sand	Nbn
12.5–	GRAVEL OR BOULDERS No Penetration	

Water Content % ● 10 20 30 40

Temperature °F 10 15 20 25 30 35



Completion Depth 12.5'

Date Apr. 23/72

Depth to Water in Boring Dry

Page 1 of 1

Penetration Resistance N 10 20 30 40 50

Dwg. No.

BROOKER & ASSOCIATES

PROJECT	Dawson City	TESTHOLE No.	13
SURFACE ELEVATION	1052.8'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description	Water Content % (10 20 30 40)	Temperature °F (10 15 20 25 30 35)
0–1.5	PEAT - roots & wood dark brown			
1.5–6	SILT - peat mixed - some roots & peat grey - organic, some peat, dark brown	Nbn - ice lens 2-1/2"	57	
6–	Note: Artesian water condition encountered at 6 ft. Flow estimated at 50 gpm from 4-1/2" borehole. Auger removed and hole tightly plugged with 5 ft. of log.			

Completion Depth 6.0'

Date Apr. 23/72

Depth to Water in Boring Artesian

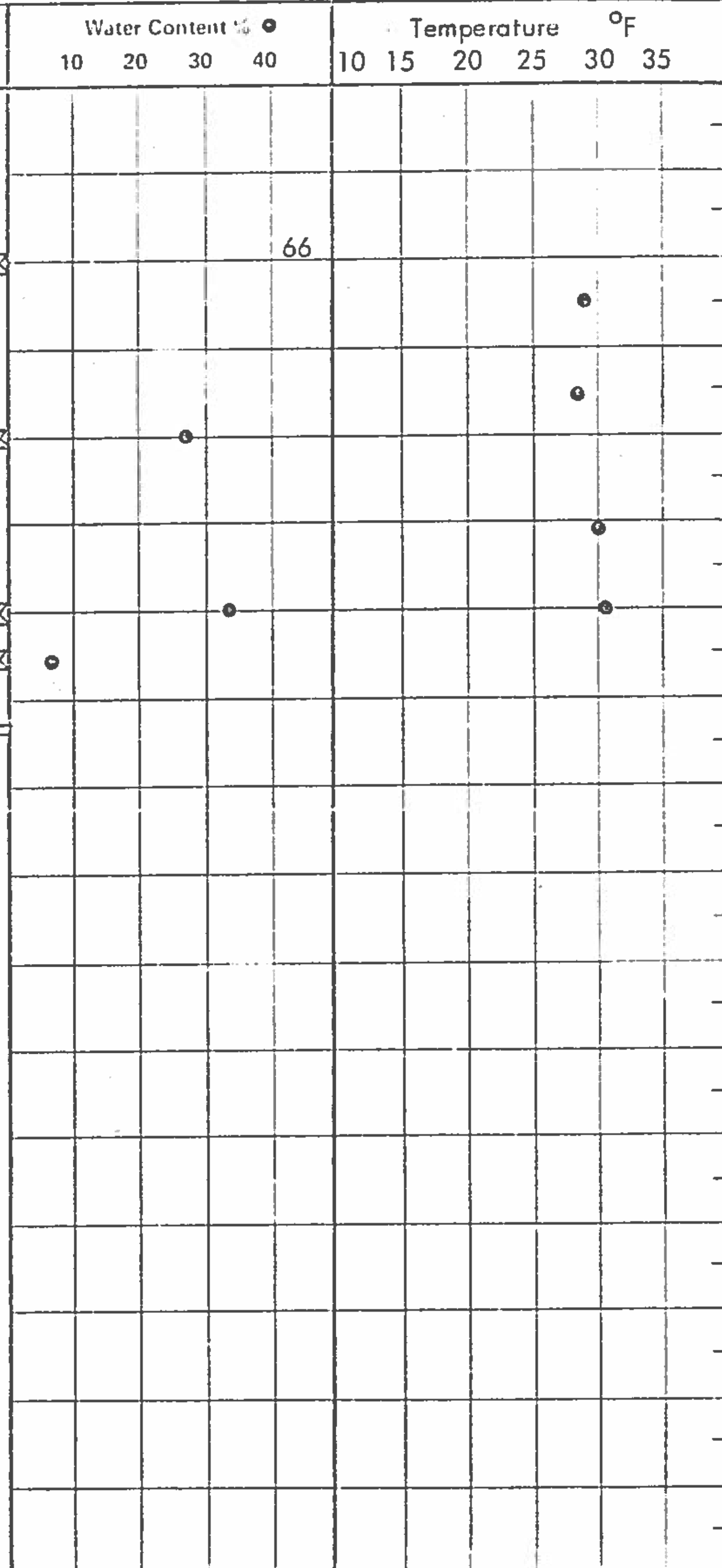
Penetration Resistance N (10 20 30 40 50)

Dwg. No.

BROOKER & ASSOCIATES

PROJECT	Dawson City	TESTHOLE No.	14
SURFACE ELEVATION	1048.2'	JOB No.	E - 381 - C

Depth ft.	Soil Description	Ice Description
0 – 1	FILL - gravel	frozen
1 – 2	PEAT - dark brown	frozen
2 – 6.3	SILT - peat laminations brown - light brown to grey, some peat stratified - light brown peat laminations	frozen (to ~2.7) Vs 5% (~2.7 – 4.4) Vs 10 - 15 % (~4.4 – 7.3)
6.3 – 7.3	GRAVEL - sand & silt	
	Hole sloughed to 6.5 ft.	



Completion Depth	7' 3"	Date	Apr. 23/72
Depth to Water in Boring	Dry	Page	1 of 1

Penetration Resistance N: 10 20 30 40 50

Dwg. No.

BROOKER & ASSOCIATES

The following Borehole Logs

are from

EBA, 1974

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊕ SPT RESISTANCE ▲ 10 20 30 40 50 60 70
0 – 1	GRAVEL FILL		Seasonal Frost	
1 – 2.5	PEAT -dark brown			
2.5 – 13	SILT -med. to dark grey -organic firm -trace of fine sand -soft		Temp. @5½ 26.4°	
			Unfrozen	
			Permafrost Vs 5 - 10% Temp. @ 10½ 29.4°	
13 – 20	GRAVEL -coarse -some cobbles and boulders			
20 – 30	BEDROCK -med. hard, green grey serpentinite (chip samples only) -hard, uniform drilling		Frozen No evidence of excess ice	
30	END OF HOLE @ 30'			

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32

PROJECT	Dawson School
DATE	3/29/74
LOGGED BY	JK
ELEVATION	
DEPTH	30'
HOLE NO.	TH 1
SHEET	1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊙ SPT RESISTANCE ▲ 10 20 30 40 50 60 70
	GRAVEL FILL		Seasonal Frost	
2	PEAT -dark brown -fibrous			
4	SILT -med. to dark grey -organic, soft to firm -trace of fine sand			
6			Unfrozen	
8		X	Permafrost Vr 5 - 10%	
10			Temp 31.8°	
12	GRAVEL -med. to coarse -sandy -with cobbles and boulders -very hard drilling			
14			Frozen No evidence of excess ice	
16				
18				
20				
22				
24	END OF HOLE @ 22½			
26				
28				
30				
32				

eba	PROJECT Dawson School.	DATE 3/30/74	HOLE NO. 2
		LOGGED BY JK	
		ELEVATION	SHEET
		DEPTH 22½	1 of 1

BOREHOLE LOG
PERMAFROST REGION

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE	GROUND ICE CONDITION	MOISTURE CONTENT % ⊙ / SPT. RESISTANCE ▲ (10 20 30 40 50 60 70)
0–2	GRAVEL (FILL)-med. brown sandy, fine to coarse, some cobbles		Frozen Seasona	
2–4	PEAT -dark borwn			
4–10	SILT -med. grey some organics non plastic		Permafrost Vr 15 - 20% Temp. 30.8°	
10–12	SAND -med. grey, silty, fine grained, uniform	X	Vs - 1" top of gravel	
12–14	GRAVEL-med. brown sandy fine to med. some cobbles		NF	
	END OF HOLE			

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32

eba

PROJECT Dawson City School

DATE 3/31/74
LOGGED BY JK
ELEVATION
DEPTH 12½'

HOLE NO. 2A

SHEET 1 of 1

APPENDIX D

LABORATORY TEST DATA

EBA Engineering Consultants Ltd.

SUMMARY OF LAB TEST RESULTS

Job No.____

BORE HOLE	DEPTH (feet)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LL (%)	PL (%)	PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	ORGANIC CONTENT (%)	FIELD or EDMONTON LAB	USC	DESCRIPTION
77-1	5-6.5	17.4											
	10-11.5	7.2				0	3.1	44.8	58.3				
	19	4.5				0	3.2	18.1	78.7				
77-3	5-7	30.0											
	7.1-8.5	37.7				3	80	17	0				
	13.2	38.2											
77-4	2-4	24.2											
	4-5.8	42.0											
	6.4-7.4	38.5											
	7.4-8.9	44.8											
	8.9-10.5	45.4											
	10.5-12	66.1											
	12-13.2	30.3											
	22-30	27.8											
77-5	3	22.4											
	6.3-6.7	48.2				2	94	4	0				
	8-9.6	63.6											
	9.6-11.1	39.8											
	11.1-12.6	34.8											
	12.6-13.6	39.6											

Area ________ Page ____ of ____

EBA Engineering Consultants Ltd.

SUMMARY OF LAB TEST RESULTS

Job No. ____

BORE HOLE	DEPTH (feet)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LL (%)	PL (%)	PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	ORGANIC CONTENT (%)	FIELD or EDMONTON LAB	USC	DESCRIPTION
77-6	5-6.3	120.2								BULK UNIT WEIGHT = 82 pcf			
	6.3-7	119.9											
	7.9-9.2	37.6											
	9.2-10.2	38.7											
77-7	4.1-6.5	26.6											
	5.3-6.5	35.3											
	12-15	4.5											
77-8	5.6	106.0											
	7-7.4	118.7											
	8-8.5	23.5											
	10-10.2	23.9											
	10.2-11.6	44.2											
	11.6-12.7	27.5											
77-9	5.5-6	2352											
	7-7.5	27.4											
	9-11	9.8											
77-10	6-6.9	151.2											
	7.9-8.4	235.7											
	8.4-9.4	238.7											
	9.4-11	97.0											

Area ________ Page ____ of ____

EBA Engineering Consultants Ltd.

SUMMARY OF LAB TEST RESULTS

Job No. ____

BORE HOLE	DEPTH	MOISTURE CONTENT	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION				ORGANIC CONTENT	FIELD or EDMONTON LAB	USC	DESCRIPTION
	(feet)	(%)	LL (%)	PL (%)	PI (%)	CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	(%)			
77-11	5-6.5	36.3				3	76	21	0				
	10-11.5	32.1											
	15-16.5	5.6				0	5	40	55				
77-12	6-7	272.0											
	7.5-8.3	300.0											
	8.3-9.5	72.3								BULK UNIT WEIGHT		89 pcf	
	10-11.1	57.6											
	11.1-12.8	70.0											
77-13	4-5.1	39.6											
	5.1-6.6	58.2											
	6.6-8.5	46.8				3	83	14	0	BULK UNIT WEIGHT = 102.4 pcf			
	8.5-9.8	47.2											
77-14	4-5.5	46.9											
77-15	6-7.5	41.7											
	7.5-8	33.6											
	9.5-10.7	46.4											
	10.7-12.2	48.6								BULK UNIT WEIGHT = 106.7 pcf			
	12.2-13.6	47.8											
	13.6-15.	45.4											
	15.3-17	39.9											

Area ____ Page ____ of ____

EBA Engineering Consultants Ltd.

SUMMARY OF LAB TEST RESULTS

Job No._____

BORE HOLE	DEPTH	MOISTURE CONTENT	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION				ORGANIC CONTENT	FIELD or EDMONTON LAB	USC	DESCRIPTION
	(feet)	(%)	LL (%)	PL (%)	PI (%)	CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	(%)			
77-18	10-11.5	4.3					7.6	19.7	72.7				
	15-16.5	4.1											
	20-21.5	4.0											
	35-36.5	10.9											
77-19	5-6.5	63.6											
	10-11.5	29.9				0	27	73	0				
	12.5	25.7											
77-20	5	59.2											
	6.1	70.7											
	6.1-7.2	64.2											
	9.5	60.6											
	9.7-10.5	61.1											
	10.5-11.9	62.9											
	12.5	11.3											
77-21	4-5.5	85.4											
	6.5-6.9	38.1											
	9.5-11.1	70.5											
	11.1-11.3	23.9											

Area ________ Page ____ of ____

EBA Engineering Consultants Ltd.

SUMMARY OF LAB TEST RESULTS

Job No. ____

BORE HOLE	DEPTH (feet)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LL (%)	PL (%)	PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	ORGANIC CONTENT (%)	FIELD or EDMONTON LAB	USC	DESCRIPTION
77-22	4-4.9	34.1											
	5.4-6.7	1624											
	6.7-8	60.0											
77-23	5-6.5	36.1											
	10-11.5	7.1											
	15-16.5	46.3											
77-24	5-6.5	38.5					36.2	63.8	0				
77-25	5-5.5	44.5											
	8-8.8	76.3											
	8.8-10.4	31.7				3	77	20	0				
	10.4-11.9	37.1											

Area ____ Page ____ of ____

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Phone (403) 253-7121

GRAIN SIZE DISTRIBUTION

PROJECT ____________
ADDRESS ____________

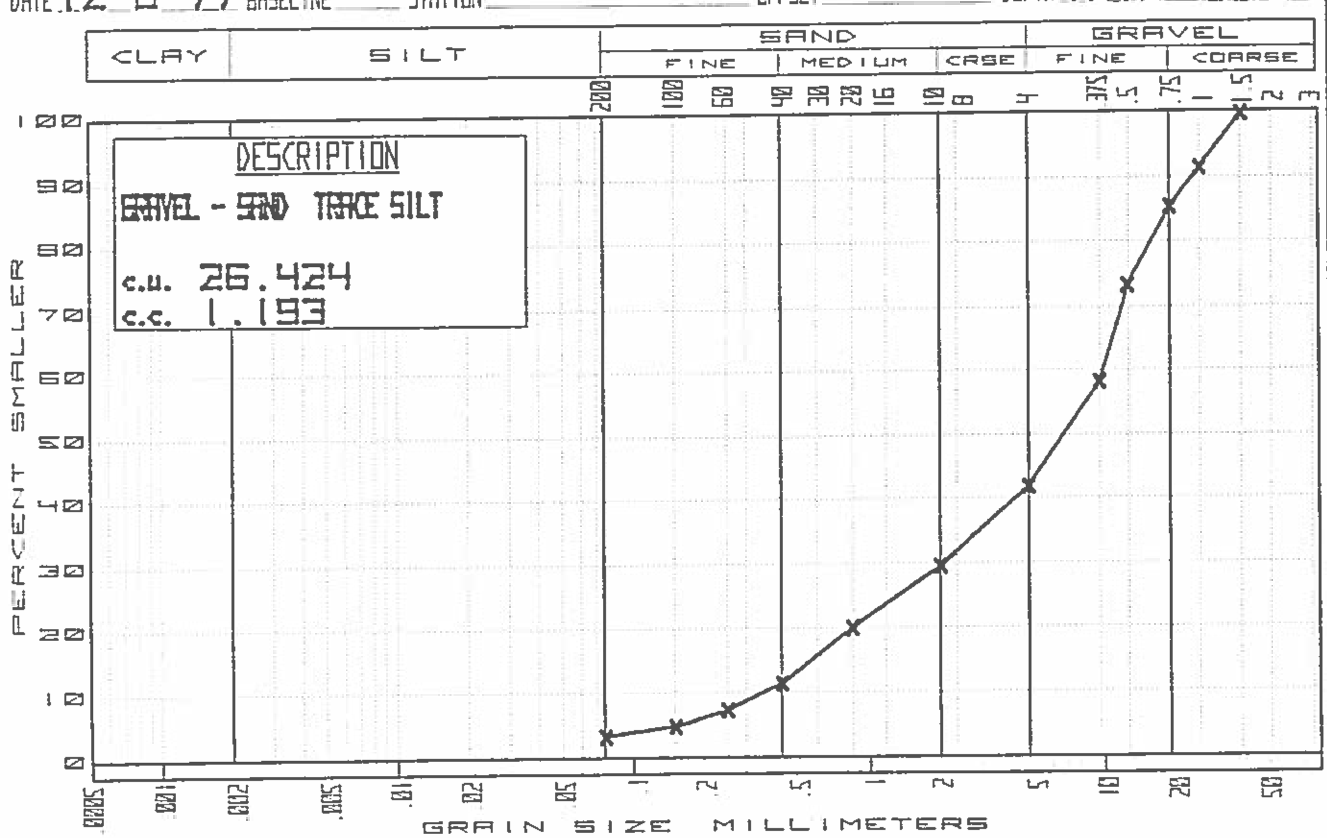
JOB NO. ____________
DATE TESTED ____________ BY ____________
CLIENT ____________

ATTENTION ____________

SIEVE	PCT SMALLER
3	
2	
1.5	100.0
1	91.5
.75	85.4
.5	73.2
.375	58.0
4	41.7
8 10	29.6
16 20	19.9
30 40	11.2
50 60	7.1
100	4.6
200	3.1

REVIEWED BY ____________ P.ENG.

JOB NO. 11-1847 SITE B.H. 1
DATE 12-8-77 BASELINE ____ STATION ____ OFFSET ____ DEPTH 10.0-11.5



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GRAIN SIZE DISTRIBUTION

PROJECT ______
ADDRESS ______

JOB NO. ______
DATE TESTED ______ BY ______
CLIENT ______

ATTENTION ______

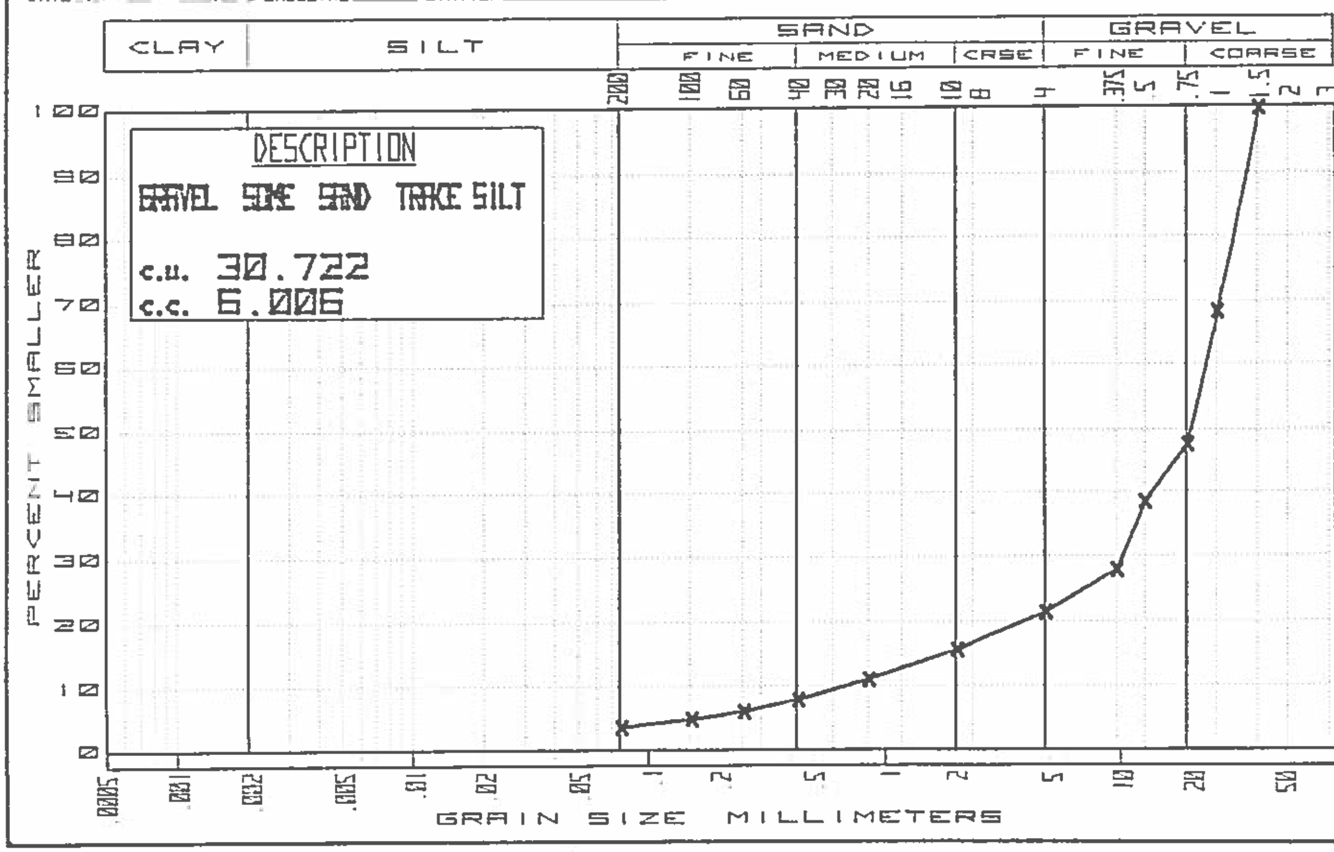
SIEVE	PCT SMALLER
3	
2	
1.5	100.0
1	68.1
.75	47.2
.5	38.2
.375	27.8
4	21.3
~~8~~ 10	15.5
~~16~~ 20	10.8
~~30~~ 40	7.6
~~50~~ 60	5.7
100	4.5
200	3.2

REVIEWED BY ______ P.ENG.

JOB NO. 11-1847 SITE B.H. 1
DATE 12-8-77 BASELINE ______ STATION ______ OFFSET ______ DEPTH 19.0

DESCRIPTION
GRAVEL SOME SAND TRACE SILT

c.u. 30.722
c.c. 6.006



GRAIN SIZE DISTRIBUTION

PROJECT ______________________

ADDRESS ______________________

____

JOB NO. ______________________

DATE TESTED __________ BY __________

CLIENT ______________________

____

____

ATTENTION ______________________

____

____

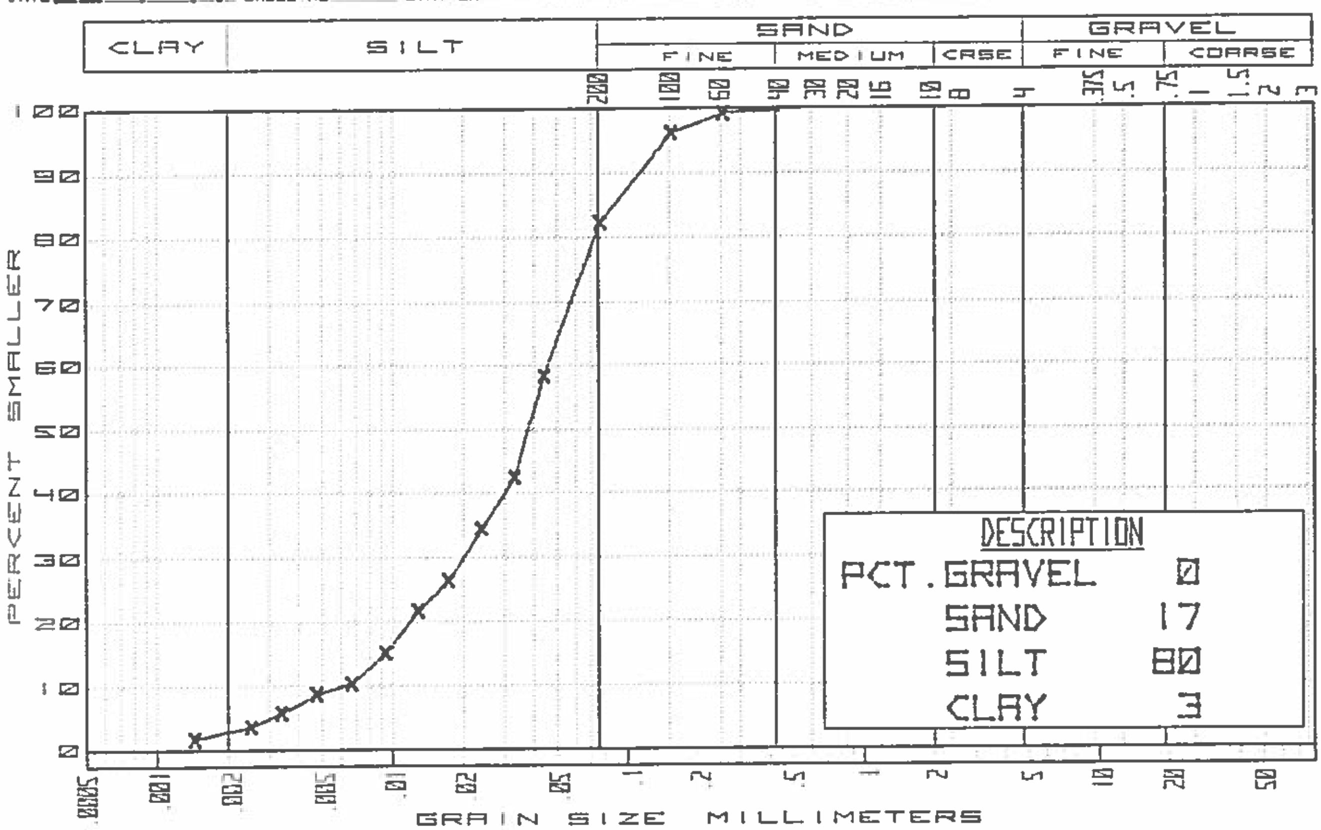
____

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
8 10	
16 20	
30 40	
50 60	
100	
200	

REVIEWED BY ______________________ P.ENG.

JOB NO. 11-1847 SITE B.H. 3

DATE 29-7-77 BASELINE ______ STATION ______ OFFSET ______ DEPTH 7.1-8.5



All tests performed in accordance with ASTM & CSA standards.

GRAIN SIZE DISTRIBUTION

PROJECT ______________________

ADDRESS ______________________

____

JOB NO. ______________________

DATE TESTED ____________ BY ____________

CLIENT ______________________

____

____

ATTENTION ______________________

____

____

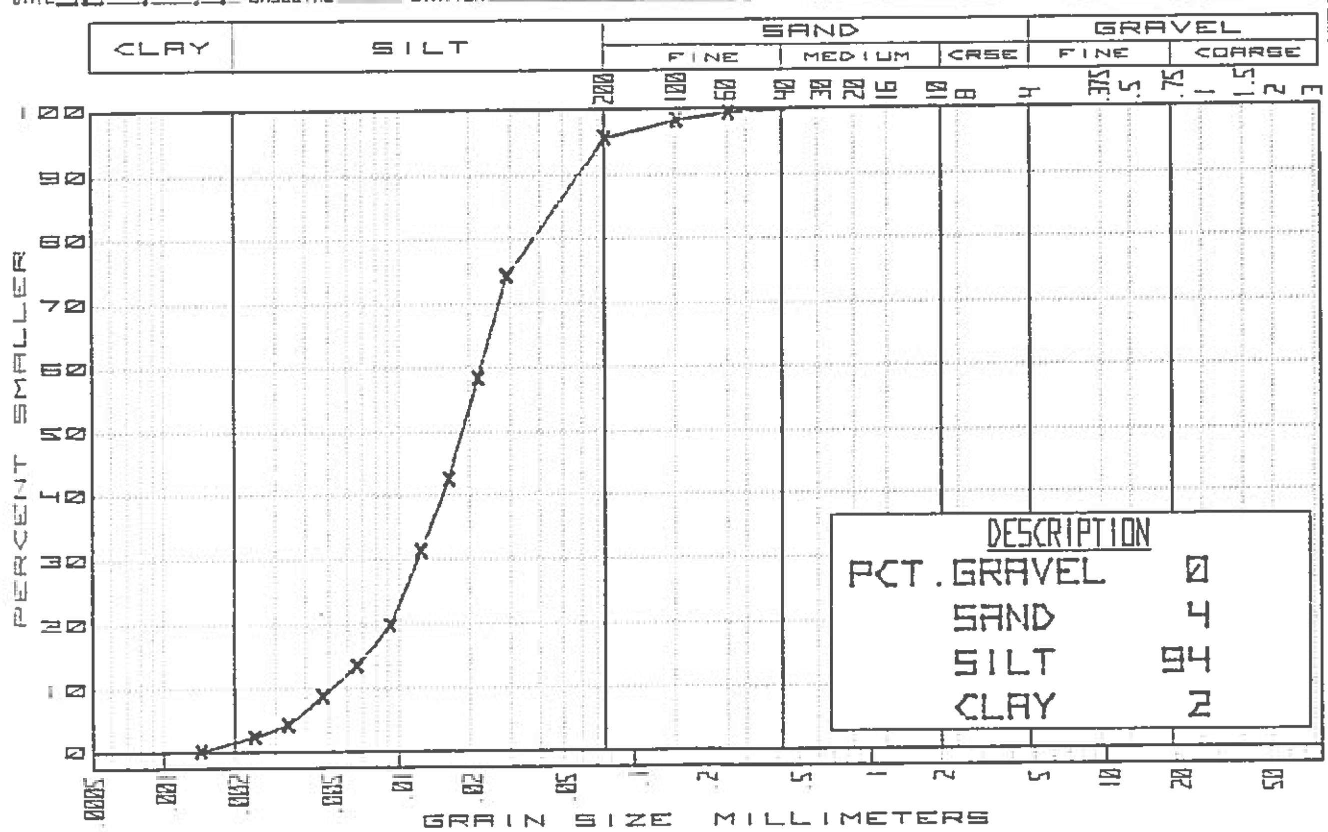
____

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
8 10	
16 20	
30 40	
50 60	
100	
200	

REVIEWED BY ______________________ P.ENG.

JOB NO. LL-1847 SITE B.H. 5

DATE 30-7-77 BASELINE ____ STATION ______ OFFSET ______ DEPTH 6.3-6.7



All tests performed in accordance with ASTM & CSA standards.

GRAIN SIZE DISTRIBUTION

PROJECT ______________________

ADDRESS ______________________

____

JOB NO. ______________________

DATE TESTED ____________ BY ____________

CLIENT ______________________

____

____

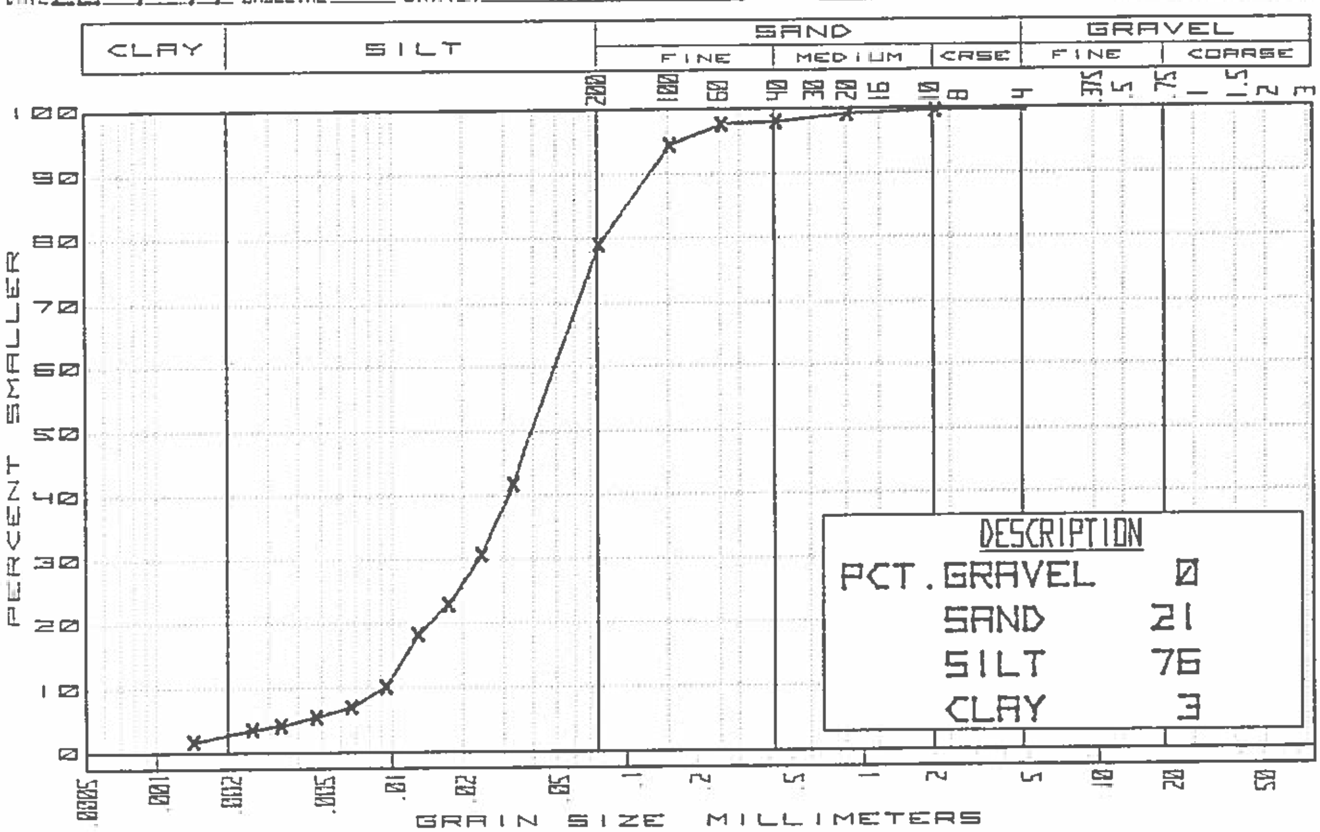
ATTENTION ______________________

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
8 10	
16 20	
30 40	
50 60	
100	
200	

REVIEWED BY ______________________ P.ENG.

JOB NO. 11-1847 SITE B.H. 11

DATE 28-7-77 BASELINE ____ STATION ____ OFFSET ____ DEPTH 5.0-6.5



All tests performed in accordance with ASTM & CSA standards.

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GRAIN SIZE DISTRIBUTION

PROJECT ____________
ADDRESS ____________

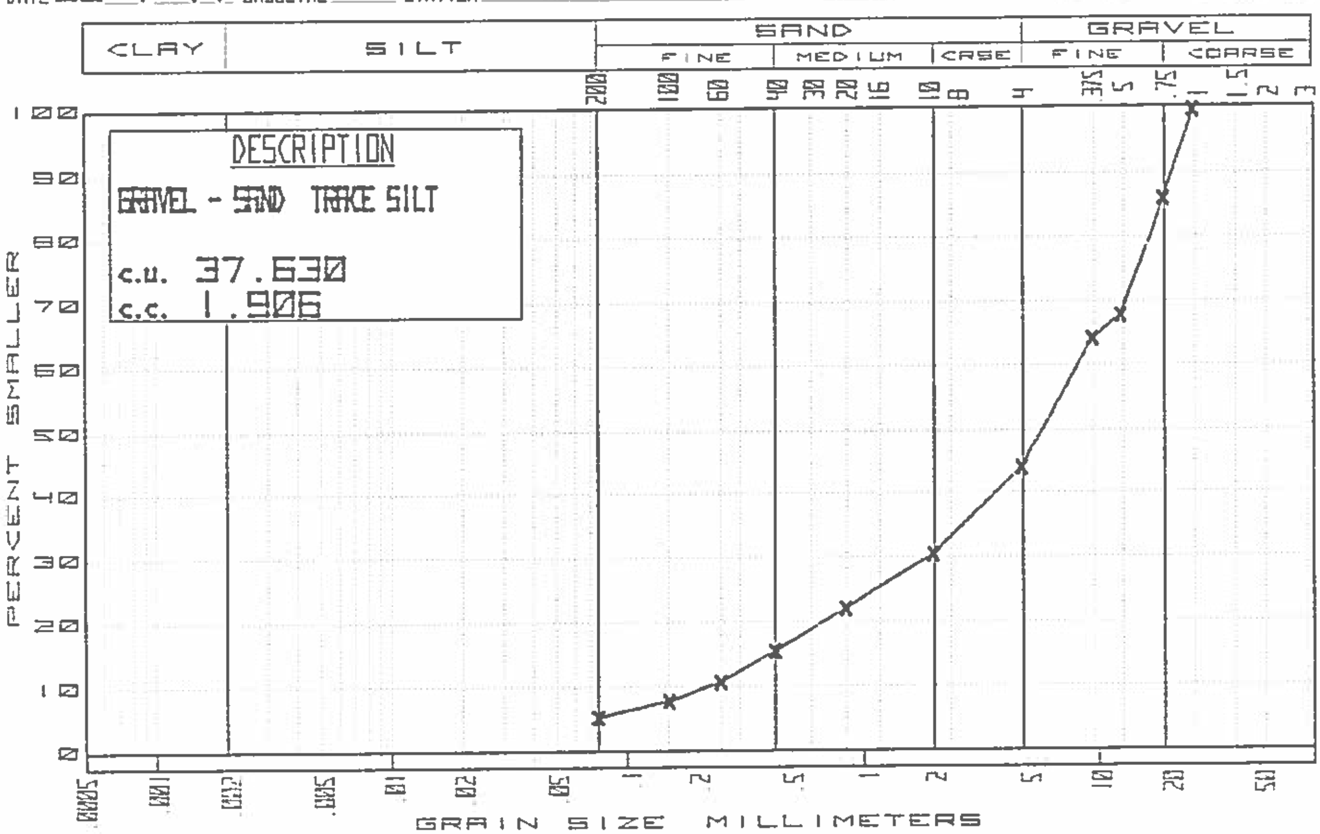
JOB NO. ____________
DATE TESTED ________ BY ________
CLIENT ____________

ATTENTION ____________

SIEVE	PCT SMALLER
3	
2	
1.5	
1	100.0
.75	86.2
.5	67.8
.375	64.2
4	44.1
~~8~~ 10	30.6
~~16~~ 20	22.2
~~30~~ 40	15.6
~~50~~ 60	10.7
100	7.8
200	5.3

REVIEWED BY ____________ P.ENG.

JOB NO. 11-1847 SITE B.H. 11
DATE 26-7-77 BASELINE ______ STATION ______ OFFSET ______ DEPTH 15.0-16.5



All tests performed in accordance with ASTM & CSA standards.

GRAIN SIZE DISTRIBUTION

PROJECT ____________________

ADDRESS ____________________

____

JOB NO. ____________________

DATE TESTED ____________ BY ____________

CLIENT ____________________

____

____

ATTENTION ____________________

____

____

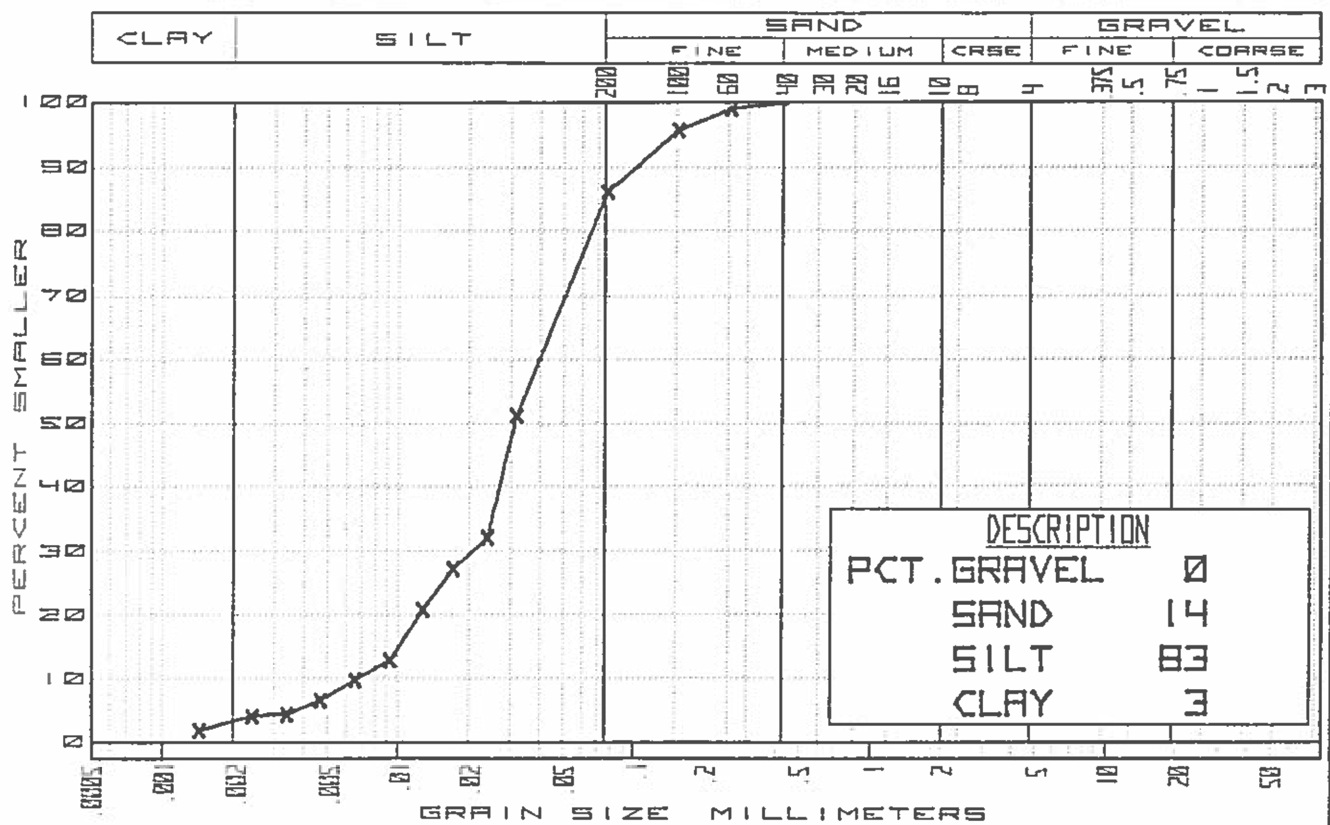
____

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
8 10	
16 20	
30 40	
50 60	
100	
200	

REVIEWED BY ____________________ P.ENG.

JOB NO 11-1847 SITE B.H. 13

DATE 17-8-77 BASELINE ______ STATION ____________ OFFSET ____________ DEPTH 6.6-8.5



All tests performed in accordance with ASTM & CSA standards.

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GRAIN SIZE DISTRIBUTION

PROJECT ______
ADDRESS ______

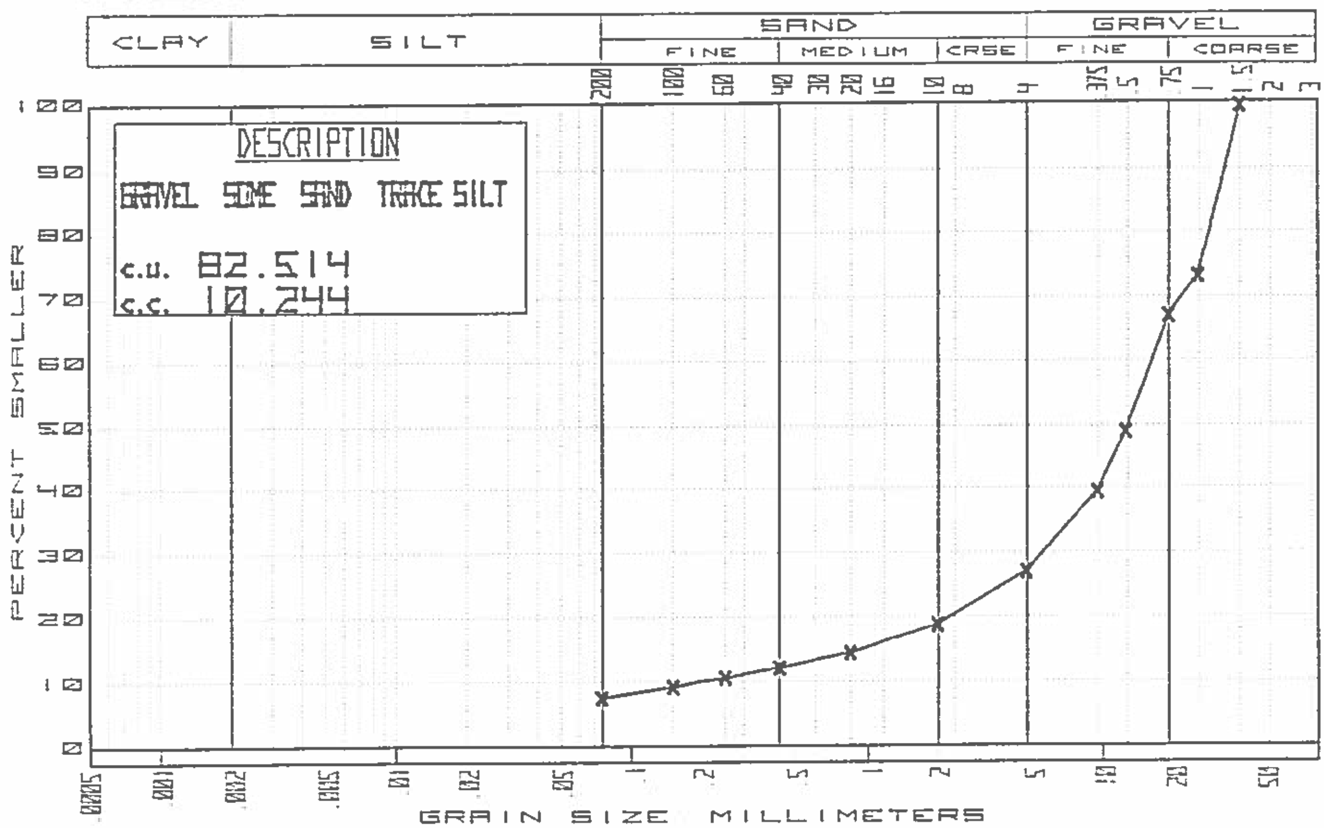
JOB NO. ______
DATE TESTED ______ BY ______
CLIENT ______

ATTENTION ______

SIEVE	PCT SMALLER
3	
2	
1.5	100.0
1	73.5
.75	67.2
.5	49.1
.375	39.7
4	27.3
~~8~~ 10	19.0
~~16~~ 20	14.7
~~30~~ 40	12.3
~~50~~ 60	10.7
100	9.3
200	7.6

REVIEWED BY ______ P.ENG.

JOB NO. 11-1847 SITE B.H. 18
DATE 21-7-77 BASELINE ______ STATION ______ OFFSET ______ DEPTH 10.0-11.5



All tests performed in accordance with ASTM & CSA standards.

GRAIN SIZE DISTRIBUTION

PROJECT ____________________
ADDRESS ____________________

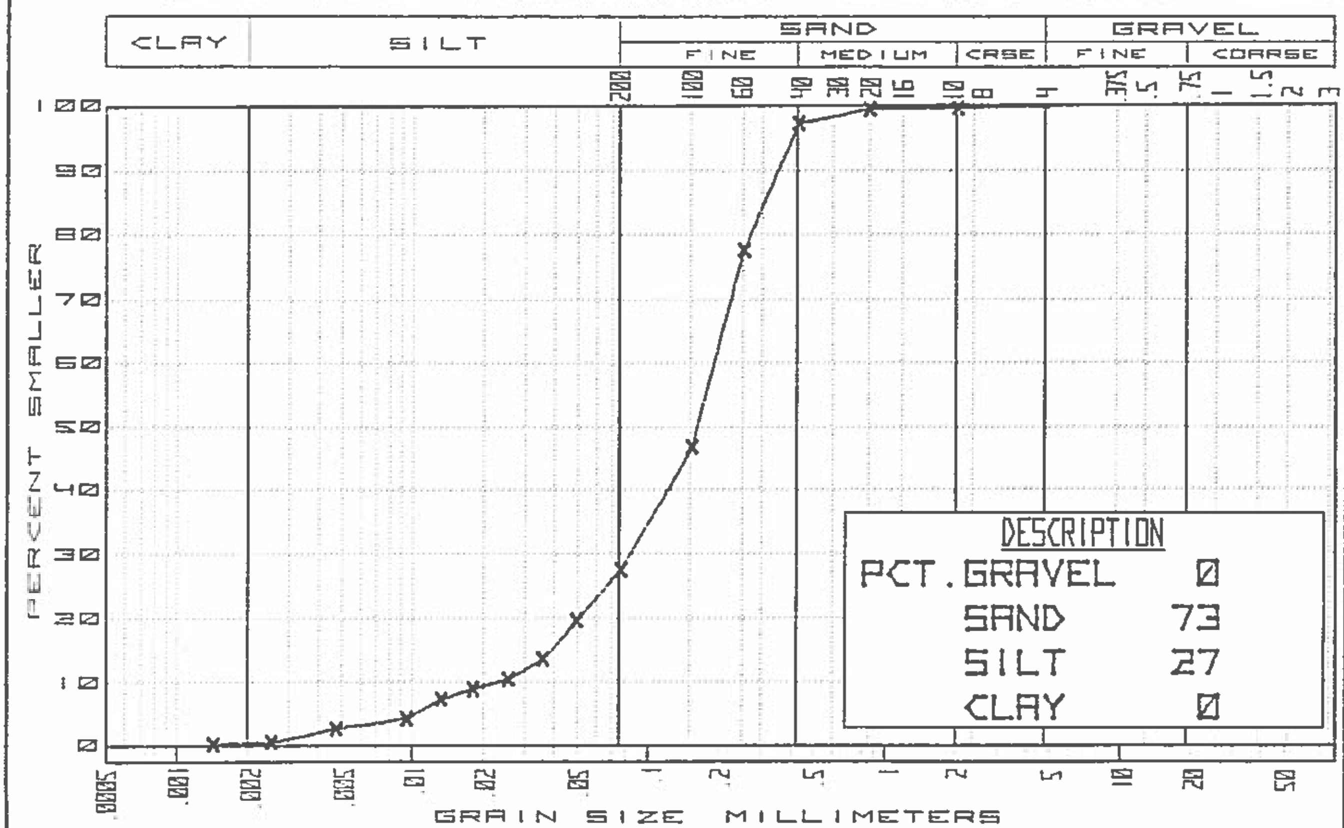
JOB NO. ____________________
DATE TESTED __________ BY __________
CLIENT ____________________

ATTENTION ____________________

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
8 10	
16 20	
30 40	
50 60	
100	
200	

REVIEWED BY ____________________ P.ENG.

JOB NO. 11-1847 SITE B.H. 19
DATE 28-7-77 BASELINE ______ STATION ______ OFFSET ______ DEPTH 10.0-11.5



All tests performed in accordance with ASTM & CSA standards.

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GRAIN SIZE DISTRIBUTION

PROJECT ____

ADDRESS ____

JOB NO. ____

DATE TESTED ____ BY ____

CLIENT ____

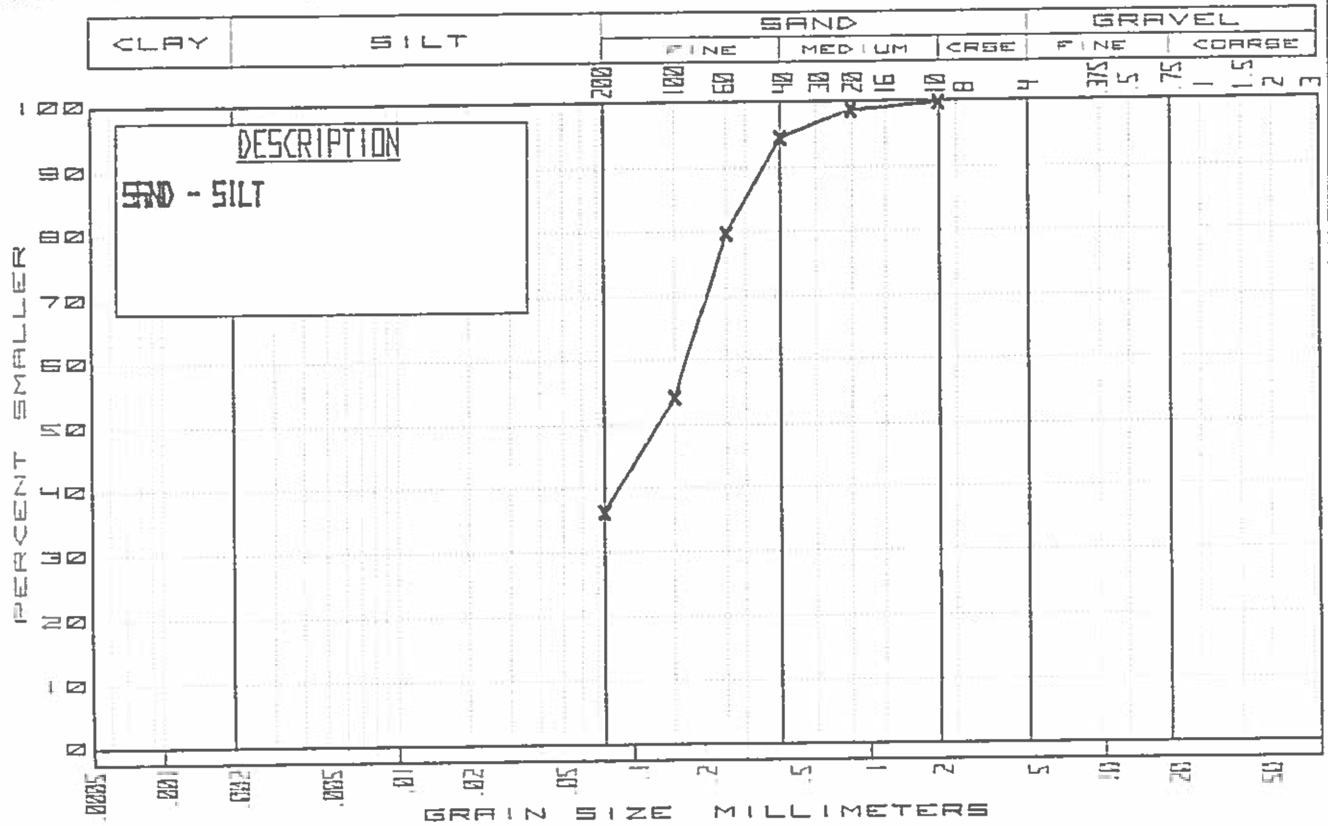
ATTENTION ____

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
10	100.0
20	98.9
40	94.6
60	79.7
100	54.1
200	36.2

REVIEWED BY ____ P.ENG.

JOB NO. 11-1847 SITE B.H. 24

DATE 21-7-77 BASELINE ____ STATION ____ OFFSET ____ DEPTH 5.0-6.5



All tests performed in accordance with ASTM & CSA standards.

GRAIN SIZE DISTRIBUTION

PROJECT ______________________
ADDRESS ______________________

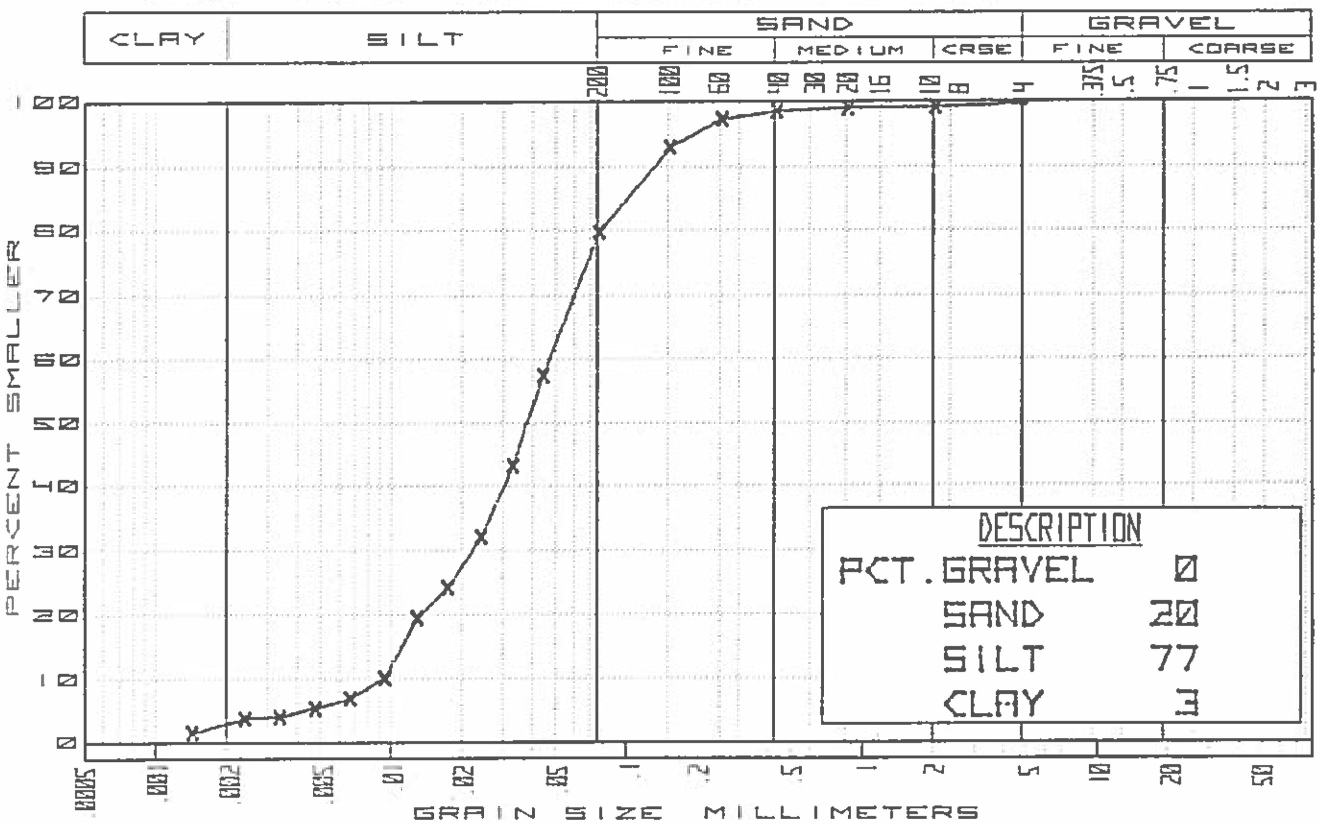
JOB NO. ______________________
DATE TESTED ____________ BY ____________
CLIENT ______________________

ATTENTION ______________________

SIEVE	PCT SMALLER
3	
2	
1.5	
1	
.75	
.5	
.375	
4	
8 10	
16 20	
30 40	
50 60	
100	
200	

REVIEWED BY ______________________ P.ENG.

JOB NO. 11-1868 SITE BH 25
DATE 27-7-77 BASELINE ______ STATION ______ OFFSET ______ DEPTH 8.8-10.4



All tests performed in accordance with ASTM & CSA standards.

The following laboratory test data

is from

EBA, 1972

SUMMARY OF TEST RESULTS

JOB No. E - 381 - C

TEST HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SPECIFIC GRAVITY	ORGANIC CONTENT %	DRY DENSITY PCF	SOIL CLASSIFICATION (UNIFIED)
			W_L	W_P	PI								
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL				
2	5	123.6	46.3	N/P							13.93		OH
2	11	81.7				5	70	25					
4	5	79.9	48.4	N/P		5	80	15			15.25		OH
4	.7	86.5	40.5	N/P									OH
4	9	63.6	39.0	N/P							11.10		OH
5	4	48.2	41.8	N/P									OH
5	10	43.1				8	40	52			5.85		
5	16	32.5						98	2				
6	3.5 - 5	31.9	37.0	N/P							7.69		OH

N/P - Non Plastic

E. W. BROOKER & ASSOCIATES LTD.

Drwg. No. ______

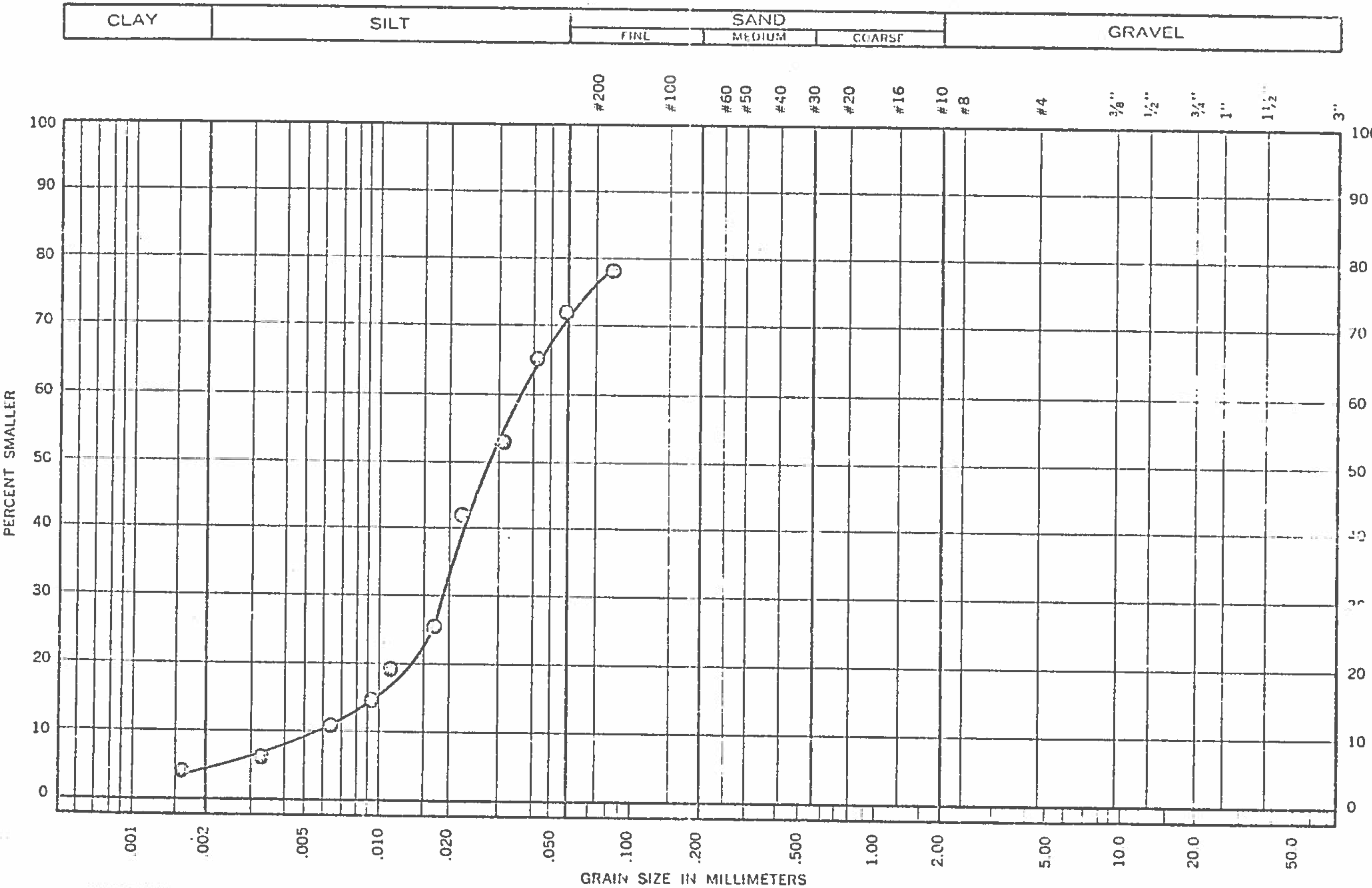
SUMMARY OF TEST RESULTS

JCB No. E - 381 - C

TEST HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SPECIFIC GRAVITY	ORGANIC CONTENT %	DRY DENSITY PCF	SOIL CLASSIFICATION (UNIFIED)
			W_L	W_P	PI								
	feet	%	%	%	%	% CLAY	% SILT	% SAND	%GRAVEL				
7	8	36.1	27.7	N/P		6	85	9					OH
8	4	28.6	30.8	N/P									OH
9	2	31.4	45.8	N/P									OH
9	4	9.8				6	32	62					
9A	15	3.5					14	67	19				
11	10	56.5				4	54	42			16.02		
11	13	2.7						31	69				
12	4	25.0				4	62	32					

N/P - Non Plastic

GRAIN SIZE DISTRIBUTION

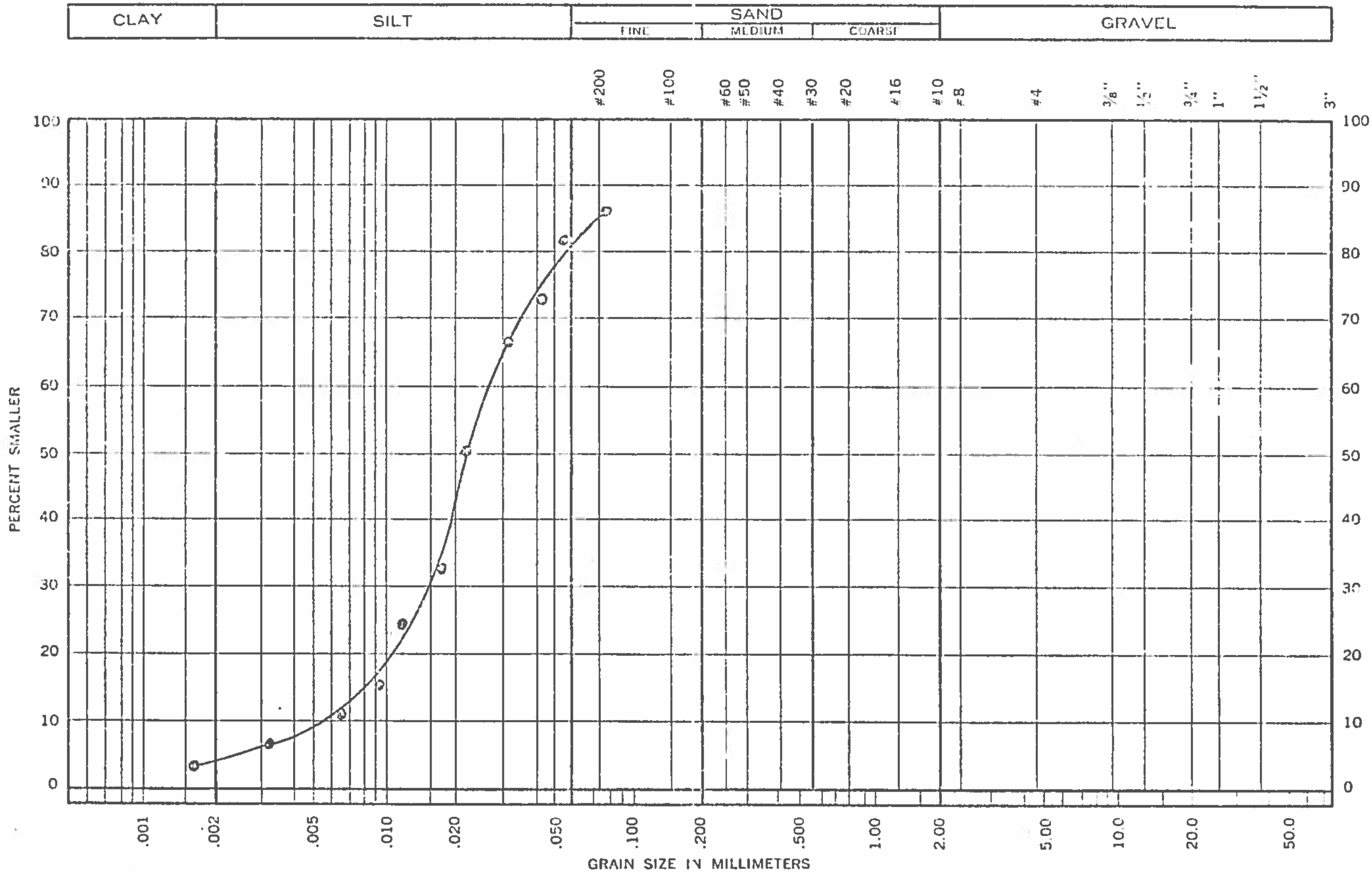


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION BROWN SILT

PROJECT DAWSON CITY
JOB No. E381-C DATE MAY 5, 1972
SAMPLE No. T.H. 2

GRAIN SIZE DISTRIBUTION

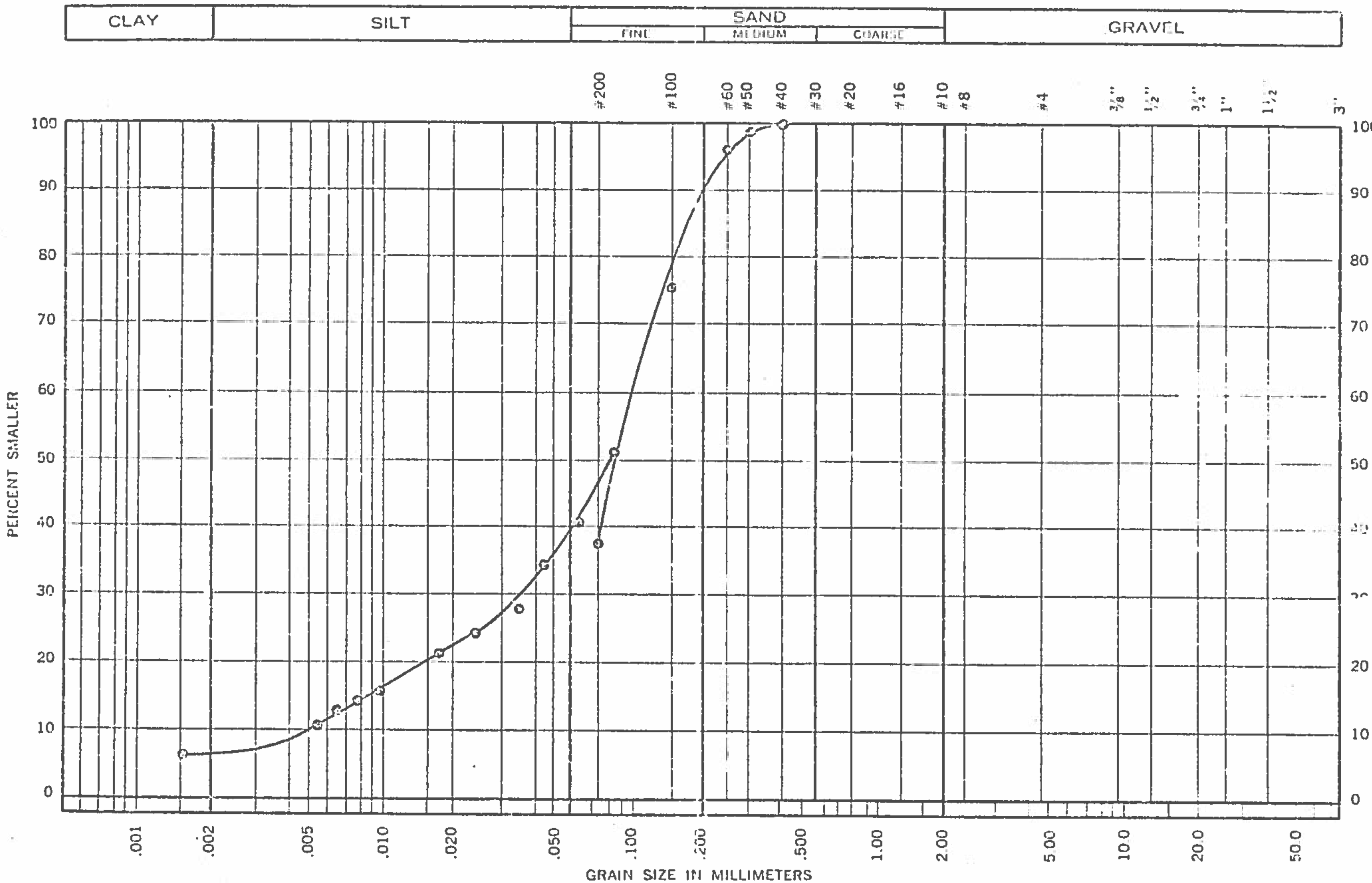


HOOKER & ASSOCIATES

SAMPLE DESCRIPTION BROWN SILT

PROJECT DAWSON CITY
JOB No. E 381-C DATE MAY 5/72
SAMPLE No. TH4
DEPTH 5'

GRAIN SIZE DISTRIBUTION



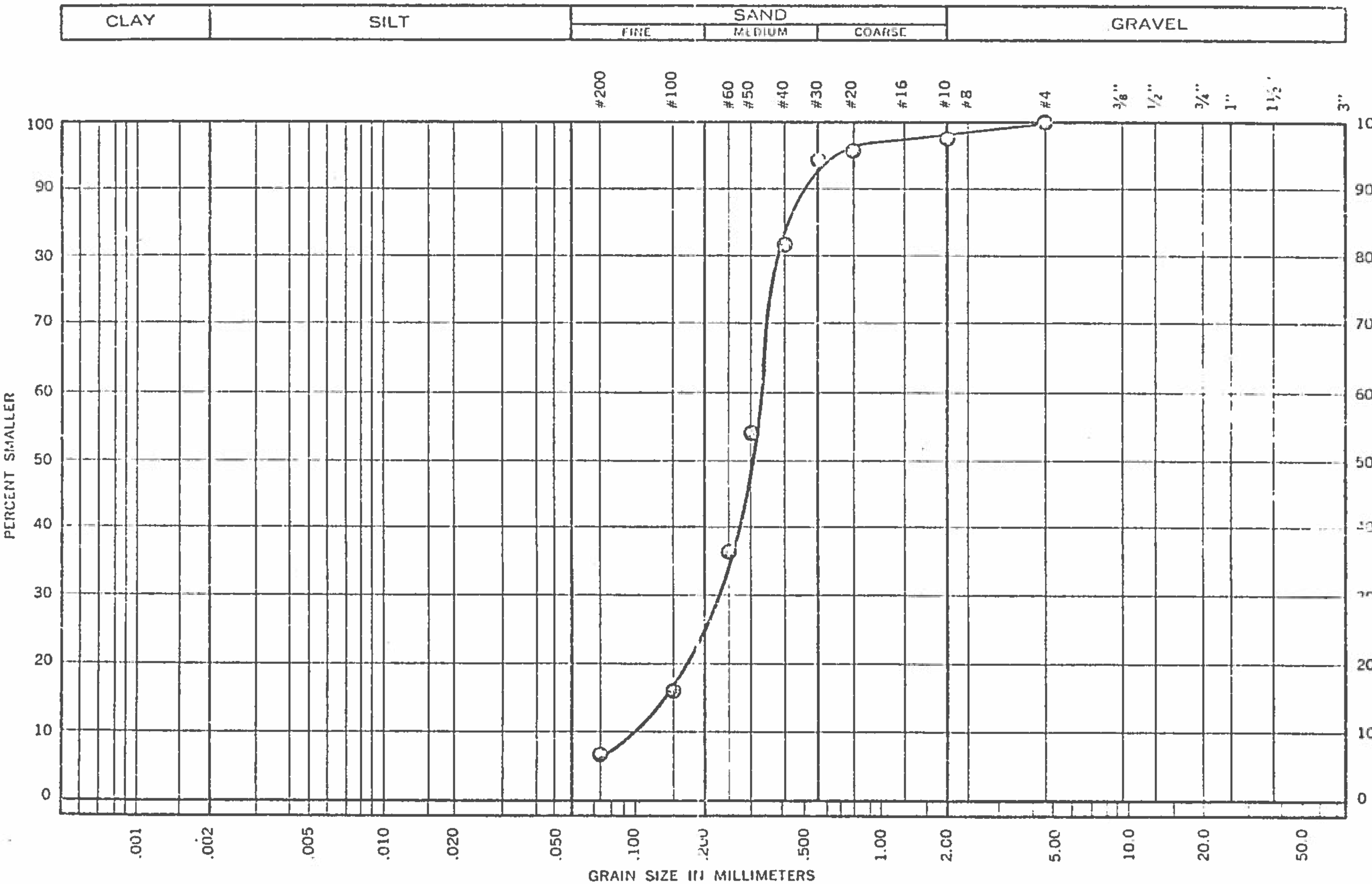
SAMPLE DESCRIPTION *SILTY SAND*

PROJECT *DAWSON CITY*

JOB No. *E-381-C* DATE *MAY 8, 1972*

SAMPLE No. *T.H. #5*

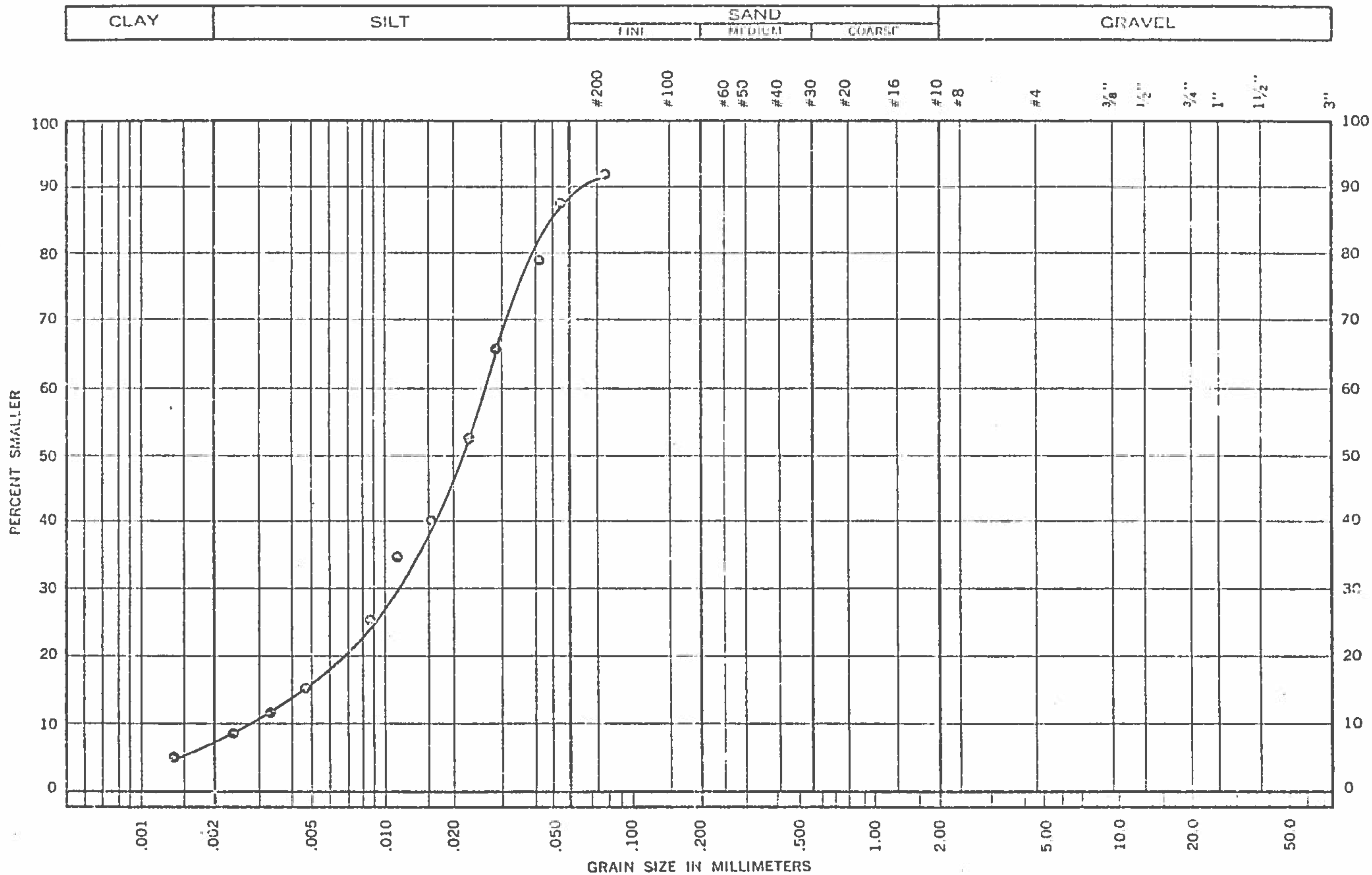
GRAIN SIZE DISTRIBUTION



SAMPLE DESCRIPTION SAND

PROJECT DAWSON CITY
JOB No. E381-C DATE MAY 5, 1972
SAMPLE No. TH 5

GRAIN SIZE DISTRIBUTION

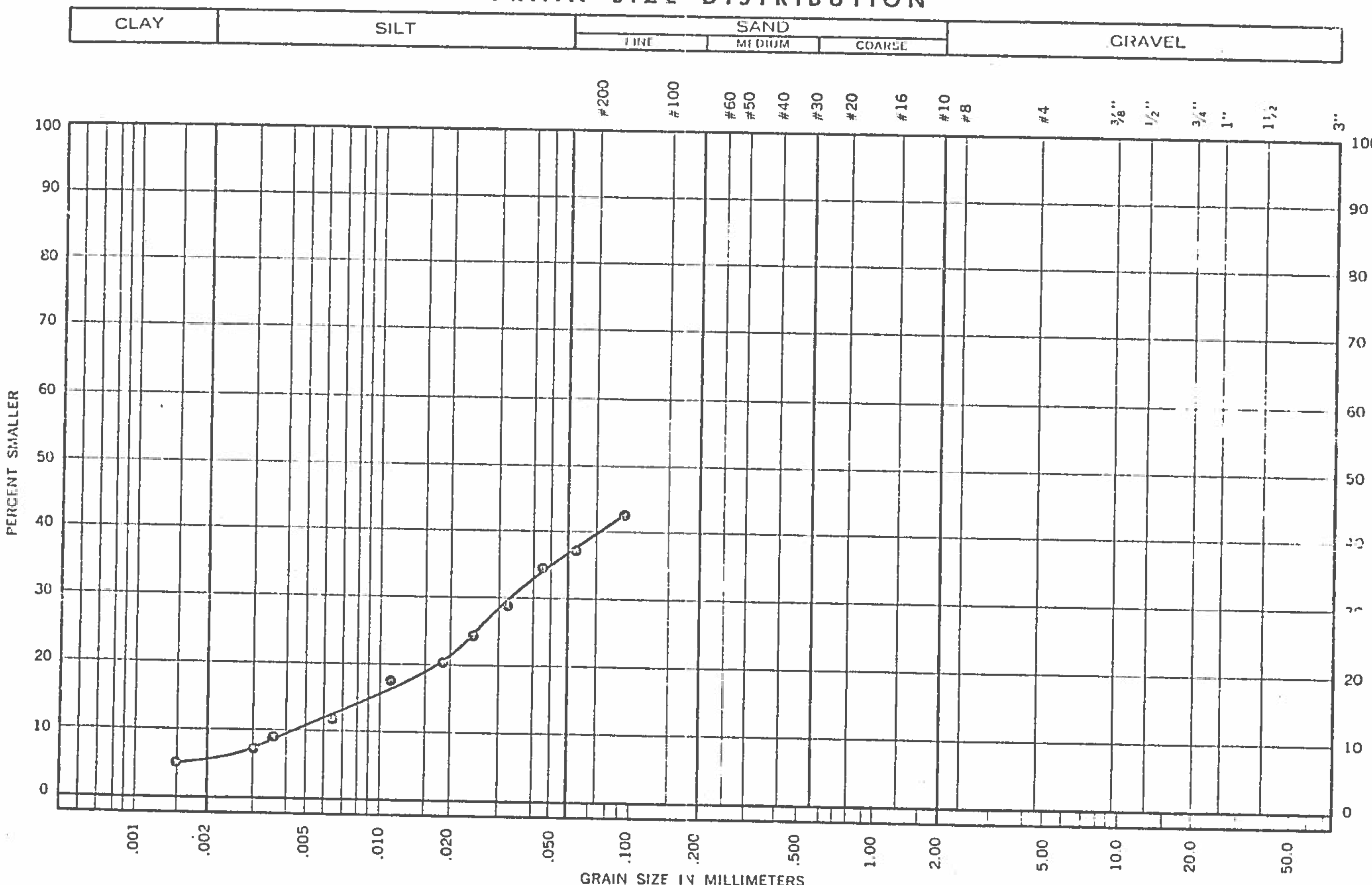


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION SILT

PROJECT DAWSON CITY Y.T.
JOB No. E-381 C DATE MAY 24, 1972
SAMPLE No. T.H. #7
DEPTH 8'

GRAIN SIZE DISTRIBUTION



BROOKER & ASSOCIATES

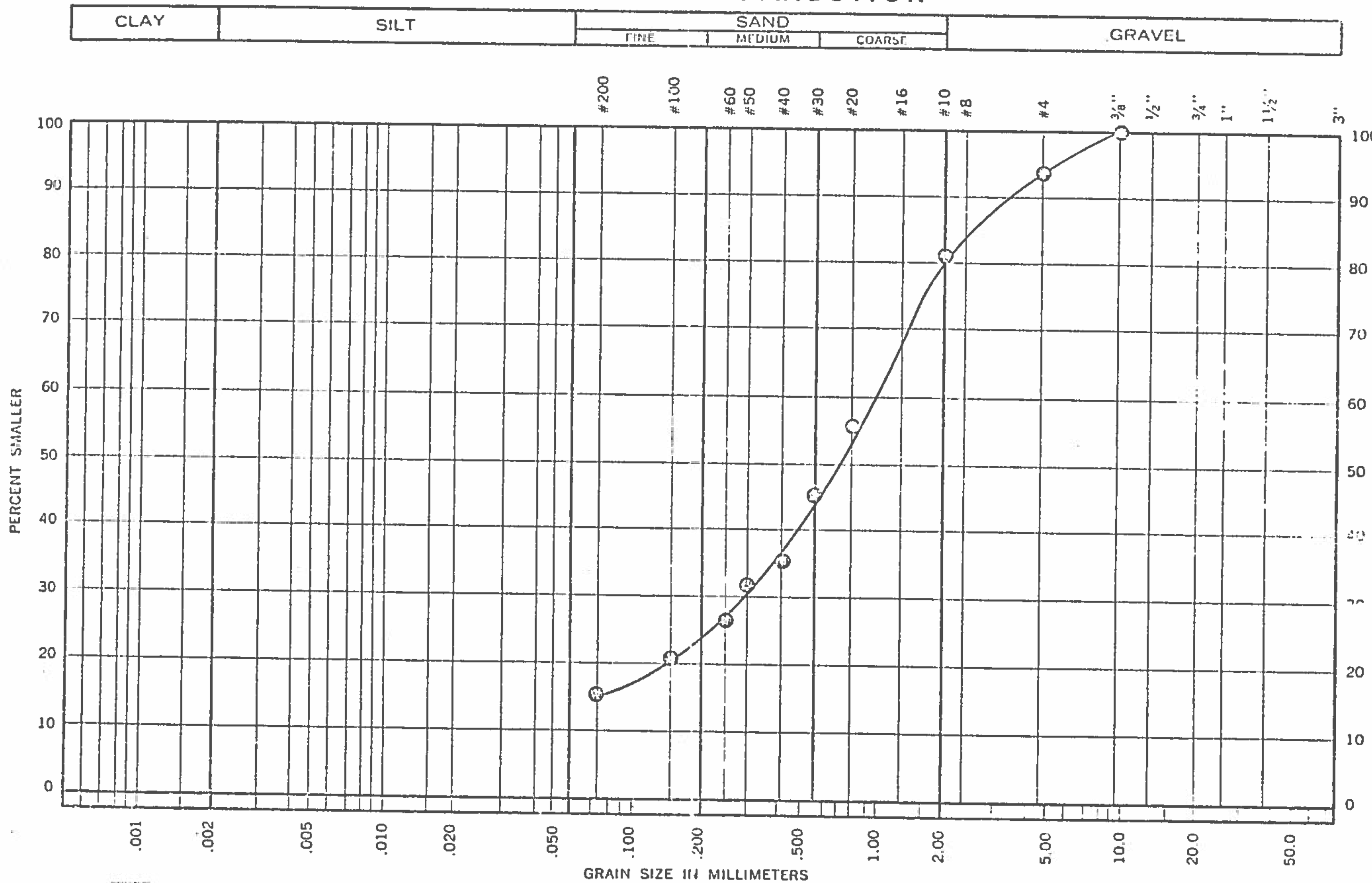
SAMPLE DESCRIPTION BROWN SILTY SAND

PROJECT DAWSON CITY

JOB No. E-381 c DATE MAY 8, 1972

SAMPLE No. T.H. # 9

GRAIN SIZE DISTRIBUTION

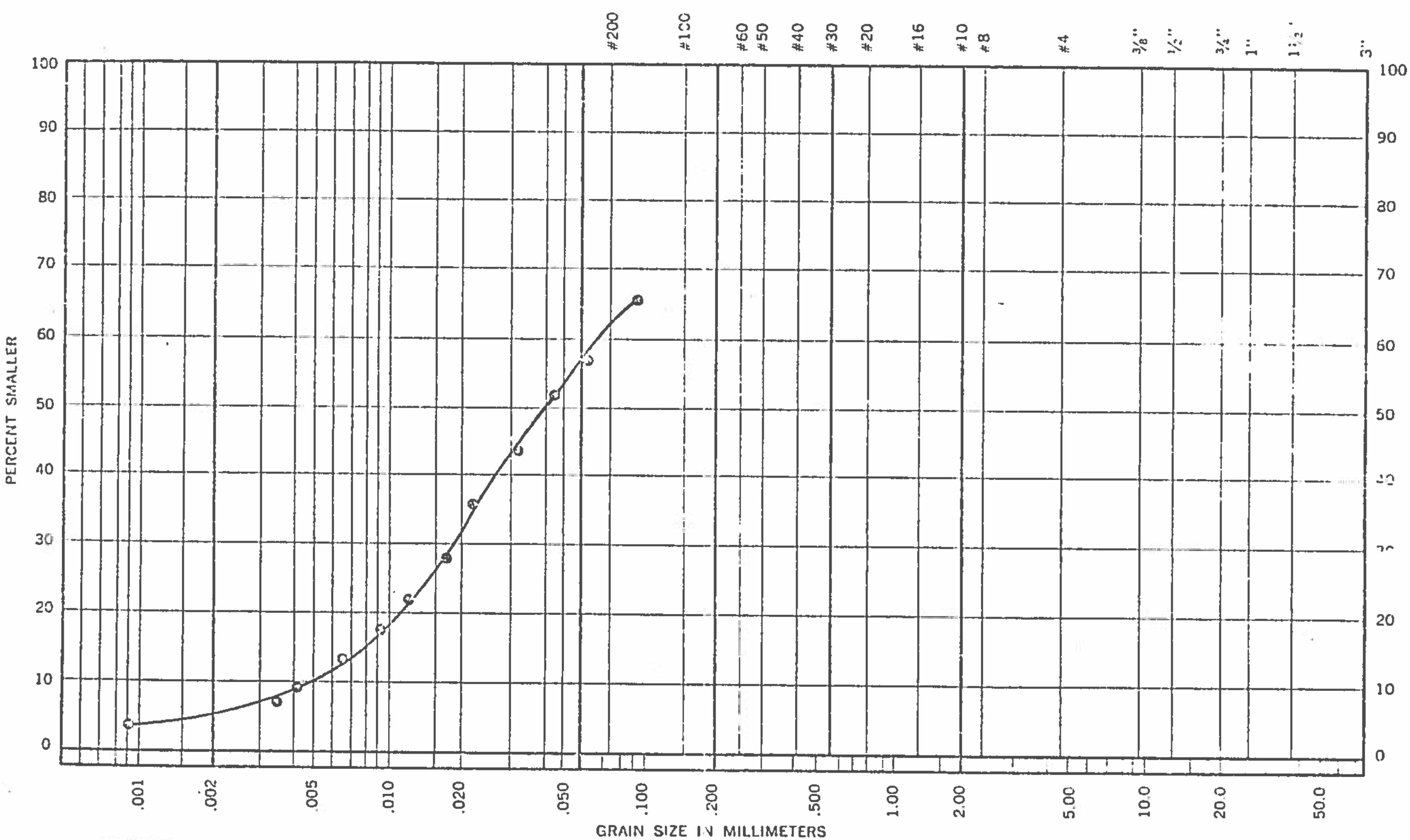


BROOKER & ASSOCIATES

SAMPLE DESCRIPTION SAND

PROJECT DAWSON CITY
JOB No. E 381-C DATE MAY 4, 1972
SAMPLE No. TH. 9A
DEPTH 15'

GRAIN SIZE DISTRIBUTION



BROOKER & ASSOCIATES

SAMPLE DESCRIPTION GREY SAND AND SILT ORGANIC

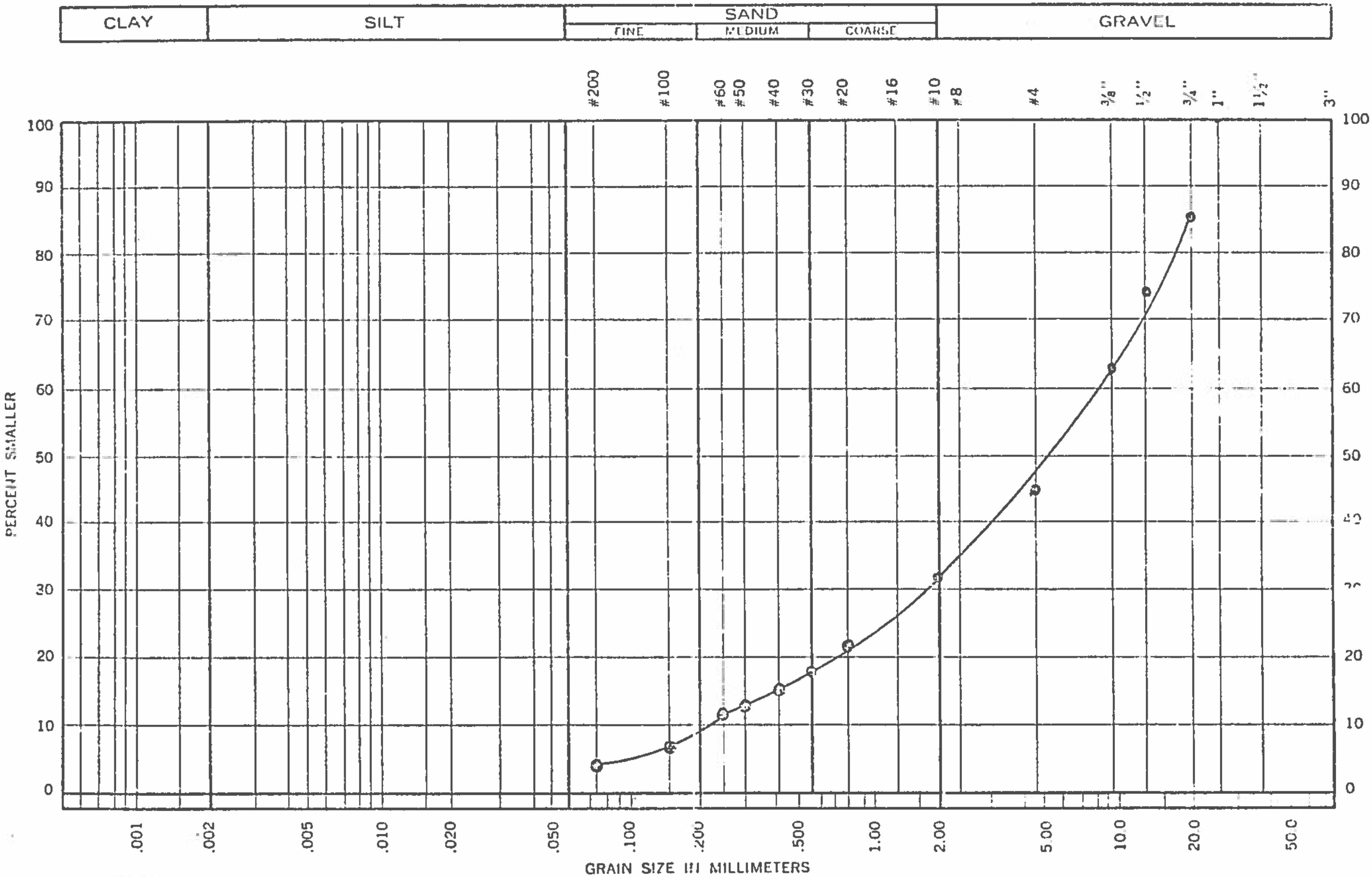
PROJECT DAWSON CITY

JOB No. E-381C DATE MAY 8, 1972

SAMPLE No. T.H. # 11

DEPTH

GRAIN SIZE DISTRIBUTION

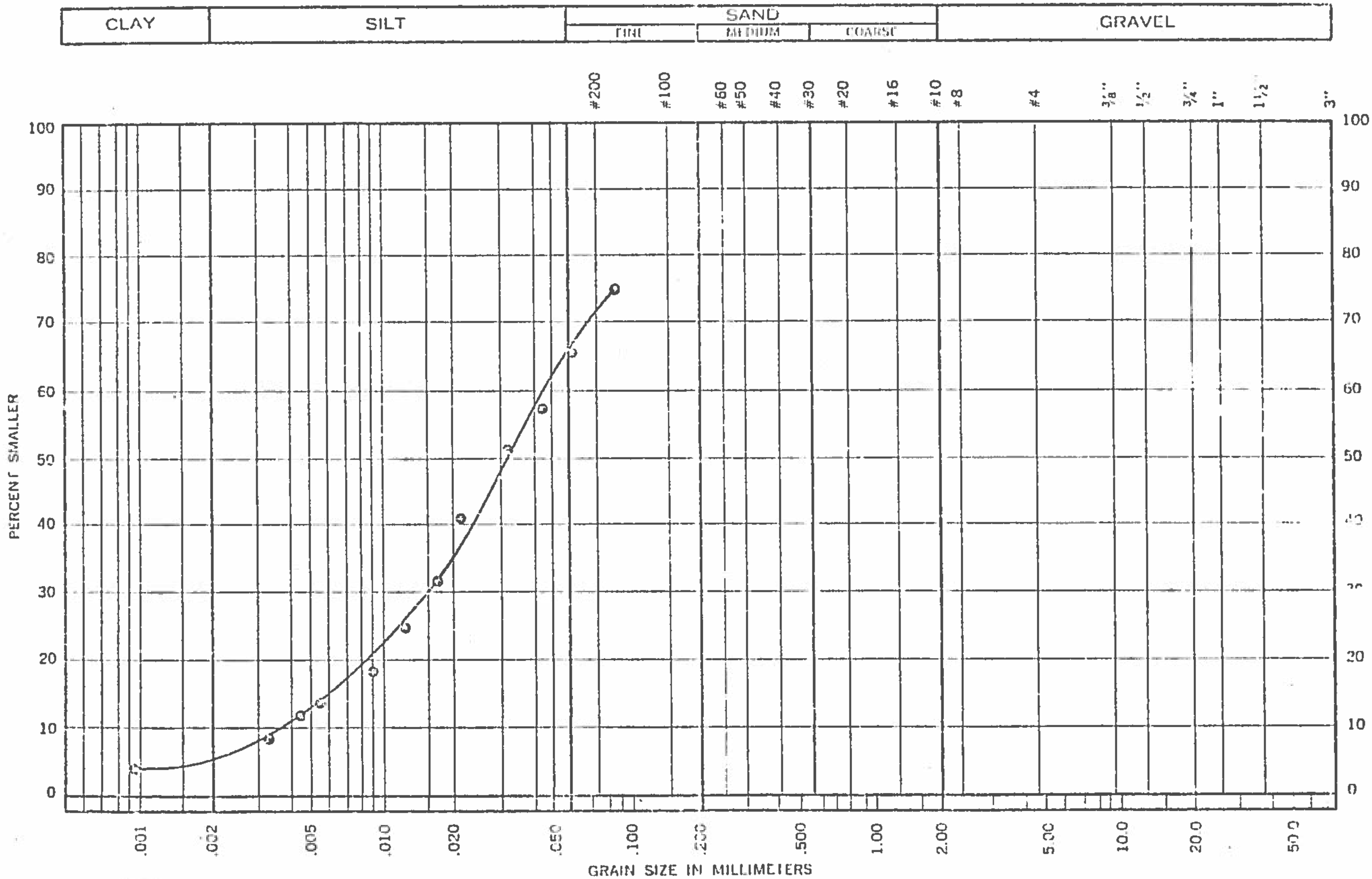


SAMPLE DESCRIPTION MED. BROWN SANDY GRAVEL

PROJECT DAWSON CITY
JOB No. E381-C DATE MAY 5/72
SAMPLE No. T.H. 11
DEPTH 13'

BROOKER & ASSOCIATES

GRAIN SIZE DISTRIBUTION



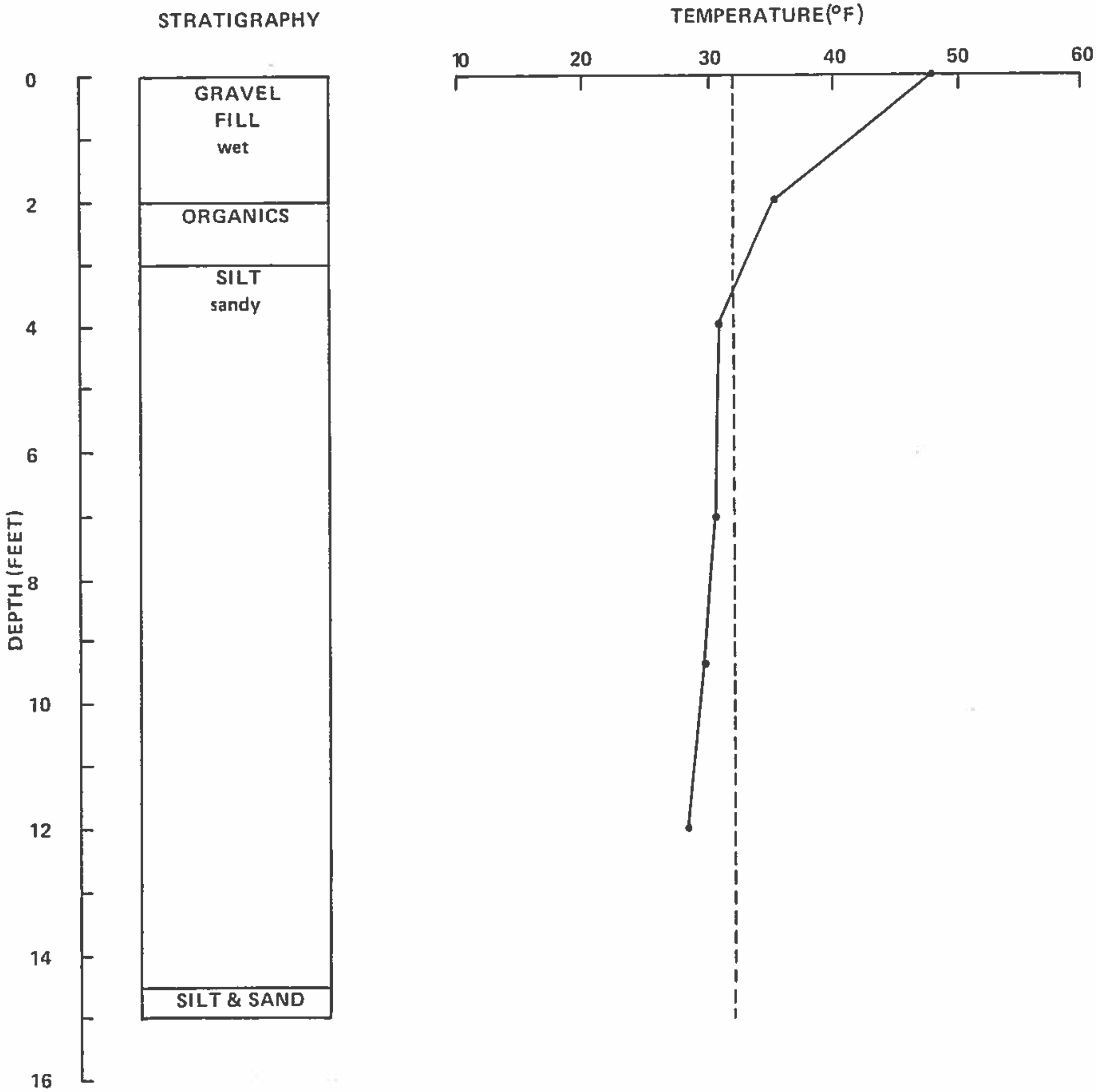
BROOKER & ASSOCIATES

SAMPLE DESCRIPTION BROWN SANDY SILT - ORGANIC

PROJECT DAWSON CITY
JOB No. E-3BIC DATE MAY 8, 1922
SAMPLE No. T.H.# 12
DEPTH 4'

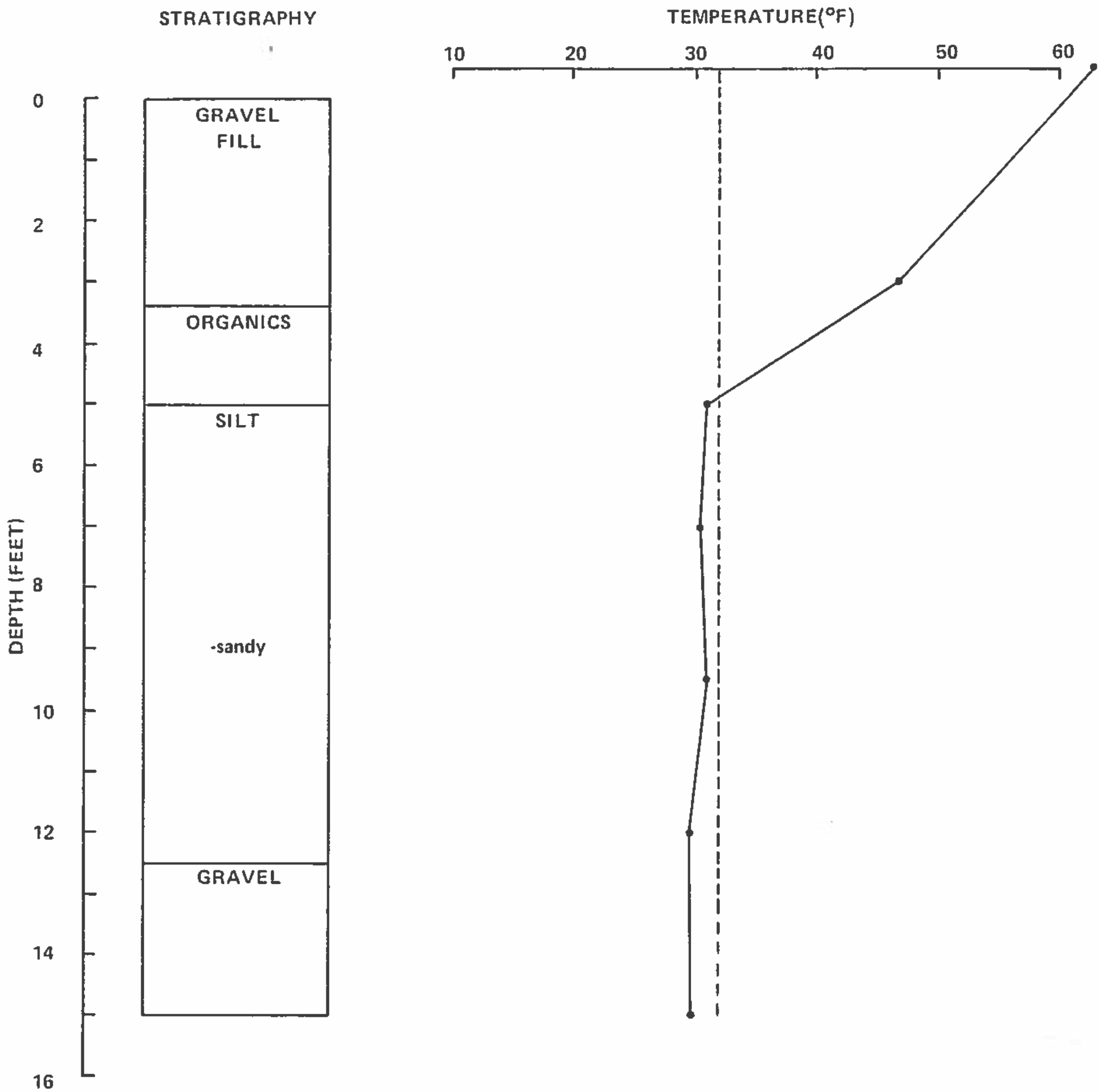
APPENDIX E

TEMPERATURE PROFILES



TEMPERATURE PROFILE
BOREHOLE 77 - 15
JUNE 12, 1977

DAWSON CITY	
TEMPERATURE PROFILE	
EBA Engineering Consultants Ltd.	
JOB No.: 11-1847	DATE: 13/10/77
DRAWN BY: DFC	DRAWING No.:
REVIEWED BY:	E - 1



TEMPERATURE PROFILE
BOREHOLE 77 - 20
JUNE 12, 1977

DAWSON CITY	
TEMPERATURE PROFILE	
EBA Engineering Consultants Ltd.	
JOB No.: 11-1847	DATE: 13/10/77
DRAWN BY: DFC	DRAWING No.:
REVIEWED BY:	E-2

GROUND TEMPERATURE PROFILE
RED FEATHER SALOON (B.H.#5)

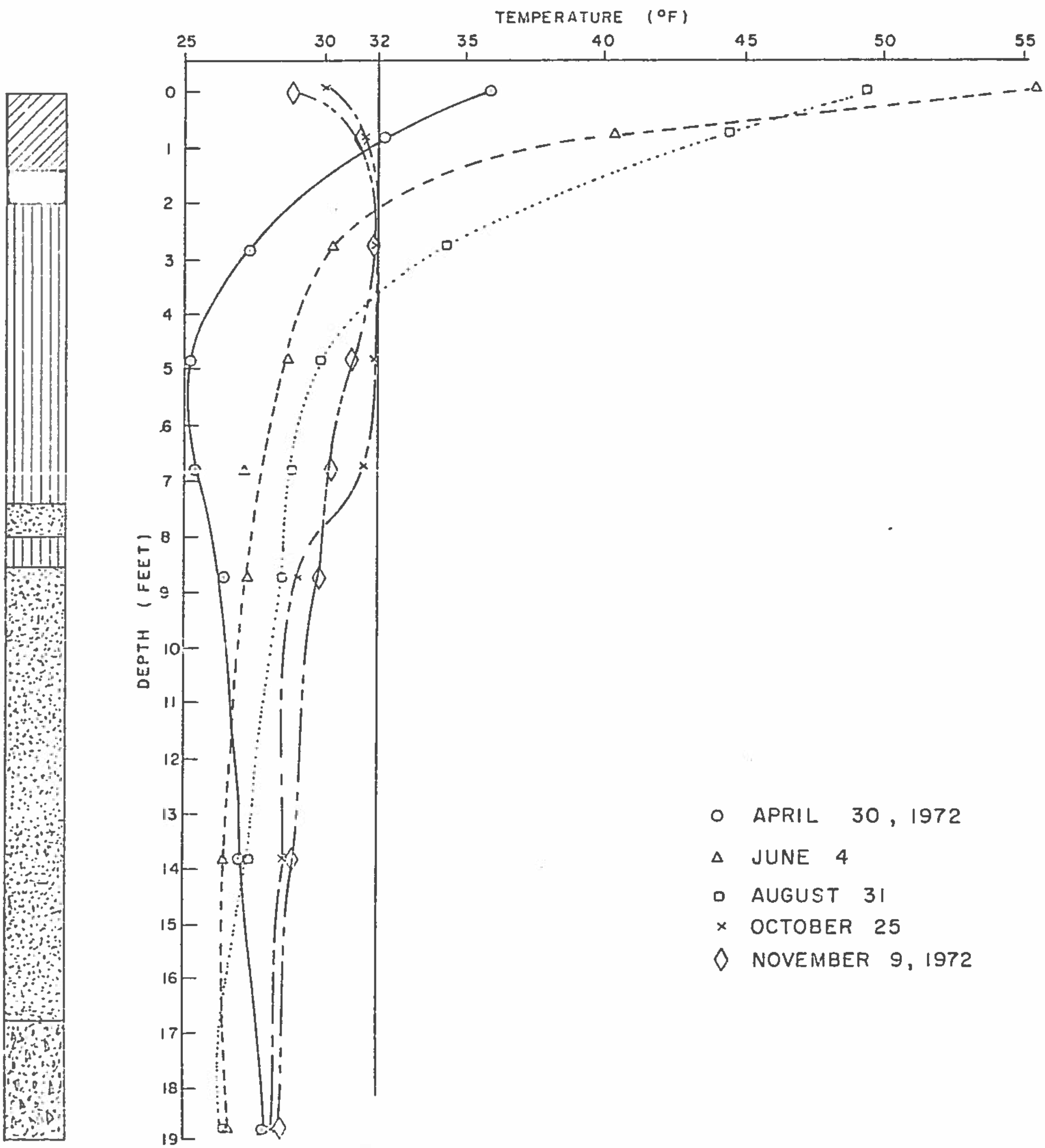


FIGURE D1

GROUND TEMPERATURE PROFILE
COMMISSIONER RESIDENCE (B.H.#9)

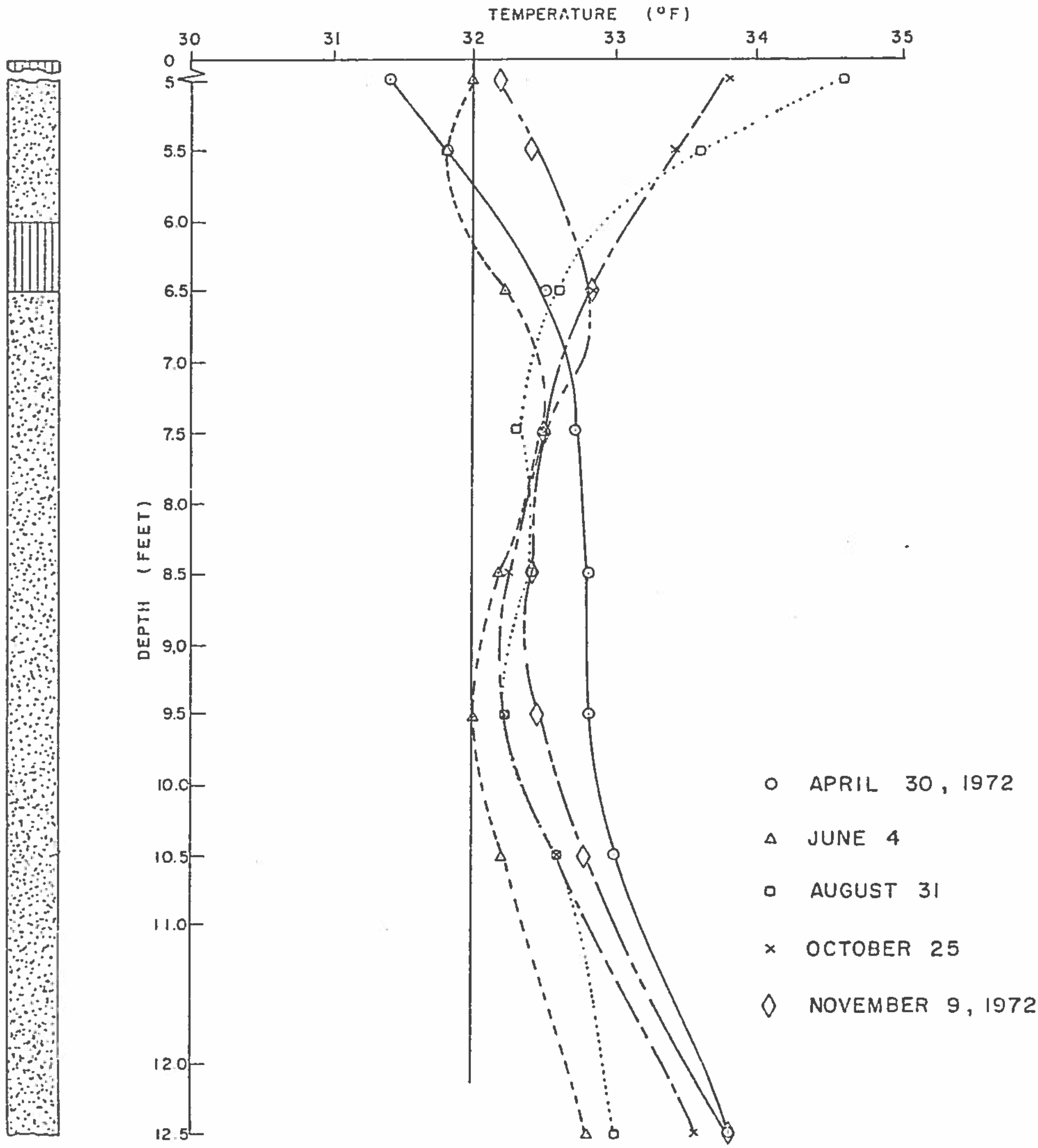


FIGURE D2

GROUND TEMPERATURE PROFILE
POST OFFICE (B.H. #4)

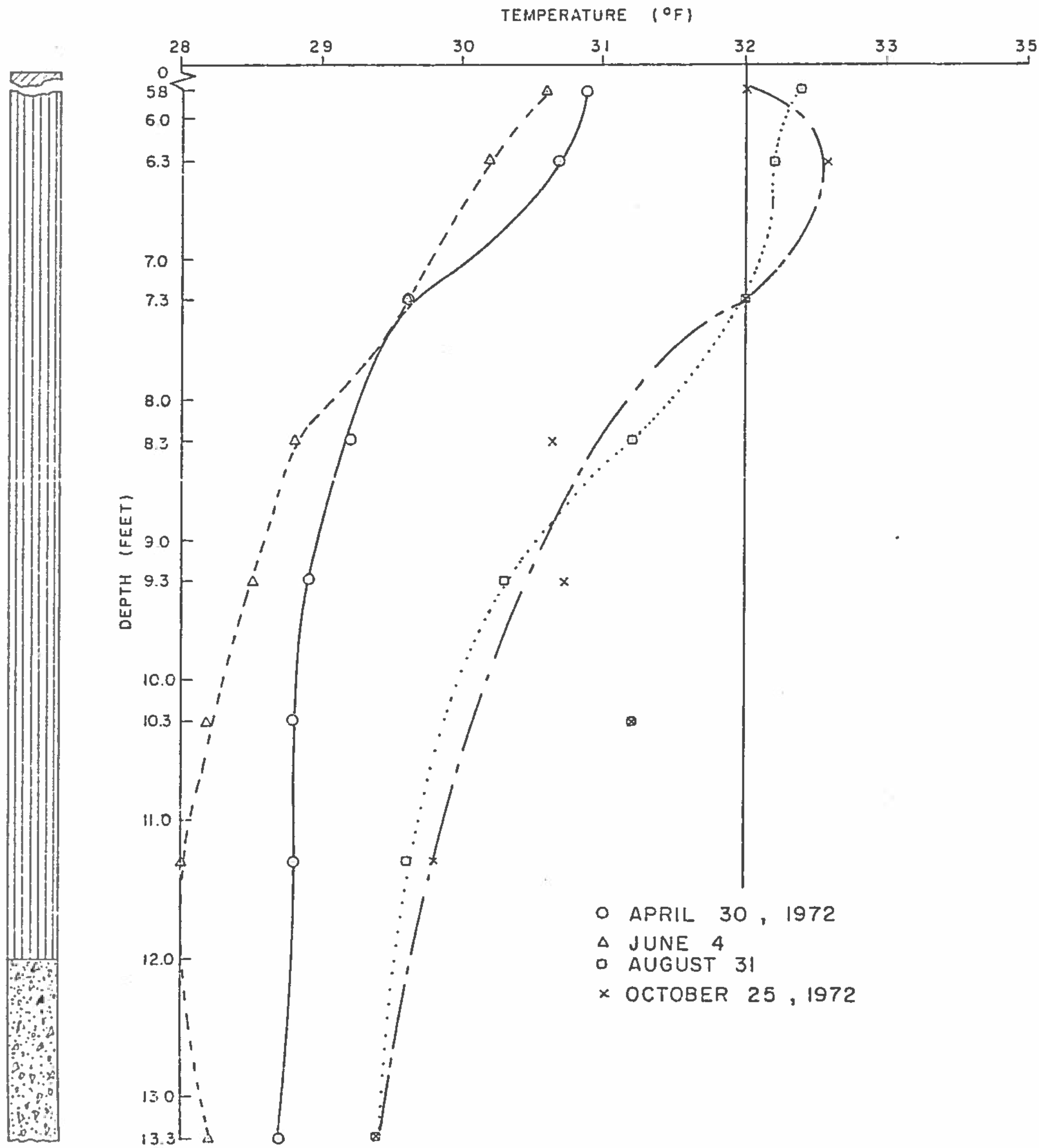


FIGURE D3