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March 21, 1996
Project No. KX11457

City of Merritt
c/o Urban Systems Ltd.
7 St Paul Street West
Kamloops, BC
V2C 1E9

Attention: Gary Stickel

Dear Sir:

Re: Geotechnical Investigation
Proposed Water and Sewer Services
Collettville, BC

1.0 INTRODUCTION

AGRA Earth & Environmental (AEE) was retained by Urban Systems, on behalf of the City of Merritt, to carry out a geotechnical investigation for the proposed new water and sewer services for Collettville.

Authorization to proceed with this investigation was received by facsimile transmission from Gary Stickel on January 26, 1996.

This report presents the results of the field work and laboratory testing, together with recommendations for geotechnical aspects of the design and construction of the proposed services.

2.0 DESCRIPTION OF PROJECT AND SITE

The Collettville community is understood to have an outdated water distribution system, but no municipal sewer system. Based on the information supplied by Urban Systems, a new water distribution system, and a sanitary sewer system is to be constructed to service the community. AEE understands that the proposed invert levels for the services will generally range from about 2 to 4 m below the ground surface. A sewerage lift station is to be constructed on a site located between Government Road and the Coldwater River, to the west of Main Street. It is understood that, as presently proposed, the lift station will have a base level about 5 m below the existing ground surface, and may be a prefabricated structure.

AEE's terms of reference for this project were as follows:

- to determine the general subsurface conditions along the route of the proposed water and sewer mains, and at two alternate locations for the lift station
- to install water level measuring devices throughout the community, and to monitor the water level bi-monthly over the next 2 months
- to prepare a report summarizing the results of the investigation, together with geotechnical recommendations for:
  - sewer and watermain construction
  - lift station installation
  - dewatering requirements for construction
  - re-use of the native soils for pipe bedding and trench backfill
  - roadway reinstatement

3.0 INVESTIGATION METHODOLOGY

The field work for this investigation was carried out on February 8, 9 and 12 to 14, 1996. During this period, 22 boreholes numbered BH-1 to BH-16 and BH-20 to BH-23, were drilled along the routes of the proposed water and sewer mains, using a truck mounted air-rotary drill rig. These boreholes were advanced to depths ranging from 3.5 to 5.7 m, ie to 1 to 1.5 m below the proposed invert level for the sewer. Three boreholes, numbered BH-17, BH-17A and BH-19, were drilled to depths of 4.5 to 9.4 m, at alternative locations for the sewerage lift station. BH-17A and BH-19 were drilled using a hollow stem auger drill rig after BH-17 could not be advanced below 4.5 m depth. BH-18, which was to be put down between BH-17 and BH-19, was deleted. Sampling was carried out in the boreholes primarily by Standard Penetration testing using, 50 mm and 75 mm diameter split spoon samplers. The soil samples obtained from the boreholes were classified visually, and the consistency of clayey soils was measured using a pocket penetrometer. The samples were stored in plastic bags and taken to our laboratory for examination and testing. The laboratory testing carried out on the soil samples consisted of gradation analyses, Atterberg Limit testing and moisture content determinations. Cone penetration tests were driven beside BH-17 and BH-19, and were labelled BH-17B and BH-19A, respectively.

Standpipes were installed in BH-4, BH-7, BH-10, BH-11, BH-12, BH-13, BH-14, BH-17, BH-19, and BH-23 to permit monitoring of the water level. The standpipes used consisted of 75 mm diameter PVC pipe, with the lower metre slotted and covered with a layer of geotextile.

The locations and ground surface elevations of boreholes having standpipe installations were surveyed by Urban Systems. The locations of the remaining boreholes were referred to existing surface features. The approximate locations of the boreholes are shown on Figure 2, in Appendix A.

4.0 SUBSURFACE CONDITIONS

A detailed description of the subsurface conditions encountered at the individual borehole locations is given on the borehole logs in Appendix B. The following is a summary of the soil and groundwater conditions at the borehole locations.

4.1 SEWERAGE LIFT STATION

BH-17 and BH-19 were drilled at alternative locations for the lift station, as proposed at the time of the field work. BH-17 could not be advanced below 4.5 m depth using the air rotary equipment, due the gravel caving into the hole. BH-17A was subsequently drilled about 3 m to the east of BH-17, and BH-19 was drilled at the northerly location shown on Figure 2, using a drill rig equipped with hollow stem augers.

BH-17, BH-17A and BH-19 encountered gravelly sand and sandy silt to depths of 1.2 m and 1.6 m, respectively below the ground surface. Sandy gravel was encountered below the sand and silt at these locations, and at the ground surface at BH-17A. The gravel extended to a depth of about 5.5 m and had measured N-values ranging from about 8 to 20 blows per foot, with the values decreasing with depth. The lower N-values were considered to probably be influenced by drilling below the water level in relatively clean granular soil. The blow counts measured in cone penetration tests carried out beside BH-17 and BH-19 ranged from about 10 to 40 blows per 300 mm. Based on the results of our testing, the gravel and sand at the borehole locations was assessed to have a compact to loose relative density. The results of a gradation analysis carried out on a combined sample of the gravel and sand from BH-19 is shown in Appendix C. It should be noted that the clay content shown on the gradation chart reflects the presence of clay layers in the gravel.

Fine to coarse sand, with some gravel, to gravelly sand was encountered below about 5.5 m depth at both BH-17A and BH-19. The sand extended to depths of about 8.8 m and 9.2 m at these locations, and was assessed to have a loose to compact relative density. The gradation of a sample of the sand from BH-19 is shown in Appendix C.

Gravel, with some sand, was encountered below depths of 8.8 m and 9.2 m.

The groundwater level measured in the standpipes installed in BH-17A and BH-19 was 2.4 m and 2.2 m, respectively below the ground surface on February 22, 1996.

4.2 WATER AND SEWER MAIN ROUTES

4.2.1 Existing Pavement Structure

Boreholes which were drilled through the roads generally encountered 50 to 65 mm of asphaltic concrete. The nature and thickness of the underlying granular fill was difficult to determine, since

it was solidly frozen. Based on visual observations 500 to 730 mm of granular fill existed at BH-5, BH-7 and BH-8, which were put down along Lindley Creek Road. The granular fill at these locations consisted of 65 to 200 mm of gravel and sand base underlain by 300 to 670 mm of sandy gravel subbase.

The boreholes along the remainder of the streets in Collettville encountered granular layers ranging in thickness from about 75 mm to 400 mm, and averaging about 150 to 250 mm. The granular fill on streets other than Lindley Creek Road generally consisted of gravel and sand.

4.2.2 Native Soils

4.2.2.1 Portion of Collettville Within 300 m of the Coldwater River

BH-13 and BH-21 encountered about 0.5 m of silty clay and silt, respectively, beneath the roadway pavement structure. Native soil, ranging from sand to gravel and sand was encountered below the clay and silt at these borehole locations, and directly beneath the pavement structure at BH-14, BH-15, BH-20 and BH-22, which were drilled within 300 m of Coldwater River. The gradation of samples of the sand from BH-14 and BH-20, are shown in Appendix C.

The Standard Penetration Resistance, N-values measured in the above noted boreholes ranged from 9 to in excess of 50 blows per 300 mm, and the relative density of the granular soils is assessed to generally range from loose to very dense.

BH-21 and BH-22 were terminated in gravel and sand/sand and gravel at 3.4 m and 2.9 m depth. At BH-13 and BH-14, the granular soils were underlain by firm to soft silty clay at a depth of 2.5 m and 3.5 m. Sandy silt, to silt with a trace to some clay was encountered below depths of 3.4 to 4.5 m.

4.2.2.2 Remainder of Collettville Community

Borehole BH-4, which was drilled along the alignment of the proposed extension of Chestnut Avenue, encountered stiff silt, with a trace of clay to about 1.6 m below the ground surface. The silt was underlain by stiff silty clay to 3.5 m depth. Pocket penetrometer measurements of 1.2 kg/sq cm were obtained on samples of the clay, indicating an undrained shear strength of about 60 kPa.

The remaining boreholes drilled along the sewer and water main routes encountered native soil consisting of silty clay directly beneath the pavement structure or the ground surface. The clay at the borehole location contained some silt and sand layers and partings. The N-values measured in the clay generally ranged from about 5 to 10 blows per 0.3 m. Pocket penetrometer measurements generally ranged from 0.8 to 3.5 kg/sq cm, indicating a firm to very stiff consistency.

Atterberg limit testing carried out on samples of the clay from BH-1, BH-12 and BH-16 gave liquid limit values of 40 to 48 and plasticity indices of 20 to 24, indicating a clay of intermediate plasticity. The natural moisture content of samples of the clay was generally found to range from about 25 to 35 percent down to a depth of about 3.5 m, although values as low as 14 percent were measured to 2 m depth at BH-1. At BH-9, the moisture content of a clay sample at 4.8 m depth was 43 percent.

4.2.3 Groundwater Conditions

The water levels measured in the standpipes installed in the boreholes generally ranged from 2.0 to 4.0 m below the ground surface on February 22, 1996. The water level was at 1.3 m depth at BH-12, but is considered to probably be influenced by the water level in the adjacent ditch.

5.0 DISCUSSION OF PROPOSED SERVICE INSTALLATIONS

The boreholes put down during this geotechnical investigation generally encountered granular soils, ranging from sand to gravel and sand, in the portion of Collettville within 200 to 300 m of the Coldwater River. The boreholes drilled in the remainder of the community generally encountered native soil consisting of silty clay.

The water level in the granular soils is considered to be controlled by the water level in the Coldwater River. It is recommended that construction of the sewerage lift station, and the sewer and water mains which will be in the granular soils, be carried out during the late summer or early autumn, since it is anticipated that the water level will be lower at that time.

The silty clay at Collettville is considered to have a moderate potential for volume change due to change in moisture content. To minimize the potential for swelling to occur, service installations in the clay soil should be planned and carried out in a manner that minimizes moisture change.

6.0 GEOTECHNICAL RECOMMENDATIONS

6.1 SEWERAGE LIFT STATION

6.1.1 Construction Using Conventional Excavation and Backfill Techniques

Excavation

The water level measured in the standpipes in BH-17A and BH-19 was 2.2 to 2.4 m below the ground surface on February 2, 1996. The base level presently proposed for the sewerage lift station is understood to be 5 m below the ground surface, which would require excavating to about 3 m below the measure water level. Because of the high permeability of the gravel and sand, and the underlying fine to coarse sand, it is anticipated that the water level at the site is largely controlled by the water level in the adjacent portion of the Coldwater River. Dewatering

and groundwater control will therefore be a major effort at the site presently proposed. It is suggested that consideration be given to selecting a site where the clay exists, since this would significantly decrease the amount of work required in carrying out the excavation for the structure.

AEE understands that construction of the sewer and water installations for Collettville will be carried out during the period of May to October, 1996. It is anticipated that the water level at the site could rise to near the ground surface during the early summer, when the river is at a high level due to snowmelt. It would be significantly more difficult to carry out the excavation for the lift station when the water level is high, and AEE suggests that construction of the lift station be deferred until as late as is practical, in order to allow the water level to drop as much as possible.

Groundwater control will be required during excavation for a lift station constructed using open excavation and backfilling techniques, in order to minimize sloughing of the sides of the excavation, and also to minimize disturbance of the subgrade soil which will support the structure. Highly permeable gravel and sand to sand with some gravel was encountered to depths of at least 9 m at BH-17A and BH-19, and it will not be possible to provide a water cutoff by driving sheet piles around the excavation area. Due to the highly permeable soil at the site, and the proximity to the Coldwater River, it is recommended that the groundwater system be designed, installed and operated by a specialist in this field. The groundwater lowering system will need to be operated until the lift station is installed/constructed and backfilled to the ground surface.

The excavation for the lift station could be carried out in open cut, with 1H:1V side slopes after groundwater lowering is carried out to at least 300 mm below the proposed base level for the lift station.

An alternative to carrying out an open cut excavation, which would also reduce the amount of backfilling required around the lift station, would be to use a braced excavation using either driven steel sheet piling or soldier piles and lagging. AEE recommends that the sheeting, or piles and lagging, be extended to at least 0.6 m below the proposed base of excavation. A greater depth of embedment may be dictated by the shoring design.

Occasional cobbles were encountered in the gravel and sand at BH-17, and cobbles should also be anticipated in the area of BH-19. It may be necessary to excavate the cobbles in order to advance steel sheeting without damage, and/or disengaging the interlocks.

A braced excavation should be designed to resist lateral earth pressures calculated using a rectangular pressure distribution, with the design pressure equal to $K_a \gamma H$, where:

$K_a = 0.3$
$\gamma = 22$ KN/m^3 down to the water level

A surcharge load of 10 kPa should be added to the lateral earth pressures calculated using the parameters given above, in order to account for the loads from equipment working, and materials

placed, adjacent to the edge of the excavation. Excavated soil should not be placed within 3 m of the sides of the excavation, in order to avoid higher surcharge loads.

Bedding and Backfill

It is recommended that the soil at the base level for the lift station be reviewed by qualified geotechnical personnel after the excavation has been completed.

Based on the results of BH-17A and BH-19, the soil at the base level for the lift station is anticipated to consist of gravel, with some silt. No working mat is considered to be necessary over the native soil if a pre-manufactured lift station is installed. If the lift station is constructed in place, it is recommended that the native soil be covered with at least 150 mm of crushed gravel to minimize disturbance of the subgrade by construction activities.

The native gravel excavated at the site will be acceptable for use in backfilling the sewerage lift station, provided that all material over 100 mm diameter is removed from backfill placed within 1 m of the structure walls. In order to minimize post construction settlement, it is recommended that the backfill be placed in loose lifts of 200 to 300 mm maximum thickness and compacted to at least 90% of the maximum dry density as defined by the Standard Proctor Test (ASTM D698). The backfill should be compacted to at least 95% of Standard Proctor if grade supported structures, or paved access road is to be constructed over the backfilled area. Compaction within 1 m of the lift station walls should be carried out using hand held equipment in order to minimize compaction induced stresses.

6.1.2 Construction Without Dewatering

AEE understands that consideration is being given to constructing the sewerage lift station by advancing concrete sections down to the base level without dewatering, and then pouring a concrete base slab to support the structure. With this method soil would be excavated from within the concrete enclosure as additional sections are added. The concrete sections would be left in place.

It is considered that this method of construction is technically possible at the presently proposed site, provided that the water level inside the concrete enclosure is maintained at the same level as the water level outside, so that subgrade disturbance due to an unbalanced water head is minimized. It should be noted that some difficulties may be experienced in advancing the enclosure through the gravel due to the buildup of friction, and the presence of cobbles. Contractors should evaluate the degree of difficulty associated with advancing the enclosure when considering this method of constructing the lift station. Even with careful control of the water level during excavation, some subgrade disturbance is considered unavoidable using this method. The lift station structure is light and the friction along the walls of the enclosure may be sufficient to prevent significant settlement. It is, however, recommended that provision be made for 50 to 75 mm of post construction settlement if this method of construction is used.

It is recommended that the subgrade be inspected by a diver, and that all loosened soil be removed from within the enclosure once it is at the desired level. It may be necessary to pour a concrete plug to seal the enclosure before the base slab is constructed. The concrete plug should be structurally connected to the enclosure sections which form the exterior of the lift station, and should be poured using a tremie tube, with a balanced water level maintained as indicated above. The water level inside the concrete enclosure for the lift station should not be lowered until the combined weight of the enclosure and lift station is sufficient to resist the hydrostatic uplift.

It should be noted that a void sometimes forms in the soil along the outside of the enclosure when this method of construction is used. Provision should be made for filling this void, particulary if a grade supported structure is to be constructed adjacent to the lift station.

6.1.3 Design Pressures for Lift Station

Provided that the soil at the base of the excavation is not disturbed during excavation, the native gravel will be capable of supporting a net stress increase of 100 kPa. The total and differential settlement for a structure designed using this bearing pressure should not exceed 25 mm and 20 mm, respectively. An allowance for 50 to 75 mm of post construction settlement should be made for a structure constructed as indicated in Section 6.1.2.

The lift station should be designed to resist lateral earth pressures calculated using a triangular pressure distribution, where the design pressure equals $K_o \gamma H$. For a structure having non-yielding walls,

K_o =0.5
γ =22 kN/m^3
γ_s =12 kN/m^3

The total unit weight γ, should be used down to the water level, which based on observations by AEE, is anticipated to be to near the ground surface when the Coldwater River is at a high level. If there will be unbalanced water pressures acting on the structure, the submerged unit weight γ_s, should be used below the water level, together with the added lateral load due to hydrostatic pressures.

All surcharges, such as those from equipment or vehicles, must be considered in the design of the walls using the earth pressure coefficient listed above.

Compaction induced pressures on the walls must also be considered in the design. These pressures vary with the type of compaction equipment used and the degree of compaction imparted. With compaction to 95% of Standard Proctor or greater a minimum uniform earth pressure of 19 kPa should be added to the lateral earth pressures indicated above, down to the zone where the earth pressure equals 19 kPa. This assumes that the compaction equipment used is not larger than a 3 tonne vibratory roller.

The sewerage lift station should be designed to resist hydrostatic uplift pressures, particularly if it will be drained for maintenance. The most critical uplift pressures will occur when the Coldwater River is at a high level, as indicated above.

6.2 WATER AND SEWER MAINS

6.2.1 Excavations

6.2.1.1 Excavations in Clay

It is considered that temporary (less than 2 days) excavations in the silty clay can be carried out using 0.75 H:1V side slopes down to a depth of 5 m below the ground surface. For deeper excavations in clay, the side slopes should be flattened to 1H:1V. Excavations with steeper side slopes could be carried out using shoring to support the slopes, or at least an approved trench box to protect the workers should failure occur. This is not recommended, since it will be more difficult to achieve adequate compaction of the native clay backfill in the narrower trenches which would result.

Laboratory testing was not carried out on samples of the clay from the boreholes to determine its exact swell potential. Based upon the results of the Atterberg limit tests, and previous experience in the Merritt area, it is considered that the clay in Collettville has a moderate potential for volume change due to changes in the moisture content. Swelling could result in uplift of the service pipes, which would be undesirable - particularly for the sewers which are sensitive to grade changes. It is therefore recommended that the following precautions be carried out to minimize the amount of swelling that can occur, and the effects of swelling on the pipes:

- The clay at the subgrade level for the sewer mains, and laterals, should be protected against moisture changes (both drying and wetting) during excavation. In this regard, it is recommended that the clay subgrade be covered with the pipe bedding immediately after the trenches are dug to grade so that it is exposed to air and sunlight for as short a time as possible. If the bedding is not to be placed within one hour of excavation, AEE recommends that the clay subgrade be covered with weighted polyethylene sheets.

- The clay subgrade should be protected against exposure to standing water. In this regard, care should be exercised to ensure that surface water is not allowed to flow into the trenches. Water that does enter the trenches, from rainfall or other sources, should be pumped away.

- The pipes should have joints with sufficient flexibility to permit some deflection without opening up.

6.2.1.2 Excavations in Granular Soils

Temporary excavations (less than 3 days) can be carried out in the granular soils encountered in the northerly portion of Collettvile using 1H:1V side slopes down 5 m depth, or the water level.

In order to minimize disturbance of the subgrade, sloughing and loss of ground, groundwater control will be required for excavations taken below the water level in the sand, sand and gravel and sandy silt. In order to minimize the problems, and costs, associated with groundwater control AEE recommends that service trench excavations in the granular soils be carried out when the water level is at its lowest level. It is anticipated that this will be in the late summer and early autumn, when the Coldwater River is at its lowest level. It is recommended that water level monitoring be carried out using the standpipes installed in BH-14, BH-17, BH-19, and BH-21 to determine the optimum time for construction of the services in this part of Collettville.

In areas, such as adjacent to BH-13, BH-14, BH-15 and BH-20, where the sand/sand and gravel extend to depths of only 2.5 to 3.5 m below the ground surface, groundwater control could possibly be carried out using properly designed steel sheeting which is driven down into the underlying silt or silty clay. The sheeting would provide a partial groundwater cutoff, and reduce the amount of water that will flow into the excavations. Provided that excavation is carried out in relatively short sections (ie having a maximum length of about 10 m), it is considered that the water inflow could be controlled by pumping from well filtered sumps within the sheeted excavations.

At BH-17, BH-19, BH-21 and BH-22, the sand/sand and gravel extended to depths in excess of 4 m. In the area of these boreholes, and other areas where the granular soils extend to depths in excess of 1 m below the proposed invert level, it is considered that groundwater control can be carried out by pumping from well filtered sumps installed within sheeted excavations, provided that the excavations extend to no more than 0.3 m below the water level, and that some settlement of the pipes can be tolerated due to loosening of the subgrade.

Groundwater lowering should be carried out before trench excavation is started in areas where the proposed invert level is more than 0.3 m below the water level measured at the time of construction. It is recommended that groundwater lowering in these portions of the site be carried out by a specialist in that field.

6.3 BEDDING AND TRENCH BACKFILL

Pipe bedding should be carried out in accordance with the manufacturers specifications. An additional thickness of bedding may be required in areas where the subgrade is loosened and/or disturbed by digging below the water level in granular soils. The sand, sand and gravel/gravel and sand encountered in the boreholes contains some material larger than 12 mm size, and depending on the type of pipe used, may not be acceptable for use as pipe bedding unless the oversize material is removed before placing in the trenches.

The native sand, sand and gravel, and other granular soils in the northerly portion of the site will be acceptable for use as trench backfill. All material in excess of 100 mm diameter should be removed from fill used within 300 mm of the pipes in order to avoid damage due to impact and/or point loads. All granular backfill for the service trenches should be compacted to at least 98% of the maximum dry density as defined by the Standard Proctor Test (ASTM D698) in order to provide an acceptable subgrade for the roads.

Using granular backfill within the zone of frost action can result in differential heaving of the pavement structure in areas where the native soil consists of clay. This would be because the portions of the roads overlying the granular trench backfill would not heave, or experience less heave than the portions underlain by the native clay soil. The resultant differential movement not only creates an uneven road surface, but can result in more rapid deterioration of the pavement. It is therefore recommended that consideration be given to the use of the clay excavated from the trenches as backfill, at least within the upper 1.5 m, which can be affected by freezing during a severely cold winter. Granular backfill could be used for the lower portion of the trenches if desirable. Using the native clay as backfill is also recommended in order to seal the trenches and prevent surface water infiltration, which could create expansion of the clay subgrade.

It would be preferable to compact the clay backfill to at least 98% of Standard Proctor in order to minimize post construction settlement. The moisture content of the clay samples recovered from the boreholes put down during this geotechnical investigation generally ranged from 25 to 35%, and is anticipated to generally be 5 to 10% above the optimum water content for compaction. With these natural moisture contents it is considered that 95% of Standard Proctor is the maximum that can be practically achieved, unless construction is carried out during a consistently dry period, and the clay excavated from the trenches can be spread out and dried appropriately before placing. Clay which has a moisture content in excess of 35%, because it is from the lower portion of deep trenches, or has been exposed to rain, will be virtually impossible to compact to the specified density and should not be used as trench backfill.

Compaction even to 95% of Standard Proctor will require extra time and effort, including placing in thin lifts, and the use of suitable peg foot or pad foot compaction equipment. The lift thickness required to achieve this level of compaction will depend on the moisture content of the clay at the time it is placed, the compaction equipment used and the competence of the personnel carrying out the compaction. In general, it is considered that the maximum thickness of the loose lifts should not exceed 200 mm, and may be less. It may be possible to modify the lift thickness based on observations and testing during construction.

It is recommended that full time review and testing of clay backfilling operations be carried out by qualified geotechnical personnel to ensure that a consistent, and acceptable degree of compaction is achieved.

6.4 ROADWAY REINSTATEMENT

AEE understands that construction of a new pavement structure for the roads is not proposed in conjunction with installation of the new sewer and water mains. Based on the information given in the Urban Systems letter dated January 17, 1996, and information from our subsequent meetings and telephone conversations, the intention is to reinstate the roadway subbase and base in the trenches, and then to place a new asphaltic concrete wearing course over the entire width of the roads.

The existing pavement structure at the borehole locations was quite variable in total thickness and composition. In general, it is considered that the proposed 300 mm of pit run gravel subbase and 75 mm of 19 mm crushed gravel base equals or exceeds what was encountered and will provide a structure which is reasonably compatible.

The subbase and base in the service trench areas should be compacted to at least 100% of the maximum dry density as defined by the Standard Proctor Test (ASTM D698). It is recommended that at least 50 mm, and preferably 65 mm of hot mix asphalt be used as a surfacing.

With the use of the native silty clay as trench backfill, and the degree of compaction that is anticipated, some settlement of the portion of the roads underlain by the trenches should be expected during a period of approximately one year after construction of the new services. AEE recommends that placement of the new asphaltic concrete across the full width of the roads be deferred until one year after construction of the services to allow this settlement to take place. The asphaltic concrete in the trench areas can then be relevelled as necessary before laying the new full width wearing course.

The existing wearing course appeared to be in reasonably good condition where it was visible. It is anticipated that there will be some deterioration of the existing pavement during construction of the water and sewer mains. It is recommended that the existing pavement be inspected, and repaired as necessary, before the new wearing course is placed. The new wearing course should have a minimum thickness of 50 mm.

It should be noted that total reconstruction of the pavement structure of the streets would create a more uniform structure, which would have better performance than that created by reinstatement as discussed above. As well, a totally reconstructed roadway would also be expected to have a longer usable period before repairs are necessary.

7.0 CHEMICAL ANALYSIS OF SOIL SAMPLES

The following table summarizes the results of chemical analyses received to date on soil samples from the boreholes. The results of additional analyses will be forwarded as soon they are received. The Chemical Analyses reports are provided in Appendix D.

SUMMARY OF CHEMICAL ANALYSES ON SOIL SAMPLES

Sample Location & Depth	Soil Type	Soluble Sulphates (%)	pH	Conductivity (umhos/cm)	Total Acidity cmol (+) /kg
BH-3, 1.5 - 1.95 m	Clay		9.1	11,000	1.4
BH-7, 1.5 - 1.95 m	Clay	4.08	8.3	52,500	
BH-10, 1.5 - 1.95 m	Clay		8.6	10,700	1.4
BH-15, 1.5 - 1.95 m	Sand		8.7	274	<1.0
BH-19, 1.65 - 1.95 m	Gravel	.02	8.3	148	
BH-22, 1.5 - 1.9 m	Gravel		7.2	55	<1.0

The tests for soluble sulphate were conducted as per CSA specification CAN/CSA A 23.2-3B. The results received to date indicated a very high sulphate concentration in the clay (4.08%), and a low concentration (.02%) in the sandy gravel.

The potential degree of sulphate attack on concrete exposed to the native gravel is low, and it is considered that concrete batched with normal Portland cement could be used. The degree of sulphate attack on concrete exposed to the clay is considered to be very severe. Table 9 of CAN/CSA A 23.1-M90, recommends the use of type 50 Portland cement with a maximum water cement ratio of 0.40, and a minimum 28 day strength of 35 MPa for concrete exposed to the clay soil. Additional restrictions may be required due to structural or other considerations.

Recent research indicates that concrete made with normal Type 10 cement, and incorporating 18 to 25% fly ash by weight, results in better resistance to sulphate attack that Type 20, 40 or 50 cement. A Type 10 cement/fly ash mix is commonly used in the BC interior, and it is recommended that it be used throughout this project. A concrete mix design incorporating fly ash can be provided upon request.

The chemical testing results received to date indicate that the clay soils will exhibit very aggressive corrosion of ferrous metals. Ductile iron fittings therefore need to be well protected using anodes or other forms of corrosion protection. The rate of corrosion of metal fittings exposed to the sand/sandy gravel is indicated to range from non-aggressive to slightly aggressive. It is suggested that anodes also be placed on ductile iron fittings exposed to the granular soils.

8.0 REPORT LIMITATIONS

The recommendations given in this report were based on the soil and groundwater conditions encountered in the boreholes drilled during this geotechnical investigation. If different soil or groundwater conditions than those reported in Section 4 are encountered during construction, this office should be notified so that the recommendations can be reviewed, and modified, if necessary.

It should be noted that the transition between the area where a clay subgrade is anticipated and the area where granular soils, such as sand/sand and gravel, are anticipated will not be a finite line as indicated on Figure 2. This line has been drawn using the limited amount of subsurface information available from the boreholes drilled during this investigation, and indicates that a transition from clay to granular soils occurs between the borehole locations shown. The approximate location of the transition has been provided as general information only and is not intended for bidding or estimating purposes. Contactors bidding on the project should make their own assessment of where the change in the subgrade soil occurs.

This report has been prepared for the exclusive use of the City of Merritt and Urban Systems Ltd. for the applications described within. It has been prepared in accordance with generally accepted soil and foundation practices. No other warranty, expressed or implied, is made. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of the third party. AGRA Earth & Environmental Limited accepts no responsibility for damages suffered by any third party as a result of decisions made, or actions based on this report.

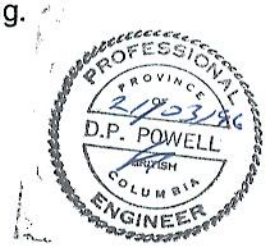
9.0 CLOSURE

AGRA Earth & Environmental Limited trusts that this report provides sufficient information for your present requirements. If you have any questions concerning this report please contact the undersigned at 374-1347.

Respectfully submitted,

AGRA Earth & Environmental Limited

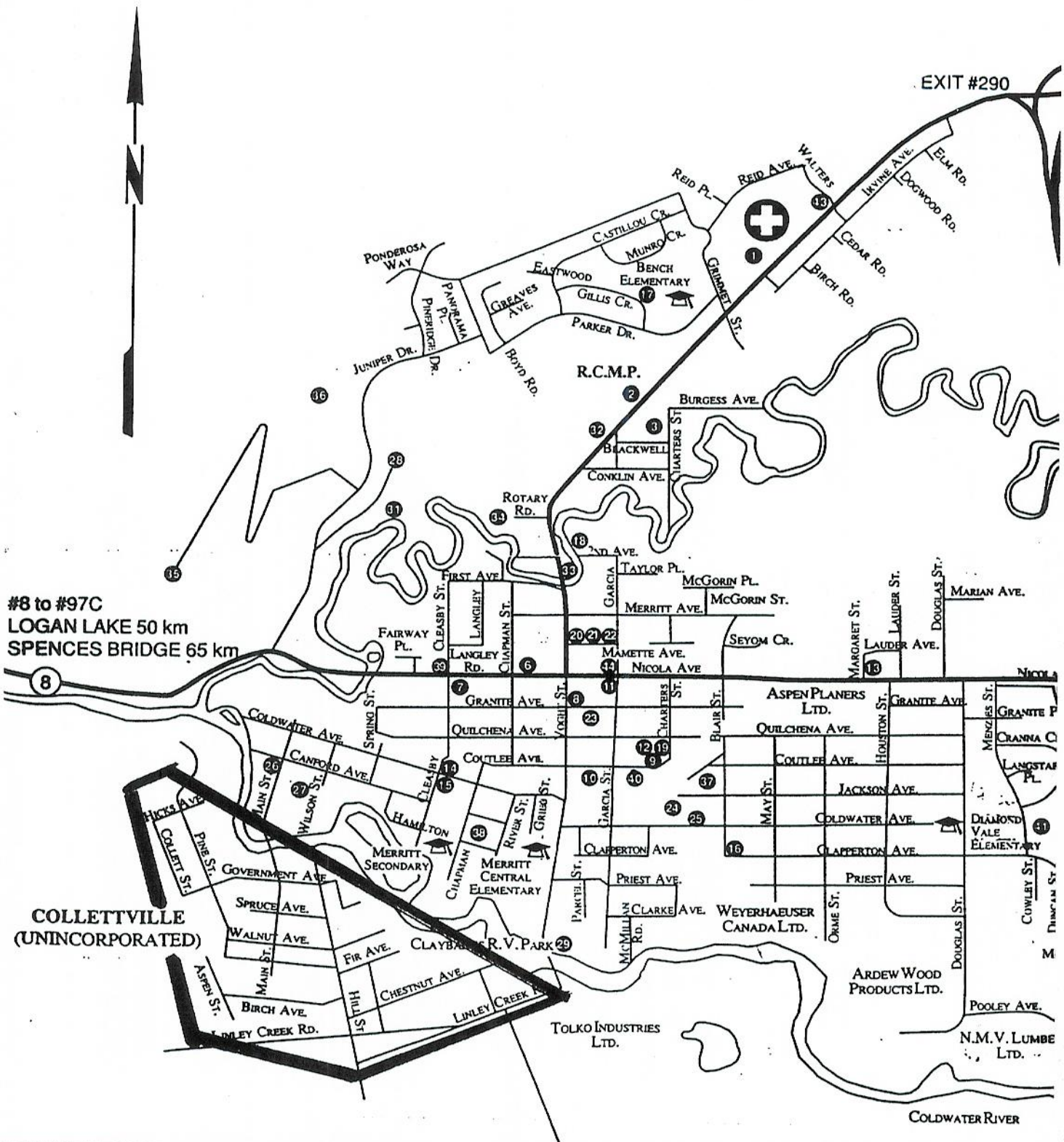
Donald P. Powell, P.Eng.
Project Engineer



Reviewed by:

Jerry A. Schmidt, P.Eng,
Senior Geotechnical Engineer

AGRA
Earth & Environmental



AGRA Earth & Environmental
Engineering and Environmental Services

KEY PLAN
COLLETTVILLE WATER AND SEWER

CLIENT: CITY OF MERRITT	Scale	Date	Drawn B	Project #	FIGURE 1
		96/02/22	DPP	KX11458	

COLDWATER RIVER

GRANULAR SUBGRADE

CLAY SUBGRADE

PROPOSED SEWERAGE LIFT STATION

BH-1
BH-2
BH-3
BH-4
BH-5
BH-6
BH-7
BH-8
BH-9
BH-10
BH-11
BH-12
BH-13
BH-14
BH-15
BH-16
BH-17
BH-17A
BH-17B
BH-19
BH-19A
BH-20
BH-21
BH-22
BH-23

CITY OF MERRITT

COLLETTVILLE WATER & SEWER DESIGN

BOREHOLE LOCATION PLAN

URBAN SYSTEMS

7052114-2

Scale 1:2000

NOTE:

The transition between the areas where clay subgrade soil and sand/ sand and gravel subgrade soils exist will not be a finite line, or at the exact location, shown on this drawing. The line shown was drawn using the limited subsurface data available, and indicates that a transition occurs between the adjacent borehole locations.

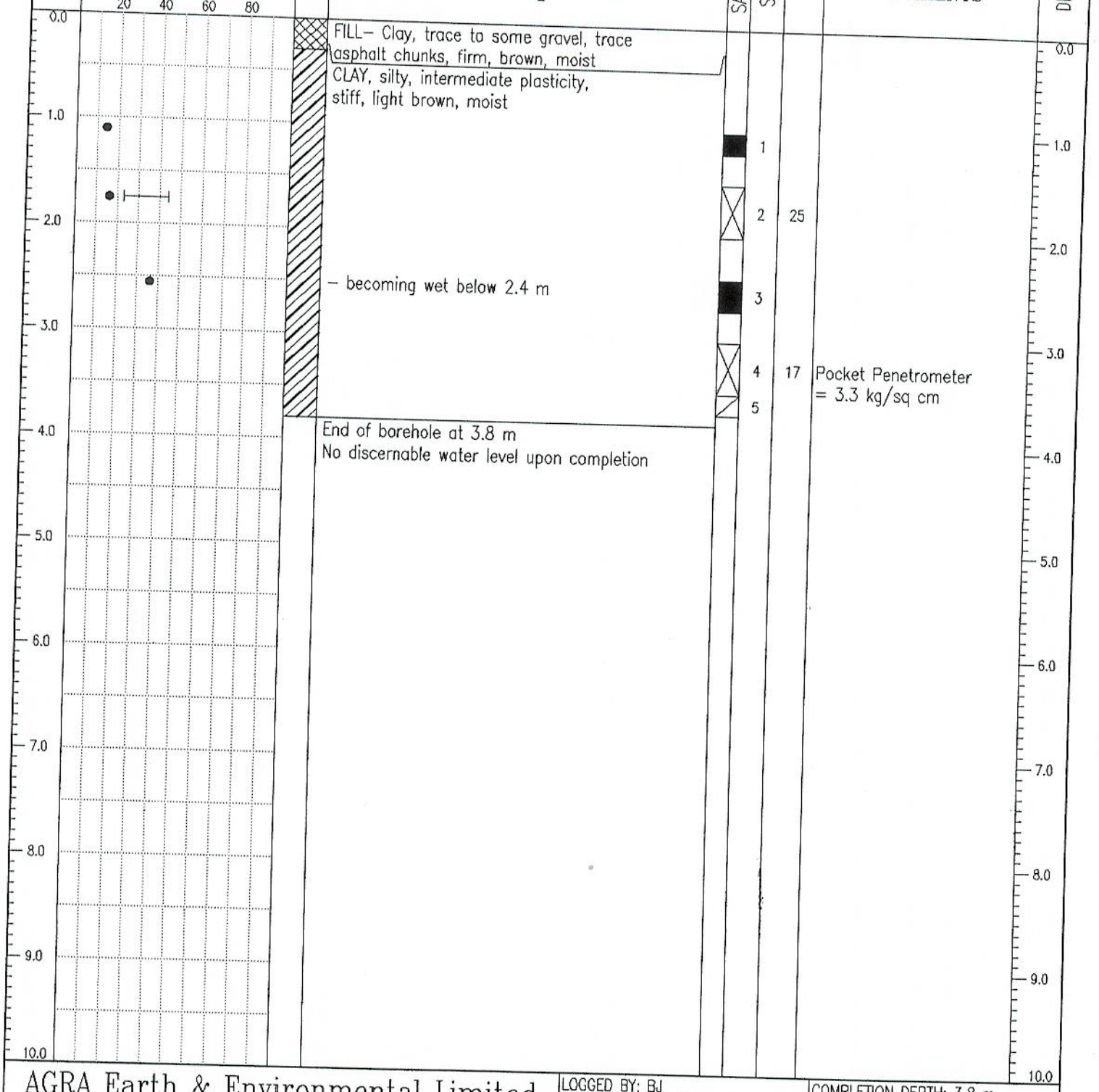
The line shown is for general information only. This drawing should be used in conjunction with AGRA Earth & Environmental Limited report KX11457. Contractors should review the borehole logs provided in this report and make their own interpretation of the location of the transition for bidding and construction purposes.

KX11457

FIGURE 2

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-1
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

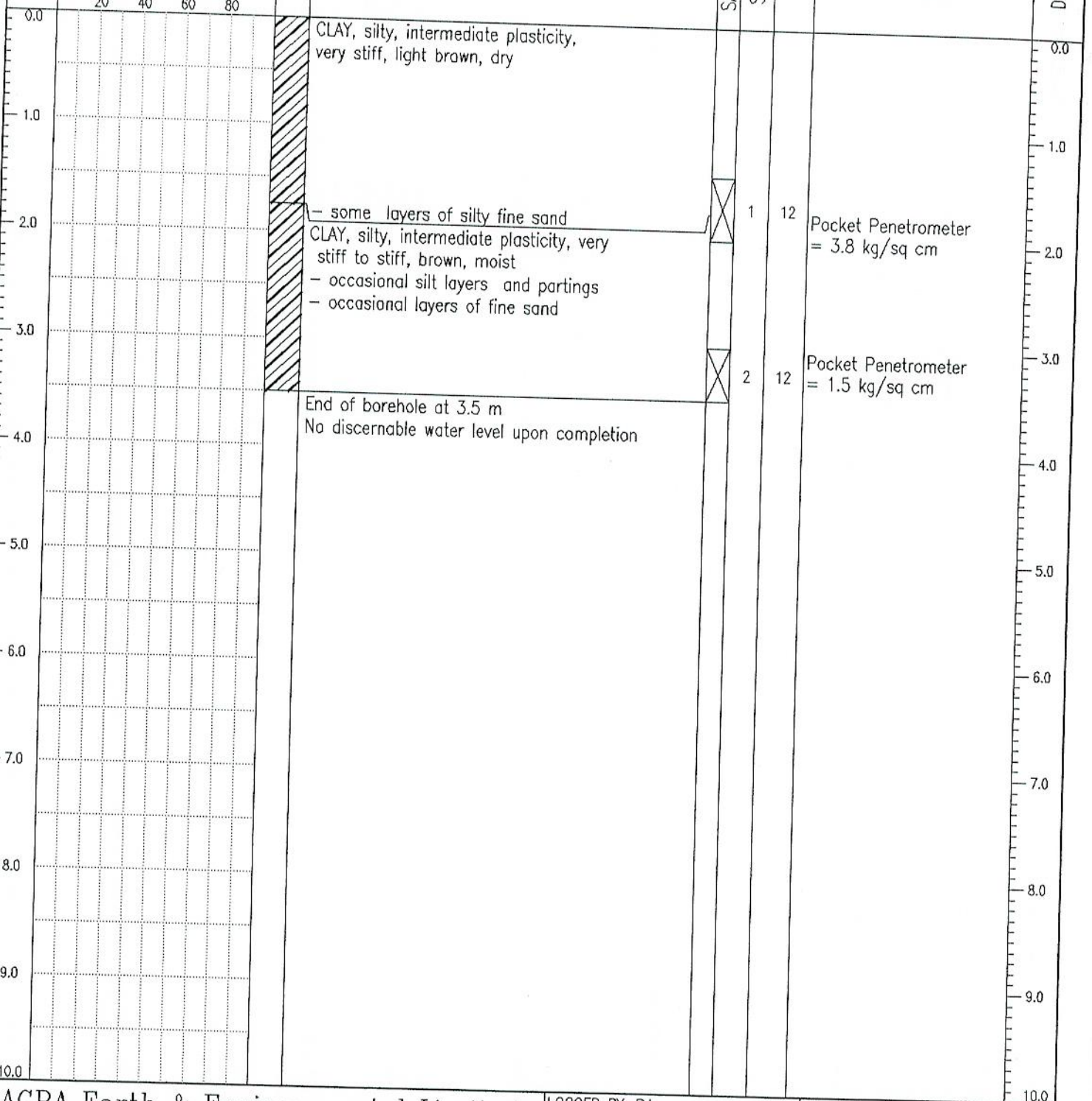


AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.8 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 3	Page 1 of 1

96/03/20 01:21PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-2
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON ▤



AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.5 m
	REVIEWED BY: DP	COMPLETE: 13/02/96
	Fig. No: 3	Page 1 of 1

98/03/20 01:22PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-3
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ☒ SPLIT SPOON

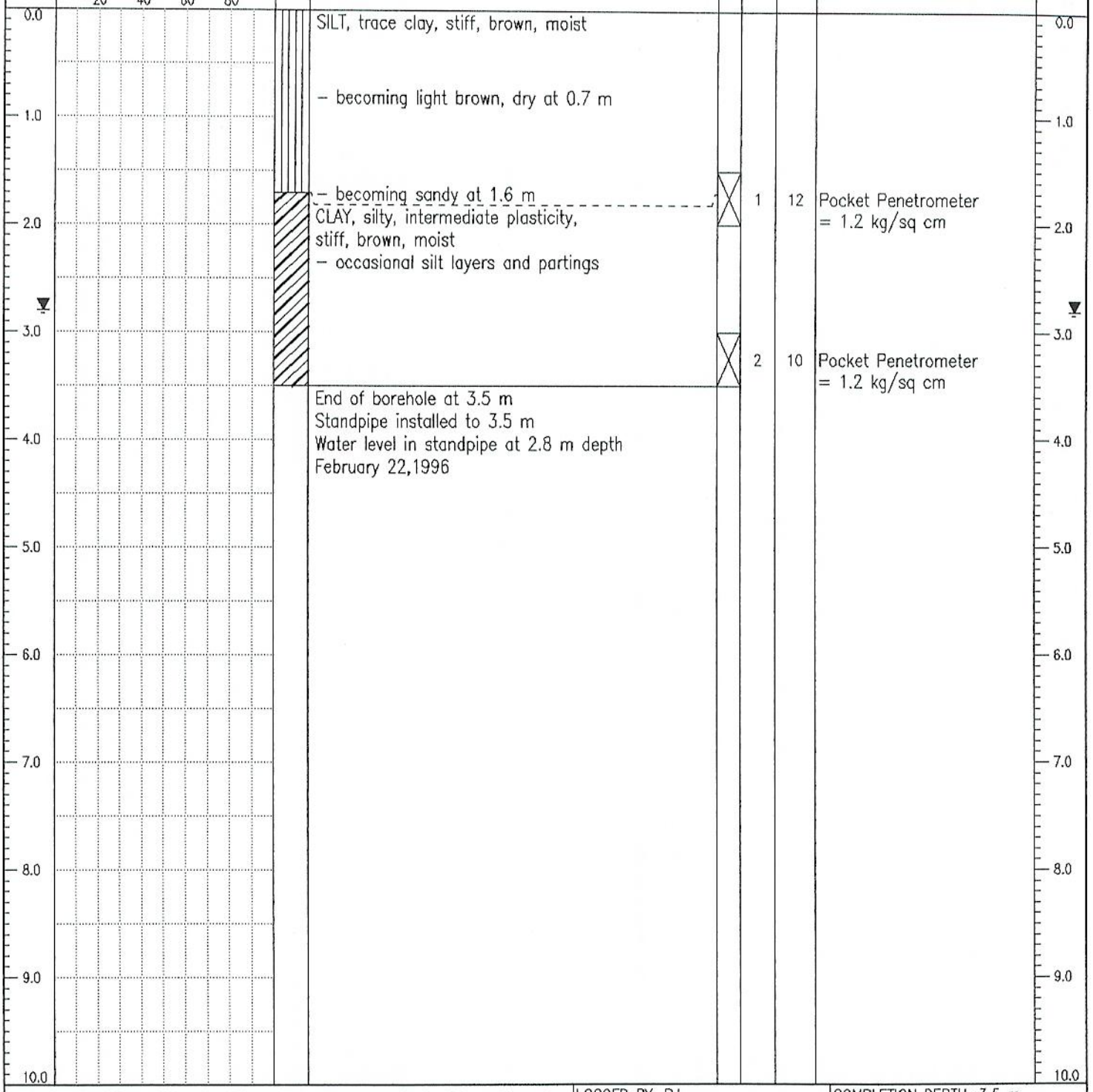
DEPTH(m)	PLASTIC / M.C. / LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			CLAY, silty, intermediate plasticity, stiff, brown,,moist					0.0
1.0			– occasional silt layers and partings					1.0
2.0				☒	1	10	Pocket Penetrometer = 1.8 kg/sq cm	2.0
3.0				☒	2	11	Pocket Penetrometer = 1.5 kg/sq cm	3.0
4.0			End of borehole at 3.5 m No discernable water level upon completion					4.0
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.5 m
	REVIEWED BY: DP	COMPLETE: 13/02/96
	Fig. No: 5	Page 1 of 1

96/03/20 01:24PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-4
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 602.70 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON



AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.5 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 6	Page 1 of 1

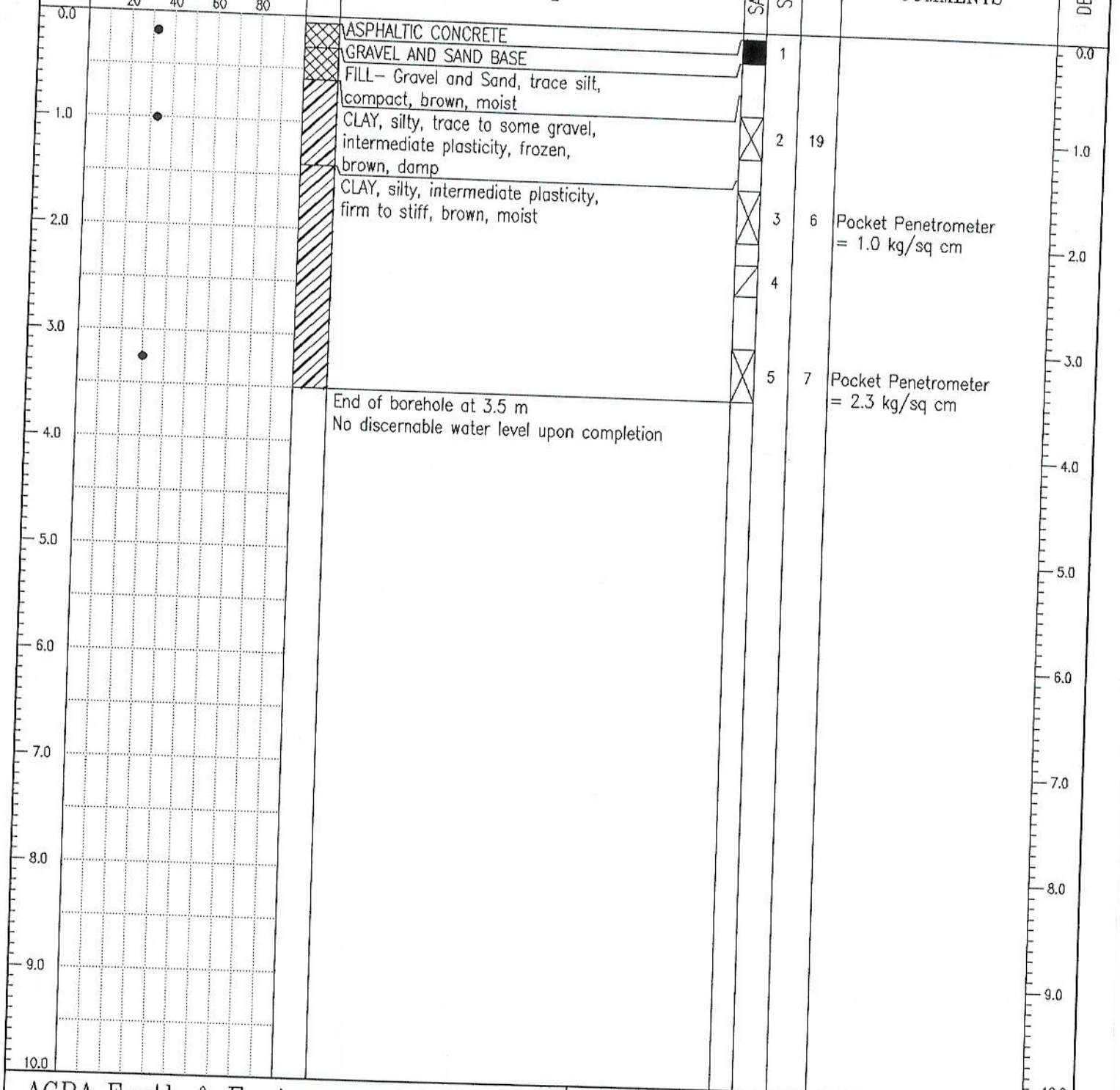
96/03/20 01:25PM

URBAN SYSTEMS/CITY OF MERRITT
COLLLETTVILLE SERVICES
COLLETTVILLE, BC

GEOTECHNICAL INVESTIGATION
AIR ROTARY DRILL RIG
ELEVATIONS: NOT TAKEN

BOREHOLE NO: BH-5
PROJECT NO: KX11457
ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON



AGRA Earth & Environmental Limited
Kamloops, B.C.

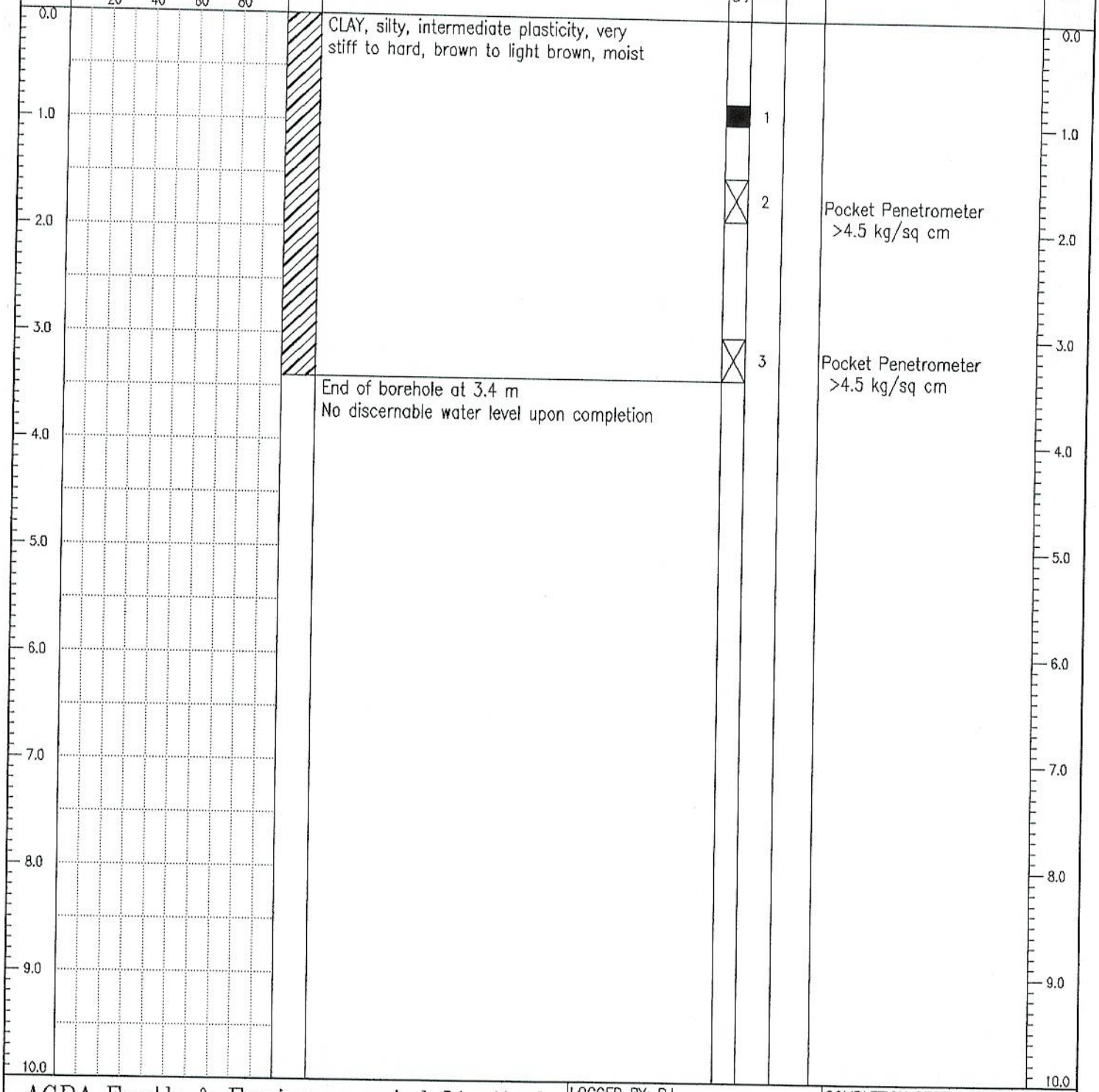
LOGGED BY: BJ
REVIEWED BY: DP
Fig. No: 7

COMPLETION DEPTH: 3.5 m
COMPLETE: 08/02/96

96/03/20 01:26PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-6
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON



AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.4 m
	REVIEWED BY: DP	COMPLETE: 09/02/96
	Fig. No: 8	Page 1 of 1

96/03/20 01:28PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-7
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 597.10 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

DEPTH(m)	PLASTIC / M.C. / LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			ASPHALTIC CONCRETE		1			0.0
			GRAVEL AND SAND BASE					
			FILL– Gravel, sandy, trace silt, compact, brown, moist					
1.0			CLAY, silty, intermediate plasticity, very stiff, brown, moist		2	28		1.0
			– frozen to 1.2 m					
					3	9	Pocket Penetrometer = 2.0 kg/sq cm	
2.0								2.0
3.0					4			3.0
					5	9	Pocket Penetrometer = 3.0 kg/sq cm	
4.0 ▼					6	10		4.0 ▼
			End of borehole at 4.2 m					
5.0			Standpipe installed to 4.2 m					5.0
			Water level in standpipe at 4.0 m					
			February 22,1996					
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 9	Page 1 of 1

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URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-8
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

DEPTH(m)	PLASTIC / M.C. / LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			ASPHALTIC CONCRETE		1			0.0
			GRAVEL AND SAND BASE					
			FILL– Gravel and sand, compact, brown, moist					
1.0			CLAY, silty, intermediate plasticity, hard to very stiff, brown, moist					1.0
2.0					2	12	Pocket Penetrometer >4.5 kg/sq cm	2.0
					3			
3.0					4	13	Pocket Penetrometer = 3.0 kg/sq cm	3.0
4.0			End of borehole at 3.5 m No discernable water level upon completion					4.0
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.5 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 10	Page 1 of 1

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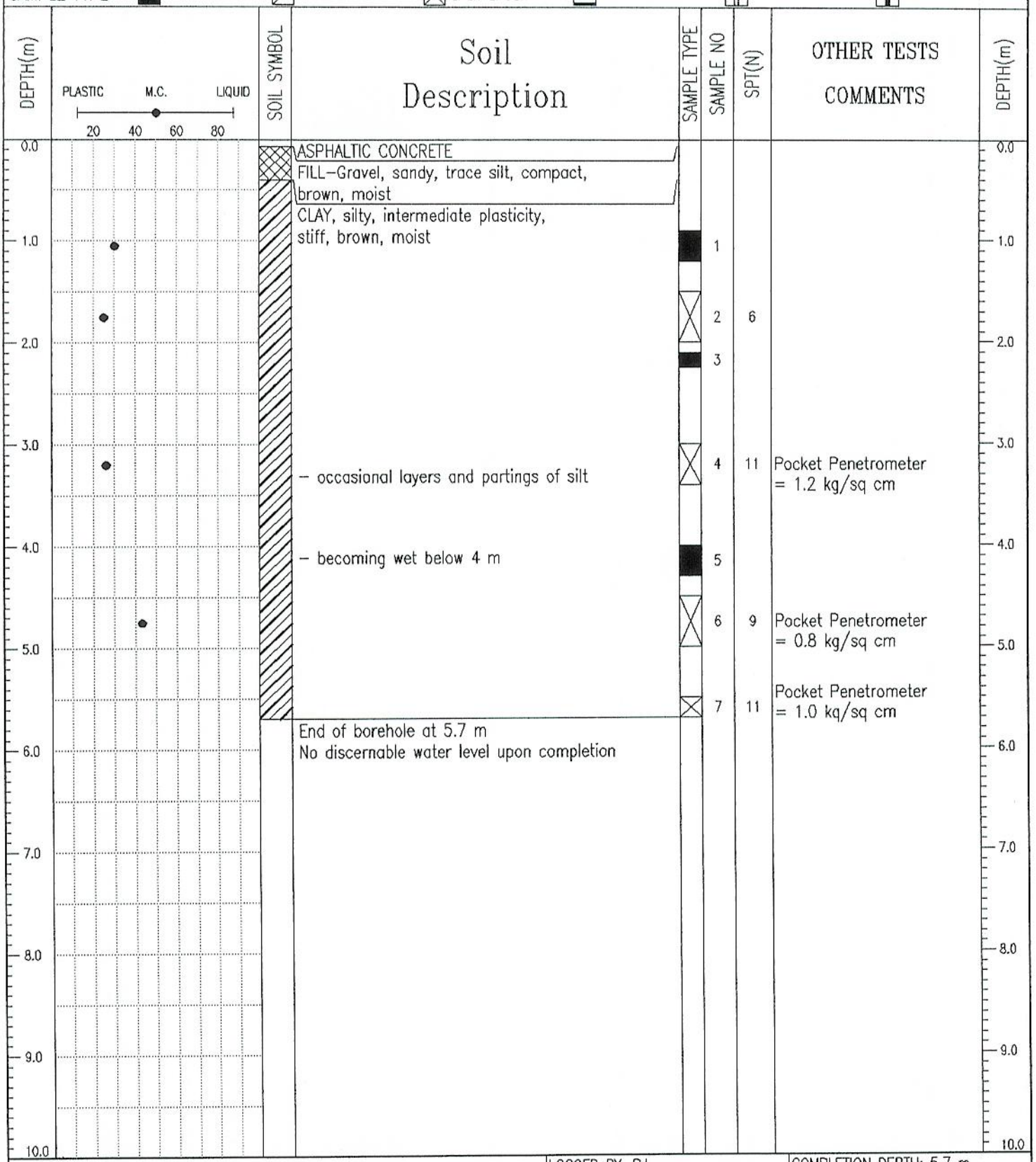
URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-9
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ⟋ SHELBY TUBE ☒ SPLIT SPOON

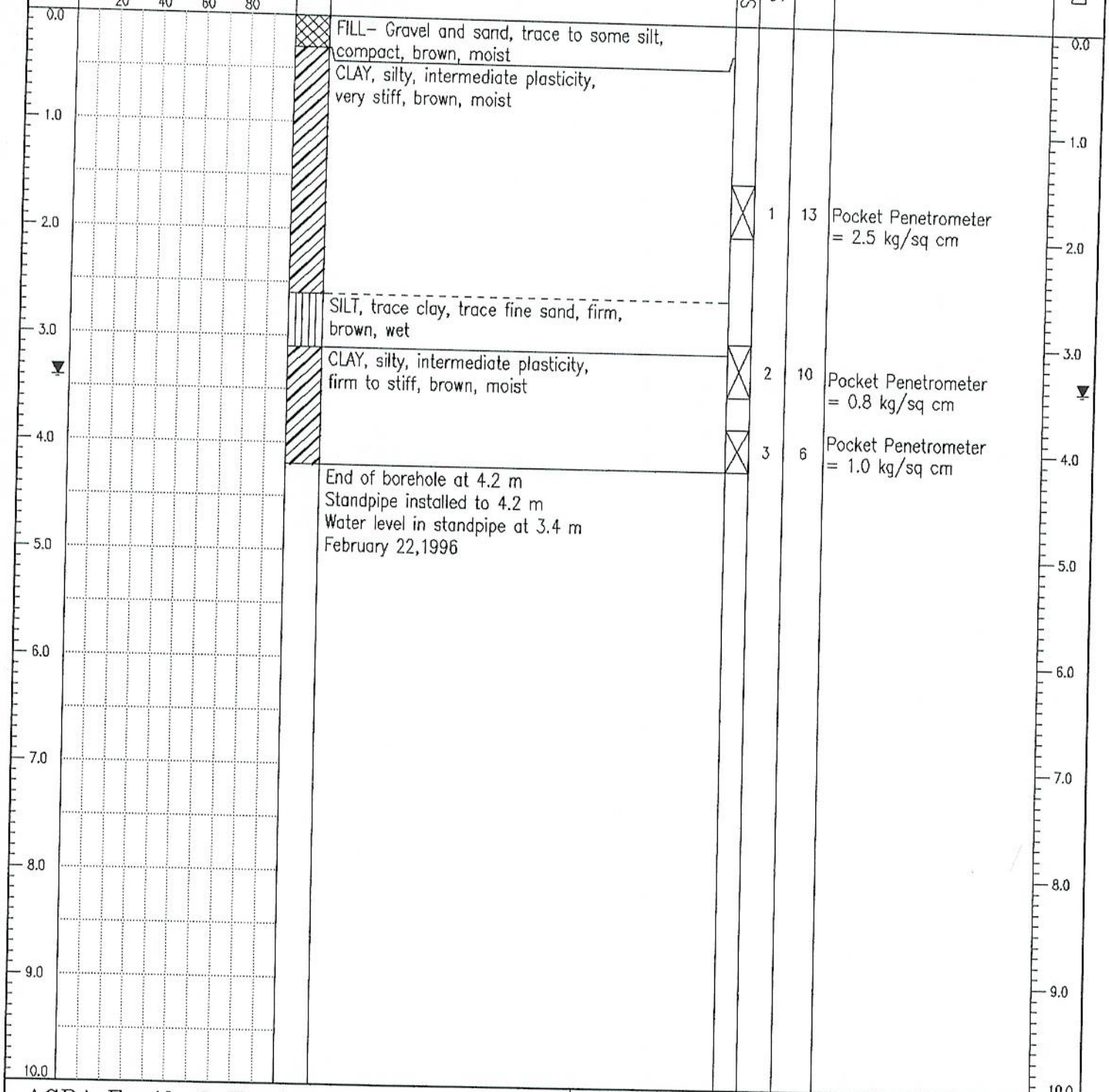


AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ REVIEWED BY: DP Fig. No: 11	COMPLETION DEPTH: 5.7 m COMPLETE: 08/02/96 Page 1 of 1

96/03/20 01:32PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-10
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 599.30 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON



AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: DP	COMPLETE: 13/02/96
	Fig. No: 12	Page 1 of 1

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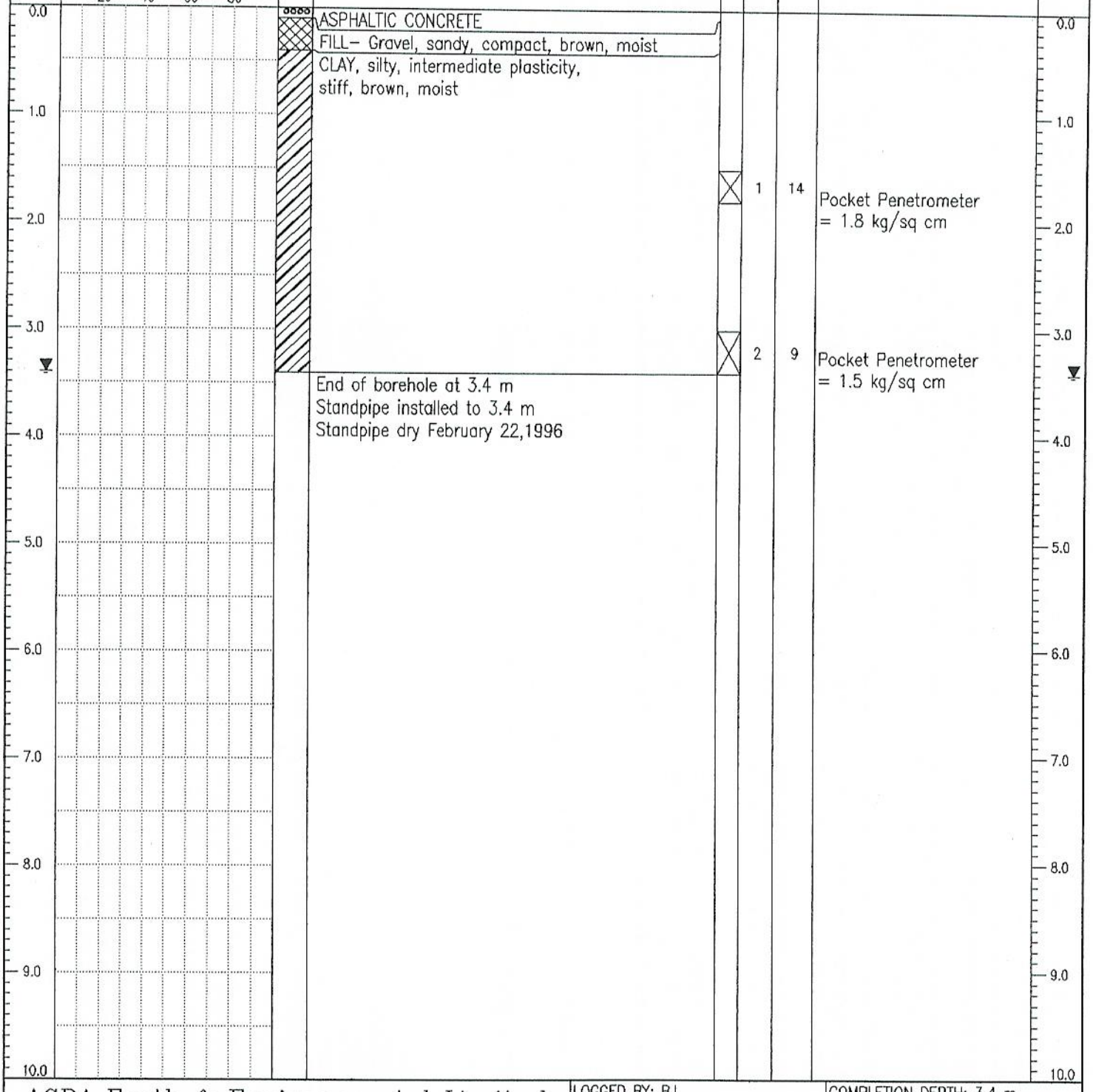
URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-11
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 590.90 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON



AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.4 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 13	Page 1 of 1

96/03/20 01:34PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-12
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 591.90 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

DEPTH(m)	PLASTIC / M.C. / LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			ASPHALTIC CONCRETE					0.0
			FILL– Gravel and sand, compact, brown, moist					
1.0			CLAY, silty, intermediate plasticity, stiff, brown, moist to wet					1.0
	•			⊠	1	12	Pocket Penetrometer = 1.0 – 1.8 kg/sq cm	
2.0				■	2			2.0
3.0	⊢•⊣			⊠	3	10	Pocket Penetrometer = 1.5 kg/sq cm	3.0
			– becoming soft below 3.7m					
4.0				⊠	4	8	Pocket Penetrometer = 0.3 kg/sq cm	4.0
			End of borehole at 4.2 m Standpipe installed to 4.2 m Water level in standpipe at 1.3 m February 22,1996					
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 14	Page 1 of 1

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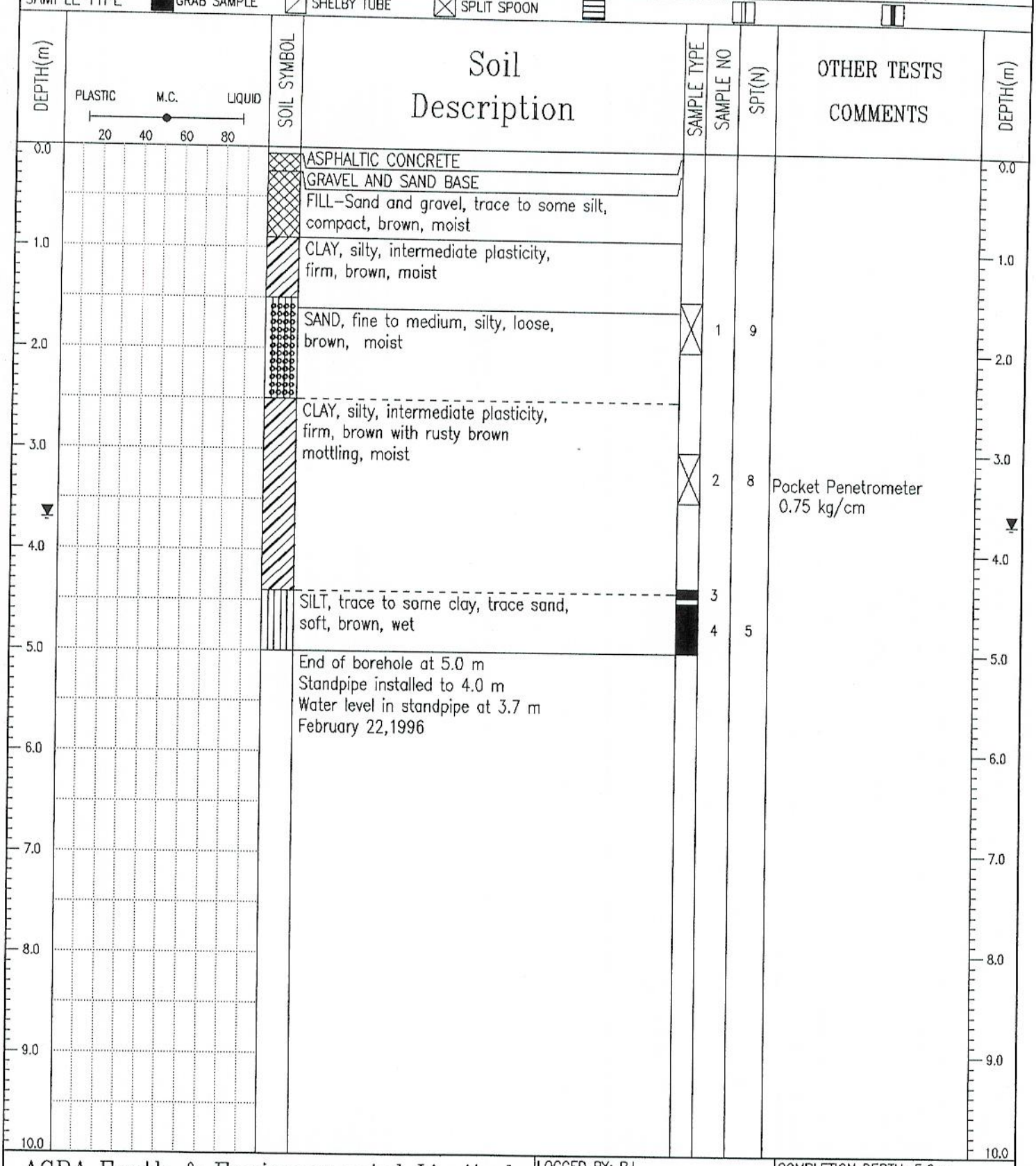
URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-13
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 591.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ☒ SPLIT SPOON



AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 5.0 m
	REVIEWED BY: DP	COMPLETE: 12/02/96
	Fig. No: 15	Page 1 of 1

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URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-14
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 591.20 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ☒ SPLIT SPOON

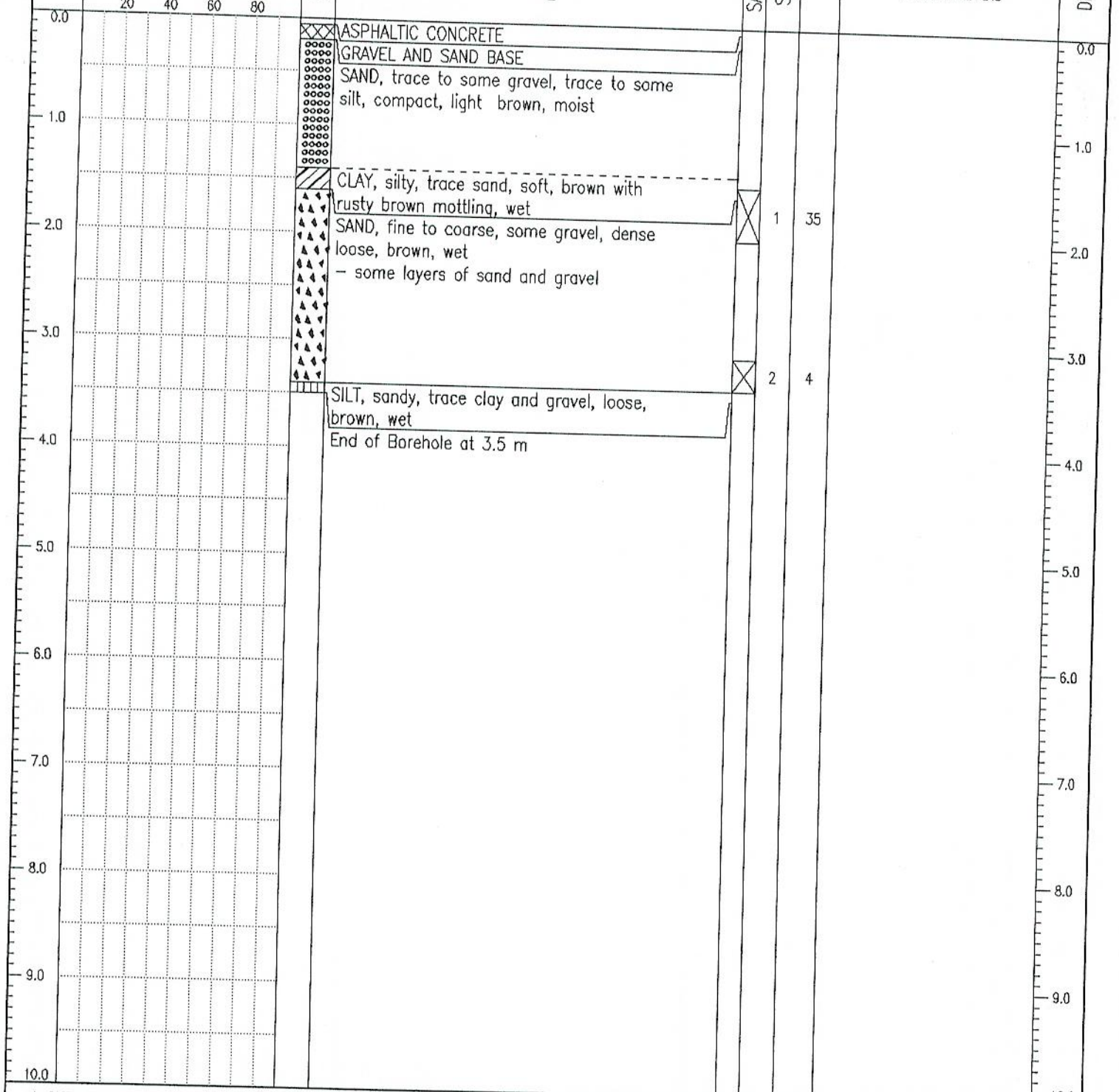
DEPTH(m)	PLASTIC M.C. LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			ASPHALTIC CONCRETE					0.0
			GRAVEL AND SAND BASE					
			SAND AND GRAVEL, trace silt, compact, brown, moist					
1.0				■	1			1.0
			– becoming SAND, some gravel, trace silt, below 1.5 m	☒	2	14		
2.0								2.0
3.0 ▼				☒	3	23	GRADATION ANALYSIS (see Appendix C)	3.0 ▼
			CLAY, silty, intermediate plasticity, soft, brown, wet	☒	4	2		
4.0								4.0
			End of borehole at 4.2 m Standpipe installed to 4.2 m Water level instandpipe at 3.0 m February 22,1996					
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: DP	COMPLETE: 08/02/96
	Fig. No: 16	Page 1 of 1

96/03/20 01:38PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-15
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ⧄ SHELBY TUBE ☒ SPLIT SPOON ☰

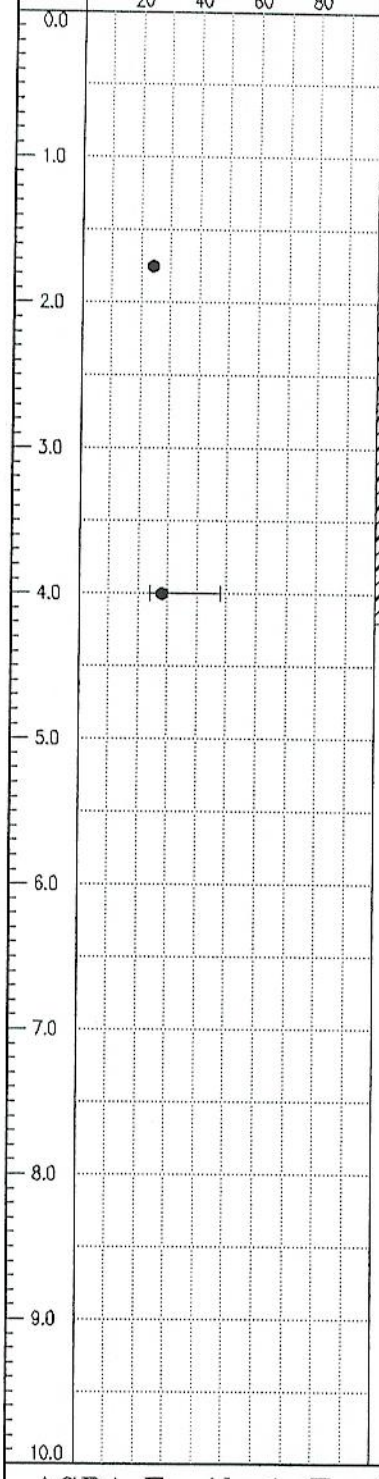


AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 3.5 m
	REVIEWED BY: DP	COMPLETE: 13/02/96
	Fig. No: 17	Page 1 of 1

96/03/20 01:30PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-16
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ☒ SPLIT SPOON



SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS
XXX	ASPHALTIC CONCRETE				
	GRAVEL AND SAND BASE				
	CLAY, silty, intermediate plasticity, hard, brown, moist				
		☒	1	21	Pocket Penetrometer >4.5 kg/sq cm
	– becoming very stiff to stiff below 3.0 m	☒	2	13	Pocket Penetrometer = 2.5 kg/sq cm
		☒	3	9	Pocket Penetrometer = 1.0 kg/sq cm
	End of borehole at 4.2 m No discernable water level upon completion				

DEPTH(m): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: DP	COMPLETE: 12/02/96
	Fig. No: 18	Page 1 of 1

96/03/20 01:41PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-17
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 589.10 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ SHELBY TUBE ⊠ SPLIT SPOON

DEPTH(m)	PLASTIC M.C. LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			SAND, gravelly, trace silt, compact, brown, moist					0.0
1.0								1.0
			GRAVEL, some sand, compact, brown, moist					
				⊠	1	22		
2.0			– occasional cobbles					2.0
▼			– becoming wet below 2.4 m					▼
3.0				⊠	2	15		3.0
4.0								4.0
			End of borehole at 4.5 m Borehole terminated due to sloughing Standpipe installed to 4.5 m Water level in standpipe at 2.4 m February 22,1996					
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited
Kamloops, B.C.

LOGGED BY: BJ	COMPLETION DEPTH: 4.5 m
REVIEWED BY: DP	COMPLETE: 08/02/96
Fig. No: 19	Page 1 of 1

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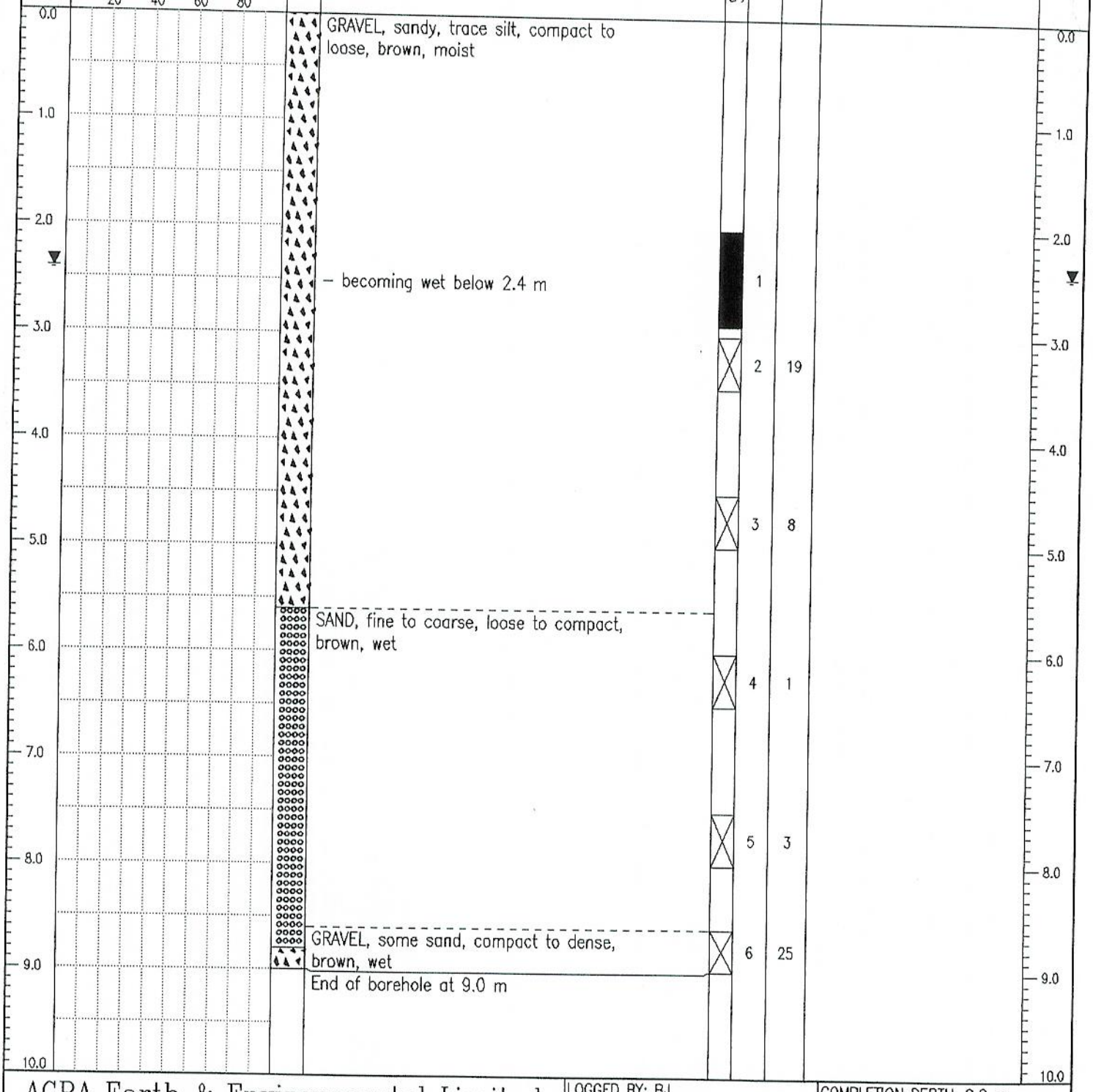
URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-17A
COLLLETTVILLE SERVICES	HOLLOW STEM AUGER DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

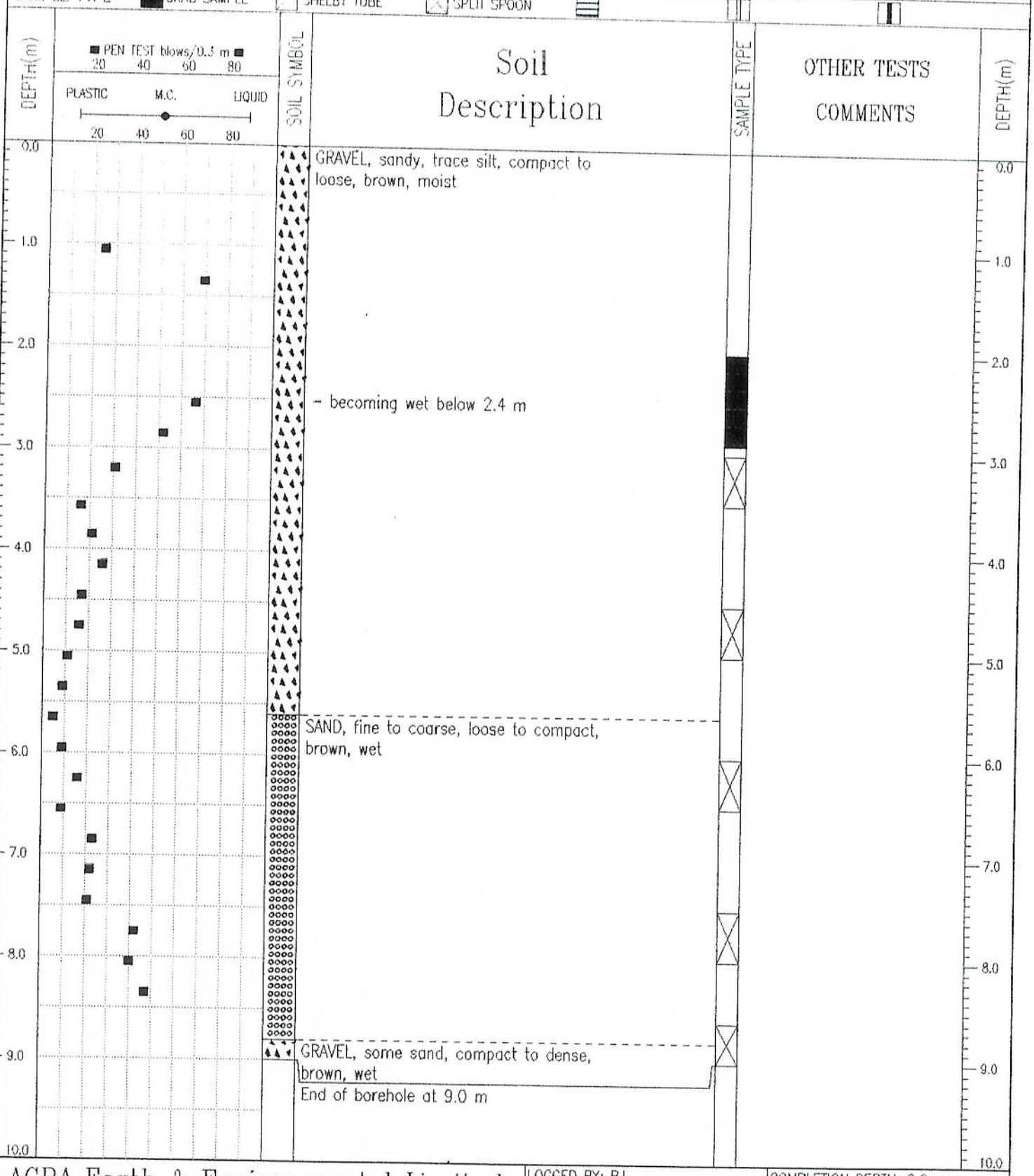


AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 9.0 m
	REVIEWED BY: DP	COMPLETE: 14/02/96
	Fig. No: 20	Page 1 of 1

96/03/20 01:43PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-17B
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ☐ SHELBY TUBE ☒ SPLIT SPOON



Soil Description

GRAVEL, sandy, trace silt, compact to loose, brown, moist

– becoming wet below 2.4 m

SAND, fine to coarse, loose to compact, brown, wet

GRAVEL, some sand, compact to dense, brown, wet

End of borehole at 9.0 m

OTHER TESTS

COMMENTS

DEPTH(m)

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 9.0 m
	REVIEWED BY: DP	COMPLETE: 14/02/96
	Fig. No: 21	Page 1 of 1

96/02/15 12:34PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-19
COLLLETTVILLE SERVICES	HOLLOW STEM AUGER DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 588.60 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ☒ SPLIT SPOON

PLASTIC M.C. LIQUID (20 40 60 80)

DEPTH(m)	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS
0.0	SILT, sandy, compact, dark brown, moist				
1.0	– some clay layers				
2.0	GRAVEL, sandy, some silt, compact to loose, brown, moist to wet – occasional clay layers	☒	1	20	
3.0		☒	2	22	GRADATION ANALYSIS COMBINED SAMPLES 2 and 3 (see Appendix C)
4.0					
5.0		☒	3	7	
6.0	SAND, some gravel to gravelly, trace silt, compact, brown, wet	☒	4	14	GRADATION ANALYSIS (see Appendix C)
7.0					
8.0		☒	5	7	
9.0					
	GRAVEL, some sand, compact, brown, wet	☒	6	25	
10.0	End of borehole at 9.4 m Standpipe installed to 4.5 m				

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ REVIEWED BY: DP Fig. No: 22	COMPLETION DEPTH: 9.4 m COMPLETE: 14/02/96 Page 1 of 1

96/03/20 01:45PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-19A
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ▩ SPLIT SPOON ▤

DEPTH(m) | ■ PEN TEST blows/0.3 m ■ 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL | Soil Description | SAMPLE TYPE | OTHER TESTS COMMENTS | DEPTH(m)

0.0 SILT, sandy, compact, dark brown, moist

1.0 – some clay layers

2.0 GRAVEL, some sand, some silt, compact to loose, brown, moist to wet
– occasional clay layers

3.0

4.0

5.0

6.0 SAND, fine to coarse, trace to some gravel, compact, brown, wet

7.0

8.0

9.0 GRAVEL, some sand, compact, brown, wet

End of borehole at 9.4 m
Standpipe installed to 4.5 m

10.0

AGRA Earth & Environmental Limited Kamloops, B.C.	LOGGED BY: BJ	COMPLETION DEPTH: 9.4 m
	REVIEWED BY: DP	COMPLETE: 14/02/96
	Fig. No: 22	Page 1 of 1

96/02/15 12:32PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-20
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ◪ SHELBY TUBE ☒ SPLIT SPOON

DEPTH(m)	PLASTIC M.C. LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			ASPHALTIC CONCRETE					0.0
			GRAVEL AND SAND BASE					
1.0			SAND AND GRAVEL, trace silt, compact, brown, moist					1.0
2.0				☒	1	11	GRADATION ANALYSIS (see Appendix C)	2.0
			GRAVEL, some sand, dense, brown, moist					
			SAND AND SILT, loose, brown, wet					
3.0			– some clay layers	☒	2	9		3.0
			SILT, sandy, loose, brown, wet					
4.0				☒	3	6		4.0
			End of borehole at 4.2 m No discernable water level upon completion					
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

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Kamloops, B.C.

LOGGED BY: BJ	COMPLETION DEPTH: 4.2 m
REVIEWED BY: DP	COMPLETE: 12/02/96
Fig. No: 22	Page 1 of 1

96/03/20 01:46PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-21
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: GEODETIC DATUM	ELEVATION: 587.80 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

DEPTH(m)	PLASTIC M.C. LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			ASPHALTIC CONCRETE		1			0.0
			GRAVEL AND SAND BASE					
			SILT, some fine sand, compact, brown, moist					
1.0			SAND, fine, trace to some silt, compact, brown, dry		2			1.0
			SAND AND GRAVEL, trace silt, very dense, grey brown, moist		3	57		
2.0			– becoming Gravel, some sand, dense, brown, wet below 2.2 m					2.0
3.0					4	41		3.0
			End of borehole at 3.4 m Standpipe installed to 3.4 m Water level in standpipe at 2.0 m February 22,1996					
4.0								4.0
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited
Kamloops, B.C.

LOGGED BY: BJ	COMPLETION DEPTH: 3.4 m
REVIEWED BY: DP	COMPLETE: 08/02/96
Fig. No: 23	Page 1 of 1

96/03/20 01:47PM

URBAN SYSTEMS/CITY OF MERRITT	GEOTECHNICAL INVESTIGATION	BOREHOLE NO: BH-22
COLLLETTVILLE SERVICES	AIR ROTARY DRILL RIG	PROJECT NO: KX11457
COLLETTVILLE, BC	ELEVATIONS: NOT TAKEN	ELEVATION:

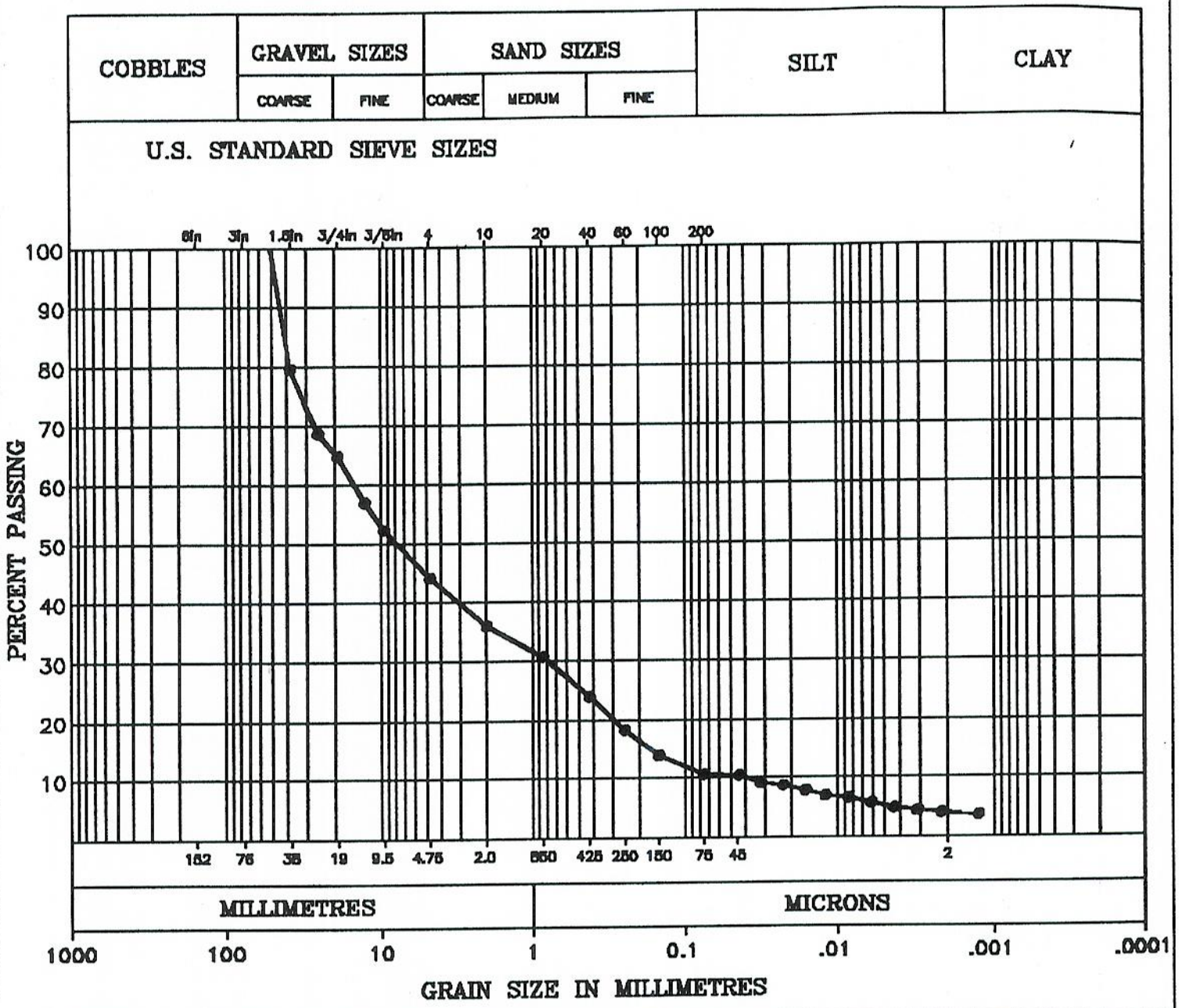
SAMPLE TYPE ■ GRAB SAMPLE ▨ SHELBY TUBE ⊠ SPLIT SPOON

DEPTH(m)	PLASTIC M.C. LIQUID (20 40 60 80)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH(m)
0.0			GRAVEL AND SAND, trace silt, compact, brown, moist	⊠	1	21		0.0
1.0								1.0
2.0								2.0
3.0			End of Borehole at 2.9 m Borehole terminated due to sloughing below 2.3 m Water level in open hole at 1.9 m upon completion					3.0
4.0								4.0
5.0								5.0
6.0								6.0
7.0								7.0
8.0								8.0
9.0								9.0
10.0								10.0

AGRA Earth & Environmental Limited
Kamloops, B.C.

LOGGED BY: BJ	COMPLETION DEPTH: 2.9 m
REVIEWED BY: DP	COMPLETE: 13/02/96
Fig. No: 24	Page 1 of 1

96/03/20 01:49PM



REMARKS: Gravel,sandy,trace silt,trace clay

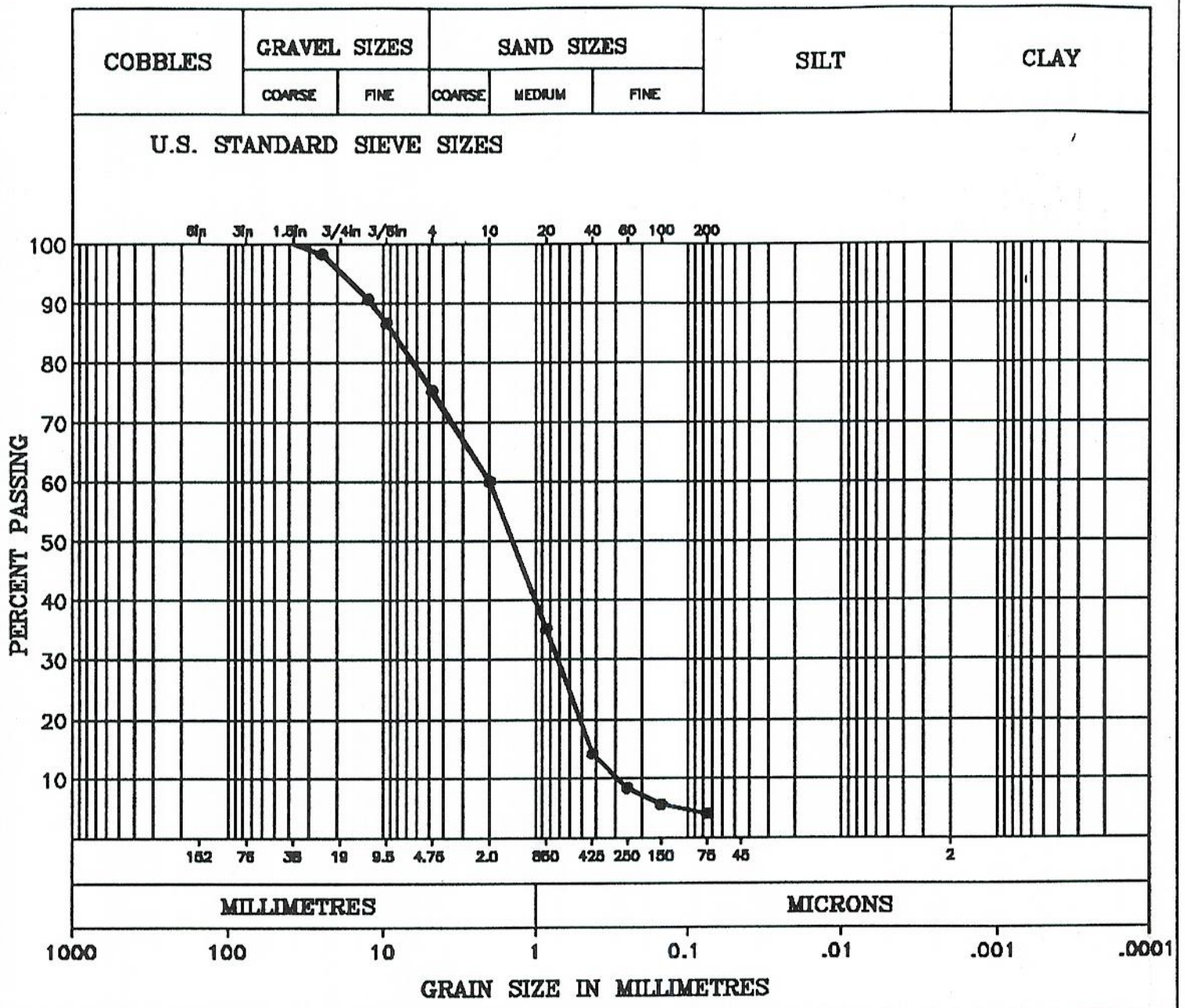
(GP)

SUMMARY

D_{10} = 0.040	mm	GRAVEL	56. %
D_{30} = 0.80	mm	SAND	34. %
D_{60} = 15.	mm	SILT SIZES	7. %
C_U = 380.		CLAY SIZES	3. %
C_C = 1.1			

AGRA
Earth & Environmental
GRAIN SIZE DISTRIBUTION

PROJECT No: KX11457 DATE: 96.02.23
LOCATION: Colletville—Water & Sewer
HOLE: BH#—19 SAMPLE:
DEPTH: 3.25—4.95 m
TECHNICIAN:



REMARKS: Sand,gravelly,trace fines (SP)

SUMMARY

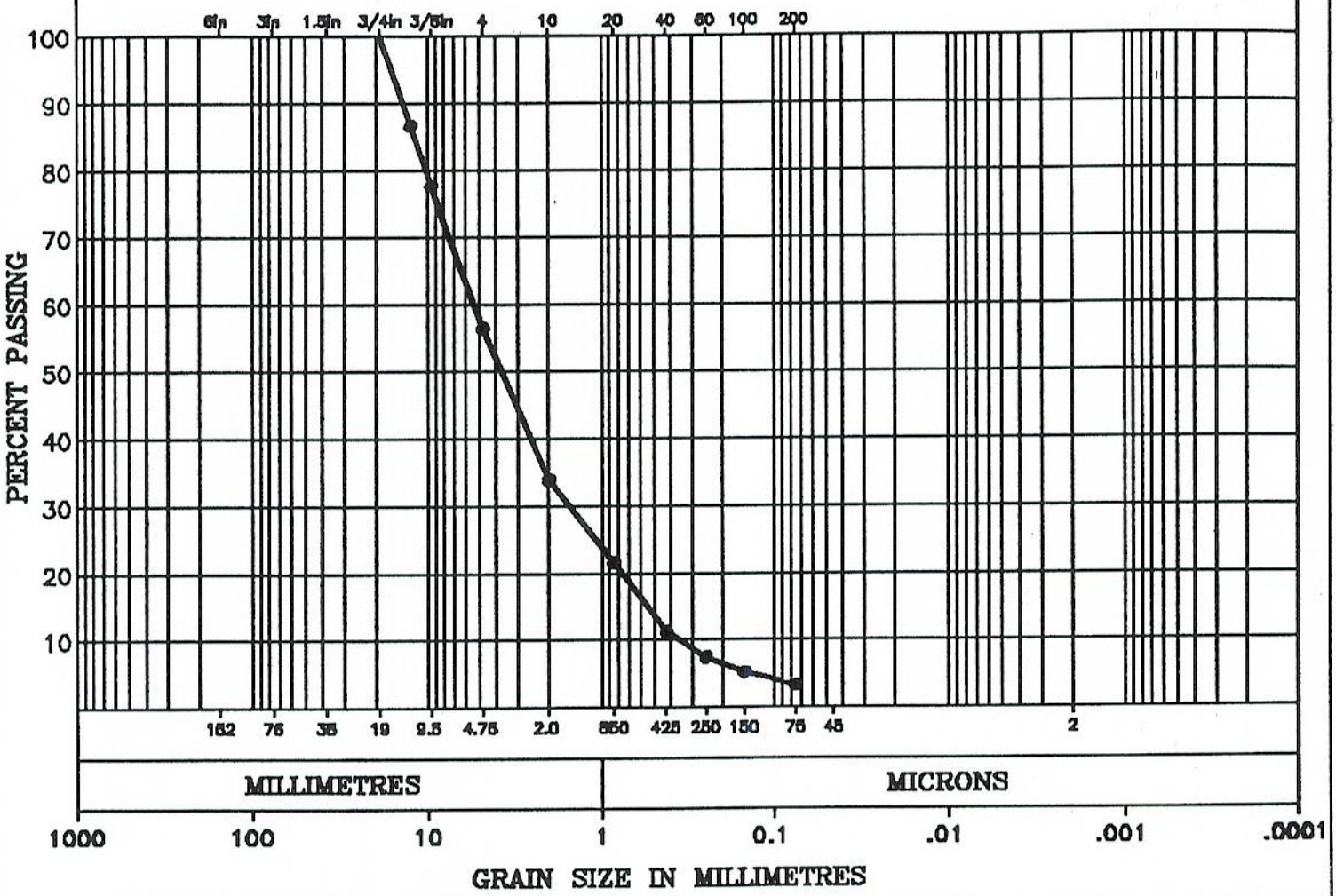
D_{10} = 0.30	mm	GRAVEL	25. %
D_{30} = 0.74	mm	SAND	71. %
D_{60} = 2.0	mm	FINES	4. %
C_U = 6.7			
C_C = 0.93			

AGRA
Earth & Environmental
GRAIN SIZE DISTRIBUTION

PROJECT No: KX11457 DATE: 98.02.20
LOCATION: Colletville-Water & Sewer
HOLE: BH#-19 SAMPLE:
DEPTH: 6.0-6.45 m
TECHNICIAN: BJ

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

U.S. STANDARD SIEVE SIZES



REMARKS: Sand & gravel,trace fines (SW)

SUMMARY

D_{10} = 0.37	mm	GRAVEL	43. %
D_{30} = 1.8	mm	SAND	53. %
D_{60} = 5.5	mm	FINES	4. %
C_U = 15.			
C_C = 1.3			

AGRA
Earth & Environmental
GRAIN SIZE DISTRIBUTION

PROJECT No: KX11457 DATE: 98.02.20
LOCATION: Colletville-Water & Sewer
HOLE: BH#-20 SAMPLE:
DEPTH: 1.5-1.95 m
TECHNICIAN: BJ

Eco-Tech LABORATORIES LTD.

ASSAYING
GEOCHEMISTRY
ANALYTICAL CHEMISTRY
ENVIRONMENTAL TESTING

10041 E. Trans Canada Hwy., R.R. #2, Kamloops, B.C. V2C 6T4 Phone (604) 573-5700
Fax (604) 573-4557

CHEMICAL ANALYSIS REPORT

Date:	4-Mar-96
Et. File No.	E228
Report On:	Soil Analysis
Report To:	**AGRA EARTH & ENVIRONMENTAL LTD.** #26-913 Laval Crescent **KAMLOOPS, BC** V2C 5P5
Attention:	**Don Powell**
Project No: #KX11457	
Received:	22-Feb-96
Samples Dated:	None Given

ECO-TECH LABORATORIES LTD.
per:

K. Mathieu

Kathy Mathieu
Environmental Lab Manager

KM/vc
Fax @: 374-2944

AGRA EARTH & ENVIRONMENTAL LTD.
Project No: #KX11457

4-Mar-96
Et. No. E228

RESULTS OF ANALYSIS - Soil
Samples Dated: None given

PARAMETERS	***1.5 - 1.95 BH7***	***1.65 - 1.95 BH19***
Soluble Sulphate (as SO_4)	40,800	200

METHODOLOGY

Analysis was performed in accordance with CSA Standard 23.2-3B

Results expressed as mg/kg on a dry weight basis

End of Report

AGRA EARTH & ENVIRONMENTAL LTD.
Results Continued

4-Mar-96
Et.No. E228

QUALITY CONTROL DATA

Methods used are based upon those found in "Standard Methods for the Examination of Water and Wastewater" 19th Edition, published by the American Public Health Association, or on US EPA methods from "Test Methods for Evaluating Solids Waste, Physical/Chemical Methods" (SW846) third Edition. Any other procedures are based on methods accepted by the B.C. Ministry of Environment.

1. QC SOLUTION RUNS:

Parameter	*Method*	*Expected (mg/L)*	*Observed (mg/L)*	*%Deviation*

2. DUPLICATE RUNS:

Parameter	*Method*	*Sample ID*	*Run 1 (mg/L)*	*Run 2 (mg/L)*	*Deviation*
Sulphate	Turbidimetric	228-1	40,800	39,800	1000

3. Blank Runs:

All blanks for each parameter were found to be less than its detection limit.

NOTE:

The control criteria for reagent blank are that the observed value for each analyte to be determined is less than its detection limit. If this in not achieved during analysis, the process will be terminated and will not be continued until the problem is solved.

End of Report

CHEMICAL ANALYSIS REPORT

Date: 19-Mar-96

Et. File No. E322 - Preliminary results

Report On: Soil Analysis

Report To: **AGRA EARTH & ENVIRONMENTAL LTD.**
#26-913 Laval Crescent

KAMLOOPS, BC
V2C 5P4

Attention: **Don Powell**

Project No: ***KX11457***

Received: 15-Mar-96
Sample Date: None Given

ECO-TECH LABORATORIES LTD.
per:

K. Mathieu

Kathy Mathieu
Environmental Lab Manager

KM/vc
Fax @:374-2944

AGRA EARTH & ENVIRONMENTAL LTD.
Project No. KX11457

Et. No. 19-Mar-96 **E322**

RESULTS OF ANALYSIS - Soil
Samples Dated: None Given

PARAMETERS	1.5-1.95m ***BH7***	1.65-1.95m ***BH19***	1.5-1.95m ***BH3***	1.5-1.95m ***BH10***	1.5-1.95m ***BH15***
pH (Units)	8.29	8.33	9.07	8.64	8.71
Conductivity (umhos/cm)	52,500	148	11,000	10,700	274
Soluble Sulphate (as SO_4)	*	*	*	*	*

Results expressed as mg/kg on a dry weight basis unless otherwise indicated.
* = Results to follow

End of Report

CHEMICAL & GEOLOGICAL LABORATORIES INC.

14203 - 129 AVENUE, EDMONTON, ALBERTA T5L 4N9

EST. 1948

TELEPHONE
(403) 454-1504
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FAX COVER SHEET

TELEPHONE NO: (403) 454-1504 TELECOPIER NO: (403) 451-4022

DATE & TIME: MARCH 21, 1996

FROM: K. SCHICK

ATTENTION: DONALD POWELL
AGRA EARTH & ENVIRONMENTAL LIMITED

SEND TO FAX NO: 1-604-374-2944

TOTAL NUMBER OF PAGES TO FOLLOW COVER SHEET: 1

COMMENTS: E96-11906-1/-4

NOTICE

CHEMICAL & GEOLOGICAL LABORATORIES INC.

DATE REPORTED: MARCH 21, 1996

LABORATORY REPORT NUMBER: E96-11906

AGRA EARTH & ENVIRONMENTAL LIMITED

DATE RECEIVED: MARCH 15, 1996

ANALYST: K. SCHICK

LAB NO:	E96-11906-1	E96-11906-2	E96-11906-3	E96-11906-4
SAMPLE POINT:	1.5 TO 1.95 m	1.5 TO 1.95 m	1.6 TO 1.95 m	1.5 TO 1.95m
SAMPLE ID:	BH-3 CLAY	BH-10 CLAY	BH-15 SANDY GRAVEL	BH-22 SANDY GRAVEL
SATURATED PASTE EXTRACT:				
pH @ 19.5°C	7.7	7.6	7.3	7.2
RESISTIVITY ohm METER	1.983	7.899	19.157	21.978
EXCHANGEABLE ACIDITY:				
cmol (+) kg^{-1} KCl ACIDITY	1.4	1.4	<1.0	<1.0

METHODOLOGY

PARAMETER	BRIEF METHOD DESCRIPTION
SAMPLE PREPARATION	AIR DRY, GRIND, SATURATED PASTE
pH	pH METER
RESISTIVITY	CONDUCTIVITY METER, CALCULATION
EXCHANGEABLE ACIDITY	EXTRACTION WITH KCl, TITRATION WITH NaOH

REFERENCES:

Carter, Martin R., Soil Sampling and Methods of Analysis Lewis Publishers, 1993
McKeague, JA, Manual on Soil Sampling and Methods of Analysis, 1978

FINAL REPORT

SUPERVISOR: _____ K. SCHICK

APPROVED BY: _____ R. LESSARD

PLEASE DIRECT INQUIRIES REGARDING THIS REPORT TO THE SUPERVISOR.