DATA SUMMARY

HYDROLOGY

SOUTH BAY 1995

September, 1995

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INTRODUCTION.

Based on the results of the initial EM geophysical survey (summer, 1994) conducted north of the tailings disposal basin, and a subsequent preliminary test drilling and piezometer installation program during the fall of 1994, a buried valley was found, which appears to be the main path for subsurface contaminant movement from the tailings area in the direction of Mud Lake.

Subsequently, Boojum Research obtained additional funding for further, much more extensive EM geophysical surveys and funding for an extensive test drilling and piezometer installation program. This latter program had as its objectives to ground truth the EM surveys and at the same time define the bedrock topography, the hydrogeological environment and the contaminant paths. The cost estimate for the test drilling and piezometer installation were prepared based on the objectives outlined above and submitted in November, 1994, prior to its submission to the client.

Once all this information had been compiled and interpreted, design scenarios for remedial measures would be developed.

The drilling and piezometer installation program was to be conducted during the late winter to ensure maximum mobility. Unfortunately, due to unforeseen climatic conditions, drilling and piezometer installation in the northern part of the Mud Lake basin was not possible, nor in any area with floating muskeg. As a result, the program was redesigned based on the new EM geophysical data and the same objectives, outlined above, for areas which were accessible during April/May, 1995. A total of ± 30 new testhole/piezometer locations were chosen. Cost estimates were obtained from a drilling company and their estimated cost fell within the estimate submitted in the fall of 1994.

The testdrilling and piezometer installation program was carried out from April 25 to May 14, 1995. Subsequently, slug tests were conducted on the piezometers to determine the hydraulic conductivity. A total of 40 piezometers were installed. 24 (deep) piezometers were completed immediately above the bedrock surface, 9 shallow piezometers were installed in close proximity to the deeper ones, and an additional 7 shallow piezometers were installed in separated locations. All of the latter shallow piezometers are located in the vicinity of the northwestern part of the tailings basin. A total of 9 testholes (without piezometer installation) were drilled. The approximate location of the testholes is shown in Plate 1.

Weather conditions during the fieldwork varied from a blizzard to + 20 ^{0}C.

The evaluation of the data and this report were delayed, because of inadequacies in the survey of the elevation and location of the new piezometers and testholes. Although, the problems with the survey data have not been solved yet, at the instruction of Boojum Research the interpretation of the data collected has proceeded.

TEST DRILLING.

Previous experience in this area had shown that whatever drilling equipment was chosen, it should have the capability of penetrating and coring bedrock. Furthermore, the drilling equipment should be such that good to excellent samples could be obtained from the sediments drilled.

Paddock Drilling Ltd. from Brandon, Manitoba was engaged to conduct the testdrilling and piezometer installation program at Southbay, Ontario. A Mobil S61 trackmounted drilling rig was used to ensure maximum mobility. Similarly, the accompanying water truck was also trackmounted. This equipment is highly versatile because augering (solid and hollow stem), mud rotary drilling and diamond coring could be performed with the same rig. The disadvantage of this multipurpose equipment is that, except for augering, it is neither a true mud rotary drilling rig nor a true diamond drilling rig. As a result, some time was lost when either of the latter two drilling modes were used. However, the availability of the three drilling methods in one machine, its relative small size and its excellent mobility more than compensated for the slightly reduced efficiency.

The general procedure at each location was as follows:

Augering was used for the upper part of the borehole. The diameter of the augers was 10 cm (4 inch). After an auger flight was drilled down (1.5 m, 5 ft), it would be pulled out of the hole. 30 cm (1 ft) samples would be collected and stratigraphic contacts noted. The total depth of the augered hole would depend on the stratigraphy encountered, but generally ranged from 6 - 7.5 m (20-25 ft). Within the tailings basin, augering would be advanced through the tailings and into the underlying muskeg, if encountered. Whenever, a clay was found under the tailings or muskeg, auger drilling would be terminated.
Prior to switching to mud rotary, BQ casing with a diameter of 10.5 cm (4 1/8 inches) would be installed to the total depth of the auger hole and pushed a short distance (about 10-15 cm) into the underlying sediment to provide a seal.

At this point in time, the operation would be changed to mud rotary drilling. Prior to the start of drilling the casing would be flushed. Initially, the hole would be drilled with water as the drilling fluid and drilling with water would be continued until such time when lost circulation became a problem. At this point, bentonite would be added to the drilling fluid. Drilling with clear water greatly facilitates sample collection. Any addition of clays to the drilling fluid, i.e. bentonite or natural clays from the formations drilled, make sample collection and washing more tedious and time consuming.
At the start of rotary drilling a tooth bit would be used, when the penetration rate became to low (hard drilling) or when rough drilling was encountered, the drillpipe was pulled out of the hole and the tooth bit exchanged for a tungsten insert button bit. The size of the rotary borehole was 9.84 cm (3 7/8 inches). The sample interval during rotary drilling was 75 cm (2.5 ft). Composite samples are collected over this interval.
Upon reaching suspected bedrock the rotary assembly would be pulled out of the hole and switched to a diamond coring assembly.

A NQ diamond coring assembly with a wireline retrievable 1.5 m (5 ft) long core barrel was used to obtain a core of the suspected bedrock. If a boulder was cored , the coring assembly would be pulled out of the hole and rotary drilling would be resumed until the next suspected bedrock surface was encountered.

The determination of bedrock was based on the physical behavior of the rig during the actual coring operation, the rocktype encountered, and the textural and geological structural characteristics of the core.

Two problems were encountered during the drilling operation. These were:

- occasional loss of seal around the surface casing during mud rotary drill, and
- lost circulation.

The loss of seal around the surface casing was more of nuisance than a real problem for boreholes outside of the tailings basin. It only occurred during rotary drilling with water and resulted in a messy drilling site and increased the consumption of make-up water. It became a more serious problem inside the tailings basin. Loss of the seal around the shoe of the surface casing caused the tailings to migrate downward into the borehole and contaminate the drilling fluid and the samples. The tailings are very fine, liquefy readily and have a much higher density than an equivalent size clastic sediment. Seals around the surface casing were always re-established by pushing additional length of surface casing down the well bore, but the contaminated mud had to be run to waste and the casing and associated mud circulation equipment had to be cleaned, before drilling could proceed.

Lost circulation was the most serious problem encountered during the drilling operation. Once sediments coarser than medium grained sand were encountered, lost circulation was inevitable. This problem becomes more severe from south to north in the area under investigation. The combined effect of high permeabilities and low hydraulic head in the aquifer was the cause of the losses of drilling fluid to the formation.
Lost circulation materials could not be added to the drilling fluid, because it would have plugged the sediments and defeated the purpose of obtaining measurements of the in-situ permeability of the sediments. In the majority of the boreholes drilling with a heavy bentonite mud and reducing the mud pump output made the losses manageable.

However, one borehole: M73 had to be abandoned before the bedrock target was reached. After fighting lost circulation for 15 hours, drilling blind, having caving problems, etc. only a depth of 10.3 m (34 ft) had been reached and the objective of penetrating bedrock was abandoned and a shallow piezometer was installed. However, obtaining the appropriate hydrogeological information in this area was crucial to the investigation. Subsequently, the rig was moved immediately east of the current location to site M79. Again, after a depth of 9.1 m (30 ft), had been reached serious lost circulation was encountered and based on the previous experience, the borehole was abandoned. It had become very apparent after these two attempts that the current drilling equipment was not suitable for drilling in this part of the area. After discussions with the drilling company, It was decided to bring out airhammer equipment and until the equipment was on site, no further attempts at drilling in this area were made.

During airhammer drilling casing is advanced at the same time and the medium used to remove drill cuttings from the borehole and water flowing into the borehole, is air. Airhammer drilling is extremely well suited for ‘hard” formations and sand and gravel. However, the presence of very fine grained sediments, especially silt and clay, can cause serious problems (plugging of airhammer) and prevent any further drilling. Also, high rates of water inflow into the borehole and the length of the water column in the borehole can seriously impede penetration rates and drilling progress.

An additional advantage of drilling with air is that a first approximation of the ionic concentration of the groundwater can be obtained by measuring the electrical conductivity of the water produced during drilling. The results of these measurements in the boreholes drilled with the airhammer will be discussed below.

Four holes, M79, M80, M81 and M83, were drilled using the airhammer equipment. The size of the casing which was hammered down was 11.4 cm (4 1/2 inches) in diameter. The airhammer bit protruding below the casing had a diameter of 10.5 cm (4 1/8 inches). Once bedrock was suspected, the 4 1/8 inch air hammer was pulled out and a 3 1/2 inch airhammer was run in to drill ahead. At this point the casing is not further advanced. Sample quality is excellent during airhammer drilling and cutting samples were used to determine if bedrock had been reached.

The daily chronology of events are listed in Appendix A.

PIEZOMETER INSTALLATION.

After the total depth of the borehole was reached, a cleanout trip was made, and the mud in the hole was displaced to water. The drillpipe was pulled out of the hole and laid down and the piezometer was installed in the open hole.

All piezometers were completed with 52.5 mm (ID) , Schedule 40, PVC threaded flush jointed pipe. Slotted PVC screens with No. 10 slot openings (0.254 mm) and a glued-on end cap were used in the completion interval. The length of the slotted screen section ranges from 30 - 150 cm. Each individual length of PVC pipe and screen had been washed by the supplier and after cleaning was sealed in a separate plastic bag to prevent contamination during transport.

Once the piezometer assembly was lowered into the hole and the screened interval placed at the appropriate depth, quartz frac sand (10/20 grade) was added to the annulus until it reached at least 30 cm above the top of the screened interval. Subsequently, bentonite pellets were added to the annulus in order to place a watertight seal on top of the sand pack. The position of the top of the frac sand, as well as the top of the bentonite pellet seal, in the annulus was determined by using a measuring tape with a sinker bar, which was also used for chasing the frac sand and pellets down the annulus. By continuously moving the tape and sinker bar up and down in the annulus it was hoped that bridging could be prevented. However, bridging of the bentonite pellets in the annulus did occur during a number of installations. The bridges would form in the annulus, either below the casing shoe of the surface casing or right at the casing shoe. To ensure that vertical migration along the well bore could not occur, another bentonite pellet seal would be placed from the bridge upward. If this was not possible, because the bridge had formed at the casing shoe, a tremmie line was washed through the bridge, pushed down the annulus for as far as it would go and a high viscosity bentonite grout would be pumped into the annulus. Pumping would continue until surface returns of the high viscosity grout occurred.

Piezometer installation in the airhammer drilled holes differs from mud rotary drilled holes. In airhammer drilled holes the piezometer assembly is lowered to the bottom of the casing and the casing is then pulled or hammered upward and out of the ground. The “plunger” action of the upward moving casing and the vibration of the hammering ensures that the unconsolidated sediment collapses around the slotted pipe section. Once a number of joints of casing had been pulled, the annulus of the casing was filled with a high viscosity grout. Further pulling of the casing, and subsequent collapse of the sediments into the annulus would create a low permeable mixture and retard vertical migration along the well bore.

The piezometer installed at M84 is primarily a water sampling point. During the drilling of the borehole only about 10 cm of moist sediment was encountered immediately above the bedrock surface. In order to be able to collect water samples, the screen was installed mainly in the bedrock and sandpacked. The portion of the screen below the bedrock surface acts as a cistern and intercepts small amounts of water flowing along the bedrock contact. The waterlevel measurements from May till September, 1995 show a gradual increase, but the waterlevel was still below the bedrock surface in September.

The construction details of the piezometers are listed in Appendix B.

PIEZOMETER DEVELOPMENT.

After installation, the piezometers were developed to remove drilling mud and filtrate from the screened sediment sections. Development work did not start for at least 24 hours after the piezometer had been installed. This was done to allow the bentonite pellets to swell and create a proper seal.

The development consisted of air surging, air pumping and pumping with an electrical submersible pump. The electrical conductivity of the water produced during development was measured sequentially in order to determine the progress of well development. Once the electrical conductivity of the water had stabilized and the water was clear, i.e. free of suspended sediment, development was stopped.

The results of the electrical conductivity measurements during development are listed in Appendix C.

HYDRAULIC CONDUCTIVITY MEASUREMENTS.

During the last few days of fieldwork and after all piezometers had been developed, hydrodynamic response or “slug” tests were conducted on all piezometers, except M66B. This latter piezometer is completed in muskeg and due to the low permeability of muskeg, a slug test in this piezometer takes several hours to complete. The reason why no test was performed on this piezometer is simply that we ran out of time. Fortunately, because of the low permeability, no electronic measuring equipment is necessary to conduct the test and it can be done manually. Rather than spending another day in the field with the associated cost of field charges, electronic equipment rental, etc., it was decided that the slug test could be conducted by Boojum personnel during a future fieldtrip. This piezometer will be tested shortly.

A hydrodynamic response test consists of measuring the rate of change of an instantaneous change in the water level. The rate of change is a measure of the hydraulic conductivity of the sediment in which the piezometer is completed. The instantaneous change of the static waterlevel in the piezometer is created by a volume change. This can be achieved by adding a known volume of water to the piezometer or extracting a known volume from the piezometer, or by dropping a slug of known volume below the static water level in the piezometer or by removing this slug from below the static water level.

Experience gained in this area during the Fall of 1994, clearly indicated that the rate of change in the water level during a slug test could not be measured manually due to the high hydraulic conductivity of the sediments. A Hermit 1000C electronic data logger equipped with a 10 psi pressure transducer was rented from Mow-Tech Ltd in Edmonton, Alberta.

The test procedure is as follows:

- The static water level is measured in the piezometer,

- The pressure transducer is lowered into the piezometer sufficiently far below the static water level that it will be submerged at all time during the test and the cable of the pressure transducer is securely fastened to the top of the piezometer,

- Lowering the pressure transducer below the water level in the piezometer will change the static water level. Electronic water level readings are taken to determine when the water level has reached equilibrium again,

- At this point the datalogger is started in order to record the slug test and the slug is dropped (instantaneously) below the water level in the piezometer,

- Once the water level has reached equilibrium again, the test is finished. A second test, for backup, is than conducted by removing the slug, as fast as possible, from below the static water level.

- The data thus obtained is downloaded from the datalogger on a computer and than interpreted to obtain the hydraulic conductivity of the sediment in the completion zone of the piezometer.

Figures 1and 2 show examples of the rate of change in the water level in a piezometer after a slug is dropped. The exponential decline, illustrated in Figure 1, is characteristic of a sediment with low to moderate hydraulic conductivity, while the damped harmonic function, shown in Figure 2, is characteristic of sediments with high to very high hydraulic conductivity. It is obvious, that different interpretation methods are required to obtain the value of the hydraulic conductivity.

The interpretation methods used are Cooper et al (1967) and Papadopulos et al (1973) for confined aquifers, Bouwer and Rice (1976) for unconfined aquifers and the “van der Kamp” method (van der Kamp, 1976; Wylie and Magnuson, 1995) for slug tests with damped harmonic responses.

The raw data obtained with the datalogger has been submitted on disk to Boojum Research Ltd for safe keeping and the calculated hydraulic conductivities are shown in Table 1.

SURVEY.

Towards the end of June, 1995 the location and collar elevation of the newly constructed piezometers and testholes were surveyed (“new” survey). The 1995 survey was apparently conducted by the same person who had done the previous survey. During the 1995 survey electronic equipment was used, whereas the 1987 survey was conducted using conventional equipment. A number of the piezometers installed in 1987 were also surveyed (“old” survey).

A review of the new survey data for piezometers which had been surveyed previously, shows considerable differences between the two surveys. This is illustrated in Table 2.
This table shows that there are differences of up to 38.1 m (125 ft) in location and up to 22 cm in elevation of the collars of the piezometers between the two surveys.

Rather than using the coordinates for the new piezometers from the 1995 survey, the location of these piezometers was plotted in their approximate position using the 1987 topographic map as a basis and the knowledge of where the holes were drilled.

However, the elevations obtained from the 1995 survey were used to calculate the elevation of various geological contacts. It is realized that a potential error may be introduced by using the 1995 survey data, but it is felt that such an error is not that significant considering the degree of variability of this geological environment. For example, a 22 centimeter difference in the measured elevation of the bedrock surface at a particular point is not critical, especially, if it is considered that the contour interval for the bedrock topography map is 5 meters.

Accurate elevation measurements are much more critical when waterlevels between piezometers are compared, especially in this area where the sediments have very high permeability. A review of the existing information indicates, that differences between the elevation of the waterlevel in the piezometers are in the range of centimeters, which is similar to the range of differences found between the old and new surveys. This means that the uncertainty about the accuracy of the 1995 survey potentially can introduce significant errors in the determination of both vertical and horizontal gradients and consequently in the flow directions and rates of groundwater flow. The implications will be further highlighted in a subsequent section of the report.

BEDROCK TOPOGRAPHY.

The bedrock topography of a portion of the area under investigation is shown in Plate 1. It is based on the location and elevation of outcrops and the position of the bedrock surface encountered in boreholes during the various drilling programs conducted in this area, the depositional environment of the recent sediments (Pleistocene) and guided by the results of the EM survey.

The bedrock surface within the Canadian Shield is characteristically irregular. Although this surface was somewhat modified by glacial erosion, very rapid lateral changes in the elevation can and do occur. This is illustrated by the outcrops in the area and for the subsurface by the detailed test drilling in the area where the dams were constructed (southern edge tailings basin). The cost of testdrilling, to obtain the information required for a reasonably accurate bedrock topography map, would be prohibitive. Based on the available information, it must be emphasized that the bedrock topography shown in Plate 1 is, at best, a “rough” approximation only.

The bedrock topography is characterized by a southward trending bedrock valley. This bedrock valley skirts the western side of Mud lake and runs under the gravel pit towards the northwestern corner of the tailings basin. In this area it appears to split in two arms. One arm follows the western tailings basin towards the south and exits the tailings basin in its southwest corner and appears to run under the eastern part of the old townsite towards Confederation lake. The other arm appears to run toward M28 and subsequently under the western part of the townsite. The north-south trending buried valley, in all likelihood, follows a major fault zone

Plate 1 also shows, that the arm of the bedrock valley under the tailing basin is joined by another tributary originating in the northeastern part of the tailings basin.

The portion of the buried valley, which is best defined, is located under the gravel pit. It is bounded on the westside by a bedrock outcrop and on the eastside by a bedrock high (TH 1). Three testholes (M79, M80, M81), more or less equally spaced, were drilled across this valley. It appears that the valley has relative steep walls and a flat bottom (the "Kalin Canyon"). Testhole M81 appears to be close to the western edge of the valley as is suggested by the presence of a considerable boulder lag just above the bedrock surface.

Both the northern extent of the buried valley under Mud lake and the southern extent of the two arms under the townsite are not defined and would require considerably more testdrilling.

It is obvious from the bedrock topography shown in Plate 1 that the tailings basin is situated on a topographic bedrock low, which in the shallow subsurface is connected to the surrounding area by a number of buried valleys. These buried valleys, south and west of the tailings basin, in all likelihood, are directly connected to Confederation Lake.

The buried valley in the area between the northern edge of the tailings basin and Mud Lake appears to be physically well defined and canyon like, while south of the northern edge of the tailings basin it splits in two arms and becomes even more diffuse south of the southern edge of the tailings basin.

STRATIGRAPHY

The stratigraphy encountered at each borehole is described in Appendix D. Three general comments can be made about the stratigraphy in the area. These are:

1. All boreholes show fining upward sequences,

2. The overall grainsize of the sedimentary section decreases from north to south, and

3. The sedimentary section becomes more interbedded and variable towards the south.

ad. 1 - Almost all boreholes show that the coarsest sediments (boulders, gravel, granules) overly the bedrock surface which than grade into subsequent finer sediments in an ascending order. In many boreholes the finest sediment is clay or silt. Depending on the location of the borehole (inside or outside of the tailings basin) the finest sediments are overlain by muskeg, fill, tailings or another sand sequence.

No clay or silt is present in locations: M24, M27, M39A, M65, M77, M79, M80, M81,M85, M86, M88, M89, TH1, TH2, TH3, TH4, TH7, and TH8. Either the clay and silt were never deposited in these locations or were subsequently eroded or removed by the activity of man.

Deposition of sand above the clay or silt layers has occurred in locations: M5, M69, M72, M76, M82, M87, TH5, TH6 and TH9.

Tailings overly sand directly in locations: M65, M76, TH2, TH3, TH7, and TH8.

Tailings are separated from the underlying sand by muskeg in locations: M24, M27, TH2 and TH4. Tailings are also underlain by muskeg/peat, according to the stratigraphic descriptions of the old testholes, in locations: M4, M5, M7, M24, M25, M26, M27, M30, and M41. Although the stratigraphic descriptions of the old testholes show the thickness of the muskeg and the type of sediment which underlies the muskeg, serious doubts were raised about its accuracy by information obtained during the 1995 drilling program from holes twinned with existing holes. This will be discussed in detail below.

ad. 2 and 3. - The proportion of coarse grained sediments (gravel, granules, very coarse grained sands) of the total section is greatest in the "Kalin Canyon", where almost the entire section comprises coarse grained sediments. In many instances the sediment particles (pebbles, granules, sand grains) appear to form an open framework, with little or no entrapped finer material. This is indicative of deposition in a very high energy environment, which considering the depositional setting (a canyon-like topographic feature) is not too surprising. Further south, near the northern part of the tailings basin the degree of confinement of the channel appears to be less and more than one channel course is present. This results in a lower energy depositional environment and as a result slightly finer sediments predominate and the thickness of individual sedimentary units becomes more variable. This lack of confinement appears to be present under most of the western part of the tailings basin. This trend continuous south of the tailings basin as is illustrated by boreholes M78 and M82. Also in this area, the frequency of the occurrence of clay stringers within sand beds increases.

A number of boreholes drilled in 1986 were twinned during the 1995 drilling program. These are: M4[TH2], M5, M24, M26, M27 and M40. The boreholes drilled in 1995 are generally within 5 meters of the existing boreholes at these locations. Table 3 shows a comparison of the stratigraphic information obtained at these locations. In this table the type and thickness of the materials encountered over the same interval drilled in 1986 is shown.

A review of this table clearly shows that, except possibly for the tailings, there is no agreement between the type and thickness of the sediments encountered at these locations. It is realized, that lateral changes do occur, but over the short distances between the boreholes (< 5m) the differences in the stratigraphy as shown in the table are highly improbable. The example above raises serious questions about the quality of the stratigraphic information collected in 1986. Therefore, none of this information will be used.

Only one of the twinned borehole locations (M40) listed in the table shows that bedrock was penetrated. The difference in the depth where the bedrock was encountered is 1.07 m. Although this difference is considerable for two holes close together, it is not uncommon in this terrain. It is therefore assumed that the bedrock contacts established during the 1986 drilling program are correct.

It is obvious from the above table that the sediments listed for the completion interval of the piezometers installed in 1986 are most likely wrong. Suspicions were already raised when the listed hydraulic conductivities were compared with the aquifer material. This is illustrated in Table 4. Also included in this table is the hydraulic conductivity determined in 1993 for one of the piezometers and the suggested aquifer material based on the holes drilled at these locations in 1995. It is obvious, that the hydraulic conductivities listed in Table 4 are much more representative of the sediments found during the 1995 drilling program at the corresponding depth.

The regional stratigraphy is shown in a number of West-East cross-sections (PL . 2). The location of the cross-sections is shown in Plate 1. Only the major sedimentary units and their relationships are illustrated in Plate 2. Details about the lithology of the stratigraphic unit and changes that occur within these units are listed in the stratigraphic descriptions (App. E).

All cross-sections show the prominence of the buried valley in the western part of the area under investigation and illustrate the decreasing lack of confinement of the buried valley from the area north of the tailings basin (I-I') to the central portion of the tailings basin (III-III').
Section II-II' indicates the presence of a discontinuous clay layer at shallow depth in the area immediately west of the northwestern part of the tailings basin. This clay layer terminates between M72 (outside tailings basin) and TH7(inside tailings basin). This section also shows that the tailings directly overly sand.
Section III-III' shows that in the central part of the tailings basin, the tailings appear to be separated from the underlying sand by muskeg in the western half of the basin, while towards the southeastern part of the tailings basin, the tailings are not only underlain by muskeg, but in turn are underlain by clay and silt (M40, M26). The silt and clay overly the sand deposits. The eastern extent of the clay and silt bed is not known.
Fill is shown to be present near M6. Piezometer M6 was destroyed when this area was excavated and used as a boneyard for the disposal of mining equipment. The area is characterized by numerous sinkholes in the fill and appears to be very permeable, because surface drainage disappears in this area. It is not known if the shallow clay layer found in M76 extended westward to the location of M6, but considering that the clay layer occurs close to surface, a hole was dug at this latter location, and the surface drainage disappears in this area, the clay layer, if originally present, was penetrated in all likelihood and a direct connection for surface water and shallow groundwater to the deeper portions of the aquifer in this area was provided.
Section IV-IV', located at the southern edge of the tailings basin, illustrates the presence of significant clay and silt deposits. Although not shown, numerous clay stringers were detected throughout the sand section (M78, App. D). The right-hand side of this section, coinciding with the position of the concrete dams, also clearly shows the rapid changes, that can occur in the position of the bedrock surface.

It cannot be emphasized enough, that the position of the bedrock surface can change rapidly in this environment, and the shape illustrated in the cross-sections and the bedrock surface map (PL.) is a function of the number of control points available.

GROUNDWATER FLOW

Precipitation falling on the tailings basin, once infiltrated, will flow vertically downward through the tailings. Upon reaching the underlying aquifer it moves laterally and predominantly towards Mud Lake. The actual path taken by the groundwater in the tailings will depend on the permeability distribution within the tailings. Both the presence of compacted muskeg and especially clay layers under the tailings will affect the groundwater flow path. Although significant vertical gradients are present across the clay layer , 0.7-0.8 m/m (M72B/M72C), the actual volume of water transported through the clay will depend on its hydraulic conductivity. (*NOTE: the vertical gradient calculation is based on the 1995 survey elevation and may therefore not be correct*). In all likelihood the bulk of the groundwater flow will be laterally along the "impermeable" contact. The actual direction at this contact will be determined by the hydraulic head distribution.

Piezometers completed in the tailings in 1986 show hydraulic conductivities ranging from 3.8 x 10^{-6} to 5.4 x 10^{-3} cm/sec. In terms of grainsizes this would correspond to the range from silt to fine-medium grained sand. Observations on the grainsizes of the tailings during the 1995 drilling program showed that the grainsizes ranged from clay to rarely very fine grained. It is questionable, that the piezometer with the exceptionably high hydraulic conductivity (H7) is in actual fact completed in the tailings. Alternatively, the hydraulic conductivity determined is in error.

No piezometers are completed in the muskeg underlying the tailings. Three piezometers were installed in muskeg in 1995 (M66B, M70B and M70C). The hydraulic conductivity ranges from 2.3 x 10^{-5} cm/sec in the upper part (M70C) to 3.1 x 10^{-6} cm/sec near the bottom (M70B) of a thick muskeg sequence. During drilling it was noted, that the lower muskeg was much more compacted than the upper muskeg. No hydraulic conductivity has, thus far, been determined in M66B, for reasons outlined above. The results obtained from location M70 strongly suggest that compaction decreases the hydraulic conductivity of muskeg. Tailings overlying muskeg will undoubtedly compact the muskeg. If the hydraulic conductivities of the muskeg underlying the tailings remains in the range of 10^{-6} cm/sec than the muskeg most likely will not represent a permeability barrier to groundwater moving downward through the tailings. However, muskeg does adsorp many of the dissolved metal ions and will retard the advancement of the contaminant front, until breakthrough occurs. It is not known, if breakthrough is occurring or has occurred in the areas where tailings overly the muskeg. If breakthrough has occurred, much greater contaminant loading of the underlying aquifer will occur and consequently with time in the discharge areas.

Part of the area of the northwestern tailings basin and the area immediately adjoining it to the west shows the presence of a clay layer in places (M5, M 72, M76, TH5 and TH6). The hydraulic conductivity of the clay layer is almost certainly less than 5.7 x 10^{-7} cm/sec. This latter hydraulic conductivity was determined in M5B, which is completed in a silty clay.

The effect of the clay layer on the shallow groundwater flow is quite significant. It results in a pseudo perched watertable in the sediments overlying the clay bed and causes groundwater mounds to be created in those areas. *NOTE: the following discussion is in part based on the 1995 survey elevation and may therefore not be correct.*

The area under discussion is located immediately west of the northwest corner of the tailings basin. The surface elevation is such that just north of M85 & M86 the ground elevation is equal to the elevation of the road, i.e. the west dike of the tailings basin. At the southern limit, near M90, it is about 2 m below the crown of the road. On the westside the land surface starts to rise gently towards the topographic high in the area. The surface sediment is sand. A number of streamlets originating in the topographic high discharge into this area. Immediately south of M83 & M90 is the boneyard and as mentioned before, the fill in the boneyard is very permeable. Furthermore, the surface topography (Fig. 3) shows that the surface drainage is directed towards the boneyard. However, most of the surface runoff will have infiltrated the sand before it reaches the boneyard, but small channels at the toe of the dike (road) indicate that southward flow of surface water does occasionally reach this area.

Piezometer M70 is completed in sand overlying the clay layer. The waterlevel in this piezometer over the period from May till September, 1995 was 6 - 30 cm below the ground surface, respectively. The shallow groundwater at this location has one of the highest dissolved metal concentrations in the total area under investigation. The electrical conductivity at the time of sampling in May, 1995 was 5725 µS/cm @ 25 ^{0}C. Subsequently an electrical conductivity of 15,050 µS/cm @ 25 ^{0}C was measured on August 15, 1995.
The closeness of the watertable to the ground surface undoubtedly will cause capillary transport of contaminated water to the surface and subsequent evaporation will result in the deposition of soluble metal salts at surface. Precipitation of bluish $CuSO_4$ has been noted in this area. Subsequent dissolution by precipitation and accompanying surface runoff will transport these ions further south towards the fill area.

Locations M72 & M87 both show the presence of clay in the shallow subsurface. The configuration of the watertable for this area is illustrated in Figure 4 and 5a. As can be seen in this figure, a groundwater mound is present and the watertable slopes steeply towards the north and the south. The shallow groundwater present in the mound will flow laterally along the clay contact and literally flow of the edge into the underlying main aquifer. This scenario will be followed wherever discontinuous clay layers are present, for example between M76 and the boneyard. Depending on the volume/ unit time and the magnitude of the dissolved metal ion concentration it is conceivable that slugs of highly contaminated water may enter the main aquifer from the edges of the clay deposits.

To determine if this clay layer is an effective barrier to dissolved metal ions, a 45 cm long splitspoon sample of the upper part of the clay layer was obtained in TH5 (see App. D). This testhole is located within the tailings basin, between piezometer nest M5 and M89. The clay is overlain by oxidized silt and sand, which in turn is overlain by tailings. Three samples of the clay core: top, middle and bottom, were submitted for chemical analysis. The dried samples were split and a paste was made using distilled water and KNO_3 water, respectively. The KNO_3 water was used to exchange any metals held by the clays. The filtrate of the paste was analyzed by ICP. Table 5 shows the results of the analyses. It is assumed that the results from the distilled water closely represents dissolved ion species in the interstitial water, while the results of the KNO_3 water reflect the contribution of the exchangeable and the dissolved ions.

As can be seen in this table a number of trace metal ions: Co, Cu and Ni have the highest concentration near the top of the clay for both the distilled and KNO_3 extractions. Co and Ni show a drastic decrease in concentration from the top to the middle sample for both extractions, while the Cu concentration over the same interval only shows a significant decrease for the KNO_3 extract. The concentration of Cu in the distilled extract shows a gradual decrease from the top to the bottom of the core and differs in that respect from the other two metals. The concentration of Cu in the KNO_3 extract for the middle and bottom sample is

similar to the concentration present in the equivalent distilled extracts. The concentration of Co and Ni in the two different extracts of the middle and bottom sample is low and remains more or less the same.
The concentration of Co and Ni in the KNO_3 extract of the top clay sample is not only at least one order of magnitude greater than the middle sample, but also about an order of magnitude greater than the equivalent distilled extract. This indicates that the bulk of these metal ions is held in the exchange position on the clay, The apparent great affinity for exchange onto the clay limits the downward movement of these metals.
Cu shows a much less dramatic trend. The concentration of Cu in the KNO_3 extract for the top clay sample is only about 2.3 x greater than in the distilled extract for the same sample interval. This much smaller difference, as compared to Co and Ni, and the gradual decline in concentration with depth suggests that Cu has a much lower affinity for cation exchange than the other two metal ions.
The concentration of Zn in both extracts remains more or less constant for all samples and Zn appears to have no affinity for cation exchange.

These results tend to indicate that the movement of dissolved Co and Ni is retarded by the clay and to a lesser extent Cu, but that Zn can move relatively freely. However, these conclusions are based on one set of samples from a single location only. Several samples from different parts of the tailing basin will be needed to determine if the observations are correct. Also piezometers would have to be completed in the clay sediments to obtain water samples of the interstitial water. In addition, areas outside the tailings basin with uncontaminated groundwater would have to be included to determine the range of the natural background concentrations of these metals in the clay deposits.

The results obtained from piezometer nest M72, however, appear to contradict the notion that the clay layer acts as an impermeable boundary. This nest has three piezometers: M72C, shallow and above the clay layer; M72B, intermediate and below the clay layer; and M72A, deep and immediately above the bedrock contact. The concentration of a number of ions, pH, Eh and the electrical conductivity is listed in Table 6. This table shows that the highest ion concentration and electrical conductivity (E.C.) occurs in the shallow piezometer and that these parameters decrease with depth. Similarly, the pH shows that the shallow groundwater is acidic and becomes less acidic to near neutral with depth. The Eh trend indicates that the shallow water has an oxidizing environment and with depth this becomes a progressively more reducing environment. (NOTE: no detailed discussion of the groundwater chemistry will be made in this report. Dr. van Everdingen is reviewing that aspect of the investigation and his findings will be presented in a separate report. The use of chemical data in this report is primarily for corroboration).

The trend in Table 6 strongly suggests downward migration of contaminated water. In other words, contaminated water is moving through the clay layer in this area and the clay layer does not retard downward contaminant transport.

It is known that the edge of the clay layer is between M72 and M89. The hydraulic conductivity in the upper part (M72B) of the main aquifer is 6.49×10^{-3} cm/sec and is greater than in the deeper part (M72A = 3.34×10^{-3} cm/sec). If the appropriate hydraulic gradient exists, contaminated water flowing of this edge could conceivably backtrack under the clay layer in a northerly direction following the permeable sand, which than would explain the contaminated water under the clay at M72B. However, the hydraulic head (waterlevel) in piezometer M72B is always higher than in the other piezometers in the area over the period from May - September, 1995 (Fig. 5b). This prevents water flowing of the edge between locations M72 and M89 from backtracking. This figure also shows that the hydraulic head (waterlevels) decreases towards M73, i.e. the north.

Another possible explanation may be that the general area of M72 represents a major discharge point from the tailings basin for groundwater flowing under the clay layer. This possibility is highly unlikely, because the hydraulic head in piezometer M5E, completed in the sand under the clay layer is at a lower elevation than M72B, indicating that groundwater flow is taken place from M72B towards M5E and not vice versa.

No serious completion problems were encountered during piezometer construction at location M72. Bentonite pellets were placed in the annulus of both M72A and M72B from the bottom of the clay layer to ground surface, which rules out cross-contamination.

Alternatively, the question: why does it appear that the highly contaminated shallow groundwater is flowing through the clay layer, may simply be due to erroneous survey data. This possibility was pointed out before.

M72A, completed immediately above bedrock, shows relatively uncontaminated water in comparison to M83A, which is also completed immediately above bedrock. The only difference between the two locations is that piezometer M38A is deeper. M83A was airhammer drilled and the electrical conductivity of the produced water was measured. The hole is cased to the bit during drilling and the produced water should be a fair reflection of the in-situ water. However, mudsize particles created by the drilling are inevitably present in the produced water and will affect its electrical conductivity. The electrical conductivity of the produced water was measured in four holes (M79, M80, M81 and M83) and listed in Appendix E. The results are shown in Figure 6. As can be seen in this figure a relative abrupt change takes place in the electrical conductivity of the formation water once the contaminated zone is encountered. Furthermore, it is obvious that the contamination is restricted to the lower part of the aquifer. The elevation of the top of the contaminated water in M38A is at approximately a depth of 12.19 m (40 ft) or an elevation of 404.5 m. This elevation is approximately 1.2 m lower than the bottom of the screen in M72A, which explains why no highly contaminated water was found in this piezometer.

The regional groundwater flow is illustrated in Plate 3. The hydraulic head distribution is based on the waterlevels measured in piezometers completed immediately above the bedrock surface on July 29, 1995. It is assumed, that the contrast in hydraulic conductivity between the bedrock and the overlying permeable sand and gravel deposits is sufficiently large that, for all practical purposes, the bedrock surface can be considered impermeable. Groundwater will, therefore, laterally flow along this surface. *NOTE: the following discussion is in part based on the 1995 survey elevation and may therefore not be correct.*

As can be seen in Plate 3, the tailings basin is partially surrounded by groundwater recharge areas. These areas correspond to topographic highs which are predominantly bedrock hills. Pine trees grow characteristically in those areas. Fresh groundwater flows from these recharge area towards the tailings basin and is in places conveyed for a considerable distance under the tailings basin. M26B, located more or less in the middle of the tailings basin, was completed near the bedrock surface contact in a NE-SW trending tributary to the main buried valley. The chemical analysis shows that the water from this piezometer is uncontaminated. Uncontaminated groundwater is also present in the arm of the main buried valley west of the tailings basin near M28. This uncontaminated water flows northerly in the direction of M83.

All piezometers near the edge of the northeastern part of the tailings basin (M1, M61, M68) show uncontaminated water, although a steep hydraulic gradient from the tailings basin towards M61 appears to be present. (M61 was surveyed in 1995 !).

It is obvious from Plate 3 that the north-south trending buried valley on the western edge of the tailings basin is the main groundwater discharge path for the tailings basin. Contaminated groundwater in the tailings basin flows along the buried valley towards Mud Lake and discharges into Mud Lake. The waterlevels in all piezometers completed in the immediate vicinity of Mud Lake (M58, M59, M60A & B, M62 and M63) are above the lake level. It is known that active discharge (springs) of contaminated groundwater occurs in the northern part of Mud Lake near M62and M63. No piezometers have, as yet, been installed in the deeper part of the aquifer in this area. Also the configuration of the buried valley and its extent in this area are unknown at the present time. However, the evidence of groundwater discharge in this area indicates that a major change is occurring along the path of the buried valley. This could be a facies change in the sediment of the buried valley resulting in a sharp reduction of the permeability of the aquifer and/or a significant change in the physical continuity of the buried valley. In other words, the northern part of Mud Lake may be the start of the main buried valley aquifer. Additional subsurface data will be required to resolve this.

The dams constructed in the southeastern part of the tailings basin to prevent major discharge of contaminated groundwater into Boomerang Lake have achieved, in principle, their objective of creating a low to very low permeability wall (boundary) as is manifested by the steep hydraulic gradients between the tailings basin and Boomerang Lake. However, Plate 3 also shows that, at least in three places, seepage is still occurring.

Another area which warrants discussion is the southwest corner of the tailings basin. Plate 1 indicates that the bedrock topography is not well defined in this area, especially in the area southwest of M78, i.e. old townsite.
The groundwater immediately above the bedrock in location M78, which is situated south of the tailings basin, is highly contaminated. This indicates that contaminated groundwater is flowing towards the south from the tailings basin. The EM survey for this area shows the presence of a well defined, but relatively small anomaly. However, it is known from the stratigraphic information in boreholes M78 and M82 that significant clay deposits are present in the shallow subsurface, which will mask the effect of the contaminated groundwater in the EM surveys. The water chemistry indicates that contaminated water has traveled southward to at least the location of M82. The hydraulic head in M78A confirms that movement is taken place from the tailings basin towards the south. However, the hydraulic head in piezometers M20, M21, M42 and M82 indicate that groundwater flows in a northerly direction towards M78. This contradicts the other observations. However, it should be pointed out, that the difference in hydraulic head between M20, M21 and M82 and M78 is only 6 - 10 cm. This range falls well within the range of errors observed between the 1986 and 1995 survey of the elevation of the piezometers. Also, the apparent differences in hydraulic head could result from density differences between the groundwater present in different locations. Until such time, when the uncertainty in the survey data has been resolved, the effect of density differences and equivalent freshwater heads will not be considered.

On the other hand, waterlevel measurements in piezometers M50 and M77A show that the hydraulic head in these piezometers is at least 150 cm lower than in M78. This difference cannot be accounted for by survey errors only. This strongly suggests that groundwater flow from the tailings basin towards the south is likely to occur. Furthermore, this significant difference in hydraulic head implies a relatively steep gradient towards the south. Steep gradients between two measuring points generally signal a drastic reduction in the permeability of the sediments. The existence of much greater variability in the stratigraphy in this area was confirmed by boreholes M78 and M80.

However, at this point in time, the stratigraphy, bedrock topography and the groundwater flow regime south of the tailings basin is not well defined. Insufficient information is available to calculate, with any degree of confidence, the volume of contaminants being transported in this area.

CONTAMINANT LOADING.

The main pathway for contaminant transport towards Mud Lake is a buried valley, which narrows to a canyon in part of the area between the tailings basin and Mud Lake. The following parameters have been established:

1. The cross-section of the buried valley (M81 - M79 - M80, Plate 2),

2. A reasonable approximation of the thickness of the contaminated water within the buried valley (Fig. 6),

3. A reasonable approximation of the hydraulic conductivity of the sediments (M73, M79, M80, M81), and

4. the hydraulic gradients (if the survey data is correct).

ad. 1& 2 -The cross-section of the buried valley in the canyon containing contaminated water is : ± 250 m^2 (- A -)

ad. 3 - The hydraulic conductivity for the lower part of the sediments in the buried valley ranges from 1.57 to 2.60 x 10^{-1} cm/sec. (- K -)

ad. 4 - The hydraulic gradient is based on M39A and M80. This gradient is not constant but varies with time. It was 8.202 x 10^{-4} on June 28, 1995; 7.697 x 10^{-4} on July 29, 1995 and 6.246 x 10^{-4} on September 23, 1995. (- h -)

Based on these parameters and the simple relationship: Q = K x A x h, the following rates were calculated.

	Hydraulic Conductivity = 0.157 cm/sec			Hydraulic Conductivity = 0.26 cm/sec		
	l/sec	l/day	l/year	l/sec	l/day	l/year
28-06-95	0.322	27820	10,154,590	0.533	46050	16,808,690
29-07-95	0.302	26090	9,523,870	0.500	43200	15,768,000
23-09-95	0.245	21170	7,726,320	0.406	35080	12,803,615

It should be realized that every cm of error in the elevation of the waterlevels between M39A and M80 introduces a change of 7.5 - 10 % in the above listed values.

It appears that a minor amount of contaminated groundwater may also enter the Mud Lake area from M74 towards M58. Assuming that the top of the contaminated water is at an elevation similar to the one used in the previous calculation and the lowest point on the bedrock surface is at an elevation of 400.5 m, the cross-section contributing contaminated water ranges from 36 - 50 m^2 . Based on M58, M66A and M74 the average hydraulic conductivity is 1.87×10^{-2} cm/sec and the gradient, based on one set of readings: May 12, 1995, between M74 and M58 is 5.738×10^{-5}.
The contribution through this path may range from 3.85 to 5.35×10^{-4} l/sec, which is about 10 % of the rate flowing through the "Kalin Canyon". It should be pointed out, that this pathway and consequently the cross-section is not as well defined as the previous one.

The contribution of groundwater flow to the contaminant loading of Mud Lake is somewhat lower than the previous estimate of 0.6 l/sec. However, the volume of water/unit time is only one part of the equation, because the concentration and temporal changes of the ions of concern also has to be considered in order to determine the yearly loading of Mud Lake. No information, as of this time, is available on the temporal changes of the ion concentrations in the groundwater. Also the yearly variation of the hydraulic gradient has not been determined, simply because the new piezometers have only been measured for a few months.

CONCLUSIONS

Sand and gravel deposits overly the bedrock surface under the tailings basin. The tailings lie directly upon sand or are separated from the sand by muskeg and/or clay.

The configuration of the bedrock surface shows that a major north-south trending buried valley is present under the western part of the tailings basin. This buried valley is the main path for the migration of contaminated groundwater from the tailings basin towards Mud Lake. North of the tailings basin under the gravel pit the buried valley becomes canyon-like.

The extent of this buried valley under Mud Lake and southwest of the tailings basin has not been defined.

The stratigraphy shows that the coarsest sand and gravel deposits occur under the gravel pit in the northern part of the area under investigation. Southward from this point the degree of confinement decreases and the sediment becomes finer and more interbedded. Southwest of the tailings basin clay stringers within the sand are common.

The hydraulic conductivities of the sand and gravel deposits in the buried valley proper range from 3.34 to 330 x 10^{-3} cm/sec.

Information obtained on the electrical conductivity of produced water during airhammer drilling shows that only the bottom portion of the buried valley north of the tailings basin is contaminated.

Chemical analyses of the groundwater show that the groundwater above the bedrock contact near the northwestern portion of the tailings basin is not contaminated and that the deep groundwater in the central part of the tailings basin at location M26B is also not contaminated. M26B is situated in a northeast-southwest trending tributary to the main north-south buried valley.

The most contaminated water is present in piezometer M72C, located in a topographically low area immediately west of the northwest corner of the tailings basin.

The uncertainty in the 1995 survey results, especially the elevation, can introduce potentially significant errors in the determination of the groundwater flow directions and the conclusions reached regarding the groundwater flow and contaminant loading of Mud Lake may, therefore, not be correct. With this clear understanding, the following conclusions regarding hydraulic gradients, groundwater flow directions and contaminant loading have been reached.

Hydraulic gradients are small, but do indicate a primarily northerly flow of groundwater and contaminants from the tailings basin.

The rate of contaminant flow towards Mud Lake ranges from 0.25 to 0.53 l/sec in the buried valley north of the tailings basin.

The groundwater flow environment southwest of the tailings basin shows a number of contradictions which may be inherent to the inaccurate survey data. Until the discrepancies in the survey data are solved, further discussion of the implications of contaminated groundwater and the rate of groundwater flow is an exercise in futility.

Similarly, design concepts for remedial action within the groundwater environment have not be discussed.

RECOMMENDATIONS

It is imperative, that all piezometers are re-surveyed and accurate elevations are established as well as their locations.

In order to be able to calculate the contaminant loading of Mud Lake accurately, it is recommended that piezometers M79, M80 and M81 are sampled regularly to determine the temporal changes in the water chemistry in the “Kaolin Canyon”, i.e. the main path of contaminated groundwater discharging into Mud Lake.

Muskeg appears to underlay the tailings over a considerable area The presence of muskeg under the tailings may significantly retard the migration of metal ions. It is not known at this time if breakthrough has taking place, is occurring or has not occurred. If breakthrough is occurring contaminant loading of the underlying aquifer could increase drastically with time, which, in turn, would increase the contaminant loading of Mud Lake and may require a much more extensive remediation effort in the northern part of Mud Lake. It is, therefore, recommended that the “state of breakthrough” of the muskeg be further investigated.

Drilling in the north end of Mud Lake presents major drilling technical problems. Target selection for drilling in the old townsite, southwest of the tailings basin present another problem due to the apparent rapid changes in the position of the bedrock surface, which would require a vast number of holes to define. It is, therefore, recommended that prior to any further drilling, the use of non-invasive techniques, such as hammer seismic, ground penetrating radar, etc., is investigated to determine if these methods can be used in defining the bedrock surface. If the listed methods or other techniques can provide relative reliable information on the approximate position of the bedrock surface, it is further recommended that these techniques are applied to both areas not only to minimize the cost of further test drilling, but also to focus any future drilling program better.

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TABLE 1. Calculated hydraulic conductivities.

Piezometer	Hydraulic conductivity x 10^{-3} (cm/sec)	Piezometer	Hydraulic Conductivity x 10^{-3} (cm/sec)
M5N	7.38	M86	84.60
M24N	15.20	M87	1.89
M26B	7.18	M88	3.28
M27C	221.00	M89	7.39
M40B	4.00	M90	dry
M64	2.39		
M65	14.60		
M66A	33.10		
M66B	--		
M67	17.10		
M68	4.24		
M69	31.50		
M70A	4.06		
M70B	0.0031		
M70C	0.0230		
M71	2.07		
M72A	3.34		
M72B	6.49		
M72C	0.735		
M73	112.00		
M74	14.00		
M75	13.00		
M76	7.35		
M77A	43.00		
M77B	7.80		
M78A	104.00		
M78B	14.20		
M79	142.00		
M80	260.00		
M81	222.00		
M82	9.24		
M83A	99.00		
M83B	330.00		
M84	--		
M85	83.50		

TABLE 2. Difference in meters between survey parameters for same hole locations 1986 and 1995 surveys.

Piezometer	Northing	Easting	Elevation
M30	0.000	0.000	0.042
M18	- 0.001	0.001	-0.085
M21	- 9.719	- 6.483	0.060
M20	- 7.347	- 4.668	0.121
M24E	-38.123	-10.603	**
M24W	-38.278	- 9.738	**
M40A	5.479	-12.609	0.226
M4	-22.329	-30.602	-0.044
M39	-19.698	-24.274	**

NOTE: ** New extensions put on these piezometers.

TABLE 3. Thickness (m) of material encountered, in descending order (from left to right), over the same interval in twinned borehole locations: 1986 and 1995.

Borehole	Tailings	Fill	Muskeg	Sand	Clay/Silt	Sand
M4 1986	3.20	--	0.03	4.39		
TH2 1995	0.91	2.14	0.23	1.29		
M5 1986	1.68	--	0.03	12.61	--	
1995	1.68	--	0.07	2.06	3.01	7.50
M24 1986	2.13	--	0.03	6.06	--	
1995	2.23	--	0.10	2.85	0.15	2.89
M26 1986	3.05	--	0.03	2.56		
1995	5.18	--	1.46			##
M27 1986	5.18	--	0.98	--		
1995	4.42	--	1.52	0.22		
M40 1986	4.27	--	--	1.52	--	**
1995	4.11	--	0.77	--	0.84	1.44

NOTES:

(M26): total thickness of muskeg is 3.05 m, underlain by 4.71 m of clay/silt
** (M40): bedrock surface encountered in 1986 at 5.79 m, in 1995 at 7.16 m.

TABLE 4. Aquifer material of completion zone:1986 versus 1995 and hydraulic conductivities determined in 1986 and 1993.

Piezometer	Aquifer material 1986	Hydraulic Conductivity (cm/sec) 1986	Hydraulic Conductivity (cm/sec) 1993	Aquifer material 1995
M 5B(= 5W)	coarse sand	5.2×10^{-5}	5.4×10^{-7}	silty clay
M24A(=24E)	sand	7.1×10^{-5}		very fine-fine gr. sand
M24B(=24W)	sand	7.7×10^{-5}		very fine-fine gr. sand
M26	sand	3.8×10^{-5}		tailings/muskeg
M27A(=27S)	tailings	2.1×10^{-5}		tailings/muskeg
M27B(=27N)	tailings	8.0×10^{-6}		tailings

TABLE 5. Chemical analyses of clay sample extracts (mg/L); splitspoon sample TH5.

Ion	TOP		MIDDLE		BOTTOM	
	Distilled water	KNO_3 water	Distilled water	KNO_3 water	Distilled water	KNO_3 water
Al	2.40	6.90	2.47	5.51	1.80	3.82
Ba	0.023	0.065	0.39	0.095	0.015	0.043
B	0.07	0.08	0.16	0.06	0.09	0.12
Ca	24.6	45.2	40.3	38.7	67.7	71.0
Cd	0.068	0.072	0.08	0.069	0.069	0.049
Co	0.564	5.70	0.15	0.13	0.14	0.21
Cu	0.399	0.927	0.342	0.328	0.206	0.181
Fe	20.80	24.10	20.90	21.30	16.90	12.10
Mg	6.51	6.20	6.39	5.75	6.35	6.27
Mn	2.72	3.04	3.85	3.20	4.20	3.07
Ni	0.24	2.80	0.02	0.03	0.03	0.06
S	59.7	63.1	78.6	65.7	19.0	70.9
Zn	20.4	21.2	25.3	21.6	24.0	18.4

TABLE 6. Concentration of Fe, Zn, Co and Cu and pH, Eh and electrical Conductivity in piezometer nest M72 (sampled May 16, 1995).

Parameter		M72C (shallow)	M72B (intermediate)	M72C (deep)
pH	(units)	4.66	5.99	6.69
Eh	(mv)	+ 143	- 7	- 143
E. C. @ 25^0C	(μ S/cm)	5360	3890	1130
Fe	(mg/l)	7690	3590	250
Zn	(mg/l)	1430	734	13.5
Co	(μg/l)	5360	3860	81
Cu	(μg/l)	1160	574	< 5

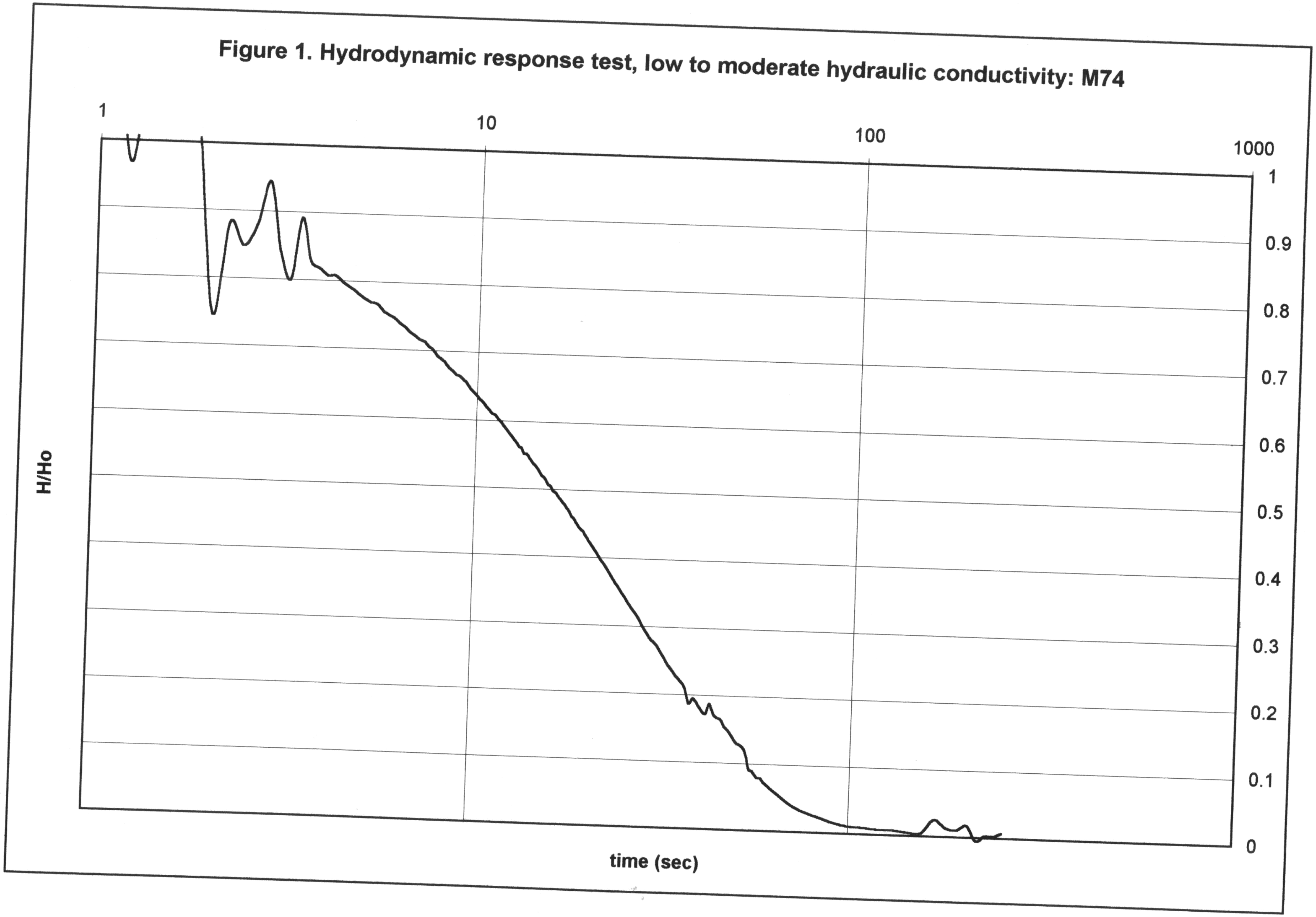


Figure 1. Hydrodynamic response test, low to moderate hydraulic conductivity: M74
1
10
100
1000
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
H/Ho
time (sec)

Figure 2. Hydrodynamic response test, high to very high hydraulic conductivity: M80

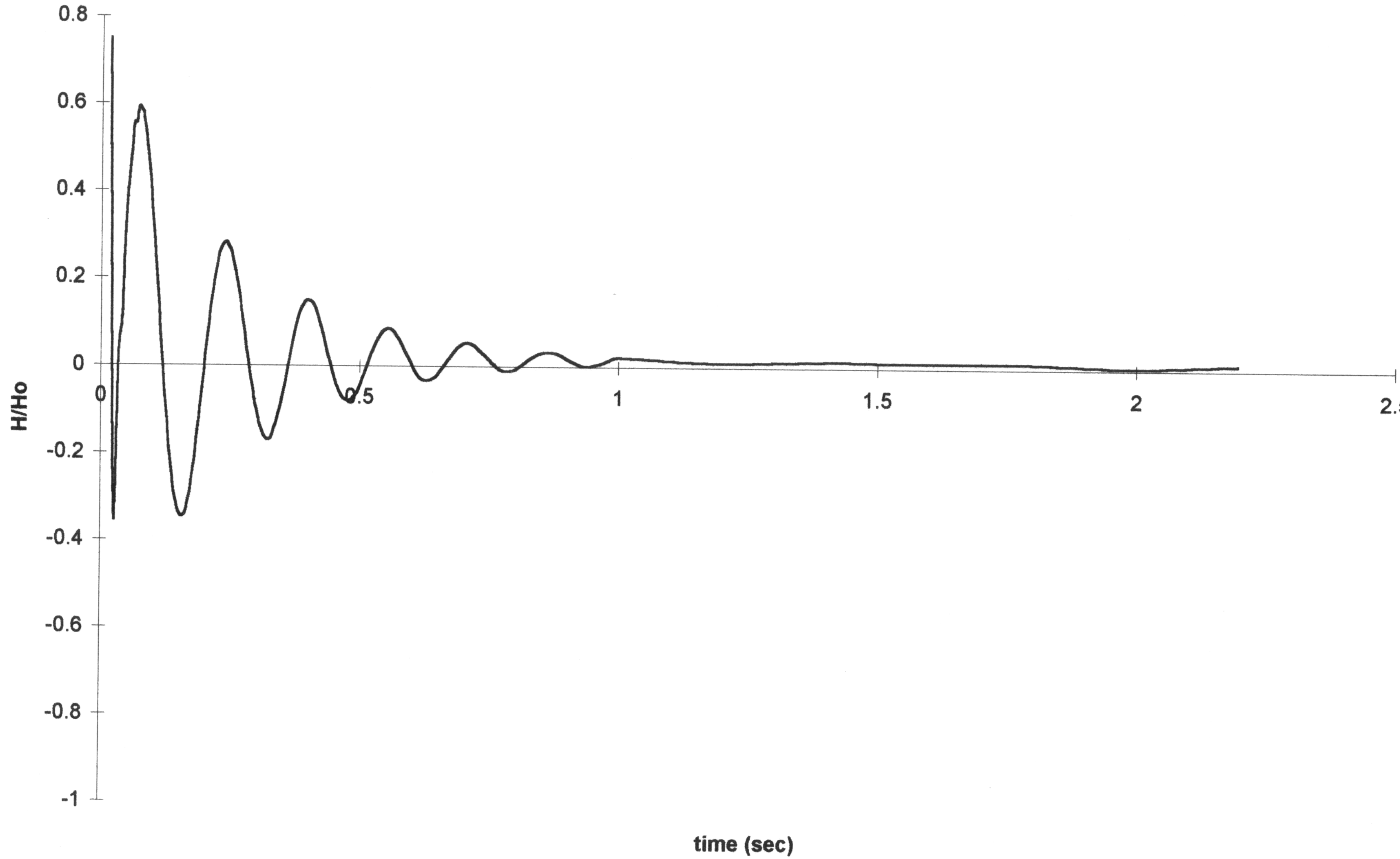


Figure 3. Configuration of topography, west of northwestern part of tailings basin

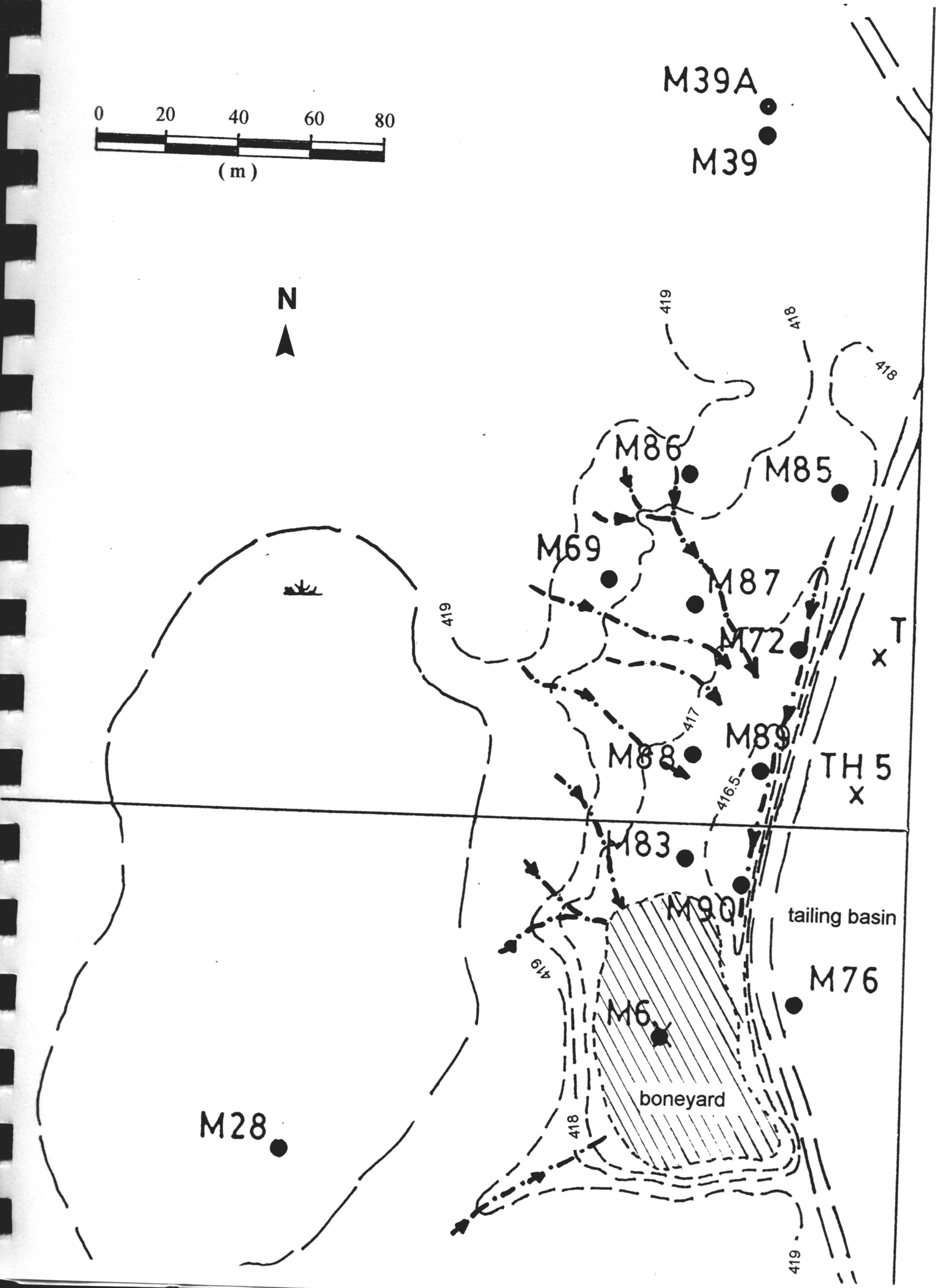


Figure 4. Configuration of watertable (June 28, 1995), west of northwestern part of tailings basin

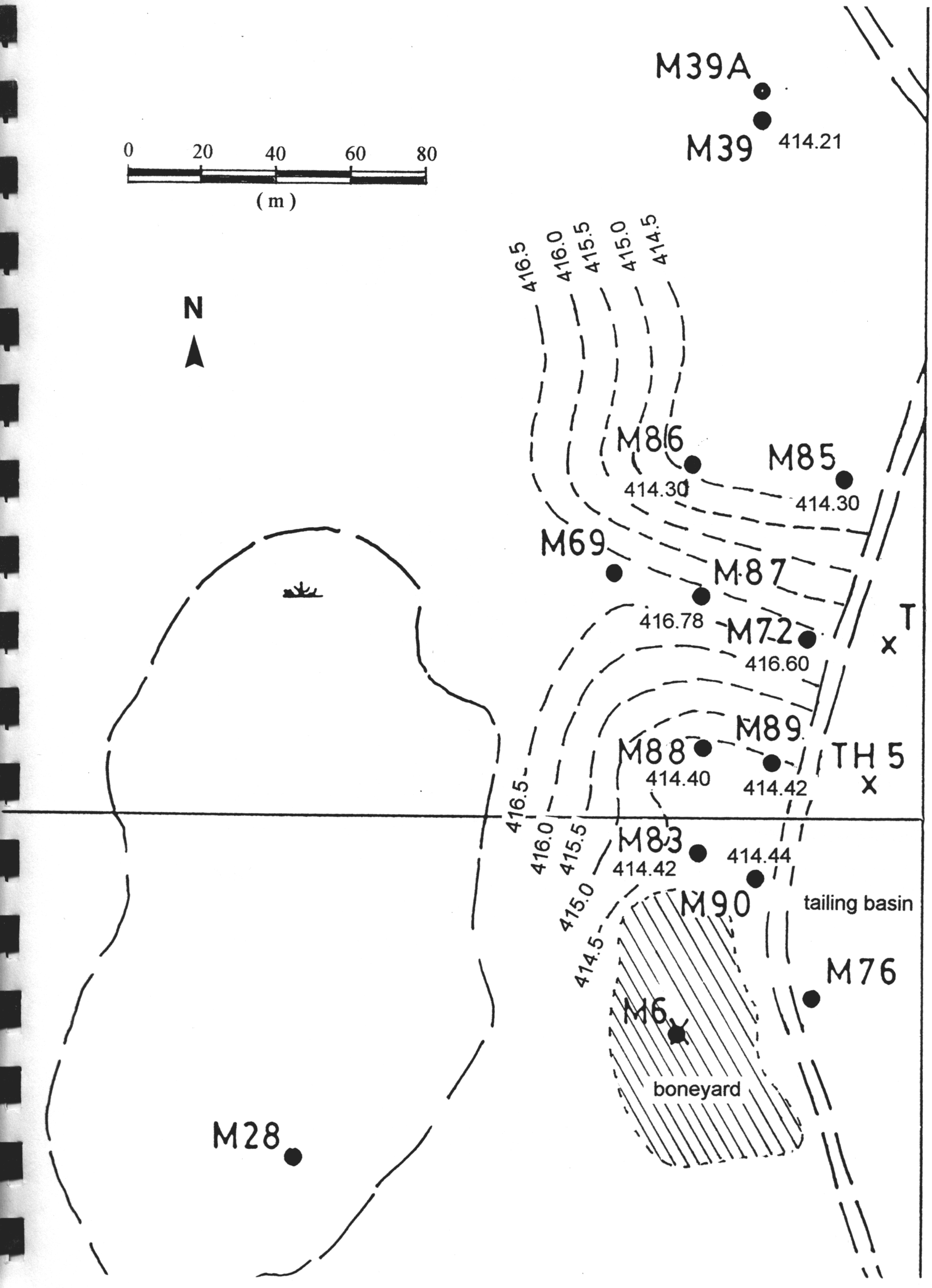


Figure 5A. Elevation of waterlevel versus time in piezometers M83B, 89, 72C, 85, 39 and 73

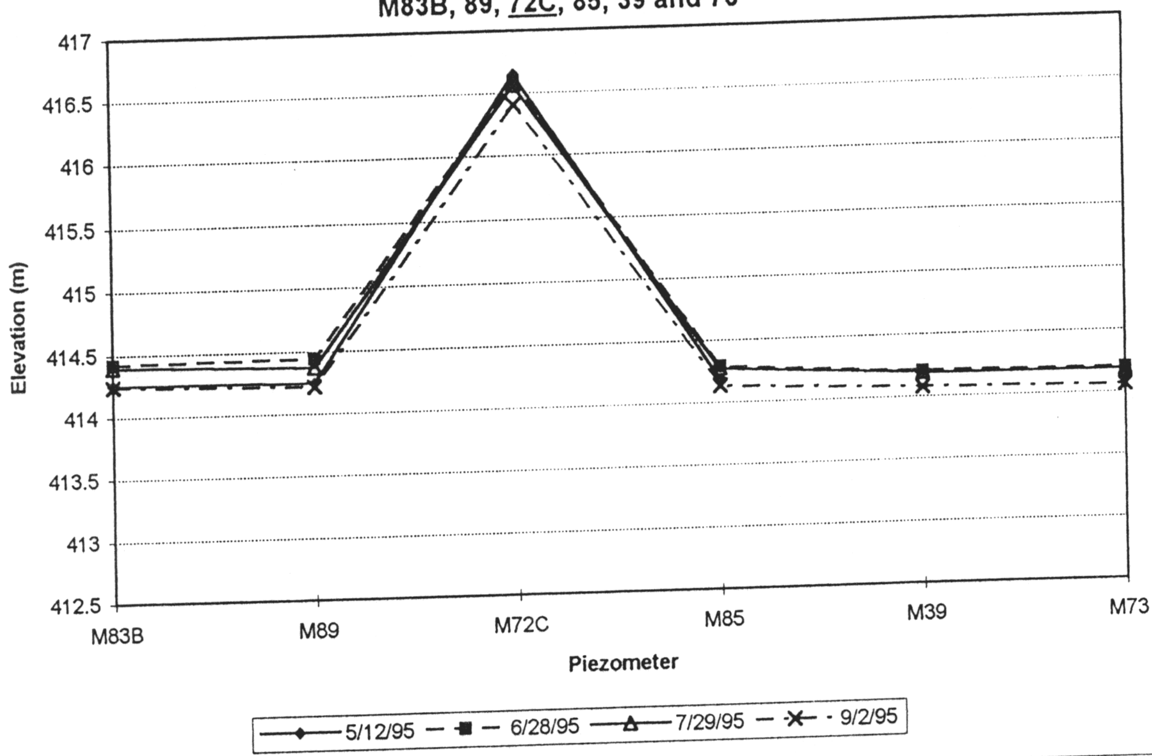
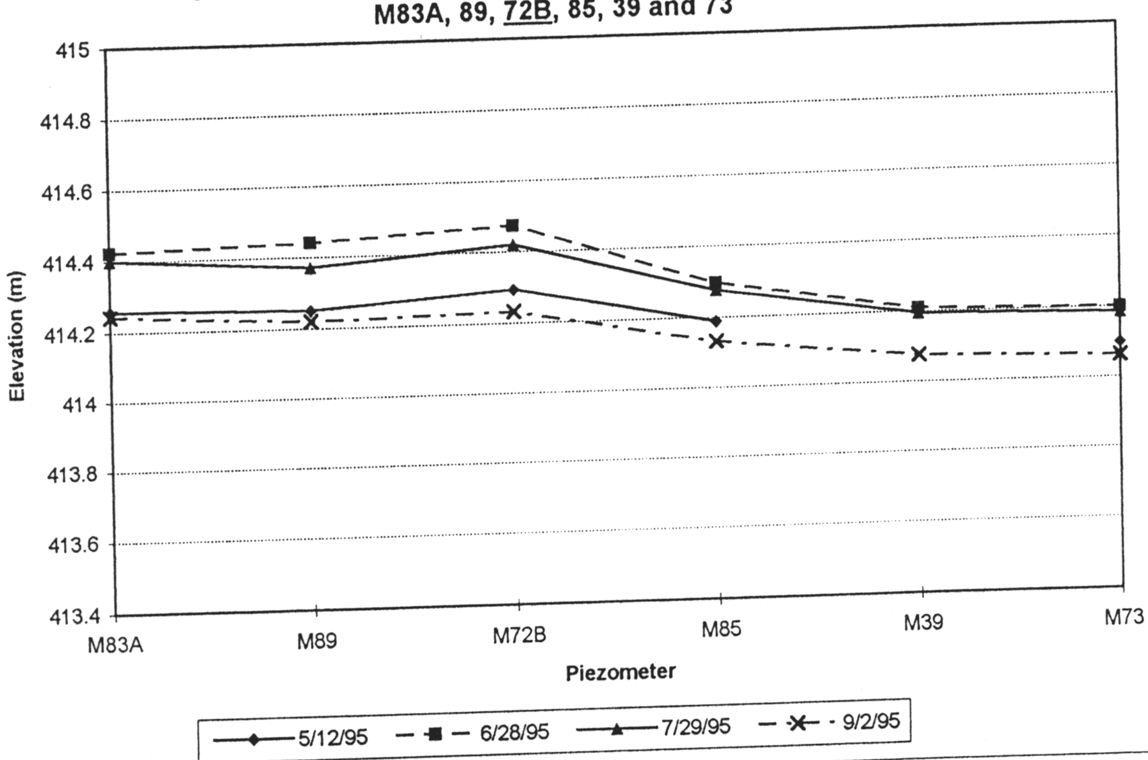


Figure 5B. Elevation of waterlevel versus time in piezometers M83A, 89, 72B, 85, 39 and 73



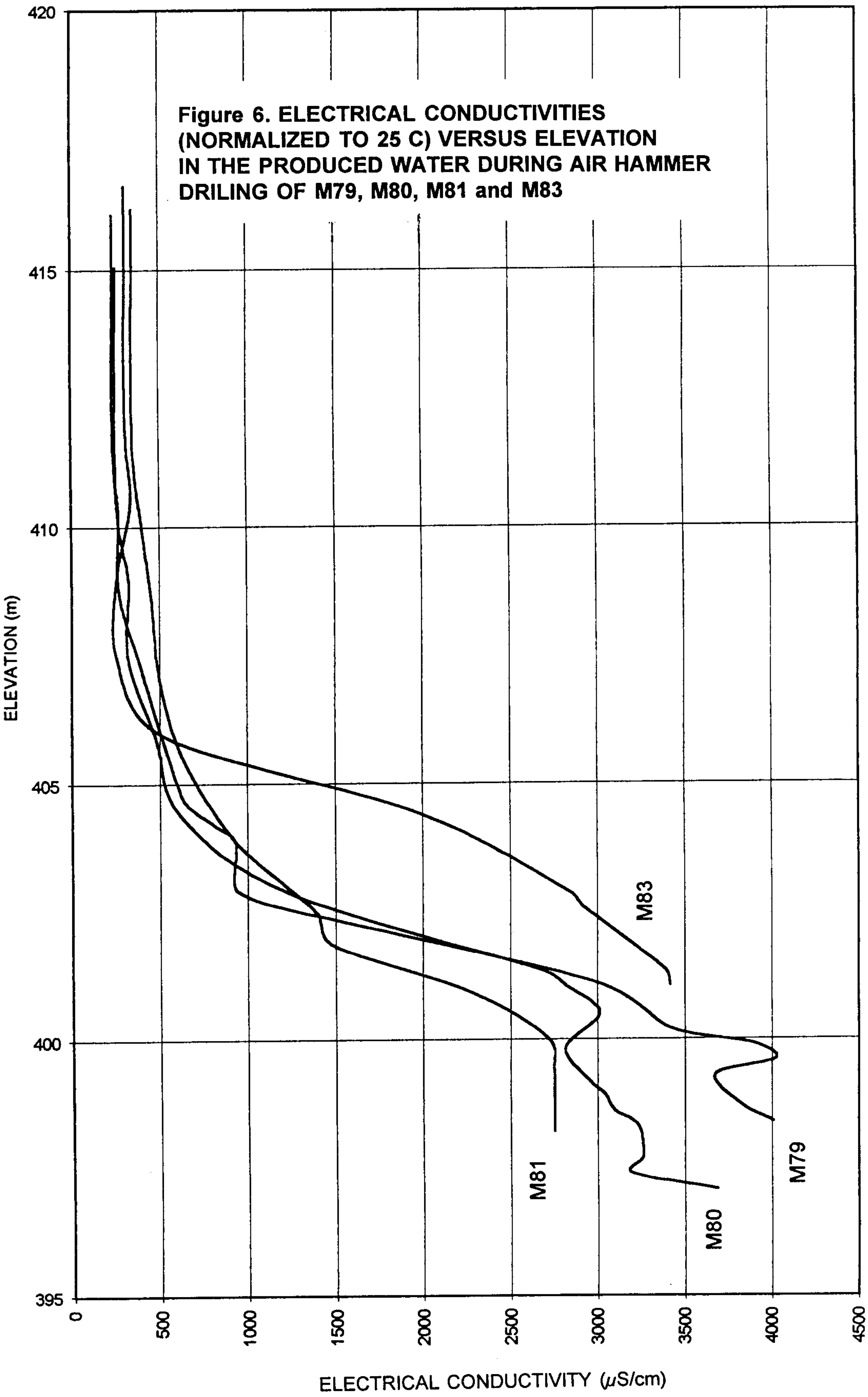


Figure 6. ELECTRICAL CONDUCTIVITIES
(NORMALIZED TO 25 C) VERSUS ELEVATION
IN THE PRODUCED WATER DURING AIR HAMMER
DRILING OF M79, M80, M81 and M83
ELEVATION (m)
420
415
410
405
400
395
0
500
1000
1500
2000
2500
3000
3500
4000
4500
ELECTRICAL CONDUCTIVITY (µS/cm)
M83
M81
M80
M79

APPENDIX A: DAILY CHRONOLOGY

CHRONOLOGY OF EVENTS

April 25, 1995.

10:10	Leave Calgary for Dryden, Ontario.
14:10	Arrive in Dryden, pick up supplies at various stores and drive to Ear Falls.
20:00	Meeting with driller and discuss sampling requirements, drilling procedures, completion techniques with special emphasize on placement of seals.

April 26, 1995.

07:45	Arrive on site, locate first few holes, move rig to location M64.
09:00	Start drilling. Auger down to 5 ft, switch to rotary and mud up. Drill and sample to 12.5 ft.
10:00	POOH (pull out of hole), switch to coring, core 3 ft, POOH and recover core.
11:00	Install piezometer, sand pack, place bentonite pellets.
11:40	Rig down, install submersible pump and pump piezometer.
12:15	Lunch.
12:45	Move and rig up on location M65.
13:00	Auger and sample to 9 ft.
13:20	Run casing and rig up for coring.
13:30	Core, recover core, install piezometer, sandpack and place bentonite seal.
14:15	Rig down and move to site M66A.
14:30	Clear site and rig up.
14:45	Auger down to 15 ft, sample, run casing.
15:15	Switch to rotary, mud up.
15:40	Drill and sample to 27 ft, POOH, switch to coring.
16:30	Core, trip[out, recover core.
17:15	Install piezometer, sandpack and place bentonite seals.
18:00	Shutdown and leave for town.

April 27, 1995.

07:45	Arrive on site, rig service, move 5 ft, set up on M66B.
08:00	Auger to 10 ft.
08:15	Tried to install piezometer, hole caved.
08:25	Run casing, washout hole, install piezometer, sandpack and install bentonite seal.
08:45	Rig down and pack up.
09:00	Install airlift pump and pump piezometer.
09:30	Move to M5C and setup.
09:45	Auger to 10 ft and sample, switch to rotary drilling.
10:00	Start drilling, leaks on outside of casing, fix.
10:30	Drill from 10-32.5 ft, with water, losing circulation, mix mud.
11:15	Drill ahead to 40 ft, no further penetration.
12:00	POOH, switch to coring, core and recover (boulder)
12:30	Switch back to rotary drilling, lost circulation, mix mud, and drill ahead to 54 ft.

14:30	POOH, trip in hole with core barrel, core, POOH and recover core.
15:30	Make up screen and riser pipe, RIH (run in hole), bridged. POOH.
15:45	Cleanout trip.
16:00	Tried installing piezometer, bridged again.
16:15	Cleanout trip, tried installing piezometer.
16:45	Cleanout trip and install piezometer.
17:30	Sandpack and place bentonite seal.
19:00	Shutdown.

April 28, 1995.

07:45	On site, and install airlift pump and pump piezometer.
08:15	Rig down, move and set up on M67.
08:30	Auger to 8 ft, refusal. backfill hole move ahead 5 ft and start again.
08:45	Auger to 15 ft and sample.
09:00	Install casing, switch to rotary, drill ahead to 21.5 ft with tooth bit.
10:00	POOH, switch to button bit and RIH, try drilling ahead.
10:20	POOH, switch to core barrel, RIH, core and recover core.
11:15	Install piezometer, sandpack, place bentonite seal. Rig down.
11:45	Move to M26B
12:00	Set up and auger and sample to 15 ft.
12:15	Lunch
12:45	Switch to rotary drilling, mud up and drill ahead to 44.5 ft.
15:30	POOH and switch to button bit, RIH and drill ahead to 53 ft.
16:00	POOH, switch to core barrel, RIH, core and recover core.
17:30	Shutdown for the day.

April 29, 1995.

07:45	On site, rig service. RIH, ream from 41 ft to bottom.
09:15	Thin mud and POOH.
09:30	Install piezometer, sandpack and place 4 ft of bentonite pellets, bridged at 40 ft. Steel tape, used for measuring top of placed pellets, stuck at 26 ft. cut off. Resume placement of pellets, bridged at bottom of casing.
10:45	Temporarily abandon site in order to get additional material (tremmie line) from town (3 hr round trip). rig down and move to site M68.
11:00	Rig up, auger and sample to 10 ft, install casing, switch to rotary drilling, mix light mud.
11:40	Drill ahead to 14.5 ft, POOH. RIH with core barrel and core.
12:30	Recover core, RIH with bit, replace mud with clean water, install piezometer, sandpack and place bentonite pellets. Rig down.
13:30	Lunch.
14:00	Move back to M26B, set up, wash annulus and bentonite plug at casing shoe, wash tremmie line down to 32 ft (refusal), circulate.
15:30	Mix bentonite grout, pump down, good surface returns, pull casing and top up hole with bentonite grout.
16:30	Rig down and move to 40B.
16:45	Set up, auger and sample to 14.5 ft
17:00	Shutdown.

April 30, 1995 (sunday).

09:15	On site, auger to 20 ft, install casing, switch to rotary and mud up. Drill ahead and sample to 23.5 ft.
10:15	POOH, RIH with core barrel, core, recover core, flush hole.
11:15	Install piezometer, sandpack, place bentonite pellets, rig down.
12:00	Lunch
12:30	Move to site M69, rig up, auger and sample to 25 ft.
13:00	Install casing, switch to rotary drilling, mud up, wash to bottom of casing and drill ahead to 29.5 ft, hard and refusal.
14:15	POOH, RIH with core barrel, core, boulder, POOH, RIH wit bit.
14:30	Mix mud, fix leaks around casing.
15:00	Drill to 38 ft, solid drilling, drill into rock for 4 inches. POOH to core.
16:30	RIH with core barrel, core to 40 ft, recover core, badly broken, fault zone.
17:00	RIH for cleanout trip, circulate hole clean.
17:30	Install piezometer, place sandpack and bentonite pellets.
18:30	Shutdown for the day.

May 1, 1995.

07:45	Arrive on site, pack up and move to decant pond.
08:30	Move through bush to location M70A.
09:00	Set up, auger and sample to 30 ft.
09:30	Install casing to 30 ft and switch to rotary drilling, mix mud and drill ahead.
10:20	Lost circulation, mix mud, drill ahead to 34 ft.
11:00	POOH, switch to core barrel, core, recover core, flush hole.
11:45	Install piezometer, sandpack and place 2 ft of bentonite pellets.
12:45	Lunch.
13:15	Install tremmie line and pump bentonite grout into annulus; recover casing.
14:15	Move to M70B, auger down to 17 ft, install piezometer, sandpack, place 2 ft of bentonite pellets.
14:30	Mix bentonite grout, install tremmie line and pump into annulus.
14:40	Move ahead 7 ft to site M70C, auger down to 13 ft, install piezometer, sandpack and place pellets.
15:15	Rig down and prepare for move to M71.
15:55	Set up on location.
16:20	Auger and sample to 14 ft. Install casing.
16:45	RIH with core barrel, core and recover core.
17:00	Install piezometer, sandpack and place bentonite pellets.
17:30	Rig down and move through bush back to decant pond.
18:00	Shutdown for the day.

May 2, 1995.

08:00	On site, move rig to location M72A, set up, auger and sample to 20 ft.
09:00	Install casing, switch to rotary drilling, mix mud.
09:30	Drill and sample to 36.5 ft, refusal.
10:45	POOH, switch to core barrel, RIH, core, recover core.
12:15	Lunch.
12:45	Resume coring.
13:15	Recover core, laydown core barrel, tried installing piezometer.
13:30	Cleanout trip, circulate and condition hole.
13:45	Install piezometer, sandpack and place bentonite pellets.
14:30	Rig down and pack up.
15:00	Move to site M73 (gravel pit) and set up.
15:30	Auger down to 40 ft, stop in boulders, abandon hole.
16:10	Move a few feet ahead. Auger to 15 ft, mix mud, wash and drill casing down. Drill out casing.
17:00	Shutdown for the night.

May 3, 1995.

07:45	On site, rig service, start drilling, losing mud, mix mud. Serious mud losses. Hole not standing open. Change drilling method. Pull casing out of hole.
09:00	Run in hole with different casing with a retrievable bit at end of casing. Drill casing down. Very slow drilling and no drill cuttings returned to surface. Drill ahead to 27.5 ft.
14:30	Recover retrievable bit and drill ahead with button bit. Constantly fighting lost circulation, drilling blind at times. Serious hole stability problems.
17:45	Shutdown for the night.

May 4, 1995.

07:45	On site, cleanout hole and ream to 34 ft., attempt to drill ahead. Excessive mud losses and serious hole stability problems. No further attempts to reach bedrock at this location with present drilling method.
09:10	Install piezometer, sandpack and place 2 ft thick bentonite pellet seal. POOH, break casing (tight).
10:00	Pack up and move to location M79.
10:15	Set up , auger and sample to 35 ft. No significant boulders or coarse gravel. Abandon hole, backfill and move ahead 5 ft.
11:00	Drill down casing with retrievable bit, drill to 26 ft. Start losing circulation and hole.
12:00	Mix mud repeatedly, drill ahead to 28.5 ft, losing significant volumes of mud.
13:00	Mix very heavy mud and polymer. Drill 6 inches, lose circulation; mix mud, drill 6 inches, lose circulation, mix very heavy mud again. Drill 6 inches, complete loss of circulation. No further drilling. Decide to pull out of hole and temporarily abandon site until air hammer and casing advancer equipment arrives on site.
13:45	Rig down and move to next site (TH 1).

14:00	Set up, auger and sample down to 11.5 ft, refusal. Run casing in hole.
14:30	Pick up core barrel, RIH, core 4 ft.
15:00	Recover core, backfill hole with bentonite pellets. Pack up and move to site M74.
15:30	Set up on location. Auger down to 5 ft. Boulder and gravel fill, rough drilling.
16:30	Wash and run in casing, drill out casing.
17:30	Shutdown for the day.

May 5, 1995.

07:45	On site, mix mud and drill ahead to 37.5 ft.
09:15	POOH, pick up core barrel, RIH, core to 40 ft, back in sand and gravel.
09:30	POOH, recover gravel and pieces of boulder, RIH with button bit, drill ahead to 42 ft. hard drilling. POOH and RIH with core barrel.
10:30	Core to 46 ft, recover core.
11:00	Install piezometer, sandpack, place bentonite pellets and bentonite grout.
12:30	Rig down and move to drill testholes 2, 3 and 4.
12:45	Lunch.
13:15	Auger testholes and backfill testholes with bentonite pellets.
14:45	Move to M72B, auger to 17.5 ft, wash down casing, install piezometer, sandpack and place pellets.
16.00	Move a few feet, auger to 5 ft, install piezometer, sandpack and place pellets.
16:15	Shutdown.

May 6, 1995.

07:45	On site, pack up and move to site 27C.
08:00	Set up and auger and sample to 20 ft.
09:00	Wash down casing, mix mud. drill out casing (full of tailings). Too much tailings in mud, dump mud and mix new mud.
09:30	Start rotary drilling, mud ring and plugged bit at 29 ft. POOH and clean bit. RIH, drill ahead to 41 ft. Hard drilling, drill in rock for 10 inches. POOH to pick up core barrel, RIH.
12:00	Core, 1.5 ft, POOH and recover core.
12:30	Install piezometer, sandpack and place bentonite pellets.
14:00	Rig out, move to next location and lunch.
14:30	Set up on 24N, auger and sample to 20 ft, install casing, wash out casing.
15:00	Mix mud and rotary drill to 38 ft, hard drilling.
16:15	POOH to core, RIH with core barrel, core.
16:30	Recover only 8 inches of core insufficient. RIH with bit for cleanout trip, POOH and pick up core barrel.
17:00	Core.
18:00	POOH with core barrel, recover core, install piezometer, sandpack and place pellets.
19:00	Shutdown for the night.

May 7, 1995 (sunday).

08:45	On site, clean up and move to site M75.

09:00 Auger and sample to 30 ft.
09:50 Run in surface casing, mix mud, clean hole and start drilling 1 ft into muskeg. Circulate, after a short while tailings in mud. Pull up into casing and circulate casing with clean water until free of tailings. Drill ahead to 32.5 ft with clean water, still tailings in water. Drill ahead to 35 ft, hit clay at 34 ft.. POOH, wash down another length of casing to 34.5 ft.
11:30 Start drilling.
12:45 Lunch, dump mud (too silty)
13:15 Mix new mud and drill ahead to 61.5 ft. hit boulder (?), drill ahead 1.5 ft, no change, POOH to core. RIH with core barrel, core, recover core.
15:00 Install piezometer, sandpack and place pellets. After 2.5 ft of placed pellets, bentonite pellets started to bridge at casing shoe.
16:00 Install tremmie line, mix bentonite grout and displace in hole from 58.5 ft to surface. Pull surface casing into muskeg. Tried to displace bentonite mud ring at casing shoe, not successful. Slowly pull surface casing and keep filling hole with grout.
17:25 Rig down and move to site M76.
18:00 Shutdown for the day.

May 8, 1995.

07:45 On site, auger and sample to 20 ft.
08:00 Wash down casing to 17.5 ft, install piezometer, sandpack and place bentonite pellets while pulling casing.
09:00 Rig down and move to site 77A.

09:15 Set up, auger and sample to 17 ft, refusal. Wash down casing.
10:00 RIH with core barrel and core.
10:30 Recover core.
10:45 Install piezometer, sandpack and place pellets.
11:30 Move 5 ft to location M77B, auger to 10 ft, wash down casing, install piezometer, sandpack and place pellets.
12:00 Rig down and move to site 78A, set up, sample and auger to 35 ft.
12:30 Lunch.
13:00 Run and wash casing into auger hole, mix mud, wash out casing.
14:00 Rotary drill and sample to 62.5 ft. Hit bedrock (?).
15:15 POOH, switch to coring, core boulder. POOH, recover core. RIH with bit, fight gravel and boulders till 79 ft, lost circulation, mix mud and clean to bottom.
18:00 Shutdown for the night.

May 9, 1995.

07:45 On site, run in hole, 5 feet (1.52m) of fill on bottom, clean out and circulate.
08:00 POOH, change to core barrel and run in, core, POOH, recover core.
08:45 Install piezometer, sandpack screen and place bentonite seal, mix heavy bentonite grout and pump down annulus.
10:45 Rig down and move to location M79. Rig up.
11:00 Rig up for air hammer drilling.
12:45 Start air hammer drilling.
13:15 Lunch

13:45 Continue air hammer drilling.
17:00 Finish air drilling, Install piezometer (natural sandpack), pull out drive casing and place heavy bentonite grout in annulus from 40 ft (12.2m) to surface.
18:30 Shut down for the night.

May 10, 1995.

07:45 On site, rig down and move to site 80. Change air hammer.
08:30 Air hammer to 60 ft.
10:30 Plugged air hammer, POOH, clean hammer, RIH, hammer ahead with casing advancer to 64.5 ft.
11:45 POOH, change for smaller diameter air hammer (no casing advance). air hammer to 69.5 in mafic volcanic (no change).
12:45 Lunch.
13:15 Install piezometer, pull casing, sediment collapsed around screen. from 40 ft, fill casing with bentonite grout, pull casing while topping up casing with grout.
14:15 Rig down and move to site M81 (next to M73)
14:30 Set up and start air hammer drilling.
15:00 Plugged bit at 30 ft. POOH, and clean.
15:45 Air hammer and sample to 55 ft. Suspect bedrock.
17:00 POOH, change air hammers, and RIH with smaller air hammer.
17:30 Broke through boulder (3 ft thick). POOH, switch back to larger air hammer and RIH. Does not want to drill.
18:45 Shutdown for the night.

May 11, 1995.

07:45 On site, POOH, change bit, RIH, pull casing a few feet up, air lift hole. drill ahead. Fractured meta volcanics and/or boulders, then solid rock.
10:00 POOH change air hammer to small air hammer, RIH and drill 7 ft into bedrock. no change. POOH.
10:45 Hammer casing out of bedrock.
11:00 Install piezometer, natural pack around screen, install 1 ft bentonite seal from 43-42 ft. Bentonite grout from 40 ft to surface; recover casing.
12:30 Lunch
13:00 Rig down and move back to site M78A to install interim depth piezometer M78B.
13:15 Set up and auger to 45 ft, wash down casing to 50 ft.
14:30 Install piezometer, sandpack, place pellets. Pellets bridged at casing shoe after 6 inches had been placed.
15:15 Mix grout, pump down while pulling casing.
16:15 Rig down and move to site M82.
17:00 Rig up, auger and sample to 20 ft, wash down casing.
17:45 Shutdown for the night.

May 12, 1995.

07:45 On site, thaw out equipment and mix mud.
08:30 Rotary drill and sample to 65 ft.
10:00 POOH, pick up core barrel, RIH and core.

11:00 Recover core, tried installing piezometer, bridged at 32 ft. POOH and RIH for cleanout trip, circulate and condition hole, POOH.
11:30 Install piezometer, sandpack, place 1.25 ft of pellets, bridged at 32 ft. Bentonite grout from 32 ft to surface.
12:45 Rig down.
13:00 Lunch.
13:30 Move to site M83.
13:45 Rig up, auger and sample to 25 ft.
14:15 Switch to air hammer drilling.
14:45 Air hammer drill to 45 ft.
16:00 Plugged bit, POOH, clean air hammer, RIH, tried drilling ahead, plugged bit again.
16:45 Quit for the day; rotten weather conditions, blowing snow, 8-10 inches of snow received during the day, drifting. Slid into ditch in tailings area.

May 13, 1995.

08:00 On site, POOH, clean air hammer, washout hole with high pressure water hose.
08:45 RIH, air hammer drill to 53 ft (2 ft into bedrock). POOH, change to smaller air hammer.
10:30 Drill ahead to 58 ft. Meta volcanics, no change. POOH.
11:00 Install piezometer, natural sandpack to 40 ft., bentonite grout to surface.
12:30 Move ahead 5 ft, auger to 17.5 ft, wash down casing, install piezometer, sandpack and place bentonite pellets in annulus to surface.
13:45 Rig down.
14:00 Lunch.
14:30 Move to location M84 (mine site)
15:00 Rig up, tried augering, no success. Switch to air hammer drilling. Hammer casing down to 9 ft. (bedrock) POOH with air hammer bit and switch to small air hammer bit. Air hammer drill down to 14 ft. Install piezometer, sandpack and place bentonite pellets.
16:45 Rig down and move to vicinity of site M83.
17:00 Set up on location M85, auger down, install piezometer, sandpack, place pellets; move to site M86 and do the same; move to site M87, auger and install piezometer, sandpack and place pellets.
18:30 Shutdown for the night.

May 14, 1995.

07:45 On site, drill and install piezometers at locations M88, M89 and M90 and finish piezometer installation.
10:00 Move to tailings area and drill 5 additional testholes to determine the presence and subsurface position of clay layer. All testholes backfilled with bentonite pellets and auger cuttings. At location of TH 5 (near M5C) an 18 inches long splitspoon sample was taken in the top of the clay bed.
13:00 Rig release. Work on well development.
17:45 Leave site.

May 15, 1995.

08:00 Build slug for hydraulic conductivity testing (slug test). Wait for stores to open to get supplies.
11:30 Left for mine site
12:45 Arrive on mine site and conduct slug tests.
18:15 Leave site for Ear Falls.

May 16, 1995.

06:45 Leave Ear Falls for mine site.
08:00 Arrive on mine site and conduct slug tests Weather poor, driving rain.
17:45 Leave mine site for town.

May 17, 1995.

06:45 Leave Ear Falls for mine site.
07:50 Arrive on mine site and conduct slug tests, finish testing. Fix piezometers M39, M39A, M60A and M60B.
19:00 Leave mine site for town.

May 18. 1995.

Pack up, leave for Dryden and fly back to Calgary. Ship slug test equipment back (by air) to Edmonton.

APPENDIX B: TESTHOLE INFORMATION, BEDROCK ELEVATION AND PIEZOMETER CONSTRUCTION DETAILS

PIEZOMETER NO: M5N

Ground elevation: 417.674m Date: 27/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND (fill), brown yellow, fine-medium grained, pebbly, subangular-subrounded, oxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, mottled grey brown, very fine grained, oxidized.
2.00 - 3.00	0.61 - 0.91	TAILINGS, mottled brown grey, silt-clay size, slightly oxidized.
3.00 - 4.00	0.91 - 1.22	TAILINGS, grey, silt size.
4.00 - 5.50	1.22 - 1.68	TAILINGS, grey, clay size.
5.50 - 5.75	1.68 - 1.75	ORGANICS (grass, roots, leaves, etc).
5.75 - 7.00	1.75 - 2.13	SAND, brown yellow, medium grained, minor coarse grained and granules, quartz, trace feldspar, subangular, well sorted.
7.00 - 8.00	2.13 - 2.44	SAND, as above, predominantly medium grained.
8.00 - 9.00	2.44 - 2.74	SAND, brown yellow grey, fine-medium grained, quartz, minor mafics, trace feldspar, subangular, well sorted.
9.00 - 10.00	2.74 - 3.05	SAND, grey with brownish tinge, medium grained, with coarse grained fraction, subangular, well sorted.
10.00 - 12.50	3.05 - 3.81	SAND, as above, oxidized in part, becoming clayey with depth.
12.50 - 15.00	3.81 - 4.57	CLAY, grey, soft, plastic, trace silty.
15.00 - 17.50	4.57 - 5.33	CLAY, as above, more silty.
17.50 - 20.00	5.33 - 6.10	SILT, grey, interbedded with CLAY, as above, sandy in places.

PIEZOMETER M5N CONTINUED

20.00 - 22.50	6.10 - 6.86	SILT, grey, clayey grading to SAND, grey, very fine grained, quartz, subangular-subrounded, well sorted.
22.50 - 25.00	6.86 - 7.62	SAND, grey, very fine grained, as above, with SILT beds, occasionally CLAY beds.
25.00 - 27.50	7.62 - 8.38	As above, minor fine grained fraction.
27.50 - 30.00	8.38 - 9.14	SAND, grey, fine grained, quartz, minor mafics, subrounded-subangular, well sorted.
30.00 - 32.50	9.14 - 9.91	SAND, as above, progressively coarser with depth, lost circulation.
32.50 - 35.00	9.91 - 10.67	SAND, black, coarse-very coarse grained, predominantly mafics, trace feldspar, minor quartz, angular-subangular, well sorted, interbedded with medium & medium-coarse grained SAND.
35.00 - 37.50	10.67 - 11.43	SAND, black, medium-coarse & coarse grained, mafics, subangular, sorted.
37.50 - 40.00	11.43 - 12.19	SAND, black, grey, medium grained with medium-coarse grained fraction, mafics, quartz, angular-subrounded, well sorted.
40.00 - 45.00	12.19 - 13.72	BOULDERS, GRAVEL, coarse with a medium & medium-coarse grained matrix.
45.00 - 51.50	13.72 - 15.70	SAND, black, very coarse grained, granules, pebbles, predominantly mafics, trace feldspar, subangular-angular, well sorted.
51.50 - 53.00	15.70 - 16.15	SAND, grey, black, medium grained, quartz, mafics, trace feldspar, subangular-subrounded, well sorted.
53.00 - 54.00	16.15 - 16.45	SAND, black, coarse-very coarse, granules, pebbles, as above.
54.00 - 57.00	16.45 - 17.37	BEDROCK (basalt).

PIEZOMETER NO: M24N

Ground elevation: 417.692m Date: 6/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, sand, very fine grained-silt, oxidized.
1.00 - 3.00	0.30 - 0.91	TAILINGS, grey-pale yellow, silt size, interbedded oxidized and unoxidized.
3.00 - 4.00	0.91 - 1.22	TAILINGS, grey, silt-clay size, unoxidized.
4.00 - 5.00	1.22 - 1.52	TAILINGS, grey, clay size, unoxidized.
5.00 - 6.00	1.52 - 1.83	TAILINGS, grey, silt size, unoxidized.
6.00 - 7.00	1.83 - 2.13	TAILINGS, grey, silt-very fine grained size, unoxidized.
7.00 - 8.00	2.13 - 2.44	TAILINGS, as above, ORGANICS, black, 4 inches (10cm), and SAND, brown yellow, very fine grained-silt size, quartz, subrounded, well sorted, oxidized.
8.00 - 9.00	2.44 - 2.74	SAND, as above, more silty, slightly oxidized.
9.00 - 10.00	2.74 - 3.05	SAND, as above, grey- pale yellow, more sandy.
10.00 - 12.00	3.05 - 3.66	SAND, yellow, very fine grained, quartz, subrounded, well sorted, oxidized.
12.00 - 13.00	3.66 - 3.96	SAND, yellow brown, fine grained with fine-medium grained component, quartz, mafics, subangular-subrounded, well sorted.
13.00 - 14.00	3.96 - 4.27	SAND, yellow brown, fine-medium grained, and as above.
14.00 - 16.00	4.27 - 4.88	SAND, fine grained, as above, interbedded with SAND, grey, fine & fine-medium grained, quartz, trace mafics, subangular-subrounded, well sorted, unoxidized; with depth generally slightly finer.
16.00 - 17.00	4.88 - 5.18	SAND, grey-grey brown, very fine grained-silt size, quartz, subrounded, well sorted.

PIEZOMETER M24N CONTINUED

17.00 - 18.00	5.18 - 5.49	SILT, grey & SAND, grey, very fine grained, quartz, subrounded, well sorted.
18.00 - 19.00	5.49 - 5.79	SAND, grey, fine-medium grained, quartz, trace mafics, feldspar, subangular-subrounded, well sorted.
19.00 - 20.00	5.79 - 6.10	SAND, grey, fine grained, quartz, trace mafics, subrounded, well sorted.
20.00 - 22.50	6.10 - 6.86	SAND, green, grey, fine-medium & medium grained, mafics, quartz, subangular-subrounded, well sorted, occasionally medium-coarse grained stringer; Fe coated grains.
22.50 - 25.00	6.86 - 7.62	SAND, black, medium-coarse & coarse grained, mafics, feldspar, quartz, subangular- subrounded, well sorted; @ 23 ft (7.01m) thin fine & fine-m grained sand beds.
25.00 - 30.00	7.67 - 9.14	SAND, grey, very fine-fine & fine grained, quartz, trace mafics, subangular-subrounded, well sorted; occasionally thin beds of medium grained sand; occasionally clay stringer.
30.00 - 35.00	9.14 - 10.67	SAND, yellow-grey, fine, fine-medium grained, Fe coated grains, subrounded-subangular, well sorted. From 33.5 ft (10.2m) generally coarser.
35.00 - 37.00	10.67 - 11.28	SAND, black-yellow, medium-coarse & coarse grained, mafics, quartz, feldspar, Fe coated grains in part, angular-subrounded, well sorted; interbedded with fine-medium grained sand.
37.00 - 38.00	11.28 - 11.58	SAND, grey-black, fine, fine-medium, coarse & very coarse grained, mafics, quartz, subangular-subrounded, well sorted, pebbly.
38.00 - 41.50	11.58 - 12.65	GRAVEL, BOULDERS, SAND, as above.
41.50 - 44.50	12.65 - 13.56	BEDROCK (meta volcanics).

PIEZOMETER NO: M26B

Ground elevation: 416.541m Date: 28,29/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 2.50	00.00 - 00.75	FILL, sand, gravel, oxidized.
2.50 - 3.00	0.75 - 0.91	TAILINGS, silt-very fine grained size, unoxidized.
3.00 - 4.00	0.91 - 1.22	TAILINGS, grey, predominantly silt, clayey, unoxidized.
4.00 - 6.00	1.22 - 1.83	TAILINGS, grey, silt-very fine grained size, unoxidized.
6.00 - 10.00	1.83 - 3.05	TAILINGS, grey, silt size, clayey, unoxidized.
10.00 - 12.00	3.05 - 3.66	TAILINGS, grey, silt size, very clayey, unoxidized.
12.00 - 17.00	3.66 - 5.18	TAILINGS, grey, silt size, unoxidized.
17.00 - 23.00	5.18 - 7.01	MUSKEG (trees, shrubs, etc.).
23.00 - 27.00	7.01 - 8.23	MUSKEG, with dark brown carbonaceous clay layers.
27.00 - 30.00	8.23 - 9.14	CLAY, grey-brown grey, very plastic, soft, silty with depth.
30.00 - 34.00	9.14 - 10.36	CLAY, as above, interbedded with SILT, grey, quartz, trace very fine grained grey-clear SAND.
34.00 - 37.50	10.36 - 11.43	CLAY, grey, soft, plastic, trace silt.
37.50 - 42.50	11.43 - 12.94	SILT & CLAY, interbedded.
42.50 - 44.50	12.94 - 13.56	SAND, grey, very fine-fine grained, quartz, subrounded, well sorted, boulder @ base.
42.50 - 48.00	13.56 - 14.63	SAND, fine grained with medium grained component, quartz, common mafics, subangular-subrounded, well sorted, with small pebbles, occasionally clay layers.

PIEZOMETER M24N CONTINUED

48.00 - 50.00	14.63 - 15.24	SAND, black, fine-medium with coarse-very coarse grained component, predominantly mafics, minor feldspar & quartz, angular-subrounded, well sorted.
50.00 - 53.00	15.24 - 16.15	SAND, grey, black, fine-medium & medium grained, quartz & mafics, angular-subrounded, well sorted, pebbly.
53.00 - 59.00	16.15 - 17.98	SAND, as above with boulders up to 5" (12.5cm).
59.00 - 61.00	17.98 - 18.59	BEDROCK (basalt)

PIEZOMETER NO: M27C

Ground elevation: 417.327m Date: 6/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, gravel, sand to 4 inches (10cm), TAILINGS, clayey, unoxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, pale yellow, silt size, oxidized, with interbeds of clay size tailings, unoxidized.
2.00 - 3.00	0.61 - 0.91	TAILINGS, grey-pale yellow, silt size, slightly oxidized.
3.00 - 4.00	0.91 - 1.22	TAILINGS, grey, silt-clay size, unoxidized.
4.00 - 5.00	1.22 - 1.52	TAILINGS, grey, clay size, unoxidized.
5.00 - 6.00	1.52 - 1.83	TAILINGS, grey, silt-very fine size, unoxidized.
6.00 - 9.00	1.83 - 2.74	TAILINGS, grey, silt and clay size, unoxidized.
9.00 - 10.00	2.74 - 3.05	TAILINGS, grey, silt-very fine size, unoxidized.
10.00 - 14.50	3.05 - 4.42	TAILINGS, grey, clay size, unoxidized.
14.50 - 19.50	4.42 - 5.94	PEAT/MUSKEG.
19.50 - 22.50	5.94 - 6.86	SAND, grey, very fine-fine & fine grained, quartz, subrounded, well sorted
22.50 - 25.00	6.86 - 7.62	SAND, as above with thin beds of very coarse grained sand.
25.00 - 27.50	7.62 - 8.38	SAND, grey, fine grained, quartz, subrounded, well sorted, with thin beds of medium grained sand.
27.50 - 32.50	8.38 - 9.91	SAND, black, m-coarse & coarse grained, minor fine grained, mafics, feldspar, quartz, subangular-subrounded, well sorted, occasionally clay stringer.
32.50 - 34.00	9.91 - 10.36	SAND, as above, predominantly coarse grained; @ 32.5 ft occasionally silty clay stringer.

PIEZOMETER M27C CONTINUED

34.00 - 37.50	10.36 - 11.43	GRAVEL, fine, with fine-medium grained sand matrix.
37.50 - 40.00	11.43 - 12.19	As above & SAND, black, fine & fine-medium grained, mafics, quartz, feldspar, subangular-subrounded, well sorted, with occasionally clay stringer.
40.00 - 41.00	12.19 - 12.49	As above & SAND, grey-black, very fine, fine & fine-medium grained, with gravel stringer, occasionally coarse, coarse-very coarse & very coarse grained sand stringer.
41.00 - 43.00	12.49 - 13.11	BEDROCK (meta volcanics).

PIEZOMETER NO: M40B

Ground elevation: 417.463m Date: 29,30/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, sand, gravel, yellow brown, oxidized.
1.00 - 13.50	0.30 - 4.11	TAILINGS, clay size, minor silt size, dark grey-brown, becoming more clayey with depth and dark grey, unoxidized.
13.50 - 16.00	4.11 - 4.88	MUSKEG, with occasionally clay layers.
16.00 - 17.00	4.88 - 5.18	CLAY, grey, soft, plastic, silty interbedded with SILT, grey, quartzose.
17.00 - 20.50	5.18 - 6.25	SILT, as above, grading to SAND, grey, fine grained, quartz, minor mafics, subangular-subrounded, well sorted.
20.50 - 21.00	6.25 - 6.40	GRAVEL, pebbles in fine grained sand matrix, black.
21.00 - 22.50	6.40 - 6.86	SAND, grey-black, fine-medium grained, quartz, mafics, minor feldspar, subangular-subrounded, well sorted.
22.50 - 23.00	6.86 - 7.01	SAND, as above, predominantly angular.
23.00 - 23.50	7.01 - 7.16	GRAVEL & BOULDERS.
23.50 - 25.10	7.16 - 7.65	BEDROCK (mafic volcanic)

PIEZOMETER NO: M64

Ground elevation: 415.965m Date: 26/04/95

Depth (ft)	Depth (m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	GRAVEL, fill, oxidized
1.00 - 4.50	0.30 - 1.37	TAILINGS, grey, clayey, minor pale yellow near top.
4.50 - 8.00	1.37 - 2.45	SILT, grey, interbedded with SAND, grey, very fine grained, quartz, subangular, clayey in places.
8.00 -10.00	2.45 - 3.05	SAND, clear, grey, very fine grained, quartz, subangular, well sorted, trace organic.
10.00 -11.50	3.05 - 3.50	SAND, clear, very fine grained, minor fine grained quartz, trace mafics, subangular-subrounded, well sorted.
11.50 -12.50	3.50 - 3.81	SAND, as above, very fine-fine grained.
12.50 -15.50	3.81 - 4.72	BEDROCK (basalt)

PIEZOMETER NO: M65

Ground elevation: 416.662m   Date: 26/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.60	00.00 - 00.18	TAILINGS, yellow brown, with red brown patches, clayey, oxidized.
0.60 - 3.50	0.18 - 1.07	SAND, brown yellow, very fine grained, quartz, subangular, well sorted, silty in places, with clay lenses and interbeds.
3.50 - 4.50	1.07 - 1.37	SAND. brown grey, very fine-fine grained, quartz, subangular-subrounded, well sorted, occasionally clay lenses.
4.50 - 7.00	1.37 - 2.13	SAND, grey, grey brown, fine grained, quartz, subangular-subrounded, well sorted, progressively more coarse with depth, near base coarse grained, black, predominantly mafics, minor feldspars & trace quartz, with fine gravel, < 2 cm, slightly oxidized in places.
7.00 - 8.00	2.13 - 2.44	SAND, grey, very fine-fine grained, quartz, minor mafics, subangular-subrounded, sorted, with clay beds and lenses.
8.00 - 9.00	2.44 - 2.74	TILL, grey, pebbly, clayey. unoxidized.
9.00 -12.00	2.74 - 3.65	BEDROCK (tuff)

PIEZOMETER NO: M66A

Ground elevation: 415.572m Date: 26/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 2.50	00.00 - 00.75	ROADFILL, gravel, boulders, sand.
2.50 - 4.00	0.75 - 1.22	SAND, brown grey, fine-medium grained, quartz, mafics, subangular, well sorted, oxidized.
4.00 - 5.50	1.22 - 1.52	TAILINGS, grey, silt size, unoxidized.
5.50 -11.50	1.52 - 3.50	MUSKEG.
11.50 -15.00	3.50 - 4.57	CLAY, grey, soft, plastic, with SILT laminae and thin beds of SAND, grey, very fine grained, quartz, subangular-subrounded, well sorted.
15.00 -17.50	4.57 - 5.33	SAND, grey, silt-very fine grained, quartz, trace mafics, subrounded, well sorted.
17.50 -17.67	5.33 - 5.38	SAND, dark grey, black, fine-medium & medium grained, quartz, mafics, angular-subrounded, well sorted.
17.67 -18.00	5.38 - 5.49	BOULDERS and GRAVEL, coarse.
18.00 -27.00	5.49 - 8.23	SAND, black, coarse grained, mafics, minor feldspars, trace quartz, angular-subangular, well sorted, with pebbles (up to 1 cm), interbedded with coarse-very coarse grained sand, gravel rich in part.
27.00 -29.00	8.23 - 8.84	BEDROCK (basalt).

PIEZOMETER NO: M66B

Ground elevation: 415.615m Date: 27/05/95

For stratigraphic description see **PIEZOMETER M66A**

PIEZOMETER NO: M67

Ground elevation: 417.169 Date: 28/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.50	00.00 - 00.15	FILL, sand, oxidized.
0.50 - 2.00	0.15 - 0.61	TAILINGS, silt size, clayey, unoxidized.
2.00 - 9.00	0.61 - 2.74	TAILINGS, grey, silt-clay size, unoxidized.
9.00 - 9.50	2.74 - 2.90	MUSKEG / PEAT
9.50 -10.00	2.90 - 3.05	CLAY, grey, soft, plastic, very silty, with oxidized SILT laminae, becoming yellowish with depth.
10.00 -12.00	3.05 - 3.66	SILT, yellow-grey, sandy in part, slightly-very oxidized.
12.00 -13.00	3.66 - 3.96	SAND, grey, very fine grained, quartz, subrounded, well sorted, with silt interbeds.
13.00 -14.00	3.96 - 4.27	CLAY, SILT & SAND, yellow-grey, as above, non-slightly oxidized.
14.00 -17.50	4.27 - 5.33	SILT, pale yellow grey, sandy, trace clay, slightly oxidized, grading to SAND, grey, very fine grained, quartz, subangular-subrounded, well sorted, occasionally clay stringers.
17.50 - 19.00	5.33 - 5.79	SAND, grey, very fine grained, minor fine grained, quartz, subangular-subrounded, well sorted.
19.00 - 21.50	5.79 - 6.55	SAND, black, fine, fine-medium and medium grained, occasionally granules, mafics, trace feldspars & quartz, subangular, well sorted
21.50 - 24.00	6.55 - 7.31	BEDROCK (basalt).

PIEZOMETER NO: M68

Ground elevation: 416.030m Date: 29,30/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 2.50	00.00 - 00.76	FILL, gravel, yellow brown-black,
2.50 - 3.00	0.76 - 0.91	MUSKEG/ORGANICS (leaves, branches, needles, sticks, etc.).
3.00 - 4.00	0.91 - 1.22	CLAY, grey-dark medium grey, minor organic, relatively soft.
4.00 - 5.00	1.22 - 1.52	CLAY, light-medium brown, silty.
5.00 - 6.00	1.52 - 1.83	CLAY, brown, with silt laminae, oxidized.
6.00 - 7.00	1.83 - 2.13	SILT, grey brown, clayey, organic.
7.00 - 8.00	2.13 - 2.44	SILT, brown, sandy, very organic.
8.00 - 10.00	2.44 - 3.05	SAND, brown grey, very fine grained, silty, organic, subangular-subrounded, well sorted.
10.00 - 11.50	3.05 - 3.50	SAND, black, coarse grained, mafics, angular, well sorted.
11.50 - 12.50	3.50 - 3.81	SAND, black, medium-coarse grained, with fine grained component, mafics, minor quartz, angular-subangular, pebbly, well sorted.
12.50 - 14.50	3.81 - 4.42	As above, progressively more pebbly, grading to GRAVEL.
14.50 - 16.00	4.42 - 4.88	BEDROCK (mafic volcanic)

PIEZOMETER NO: M69

Ground elevation: 418.580m Date: 30/04/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, gravel, yellow brown, oxidized.
1.00 - 3.00	0.30 - 0.91	SILT, pale yellow, clayey, slightly oxidized, in part yellow brown and deeply oxidized.
3.00 - 4.00	0.91 - 1.22	SILT, as above with thin bed of SAND, brown grey, very fine-fine grained, quartz, subangular-subrounded, well sorted, oxidized.
4.00 - 7.00	1.22 - 2.13	SAND, grey-yellow grey, very fine grained, slightly clayey in part, quartz, subrounded, well sorted, slightly oxidized.
7.00 - 9.00	2.13 - 2.74	SAND, pale yellow, very fine-fine grained, quartz, subrounded, well sorted, slightly oxidized.
9.00 - 11.00	2.74 - 3.35	CLAY, grey, plastic, with thin bed of SAND, grey, fine grained, quartz, mafics, subangular, well sorted, unoxidized.
11.00 - 12.00	3.35 - 3.66	SAND, grey-pale yellow, very fine-fine grained, quartz, minor mafics, subangular-subrounded, well sorted.
12.00 - 13.00	3.66 - 3.96	SAND, grey, trace pale yellow, very fine grained, quartz, subrounded, well sorted, clayey in part.
13.00 - 16.00	3.96 - 4.88	SAND, grey-black, fine grained, quartz, mafics, subangular-subrounded, well sorted.
16.00 - 18.00	4.88 - 5.49	SAND, black, medium grained with coarse grained component, mafics, feldspar, minor quartz, subangular, well sorted, pebbly near base.
18.00 - 19.00	5.49 - 5.79	SAND, grey-black, very fine-medium grained, interbedded, mafics, feldspar, quartz, subangular-subrounded, well sorted, occasionally clay stringer or lens.
19.00 - 20.00	5.79 - 6.10	SAND, black, very coarse grained, mafics, feldspar, pebbly.

PIEZOMETER M69 CONTINUED

20.00 - 25.00	6.10 - 7.62	As above, with pebbles up to 3 cm, near base very fine-very coarse grained sand.
25.00 - 27.50	7.62 - 8.38	As above, interbedded with SAND, black, medium grained, mafics, feldspar, subangular, well sorted.
27.50 - 28.00	8.38 - 8.53	SAND, very coarse grained, as above, pebbly.
28.00 - 30.00	8.53 - 9.14	BOULDER.
30.00 - 32.50	9.14 - 9.91	SAND, black, grey, fine-medium grained, mafics, feldspar, trace quartz, subangular, well sorted, pebbly.
32.50 - 35.00	9.91 -10.67	SAND, black, coarse-very coarse grained, mafics, feldspar, rock fragments, subangular-subrounded, well sorted, pebbly.
35.00 - 37.50	10.67 -11.43	GRANULES, GRAVEL, fine, mafics, rock fragments, subangular-subrounded.
37.50 - 40.00	11.43 -12.19	BEDROCK (mafic volcanic, intensely fractured)

PIEZOMETER NO: M70A

Ground elevation: Date: 1/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	MUSKEG, dark brown, peaty.
1.00 - 12.00	0.30 - 3.66	MUSKEG, light-medium brown, watertable at aproximately 6 ft.
12.00 - 16.00	3.66 - 4.88	MUSKEG, olive brown, more decomposed, densely packed.
16.00 - 17.00	4.88 - 5.18	MUSKEG, olive brown, strongly decomposed with light grey CLAY layers.
17.00 - 18.00	5.18 - 5.49	CLAY, light grey, soft, plastic, numerous shell fragments (Gastropods, Mollusks).
18.00 - 28.00	5.49 - 8.53	CLAY, light grey, soft, plastic, massive, no apparent bedding.
28.00 - 31.00	8.53 - 9.45	CLAY, light grey, silty.
31.00 - 32.50	9.45 - 9.91	SAND, grey, very fine, fine & medium grained, quartz, mafics, subrounded, well sorted.
32.50 - 34.00	9.91 - 10.36	SAND, black, coarse grained, mafics, minor feldspar & quartz, subangular, well sorted. Near base GRAVEL, up to 3 cm, clayey matrix (TILL?)
34.00 - 35.50	10.36 - 10.82	BEDROCK, (meta-volcanic, strongly sheared)

PIEZOMETER NO: M70B

Ground elevation: Date: 1/05/95

For stratigraphic description see **PIEZOMETER M70A**

PIEZOMETER NO: M70C

Ground elevation: Date: 1/05/95

For stratigraphic description see **PIEZOMETER M70A**

PIEZOMETER NO: M71

Ground elevation: 415.224m Date: 1/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 4.00	00.00 - 01.22	MUSKEG.
4.00 - 11.00	1.22 - 3.35	CLAY, light grey, silty.
11.00 - 14.00	3.35 - 4.27	SILT, grey clayey, grading to SAND, grey, fine grained, quartz, subrounded, well sorted.
14.00 - 15.50	4.27 - 4.72	BEDROCK (meta-volcanic, moderately-strongly sheared)

PIEZOMETER NO: M72A

Ground elevation: 416.726m Date: 2/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 2.00	00.00 - 00.61	SAND, brown yellow-brown yellow grey with depth, fine grained, quartz, subrounded, well sorted, oxidized.
2.00 - 3.00	0.61 - 0.91	SAND, grey-brown yellow grey, fine grained with medium grained component, subangular-subrounded, well sorted.
3.00 - 4.00	0.91 - 1.22	SAND, grey-black, m grained, mafics, quartz, feldspar, subangular well sorted, grading to SILT, pale grey, sandy and clayey.
4.00 - 5.00	1.22 - 1.52	SAND, pale yellow grey, very fine grained, quartz, subrounded, slightly oxidized, with silt & clay beds.
5.00 - 6.00	1.52 - 1.83	CLAY, grey, pale yellow grey, soft, plastic, interbedded with SILT, pale yellow grey and SAND, very fine grained, as above.
6.00 - 7.00	1.83 - 2.13	CLAY, grey, soft, plastic.
7.00 - 9.00	2.13 - 2.74	CLAY, as above with interbeds of SILT, grey.
9.00 - 10.00	2.74 - 3.05	As above, more clayey.
10.00 - 11.00	3.05 - 3.35	SILT, grey, quartzose grading to SAND, grey, very fine grained, quartz, subrounded, well sorted.
11.00 - 12.00	3.35 - 3.66	SAND, grey-black, very fine grained, quartz, trace mafics, subrounded, well sorted, interbedded with SILT.
12.00 - 13.00	3.66 - 3.96	SAND, pale yellow grey, very fine-fine grained, quartz, trace mafics & feldspar, subangular-subrounded, well sorted, slightly oxidized, becoming slightly coarser with depth.
13.00 - 14.00	3.96 - 4.27	SAND, yellow grey, fine grained, trace medium grained, quartz, mafics, trace feldspar, subangular-subrounded, well sorted, oxidized.

PIEZOMETER M72A CONTINUED

14.00 - 15.00	4.27 - 4.57	SAND, pale yellow, very fine grained, quartz, subangular-subrounded, well sorted, slightly oxidized, grading to SAND, fine grained, as above, slightly oxidized.
15.00 - 16.00	4.57 - 4.88	SAND, brown yellow, fine grained with medium grained component, quartz, trace mafics & feldspar, subangular, well sorted, oxidized.
16.00 - 17.00	4.88 - 5.18	SAND, grey, pale brown grey, very fine grained, quartz, trace mafics, subangular-subrounded, well sorted, clayey in part.
17.00 - 18.00	5.18 - 5.49	SAND, grey green, very fine-fine grained, quartz, mafics, subangular-subrounded, well sorted & SAND, very fine grained, as above.
18.00 - 19.00	5.49 - 5.79	SAND, brown yellow, medium grained, mafics, quartz, feldspar, subangular, well sorted, oxidized, pebbly.
19.00 - 20.00	5.79 - 6.10	SAND, as above, predominantly fine-medium grained.
20.00 - 22.50	6.10 - 6.87	SAND, medium grained, as above, with medium-coarse grained component, slightly oxidized.
22.50 - 25.00	6.87 - 7.62	SAND, black, medium-coarse & coarse grained, mafics, feldspar, trace quartz, subangular-subrounded, well sorted.
25.00 - 27.75	7.62 - 8.46	SAND, as above & SAND, fine-medium grained, mafics, quartz, feldspar, subangular-subrounded, well sorted, occasionally clay stringer, hard, minor very coarse grained sand.
27.75 - 30.00	8.46 - 9.14	SAND, black, medium-coarse & coarse grained, as above, very pebbly, granules, small boulders.
30.00 - 32.50	9.14 - 9.91	SAND, grey, black, fine-medium grained, with beds of m-coarse grained sand, occasionally pebbles and granules, occasionally hard grey clay stringer.
32.50 - 35.00	9.91 - 10.67	SAND, black, medium- very coarse grained, rock fragments, mafics, felsic fragments, feldspar, angular-rounded, well sorted, pebbly.

PIEZOMETER M72A CONTINUED

35.00 - 36.50	10.67 - 11.12	SAND, black, fine-medium grained, as above, pebbly in part.
36.50 - 39.00	11.12 - 11.89	BEDROCK (mafic volcanic).

PIEZOMETER NO: M72B

Ground elevation: 416.704m Date: 2/05/95

For stratigraphic description see **PIEZOMETER M72A**

PIEZOMETER NO: M72C

Ground elevation: 416.711m Date: 2/05/95

For stratigraphic description see **PIEZOMETER M72A**

PIEZOMETER NO: M73

Ground elevation: 415.385m Date: 2,3/05/95

For stratigraphic description see **PIEZOMETER M81**

PIEZOMETER NO: M74

Ground elevation: 414.769m Date: 4/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 5.00	00.00 - 01.52	FILL, boulders, gravel, sand.
5.00 - 5.50	1.52 - 1.68	PEAT.
5.50 - 10.00	1.68 - 3.05	CLAY, light grey, soft, plastic, interbedded with SILT, light grey, quartzose; more silty with depth and trace very fine grained SAND.
10.00 - 12.50	3.05 - 3.81	SAND, grey, very fine grained, silty, quartz, trace mafics, subrounded, well sorted; occasionally clay stringer.
12.50 - 15.00	3.81 - 4.57	SAND, grey, black, fine-medium grained, minor fine grained, quartz, mafics, subrounded, well sorted.
15.00 - 20.00	4.57 - 6.10	SAND, grey-black, fine grained with medium grained component, predominantly quartz, minor mafics, subrounded, well sorted.
20.00 - 22.50	6.10 - 6.86	SAND, as above & SAND, black, medium, medium-coarse & coarse grained, with very coarse grained component, mafics, feldspar, minor quartz, subangular, well sorted.
22.50 - 25.00	6.86 - 7.62	SAND, grey-black, very fine-fine & fine grained, quartz, trace mafics, subrounded, well sorted, with thin beds of medium-coarse grained sand.
25.00 - 27.50	7.62 - 8.38	SAND, grey-black, very fine, very fine-fine & fine grained, quartz, trace mafics, subrounded, well sorted, with medium grained sand stringer.
27.50 - 30.00	8.38 - 9.14	SAND, grey-black, fine grained with fine-medium grained component, quartz, mafics, feldspar, subangular-subrounded, well sorted.
30.00 - 32.50	9.14 - 9.91	SAND, grey-black, very fine-fine grained with minor fine-medium grained, quartz, subrounded, well sorted.

PIEZOMETER M74 CONTINUED

32.50 - 35.00	9.91 - 10.67	SAND, grey, very fine grained, fine grained, quartz, subrounded, sorted, occasionally light grey silty clay stringer; @ 33 ft (10.06m) SAND, black, coarse grained, mafics, minor quartz, feldspar, subangular, well sorted.
35.00 - 37.00	10.67 - 11.28	SAND, grey-black, fine-medium grained, quartz, mafics, subangular-subrounded, well sorted with thin beds of medium-coarse & coarse grained sand, pebbly.
37.00 - 42.00	11.28 - 12.80	BOULDERS (6 inches), GRAVEL, medium, <5cm, rounded, SAND, black, fine-coarse grained, quartz, mafics, feldspar, angular-subrounded, well sorted, coarsening with depth.
42.00 - 46.00	12.80 - 14.02	BEDROCK (meta volcanics).

PIEZOMETER NO: M75

Ground elevation: 417.865m Date: 7/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.67	00.00 - 00.20	FILL, sand, very fine-medium grained, oxidized.
0.67 - 2.00	0.20 - 0.61	TAILINGS, grey, pale yellow, silt-very fine grained size, slightly oxidized-unoxidized.
2.00 - 5.00	0.61 - 1.52	TAILINGS, grey, predominantly silt, clayey, unoxidized, more clay size with depth.
5.00 - 6.00	1.52 - 1.83	TAILINGS, grey, silt size, minor clay size, unoxidized.
6.00 - 7.00	1.83 - 2.13	TAILINGS, grey, silt size, minor very fine grained size, unoxidized
7.00 - 8.00	2.13 - 2.44	TAILINGS, grey, silt size, minor clay size, unoxidized.
8.00 - 9.00	2.44 - 2.74	TAILINGS, grey, silt size, unoxidized
9.00 - 10.00	2.74 - 3.05	TAILINGS, grey, silt & very fine grained size, unoxidized
10.00 - 12.00	3.05 - 3.66	TAILINGS, grey, silt & very fine grained size, unoxidized, more silt size with depth.
12.00 - 13.00	3.66 - 3.96	TAILINGS, grey, silt & clay size, unoxidized.
13.00 - 15.00	3.96 - 4.57	TAILINGS, grey, silt size, minor clay size, unoxidized.
15.00 - 18.00	4.57 - 5.49	TAILINGS, grey, clay & silt size, unoxidized.
18.00 - 19.00	5.49 - 5.79	TAILINGS, grey, silt & clay size, unoxidized.
19.00 - 20.00	5.79 - 6.10	TAILINGS, grey, clay & silt size, unoxidized.
20.00 - 22.00	6.10 - 6.71	TAILINGS, grey, clay size, unoxidized.
22.00 - 25.00	6.10 - 7.62	TAILINGS, grey, clay & minor silt size, unoxidized

PIEZOMETER M75 CONTINUED

25.00 - 34.00	7.62 - 10.36	MUSKEG (trees, shrubs, etc. at top), more compacted with depth.
34.00 - 35.00	10.36 - 10.66	CLAY, dark grey-grey, silty, organic, occasionally pale yellow & slightly oxidized.
35.00 - 40.00	10.66 - 12.19	CLAY, light grey, soft. plastic, silty in part, progressively more silty with depth.
40.00 - 42.50	12.19 - 12.95	CLAY, light grey, as above interbedded with SILT, grey, quartzose, trace-minor SAND, grey, very fine grained, quartz, subrounded, well sorted.
42.50 - 45.00	12.95 - 13.72	SILT, as above, minor CLAY, as above; minor SAND, very fine grained. as above.
45.00 - 50.00	13.72 - 15.24	As above.
50.00 - 55.00	15.24 - 16.76	SILT, light grey, quartzose, interbedded with common SAND, grey, very fine grained, quartz, subrounded, well sorted; occasionally clay stringer.
55.00 - 57.50	16.76 - 17.53	SAND, grey, very fine grained, quartz, subrounded, well sorted, interbedded with minor SILT, as above; trace very fine-fine grained sand.
57.50 - 58.00	17.53 - 17.68	SAND, grey, black, fine, fine-medium & medium grained, quartz, mafics, feldspar, subangular-subrounded, well sorted.
58.00 - 61.50	17.68 - 18.74	SAND, black, medium-coarse grained, very coarse grained, mafics, angular, well sorted, pebbly; from 60.5 ft (18.44m) very coarse grained and granules.
61.50 - 64.00	18.74 - 19.51	BEDROCK (meta volcanics).

PIEZOMETER NO: M76

Ground elevation: 417.788m Date: 8/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, sand, buff, pale yellow, very fine, minor fine grained, subrounded, well sorted, oxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, pale yellow, silt-very fine grained size, occasionally clay size, oxidized to 43cm, with depth grey and unoxidized.
2.00 - 4.00	0.61 - 1.22	TAILINGS, grey, predominantly silt, clayey, unoxidized, minor very fine grained size with depth.
4.00 - 5.00	1.22 - 1.52	PEAT/ORGANICS, with clay stringer, intermixed with tailings.
5.00 - 6.00	1.52 - 1.83	SAND, yellow brown, very fine grained, quartz, subrounded, well sorted.
6.00 - 7.00	1.83 - 2.13	SILT, pale yellow, quartzose, trace clayey, oxidized, dry.
7.00 - 10.00	2.13 - 3.05	SILT, as above, buff-pale yellow, clayey in part, trace very fine grained sand.
10.00 - 11.00	3.05 - 3.35	CLAY, grey, green grey, silty in part, plastic, moderately soft.
11.00 - 13.00	3.35 - 3.96	SILT, mottled pale yellow-grey, quartzose, minor clay, slightly oxidized.
13.00 - 14.00	3.96 - 4.27	SILT, as above & SAND, pale grey-pale yellow, very fine grained, quartz, subrounded, well sorted, oxidized.
14.00 - 16.00	4.27 - 4.88	SAND, as above, silty near top.
16.00 - 17.00	4.88 - 5.18	SAND, buff, very fine & fine grained, minor fine-medium grained, quartz, subangular-subrounded, well sorted, slightly oxidized.
17.00 - 18.00	5.18 - 5.49	SILT. buff, pale yellow, quartzose, with SAND, very fine grained, as above.

PIEZOMETER M76 CONTINUED

18.00 - 19.00	5.49 - 5.79	SAND, buff, fine grained, quartz, subangular-subrounded, well sorted.
19.00 - 20.00	5.79 - 6.10	SAND, very fine & fine grained, as above.

PIEZOMETER NO: M77A

Ground elevation: 414.557m Date: 8/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, sand, buff, pale yellow, very fine grained-silt size, clayey, pebbly, oxidized.
1.00 - 3.00	0.30 - 0.91	SAND, brown yellow, very fine grained with very fine-fine grained component, quartz, subrounded, well sorted, oxidized, from 2-3 ft (0.6-0.9m) trace silty and organic.
3.00 - 5.00	0.91 - 1.52	SAND, brown yellow, very fine-fine grained, subrounded-subangular, well sorted, oxidized.
5.00 - 7.00	1.52 - 2.13	SAND, brown, dark brown, fine, fine-medium grained, quartz, mafics, subangular, well sorted, oxidized.
7.00 - 8.00	2.13 - 2.44	SAND, brown, brown yellow, fine-medium grained, minor medium grained, & as above.
8.00 - 9.00	2.44 - 2.74	SAND, brown, predominantly fine grained with fine-medium grained component, quartz, subangular, well sorted, oxidized.
9.00 - 11.00	2.74 - 3.35	SAND, grey, fine grained, minor very fine grained, occasionally silt bed & silty clay stringer.
11.00 - 12.00	3.35 - 3.66	SAND, rust brown, very fine-fine grained, quartz, silty, trace clayey, quartz, trace mafics, subangular-subrounded, well sorted.
12.00 - 13.00	3.66 - 3.96	SAND, grey-brown, fine grained, quartz, mafics, subangular, well sorted.
13.00 - 14.00	3.96 - 4.27	SAND, grey-brown, fine- medium grained, quartz, mafics, subangular, well sorted.
14.00 - 15.00	4.27 - 4.57	SAND, black, fine-medium grained, with medium grained component, mafics, quartz, subangular, well sorted.

PIEZOMETER M77A CONTINUED

15.00 - 16.00	4.57 - 4.88	SAND, black, medium grained, with medium-coarse grained component, mafics, quartz, feldspar, angular-subangular, well sorted; trace coarse-very coarse grained sand.
16.00 - 17.00	4.88 - 5.18	SAND, black, coarse-very coarse & very coarse grained, occasionally pebbles, < 1cm, mafics, feldspar, minor quartz, subangular, well sorted.
17.00 - 22.00	5.18 - 6.71	BEDROCK (felsic volcanic)

PIEZOMETER NO: M77B

Ground elevation: 414.644m Date: 8/05/95

For stratigraphic description see **PIEZOMETER M77A**

PIEZOMETER NO: M78A

Ground elevation: 420.426m Date: 8/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 5.00	00.00 - 01.52	FILL, pale yellow grey, very fine grained-silt size, clayey, oxidized.
5.00 - 8.00	1.52 - 2.44	SOIL, black, organic, & branches, tree stumps, etc.
8.00 - 10.00	2.44 - 3.05	SILT, pale yellow grey, quartzose, trace clayey in part, mottled oxidized.
10.00 - 11.00	3.05 - 3.35	SILT, as above & occasionally SAND, pale yellow, very fine grained, quartz, subrounded, well sorted, oxidized.
11.00 - 12.00	3.35 - 3.66	SILT, as above grading to SAND, very fine grained, as above.
12.00 - 13.00	3.66 - 3.96	SAND, grey, very fine grained, quartz, subrounded, well sorted, interbedded with SILT, grey, quartzose; occasionally grey clay stringer.
13.00 - 14.00	3.96 - 4.27	SAND & SILT, as above; thin bed of SAND, grey, very fine-fine grained, quartz, trace mafics, subangular-subrounded, well sorted.
14.00 - 15.00	4.27 - 4.57	SILT, grey, green grey, interbedded with SAND, grey, very fine grained, quartz, subrounded, well sorted.
15.00 - 16.00	4.57 - 4.88	SAND, pale yellow, very fine-fine grained, quartz, trace mafics, subangular-subrounded, well sorted, interbedded with SILT, pale yellow, slightly oxidized.
16.00 - 18.00	4.88 - 5.49	SAND, grey, very fine grained, quartz, subrounded, well sorted, interbedded with SILT, grey.
18.00 - 19.00	5.49 - 5.79	As above & SAND, grey, very fine-fine & fine grained, quartz, trace mafics, subangular-subrounded, well sorted.

PIEZOMETER M78A CONTINUED

19.00 - 20.00	5.79 - 6.10	SAND, grey, very fine grained, as above, more silty & clayey.
20.00 - 23.00	6.10 - 7.01	CLAY, light grey, soft, plastic.
23.00 - 24.00	7.01 - 7.32	CLAY, as above interbedded with SILT, light grey, quartzose.
24.00 - 27.00	7.32 - 8.23	SILT, light grey, as above, interbedded with CLAY, light grey, as above.
27.00 - 28.00	8.23 - 8.53	CLAY, light grey, as above, minor SILT, as above; more silty with depth.
28.00 - 30.00	8.53 - 9.14	SILT, light grey, quartzose, trace CLAY, light grey, as above.
30.00 - 31.00	9.14 - 9.44	As above; trace SAND, light grey, very fine grained, quartz, subrounded, well sorted.
31.00 - 32.00	9.44 - 9.75	SAND, light grey, very fine grained, as above; SILT, light grey, as above; minor CLAY, as above.
32.00 - 33.00	9.75 - 10.06	SILT, light grey, as above.
33.00 - 34.00	10.06 - 10.36	SILT & CLAY, as above.
34.00 - 35.00	10.36 - 10.67	As above & SAND, light grey, very fine grained, quartz, subrounded, well sorted.
35.00 - 37.50	10.67 - 11.43	SAND, grey-clear, very fine grained, quartz, very trace mafics, subrounded, well sorted.
37.50 - 40.00	11.43 - 12.19	SAND, grey, pale buff, very fine-fine grained, quartz, mafics, subangular-subrounded, well sorted; occasionally clay stringer.
40.00 - 42.50	12.19 - 12.95	SAND, grey, buff, pale buff, pale yellow, very fine & very fine-fine grained, quartz, mafics, subangular-subrounded, well sorted, slightly oxidized; occasionally silty clay stringer.

PIEZOMETER M78A CONTINUED

42.50 - 45.00	12.95 - 13.72	SAND, grey-clear, very fine, very fine-fine & fine grained, minor fine-medium grained, quartz, trace mafics, feldspar, subangular-subrounded, well sorted; occasionally pale yellow grey clayey silt beds. Interbedded sequence.
45.00 - 47.50	13.72 - 14.48	SAND, grey-black, fine grained, with fine-medium & medium grained stringer, occasionally coarse grained, mafics, quartz, feldspar, subangular-subrounded, well sorted; occasionally clay & silt layer.
47.50 - 50.00	14.48 - 15.24	SAND, as above with stringer of coarse, coarse-very coarse & very coarse grained sand and granules; occasionally silty clay layers.
50.00 - 52.50	15.24 - 16.00	SAND, grey, fine & fine-medium grained, predominantly quartz, minor mafics, subangular-subrounded, well sorted; occasionally clayey silt stringer.
52.50 - 55.00	16.00 - 16.76	SAND, grey-black, very fine, very fine-fine, fine & fine-medium grained, occasionally medium-coarse grained, quartz, mafics, trace feldspar, subangular-subrounded, well sorted; occasionally clayey silt stringer.
55.00 - 57.50	16.76 - 17.53	SAND, grey, fine & fine-medium grained, minor medium grained, quartz, common mafics, feldspar, subangular-subrounded, well sorted; occasionally clayey silt stringer.
57.50 - 60.00	17.53 - 18.29	SAND, grey-black, very fine, fine, fine-medium, medium-coarse, coarse & very coarse grained, mafics, quartz, feldspar, subangular-subrounded, well sorted; coarser with depth; occasionally clayey silt layer.
60.00 - 62.50	18.29 - 19.05	SAND, as above, common medium-very coarse grained sand, occasionally granules, mafics, quartz, feldspar, subangular-subrounded, well sorted. Coarse fraction starts @ 61 ft (18.59m), occasionally small pebbles.
62.50 - 65.00	19.05 - 19.81	SAND, as above; boulder, 6 inches (15 cm) @ 62.5 ft.

PIEZOMETER M78A CONTINUED

65.00 - 67.50	19.81 - 20.57	SAND, black, fine, fine-medium, medium, medium-coarse & coarse grained, mafics, feldspar, quartz, subangular-subrounded, well sorted; interbedded.
67.50 - 70.00	20.57 - 21.34	SAND, black, medium-coarse & coarse grained, mafics, minor quartz & feldspar, subangular, well sorted.
70.00 - 72.50	21.34 - 22.10	SAND, as above with coarse-very coarse & very coarse grained fraction; boulder, 5 inches (12.5cm) @ 70 ft.
72.50 - 75.00	22.10 - 22.86	GRAVEL & SAND, as above.
75.00 - 77.50	22.86 - 23.62	BOULDERS, GRAVEL, and SAND, as above. rough drilling. Fractured bedrock ?
77.50 - 79.00	23.62 - 24.08	BEDROCK (meta volcanic).

PIEZOMETER NO: M78B

Ground elevation: 420.442m Date: 11/05/95

For stratigraphic description see **PIEZOMETER M78A**

PIEZOMETER NO: M79

Ground elevation: 415.392m Date: 8/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 3.00	00.00 - 00.91	SAND, brown yellow, very fine-fine and fine grained with medium grained fraction, quartz, trace mafics, subrounded, well sorted oxidized; occasionally small pebbles and granules.
3.00 - 5.00	0.91 - 1.52	SAND, brown yellow grey, fine and fine-medium grained, quartz, mafics, subrounded, well sorted; occasionally granules; near base trace coarse grained sand.
5.00 - 6.00	1.52 - 1.82	SAND, blackish, medium grained with coarse grained fraction, quartz, mafics, feldspars, subangular-subrounded, well sorted; occasionally granules; occasionally thin bed of SILT, grey, sandy; trace clayey.
6.00 - 7.00	1.82 - 2.13	SAND, brownish, fine-medium grained, quartz, feldspar, mafics, subangular-subrounded, well sorted, slightly oxidized.
7.00 - 8.00	2.13 - 2.43	SAND, as above, predominantly fine grained.
8.00 - 9.00	2.43 - 2.74	SAND, as above, predominantly medium grained, very pebbly.
9.00 - 10.00	2.74 - 3.05	SAND, greyish, fine-medium grained, as above; occasionally small pebbles.
10.00 - 12.00	3.05 - 3.66	SAND, black, medium-coarse grained with common very coarse grained fraction, granules and small pebbles, mafics, minor quartz, feldspar, angular-subrounded, well sorted.
12.00 - 13.00	3.66 - 3.96	SAND, grey, fine-medium and medium grained, quartz, mafics, subangular-subrounded, well sorted; with occasionally granules and small pebbles.

PIEZOMETER M79 CONTINUED

13.00 - 14.00	3.96 - 4.27	SAND, grey-black, medium grained with medium-coarse grained fraction, granules and small pebbles, mafics, quartz, subangular-subrounded, well sorted.
14.00 - 16.00	4.27 - 4.88	SAND, as above, predominantly fine-medium grained; common granules and small pebbles (up to 2cm).
16.00 - 19.00	4.88 - 5.79	SAND, black, medium-very coarse grained, common granules and GRAVEL, fine, <2cm, mafics, feldspar, quartz, subangular-subrounded, well sorted; highly interbedded.
19.00 - 20.00	5.79 - 6.10	Gravel, fine, <2cm, subrounded.
20.00 - 21.00	6.10 - 6.40	SAND, grey, medium grained with medium-coarse grained component, minor granules, mafics, quartz, subangular-subrounded, well sorted.
21.00 - 23.00	6.40 - 7.01	SAND, as above with occasionally pebbles.
23.00 - 24.00	7.01 - 7.31	SAND, blackish grey, medium grained, minor medium-coarse grained, mafics, quartz, feldspar, subangular-subrounded, well sorted, occasionally pebbles, <1cm; near base fine-medium sand.
24.00 - 25.00	7.31 - 7.62	GRAVEL, fine, <4cm and granules, subangular-subrounded.
25.00 - 26.00	7.62 - 7.92	GRAVEL, as above, predominantly <2cm, subrounded-well rounded; minor SAND, coarse-very coarse grained, mafics, quartz and feldspars, subrounded-subangular, well sorted.
26.00 - 27.00	7.92 - 8.23	GRAVEL, fine, <1.5cm, subrounded-well rounded and SAND, black, coarse grained; grading to
27.00 - 28.00	8.23 - 8.53	SAND, black-grey, medium grained grading to very fine grained with depth, quartz, mafics, subangular-subrounded, well sorted; occasionally clay stringers.

PIEZOMETER M79 CONTINUED

28.00 - 29.00	8.53 - 8.84	GRAVEL, fine, <4cm; GRANULES & SAND, black, very coarse grained; trace SAND, dark grey, very fine, very fine-fine & fine grained, quartzose, subangular-subrounded, trace organics.
29.00 - 31.00	8.84 - 9.45	GRAVEL, fine, GRANULES and SAND, very coarse grained, as above.
31.00 - 33.00	9.45 - 10.06	SAND, black, very coarse grained, minor medium-coarse grained, mafics, quartz, subangular-subrounded, well sorted, few pebbles; with depth predominantly coarse grained sand.
33.00 - 34.00	10.06 - 10.36	SAND, coarse grained, as above, pebbly, with granules and very coarse grained fraction.
34.00 - 36.00	10.36 - 10.97	SAND, black, fine-coarse grained, quartz, mafics, subangular-subrounded, well sorted, with stringers of GRAVEL, fine, <1cm, GRANULES and very coarse grained SAND; occasionally clay stringers; gravel coarser with depth.
36.00 - 40.00	10.97 - 12.19	SAND, black, medium-coarse grained, mafics, trace quartz, subangular-subrounded, well sorted, pebbly.
40.00 - 42.00	12.19 - 12.80	GRAVEL, fine, <3cm, GRANULES and very coarse grained SAND, black; with depth slightly more sandy.
42.00 - 43.00	12.80 - 13.11	SAND, grey-black, fine-very coarse grained, quartz, mafics, feldspars, subangular-subrounded, well sorted; highly interbedded; occasionally clay stringers.
43.00 - 44.00	13.11 - 13.41	SAND, black, coarse and very coarse grained, mafics, quartz, feldspars, subangular, well sorted and GRANULES.
44.00 - 45.00	13.41 - 13.72	SAND, as above, less granules.
45.00 - 46.00	13.72 - 14.02	SAND, as above, more coarse grained; trace clay stringers.
46.00 - 48.00	14.02 - 14.63	SAND, as above; few pebbles.

PIEZOMETER M79 CONTINUED

48.00 - 49.00	14.63 - 14.94	SAND, as above, interbedded with GRAVEL, fine, <1cm, subrounded; GRANULES and SAND, black, medium-coarse grained, mafics, quartz, subangular-subrounded, well sorted.
49.00 - 52.00	14.94 - 15.84	SAND, black, medium, coarse and very coarse grained, mafics, quartz, trace feldspar, subangular-subrounded, well sorted and GRAVEL, fine, <1cm, and GRANULES.
52.00 - 53.00	15.84 - 16.15	SAND, very fine-coarse grained, highly interbedded; occasional pebble and clay stringer.
54.00 - 56.00	16.15 - 17.07	GRAVEL, fine, <4cm, subrounded interbedded with SAND, black, coarse-very coarse grained, minor medium grained, mafics, quartz, subangular-subrounded, well sorted;
56.00 - 57.00	17.07 - 17.37	SAND, as above with GRAVEL, fine, <2cm.
57.00 - 62.00	17.37 - 18.90	BEDROCK (basalt).

PIEZOMETER NO: M80

Ground elevation: 414.462m Date:10/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 5.00	00.00 - 01.52	SAND, grey, very fine-medium grained, pebbly, silty & clayey, poorly sorted.
5.00 - 10.00	1.52 - 3.05	GRAVEL, fine, < 2cm, mafic rock fragments; GRANULES, black, mafics, subrounded and with depth SAND, black, very coarse grained, mafics, subangular-subrounded, well sorted, minor finer grained fractions.
10.00 - 15.00	3.05 - 4.57	GRAVEL, GRANULES, as above, with depth SAND, grey, fine-coarse grained, mafics, quartz, subangular-subrounded, well sorted, pebbly, SAND, grey-black, very fine-coarse grained, quartz, mafics, feldspar, subangular-subrounded, well sorted, interbedded; occasionally silty clay stringer.
15.00 - 20.00	4.57 - 6.10	GRAVEL, fine, < 2cm, subrounded; GRANULES, black, subrounded and SAND, black, very coarse grained, as above grading to SAND, grey-black, medium-coarse & coarse-very coarse grained, minor fine-medium grained, mafics, quartz, feldspar, subangular-subrounded, well sorted; near base very coarse grained, pebbly sand.
20.00 - 25.00	6.10 - 7.62	GRAVEL, fine, < 1.5cm, subrounded and SAND, black, very coarse grained, as above near top. Grading to SAND, medium-coarse grained, as above, SAND, black, medium grained, as above. Near base SAND, grey-black, fine-medium grained, quartz, mafics, feldspar, subangular-subrounded, well sorted, pebbly.
25.00 - 30.00	7.62 - 9.14	GRAVEL, as above, interbedded with coarse & very coarse grained SAND, as above; near base SAND, black, medium-coarse grained, quartz, mafics, feldspar, subangular-subrounded, well sorted.

PIEZOMETER M80 CONTINUED

30.00 - 35.00	9.14 - 10.67	GRAVEL, fine, predominantly < 1cm, subrounded, with medium-coarse grained sand matrix; SAND, grey-black, medium , medium - coarse grained, occasionally trace very coarse grained & granules, mafics, feldspar, quartz, subangular-subrounded, well sorted; near base GRAVEL, fine, < 0.8 cm, & GRANULES, subrounded, minor SAND, as above.
35.00 - 40.00	10.67 - 12.19	Interbedded sequence of GRAVEL, fine, <1cm, GRANULES and SAND, black, very coarse, coarse-very coarse, coarse & medium grained, minor fine-medium grained, mafics, quartz, subangular-subrounded, well sorted; becoming progressively finer with depth.
40.00 - 45.00	12.19 - 13.72	GRAVEL, medium, <5cm, subangular-subrounded and SAND, black, very coarse grained, as above. From 42.5 ft (12.95m) SAND, black, coarse grained, with medium grained component, mafics, trace quartz & feldspar, subangular-subrounded, well sorted, occasionally pebble.
45.00 - 50.00	13.72 - 15.24	SAND, black, medium-coarse grained, as above interbedded with GRAVEL. From 48 ft (14.63m) SAND, grey-black, very fine-coarse grained, pebbly, very clayey (TILL?).
50.00 - 55.00	15.24 - 16.76	TILL(?) till 51 ft (15.54m); GRAVEL, fine-medium, <4cm; SAND, black, coarse, very coarse grained, as above and GRANULES, grading to SAND, black, coarse-very coarse grained, mafics, trace quartz & feldspar, subangular-subrounded, well sorted, with granules and occasionally pebbles.
55.00 - 60.00	16.76 - 18.29	GRAVEL, as above; @ 56 ft (17.07m) SAND, black, medium, coarse grained, minor fine grained, mafics, quartz, subangular-subrounded, well sorted, pebbly; interbedded.
60.00 - 63.50	18.29 - 19.35	BOULDERS; SAND, as above.
63.50 - 69.50	19.35 - 21.18	BEDROCK (meta volcanics)

PIEZOMETER NO: M81

Ground elevation: 415.443m Date: 2,3&10,11/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 5.00	00.00 - 01.52	GRAVEL, fine, <2cm, fine-coarse grained sandy matrix, granules in part, oxidized.
5.00 - 18.00	1.52 - 5.49	GRAVEL, fine, predominantly < 1cm, subangular-subrounded, well sorted, and SAND, black, very coarse grained, mafics, feldspar, trace quartz, subangular-subrounded, well sorted.
18.00 - 20.00	5.49 - 6.10	GRAVEL, as above, with pebbles up to 5 cm.
20.00 - 20.75	6.10 - 6.30	BOULDER.
20.75 - 26.00	6.30 - 7.92	GRAVEL, fine, < 1 cm, subrounded, GRANULES, subangular-subrounded, SAND, black, very coarse grained, mafics, rock fragments, feldspar, trace quartz, subangular-subrounded, well sorted, very gravelly in part, boulders up to 15 cm @ 7.6 m.
26.00 - 30.00	7.92 - 9.14	SAND, black, coarse-very coarse grained, with finer grained matrix, occasionally interbeds of granules and small pebbles with fine to medium grained sand matrix.
30.00 - 32.50	9.14 - 9.91	SAND, black, coarse-very coarse grained, as above, with medium grained component, occasionally small pebbles, < 3 cm.
32.50 - 35.00	9.91 - 10.67	SAND, as above with depth very fine-fine & fine-medium grained sand beds, black, quartz, mafics, feldspar, subangular-subrounded, well sorted; occasionally clay stringer.
35.00 - 40.00	10.67 - 12.19	GRAVEL, fine, < 2 cm, subrounded, and SAND, as above; from 37-38.5 (11.28-11.73m) boulder.
40.00 - 45.00	12.19 - 13.72	SAND, black, coarse-very coarse grained, mafics, feldspar, quartz, pebbly, granules; SAND, black, medium & medium-coarse grained, mafics, feldspar, quartz, subangular-subrounded, well sorted grading to GRAVEL, medium, <4 cm, subrounded, and coarse grained SAND.

PIEZOMETER M81 CONTINUED

45.00 - 55.00	13.72 - 16.76	GRAVEL, medium-coarse, subangular-subrounded, minor SAND, black, m, coarse, coarse-very coarse grained, trace fine grained, mafics, feldspar, quartz, subangular-subrounded, well sorted.
55.00 - 58.00	16.76 - 17.68	BOULDER (meta volcanic)
58.00 - 58.50	17.68 - 17.83	GRAVEL, medium, <4cm, common <2cm, subrounded.
58.50 - 60.00	17.83 - 18.29	BOULDERS or intensely fractured BEDROCK.
60.00 - 68.00	18.29 - 20.73	BEDROCK (meta volcanics)

PIEZOMETER NO: M82

Ground elevation: 418.896m Date:12/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 3.00	00.00 - 00.91	FILL, sand and fine gravel, clayey; near base common organic content (original soil surface ?).
3.00 - 5.00	0.91 - 1.52	SAND, chocolate brown, very fine-fine grained, quartz, subrounded, well sorted, deeply oxidized; with depth slightly less oxidized and trace clay.
5.00 - 6.00	1.52 - 1.83	SAND, yellow brown, predominantly very fine grained, quartz, subrounded, well sorted interbedded with SILT, pale yellow grey.
6.00 - 7.00	1.83 - 2.13	SAND, pale yellow grey, very fine-fine grained, quartz, subangular-subrounded, well sorted; minor SILT, as above, beds.
7.00 - 8.00	2.13 - 2.44	SILT, pale yellow grey, quartzose with occasionally interbeds of SAND, rusty brown, fine grained, quartz, mafics, subangular-subrounded, well sorted.
8.00 - 10.00	2.44 - 3.05	SILT, mottled yellow grey, with interbeds of SAND, pale yellow grey, very fine grained, quartz, subrounded, well sorted, slightly oxidized; with depth generally more silty.
10.00 - 12.00	3.05 - 3.66	CLAY, grey, moderately soft with interbeds of SILT, as above.
12.00 - 15.00	3.66 - 4.57	CLAY, grey, soft, plastic.
15.00 - 16.00	4.57 - 4.88	CLAY, grey, as above with interbeds of SILT, grey, as above.
16.00 - 18.00	4.88 - 5.49	SILT, light grey, quartzose; occasionally clay interbeds.
18.00 - 19.00	5.49 - 5.79	SILT, light grey, as above.
19.00 - 20.00	5.79 - 6.10	SILT, as above interbedded with SAND, grey, very fine grained, quartz, subrounded, well sorted.

PIEZOMETER M82 CONTINUED

20.00 - 22.50	6.10 - 6.86	SAND, pale yellow, brown, very fine-medium grained, occasionally coarse & very coarse grained sand stringer, mafics, quartz, subangular-subrounded, well sorted, oxidized; occasionally granules.
22.50 - 25.00	6.86 - 7.62	SAND, pale yellow, fine-medium grained, occasionally coarse grained sand stringer, quartz, mafics, subangular-subrounded, well sorted; occasionally clayey silt stringer.
25.00 - 27.50	7.62 - 8.38	SAND, buff, fine grained, minor fine-medium grained, quartz, trace mafics, subangular-subrounded, well sorted.
27.50 - 30.00	8.38 - 9.14	SAND, buff-pale yellow, predominantly medium grained, with fine & coarse grained component, mafics, quartz, subangular-subrounded, well sorted, oxidized.
30.00 - 32.50	9.14 - 9.91	SAND, as above, slightly coarser, with occasionally oxidized clay stringer.
32.50 - 35.00	9.91 - 10.67	SAND, brown black, medium-coarse grained, minor fine-medium grained, mafics, quartz, feldspar, subangular-subrounded, well sorted. slightly oxidized.
35.00 - 37.50	10.67 - 11.43	SAND, as above, generally coarser.
37.50 - 40.00	11.43 - 12.19	SAND, black, predominantly medium grained, with fine & coarse grained component, mafics, quartz, subangular-subrounded, well sorted.
40.00 - 42.50	12.19 - 12.95	SAND, black, medium-coarse grained, mafics, quartz, feldspar, subangular-subrounded, well sorted; @ 42 ft (12.80m) granules and small pebbles.
42.50 - 45.00	12.95 - 13.72	SAND, grey-black, fine-medium grained with occasionally very coarse grains & granules, mafics, quartz, feldspar, subangular-subrounded, well sorted.

PIEZOMETER M82 CONTINUED

45.00 - 50.00	13.73 - 15.24	SAND, grey-black, very fine-fine, fine & fine-medium grained, quartz. mafics, feldspar, subangular-subrounded, well sorted; occasionally very coarse grains; occasionally clay stringer.
50.00 - 57.50	15.24 - 17.53	Interbedded SAND, as above, occasionally stringer of medium-coarse grained sand, fine gravel, and granules; pebbly in part; from 50-55 ft (15.24-16.76m) occasionally clay and silt stringer.
57.50 - 60.00	17.53 - 18.29	SAND, as above grading to SAND, black, coarse, coarse-very coarse & very coarse grained, predominantly mafics, subangular-subrounded, well sorted, pebbly in part.
60.00 - 63.00	18.29 - 19.20	GRAVEL, small BOULDERS, with fine-medium grained sand matrix.
63.00 - 67.00	19.20 - 20.42	BEDROCK (meta volcanics, intensely sheared)

PIEZOMETER NO: M83A

Ground elevation: 416.608m Date:12/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 2.00	00.00 - 00.61	SILT, pale yellow, interbedded with SAND, pale yellow, silt size-very fine grained, quartz, subrounded, well sorted; becoming clayey with depth.
2.00 - 5.00	0.61 - 1.52	CLAY, pale yellow, relatively soft, silty in part, oxidized.
5.00 - 10.00	1.52 - 3.05	SILT, pale yellow-rust brown, quartzose, oxidized; clayey near top, sandy near base.
10.00 - 11.00	3.05 - 3.35	SAND, brown, very fine grained, minor very fine-fine grained, quartz, subrounded, well sorted, silty in part, oxidized.
11.00 - 13.00	3.35 - 3.96	SILT, as above interbedded with SAND, very fine grained, as above.
13.00 - 15.00	3.96 - 4.57	SAND, brown, very fine grained grading to fine grained, quartz, trace mafics, subrounded, well sorted, oxidized.
15.00 - 16.00	4.57 - 4.88	SAND, brown, medium grained, mafics, quartz, subangular-subrounded, well sorted.
16.00 - 18.00	4.88 - 5.49	SAND, brown, fine-medium grained, as above; with depth slightly coarser.
18.00 - 19.00	5.49 - 5.79	GRAVEL, fine-medium, up to 4cm, subrounded with a very fine grained sand matrix; occasionally oxidized and unoxidized clay lenses.
19.00 - 20.00	5.79 - 6.10	SAND, brownish, medium, medium-coarse & coarse grained, mafics, quartz, subangular, well sorted, pebbly; grains Fe oxide coated.
20.00 - 22.00	6.10 - 6.71	SAND, brownish, fine-medium grained, quartz, mafics, subangular, well sorted; progressively becoming coarser with depth.

PIEZOMETER M83A CONTINUED

22.00 - 23.00	6.71 - 7.01	SAND, rusty, medium grained with fine grained component, occasionally pebbles, mafics, quartz, subangular-subrounded, well sorted; Fe oxide coated grains.
23.00 - 24.00	7.01 - 7.32	SAND, brownish, fine grained, quartz, mafics, subangular-subrounded, well sorted.
24.00 - 25.00	7.32 - 7.62	SAND, black, medium-coarse grained, trace granules, mafics, quartz, feldspar, subangular-subrounded, well sorted; minor Fe oxide coating.
25.00 - 30.00	7.62 - 9.14	SAND, medium-coarse grained, as above, pebbly; SAND, pale yellow, fine, fine-medium grained; SAND, grey, very fine-fine grained, quartz, subangular-subrounded, well sorted; near base GRAVEL, fine, <2cm, subrounded and SAND, black, coarse grained, mafics, quartz, subangular-subrounded, well sorted.
30.00 - 35.00	9.14 - 10.67	GRAVEL, as above with fine-medium grained sand matrix; GRAVEL, fine, <1cm, subrounded with coarse grained sand matrix, minor very coarse grains and granules; near base GRAVEL, coarse, >5 cm, with medium-very coarse grained sand matrix.
35.00 - 40.00	10.67 - 12.19	GRAVEL, fine, <1.5cm with fine-coarse grained sand matrix, fine-medium grained in part; SAND, black, coarse-very coarse grained, mafics, minor quartz, subangular-subrounded, well sorted, pebbly, granules grading to GRAVEL, fine, <2cm, subrounded, with medium-coarse grained sand matrix.
40.00 - 45.00	12.19 - 13.72	GRAVEL, fine, <2cm, as above till 43 ft (13.11m); SAND, black, coarse-very coarse & very coarse grained, occasionally granule and small pebble, mafics, quartz, feldspar, subangular-subrounded, well sorted grading to SAND, grey-black, very fine-fine, fine-medium, medium grained occasionally coarse & very coarse grains and small pebbles, quartz, mafics, subangular-subrounded, well sorted; occasionally clay stringer; near bottom SILT, grey, quartzose.

PIEZOMETER M83A CONTINUED

45.00 - 50.00	13.72 - 15.24	GRAVEL, fine, <2cm, subrounded, with medium-coarse grained sand matrix; SAND, grey, black, fine-medium grained, mafics, quartz, subangular-subrounded, well sorted with stringer of coarse & very coarse grained sand, very pebbly in part; near base SAND, black, medium, coarse & very coarse grained, pebbly, granules, mafics, quartz, subangular-subrounded, well sorted; occasionally silty clay stringer.
50.00 - 51.00	15.24 - 15.54	GRAVEL, BOULDERS and SAND, black, medium -coarse grained, as above.
51.00 - 58.00	15.54 - 17.68	BEDROCK, (meta volcanics)

PIEZOMETER NO: M83B

Ground elevation: 416.574m Date: 13/05/95

For stratigraphic description see **PIEZOMETER M83A**

PIEZOMETER NO: M84

Ground elevation: 426.422m Date:13/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 7.50	00.00 - 02.29	FILL, boulders, gravel, sand, dry.
7.50 - 8.00	2.29 - 2.44	SAND(?), rusty, fine-coarse grained, small pebbles, trace clayey; coated with Fe oxide.
8.00 - 8.50	2.44 - 2.59	SAND, as above and oxidized rock fragments (Gossan ?).
8.50 - 14.00	2.59 - 4.27	BEDROCK (siliceous felsic volcanic)

PIEZOMETER NO: M85

Ground elevation: 417.446m Date:13/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND, yellow brown, very fine, very fine-fine & fine grained, quartz, subangular-subrounded, well sorted, oxidized; becoming pale yellow with depth.
1.00 - 2.00	0.30 - 0.61	SAND, grey-pale yellow, very fine grained, subrounded, well sorted, oxidized.
2.00 - 4.00	0.61 - 1.22	SAND, grey-pale yellow, very fine & very fine-fine grained, quartz, subrounded, well sorted, slightly oxidized.
4.00 - 5.00	1.22 - 1.52	SAND, grey, buff, very fine grained, quartz, subrounded, well sorted, silty in part.
5.00 - 6.00	1.52 - 1.83	SAND, buff, very fine grained, as above, with interbeds of very fine-fine & fine grained sand.
6.00 - 8.00	1.83 - 2.44	SAND, as above with interbeds of fine grained sand.
8.00 - 9.00	2.44 - 2.74	SAND, grey-buff, fine grained, quartz, trace mafics, subangular-subrounded, well sorted, trace oxidized.
9.00 - 10.00	2.74 - 3.05	SAND, grey-buff, fine-medium grained, quartz, trace mafics, subangular-subrounded, well sorted; grains occasionally coated with Fe oxide.
10.00 - 12.00	3.05 - 3.66	SAND, grey, fine-medium grained with medium grained component, qt, mafics, subangular-subrounded, well sorted; with depth occasionally granules.
12.00 - 13.00	3.66 - 3.96	SAND, black, medium-coarse & coarse grained, mafics, quartz, subangular-subrounded, well sorted; occasionally granules.
13.00 - 15.00	3.96 - 4.57	SAND, as above with very coarse grained component, granules & small pebbles, <1cm, subrounded.

PIEZOMETER NO: M86

Ground elevation: 418.936m Date:13/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND, rust brown, very fine grained, quartz, subrounded, well sorted; occasionally pebbles.
1.00 - 2.00	0.30 - 0.61	SILT, pale yellow, quartzose, oxidized.
2.00 - 4.00	0.61 - 1.22	SILT, as above; trace very fine grained sand, subrounded, well sorted, oxidized.
4.00 - 6.00	1.22 - 1.83	SAND, grey-pale yellow, very fine & very fine-fine grained, quartz, subrounded, well sorted, slightly oxidized; becoming buff-grey with depth.
6.00 - 7.00	1.83 - 2.13	SAND, buff-grey, very fine grained, as above; occasionally silt and fine grained sand layer.
7.00 - 8.00	2.13 - 2.44	SAND, as above, predominantly silt size-very fine grained.
8.00 - 10.00	2.44 - 3.05	SAND, brown grey, fine-medium grained, quartz, mafics, subangular-subrounded, well sorted; Fe oxide coated grains; predominantly fine grained with depth.
10.00 - 15.00	3.05 - 4.57	SAND, buff, faint pale yellow, very fine grained, quartz, subrounded, well sorted, slightly oxidized.
15.00 - 16.00	4.57 - 4.88	SAND, black, fine & fine-medium grained, mafics, feldspar, quartz, subangular-subrounded, well sorted; occasionally very coarse grains and granules.
16.00 - 17.00	4.88 - 5.18	SAND, black, medium-coarse & coarse grained, mafics, quartz, feldspar, subangular-subrounded, well sorted; minor SAND, as above
17.00 - 19.00	5.18 - 5.79	SAND, as above, predominantly medium grained; occasionally granules and pebbles, < 4cm.
19.00 - 20.00	5.79 - 6.10	SAND, black, fine & fine-medium grained, mafics, feldspar, quartz, subangular-subrounded, well sorted; with coarse grained fraction.

PIEZOMETER M86 CONTINUED

20.00 - 21.00	6.10 - 6.40	SAND, as above, predominantly medium grained.
21.00 - 23.00	6.40 - 7.01	SAND, black, medium & medium-coarse grained, mafics, subangular-subrounded, well sorted; occasionally very coarse grains and granules.
23.00 - 25.00	7.01 - 7.62	SAND, black, as above with very coarse grains, granules and pebbles, <2cm, subrounded.

PIEZOMETER NO: M87

Ground elevation: 417.334m Date:13/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 2.00	00.00 - 00.61	SAND, grey-buff,, very fine grained, quartz, subrounded, well sorted with interbeds of very fine-fine grained sand.
2.00 - 3.00	0.61 - 0.91	SAND, grey-buff, very fine grained, quartz, subrounded, well sorted, slightly oxidized.
3.00 - 4.50	0.91 - 1.37	SAND, very fine grained, as above interbedded with SILT, pale yellow brown, quartzose, oxidized.
4.50 - 5.00	1.37 - 1.52	CLAY, pale yellow brown, oxidized, silty.

PIEZOMETER NO: M88

Ground elevation: 416.776m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND, brown, very fine-fine & m grained, quartz, subangular-subrounded, well sorted; mixed with fine-medium GRAVEL; oxidized.
1.00 - 3.00	0.30 - 0.91	SAND, brown, fine & fine-medium grained, quartz, mafics, subangular-subrounded, well sorted; with depth predominantly fine grained with a very fine grained component, pale yellow, oxidized.
3.00 - 4.00	0.91 - 1.22	SAND, as above; trace SILT, pale yellow and SAND grey-buff, pale yellow, very fine grained, pebbly (up to 5cm).
4.00 - 5.00	1.22 - 1.52	SAND, grey buff, as above, pebbly, silty in part.
5.00 - 6.00	1.52 - 1.83	SAND, buff, very fine-fine grained with very coarse grained component, mafics, quartz, subangular-subrounded, well sorted, granules and pebbles, <4cm, subrounded.
6.00 - 7.00	1.83 - 2.13	SAND, as above, predominantly fine grained.
7.00 - 8.00	2.13 - 2.44	SAND, as above, very pebbly (<3cm).
8.00 - 10.00	2.44 - 3.05	GRAVEL, fine, <1cm, subrounded, common granules and very coarse grains, very fine grained sand matrix.
10.00 - 13.00	3.05 - 3.96	GRAVEL, as above and SAND, black-brown, very coarse grained, common granules, mafics, trace quartz, subangular-subrounded, well sorted; with deeply oxidized clay pockets and lenses; pebbly near base.
13.00 - 15.00	3.96 - 4.57	As above, less oxidized, more sandy, predominantly fine-medium grained.

PIEZOMETER NO: M89

Ground elevation: 416.482m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND, brown yellow, very fine-fine & m grained, quartz, subrounded, well sorted, oxidized.
1.00 - 2.00	0.30 - 0.61	SAND, yellow, very fine grained, quartz, subrounded, well sorted, oxidized.
2.00 - 3.00	0.61 - 0.91	SAND, yellow, fine grained with fine-m grained component, quartz, mafics, subrounded-subangular, well sorted, oxidized; occasionally oxidized clayey silt stringer.
3.00 - 5.00	0.91 - 1.52	SAND, as above, predominantly fine grained; very fine grained component with depth.
5.00 - 6.00	1.52 - 1.83	SAND, yellow, fine grained, quartz, subangular-subrounded, well sorted, oxidized; pebbly.
6.00 - 8.00	1.83 - 2.44	SAND, pale yellow, medium grained with fine grained component, occasionally very coarse grains, mafics, quartz, subangular-subrounded, well sorted; oxidized; pebbly.
8.00 - 10.00	2.44 - 3.05	SAND, grey-black, medium-coarse grained, with very coarse grains, granules and pebbles, mafics, feldspar, trace quartz, subangular-subrounded, well sorted; minor Fe oxide staining; more pebbly with depth.
10.00 - 13.00	3.05 - 3.96	SAND, black, coarse grained with medium & very coarse grained component, pebbly, <2cm, mafics, trace quartz & feldspar, subangular-subrounded, well sorted.
13.00 - 14.00	3.96 - 4.27	SAND, black, medium & medium-coarse grained, mafics, quartz, subangular-subrounded, well sorted, few pebbles and granules.
14.00 - 15.00	4.27 - 4.57	SAND, black, medium grained, pebbly, <4cm), minor medium-coarse grained sand, mafics, quartz, feldspar, subangular-subrounded, well sorted.

PIEZOMETER NO: M90

Ground elevation: 416.397m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND, grey, buff, pale yellow, very fine grained, quartz, subrounded, well sorted, oxidized; clayey and silty.
1.00 - 2.00	0.30 - 0.61	SAND, pale yellow, very fine grained, quartz, subrounded, well sorted, oxidized.
2.00 - 3.00	0.61 - 0.91	SAND, as above & thin bed of SAND, buff, very fine-fine grained, quartz, subrounded, well sorted, slightly oxidized.
3.00 - 5.00	0.91 - 1.52	SAND, buff, very fine grained, quartz, subrounded, well sorted, silty; with depth fine grained sand interbeds.
5.00 - 6.00	1.52 - 1.83	SAND, black, medium grained, granules, pebbly, mafics, quartz, subrounded-subangular, well sorted.
6.00 - 7.00	1.83 - 2.13	SAND, as above & medium-coarse grained, very pebbly, moist; boulders at 7 ft. Three tries to break through the horizon with boulders. Unsuccessful holes backfilled with bentonite pellets.

TESTHOLE NO: 1

Ground elevation: 416.195m Date:3/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	SAND, brown yellow, very fine grained with fine-medium grained component, pebbly (Fill ?); boulders at surface.
1.00 - 5.00	0.91 - 1.52	SAND, brown- grey, very fine-medium grained, silty, common granules and pebbles, clayey.
5.00 - 6.00	1.52 - 1.83	SAND, brown grey, very fine-fine with medium grained component, quartz, mafics, feldspar, subangular-subrounded, well sorted; occasionally very coarse grains and small pebbles.
6.00 - 6.50	1.83 - 1.98	SILT, grey, sandy, wet.
6.50 - 7.00	1.98 - 2.13	SAND, yellow, very fine grained, quartz, subrounded, well sorted, oxidized.
7.00 - 8.00	2.13 - 2.44	SILT, pale yellow, sandy.
8.00 - 9.00	2.44 - 2.74	SAND, grey, very fine grained, quartz, trace mafics, silty in part, subrounded, well sorted.
9.00 - 10.00	2.74 - 3.05	SAND, yellow, very fine-fine & fine grained, quartz, trace mafics, feldspar, subrounded, well sorted; predominantly very fine grained with depth and clayey.
10.00 - 11.50	3.05 - 3.50	TILL, grey, sandy, pebbly.
11.50 - 15.00	3.50 - 4.57	BEDROCK (meta volcanics)

Testhole backfilled with cuttings

TESTHOLE NO: 2

Ground elevation: 417.515m Date:4/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.67	00.00 - 00.20	FILL, brown yellow, gravel, sand.
0.67 - 1.00	0.20 - 0.30	TAILINGS, yellow and grey, clay size, oxidized & unoxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, grey, clay size, minor silt size.
2.00 - 3.00	0.61 - 0.91	TAILINGS, grey, silt size, unoxidized.
3.00 - 5.00	0.91 - 1.52	FILL, sand, grey, very fine-medium grained, silty, pebbly, unsorted, dry.
5.00 - 6.00	1.52 - 1.83	FILL, as above, yellow, oxidized.
6.00 - 7.00	1.83 - 2.13	FILL, as above, yellow grey, predominantly medium grained, slightly oxidized.
7.00 - 8.00	2.13 - 2.44	FILL, as above, slightly. oxidized-unoxidized, trace moist.
8.00 - 10.00	2.44 - 3.05	SAND, grey, fine grained with fine-medium grained component, occasionally granules and pebbles, quartz, mafics, subangular-subrounded, well sorted.
10.00 - 10.75	3.05 - 3.28	MUSKEG.
10.75 - 12.00	3.28 - 3.66	SAND, brown grey, very fine-fine grained, quartz, subrounded, well sorted, trace organic.
12.00 - 13.00	3.66 - 3.96	SAND, brown grey, fine grained with very fine-fine grained component, quartz, subrounded, well sorted.
13.00 - 14.00	3.96 - 4.27	SAND, as above, predominantly very fine grained.
14.00 - 15.00	4.27 - 4.57	SAND, brown grey, fine grained with fine-medium grained component, quartz, trace mafics, subangular-subrounded, well sorted.

TESTHOLE No: 2 CONTINUED

Testhole backfilled with bentonite pellets from surface to 11 ft (3.35m) below surface.

TESTHOLE NO: 3

Ground elevation: 417.026m Date:4/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.75	00.00 - 00.23	FILL, brown yellow, gravel, sand, boulders at surface.
0.75 - 3.00	0.23 - 0.91	TAILINGS, yellow and grey, clay & silt size oxidized & unoxidized with depth.
3.00 - 5.00	0.91 - 1.52	SAND, yellow, very fine-fine grained, quartz, subrounded, well sorted, deeply oxidized; occasionally pebbles.
5.00 - 9.00	1.52 - 2.74	SAND, pale yellow-grey yellow, very fine-fine grained, clayey, silty, pebbly, unsorted (FILL?), moist between 8-9 ft (2.44-2.74m).
9.00 - 10.00	2.74 - 3.05	SAND, grey-grey brown, very fine-fine grained, quartz, subrounded, well sorted, organic.
10.00 - 15.00	3.05 - 4.57	SAND, grey-yellow, pale yellow, very fine -coarse grained, quartz. mafics, subangular-subrounded, well sorted, clayey in part, pebbly in part, oxidized; becoming progressively coarser with depth.

Testhole backfilled with:	bentonite pellets	9 - 8 ft (2.74-2.44m)
	fill	8 - 5 ft (2.44-1.52m)
	bentonite pellets	5 - 1.5 ft (1.52-0.45m)
	fill	1.5 - 0 ft (0.45- 0 m)

TESTHOLE NO: 4

Ground elevation: 416.546m Date:4/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, brown yellow, gravel, sand.
1.00 - 2.00	0.30 - 0.61	TAILINGS, yellow and grey, clay & silt size oxidized & unoxidized with depth.
2.00 - 3.00	0.61 - 0.91	TAILINGS, grey, clay & silt size, interbedded, unoxidized.
3.00 - 4.00	0.91 - 1.22	TAILINGS, grey, clay size, unoxidized.
4.00 - 5.00	1.22 - 1.52	TAILINGS, grey, clay & silt size, unoxidized.
5.00 - 7.00	1.52 - 2.13	TAILINGS, grey, clay size, unoxidized.
7.00 - 8.00	2.13 - 2.44	GRAVEL, fine, <2cm, occasionally larger pebbles, mixed with tailings (FILL?; LAG?).
8.00 - 11.00	2.44 - 3.35	MUSKEG/PEAT.
11.00 - 12.00	3.35 - 3.66	SAND, grey, fine-medium grained, quartz, subangular-subrounded, well sorted.
12.00 - 13.00	3.66 - 3.96	MUSKEG.
13.00 - 14.00	3.96 - 4.27	SAND, grey, fine grained, quartz, trace mafics, subrounded, well sorted.
14.00 - 15.00	4.27 - 4.57	SAND, grey, fine-medium grained, quartz, mafics, subangular-subrounded, well sorted.
15.00 - 16.00	4.57 - 4.88	SAND, grey-black, fine-medium & medium grained, as above.
16.00 - 17.00	4.88 - 5.18	SAND, as above, pebbly.
17.00 - 18.00	5.18 - 5.49	SAND, grey, fine-medium grained, quartz, mafics, subangular-subrounded, well sorted.
18.00 - 19.00	5.49 - 5.79	SILT, grey, quartzose & SAND, grey, very fine grained, as above.
19.00 - 20.00	5.79 - 6.10	SILT, grey, as above, clayey.

TESTHOLE No: 4 CONTINUED

20.00 - 21,50	6.10 - 6.55		CLAY, grey; SAND, grey, very fine-fine grained, quartz, subrounded, pebbly (TILL?).
21.5	6.55	Refusal (Boulders / Bedrock ?)	

Testhole backfilled with:	Fill	21.5 - 13 ft (6.55-3.96m)
	Bentonite pellets	13 - 5 ft (3.96-1.52m)
	Fill	5 - 2 ft (1.52-0.61m)
	Bentonite pellets	2 - 0 ft (0.61- 0 m)

TESTHOLE NO: 5

Ground elevation: 417.629m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, sand, brown yellow, fine-coarse grained, pebbly, oxidized to .83 ft (0.25m); TAILINGS, pale yellow, sandy.
1.00 - 2.00	0.30 - 0.61	TAILINGS, pale yellow, very fine grained size, with dark chocolate brown oxidized stringers.
2.00 - 3.00	0.61 - 0.91	TAILINGS, grey, brown yellow, very fine grained size, oxidized & unoxidized.
3.00 - 4.50	0.91 - 1.37	TAILINGS, grey, clay & silt size, unoxidized.
4.50 - 7.00	1.37 - 2.13	SAND, brown, yellow, very fine-fine grained with fine-medium grained component, quartz, trace mafics, subangular-subrounded, well sorted, oxidized.
7.00 - 8.00	2.13 - 2.44	SAND, pale yellow, fine grained with very fine grained fraction, quartz, subrounded, well sorted, oxidized.
8.00 - 9.00	2.44 - 2.74	SAND, pale yellow, very fine-fine grained, and as above.
9.00 - 10.00	2.74 - 3.05	SILT, pale yellow, quartzose interbedded with CLAY, grey-buff.
10.00 - 12.00	3.05 - 3.66	CLAY, buff, grey, soft, plastic.

Splitspoon sample taken from 10-11.5 ft (3.05-3.50m)

Hole backfilled with tamped cuttings.

TESTHOLE NO: 6

Ground elevation: 417.849m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.50	00.00 - 00.15	FILL, sand, brown yellow, fine-coarse grained, pebbly, oxidized.
0.50 - 1.00	0.15 - 0.30	TAILINGS, pale yellow, clay & silt size, oxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, pale yellow, very fine grained size, with chocolate brown oxidized interbeds.
2.00 - 4.00	0.61 - 1.22	TAILINGS, grey, brown yellow, silt-very fine grained size, oxidized & unoxidized.
4.00 - 5.00	1.22 - 1.52	TAILINGS, grey, clay size, unoxidized.
5.00 - 6.00	1.52 - 1.83	SAND, chocolate brown-rust brown, fine grained with medium grained component, quartz, mafics, subrounded, well sorted, oxidized.
6.00 - 8.00	1.83 - 2.44	SAND, pale yellow, fine grained, quartz, trace mafics, subrounded, well sorted; silty near base.
8.00 - 9.00	2.44 - 2.74	SAND, pale yellow-buff, fine & fine-medium grained, quartz, mafics, subangular-subrounded, well sorted, oxidized; Fe oxide coating.
9.00 - 12.00	2.74 - 3.66	SAND, buff-pale yellow, very fine grained, quartz, subrounded, well sorted interbedded with less oxidized silt; progressively more silt with depth.
12.00 - 12.50	3.66 - 3.81	As above, predominantly SILT with clay interbeds.
12.50 - 13.00	3.81 - 3.96	SILT & CLAY, pale yellow-buff, interbedded.
13.00 - 14.00	3.96 - 4.27	CLAY, grey, with pale yellow-buff SILT interbeds.
14.00 - 15.00	4.27 - 4.57	CLAY, grey, soft, plastic, with minor SILT.

Testhole backfilled with bentonite pellets from 6-3 ft (1.83-0.91m) below surface. rest cuttings.

TESTHOLE NO: 7

Ground elevation: 417.411m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.50	00.00 - 00.15	FILL, sand, brown yellow, fine-coarse grained, pebbly, oxidized.
0.50 - 1.00	0.15 - 0.30	TAILINGS, pale yellow, clay size, oxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, grey, silt size, unoxidized.
2.00 - 3.00	0.61 - 0.91	TAILINGS, grey, silt & clay size, unoxidized.
3.00 - 4.00	0.91 - 1.22	TAILINGS, as above; near base approx. 9 cm layer of wood fragments.
4.00 - 5.00	1.22 - 1.52	SAND, brown, rust brown, very fine-fine grained, quartz, subrounded, well sorted.
5.00 - 6.00	1.52 - 1.83	SAND, as above, predominantly. pale yellow-buff.
6.00 - 8.00	1.83 - 2.44	SAND, very pale yellow, buff, fine grained with very fine grained component, quartz, subrounded, well sorted, dry.
8.00 - 10.00	2.44 - 3.05	SAND, as above with fine-medium grained component, dry.
10.00 - 11.00	3.05 - 3.35	SAND, grey, fine-medium grained, quartz, subangular-subrounded, well sorted. wet @ 10.5 ft (3.20m).
11.00 - 13.00	3.35 - 3.96	SAND, grey, black, medium & medium-coarse grained, mafics, quartz, subangular-subrounded, well sorted; with depth predominantly medium grained and pebbly.
13.00 - 15.00	3.96 - 4.57	SAND, black, medium & medium-coarse grained, occasionally very coarse grains and granules, mafics, quartz, subangular-subrounded, well sorted.

Testhole backfilled with bentonite pellets from 7-1 ft (2.13-0.3m), rest cuttings.

TESTHOLE NO: 8

Ground elevation: 417.419m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 0.33	00.00 - 00.10	FILL, sand, brown yellow, fine-coarse grained, pebbly, oxidized.
0.33 - 1.00	0.15 - 0.30	TAILINGS, yellow, rust brown, clay size, oxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, grey, pale brown, silt & clay size, oxidized and unoxidized.
2.00 - 4.00	0.61 - 1.22	TAILINGS, grey, silt size, unoxidized.
4.00 - 7.50	1.22 - 2.29	TAILINGS, grey, clay & silt size, unoxidized.
7.50 - 8.00	2.29 - 2.44	SOIL, black, 5cm thick; SAND, brown grey, very fine grained, quartz, subrounded, well sorted.
8.00 - 10.00	2.44 - 3.05	GRAVEL, fine, <1cm, with grey fine-medium grained sand matrix. HYDROCARBON ODOR.
10.00 - 13.00	3.05 - 3.96	GRAVEL & SAND, as above, coal black, slightly coarser. faint odor.
13.00 - 14.00	3.96 - 4.27	SAND, black, very coarse grained, granules and pebbles, mafics, trace quartz, subangular-subrounded, well sorted.
14.00 - 15.00	4.27 - 4.57	SAND, as above, with medium-coarse grained fraction.

Testhole backfilled with bentonite pellets from 10 ft (3.05m) to surface.

TESTHOLE NO: 9

Ground elevation: 417.642m Date:14/05/95

Depth (ft)	(m.)	Stratigraphic Description
0.00 - 1.00	00.00 - 00.30	FILL, sand, rust brown, medium-coarse grained, pebbly, oxidized.
1.00 - 2.00	0.30 - 0.61	TAILINGS, pale yellow, clay size, oxidized.
2.00 - 3.00	0.61 - 0.91	TAILINGS, pale brown, silt-very fine grained size, unoxidized.
3.00 - 5.00	0.91 - 1.52	TAILINGS, grey, silt size, unoxidized.
5.00 - 5.33	1.52 - 1.62	SOIL, black.
5.33 - 7.00	1.62 - 2.13	SILT, very pale yellow, quartzose, slightly oxidized; occasionally very fine grained sand interbed.
7.00 - 9.00	2.13 - 2.74	SAND, very pale yellow, very fine grained, quartz, subrounded, well sorted. with depth fine grained interbeds.
9.00 - 10.00	2.74 - 3.05	SILT, very pale yellow-grey, quartzose with very fine grained sand interbeds.
10.00 - 11.00	3.05 - 3.35	SAND, grey, very fine & very fine-fine grained, quartz, subrounded, well sorted; wet.
11.00 - 12.00	3.35 - 3.66	SAND, grey, fine grained with fine-medium grained component, quartz, mafics, subangular-subrounded, well sorted.
12.00 - 13.00	3.66 - 3.96	SAND, grey-buff, medium grained, mafics, quartz, subangular-subrounded, well sorted.
13.00 - 15.00	3.96 - 4.57	SAND, brown, grey, fine-medium grained, minor coarse grained, mafics, quartz, subangular-subrounded, well sorted, occasionally very coarse grains and granules; Fe oxide stained grains.

Testhole backfilled with bentonite pellets from 11 ft (3.35m) to surface.

APPENDIX C: PIEZOMETER DEVELOPMENT

WELL DEVELOPMENT

During well development the electrical conductivity (E.C.) of the produced water was measured to determine the progress of well development. Once the electrical conductivity of the water had stabilized and the water was sediment free, development was stopped

M5C

DATE/TIME	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm	COMMENTS
28/04/95				
08:10				Start air pumping: 1-10 l/min
08:15	2350	4.75	3818	
08:25	2700	5.75	4266	
08:45	2730	5	4403	
08:55	2925	5	4718	
09:05	3000	5	4839	
09:15	3050	5	4920	
09:25	3240	6	5083	
09:35	3300	5.75	5214	
09:45	3320	6.25	5175	
09:55	3480	6.25	5424	
10:05	3490	6.5	5512	
10:15	3580	5.5	5696	
10:25	3610	7	5516	
10:35	3610	6.75	5552	Air pumping till 12:00 hrs
14:00	3800	7.25	5768	Install submersible pump
16:00	3800	9	5502	@ 14:00 hrs; pumping @
16:15	3920	9.25	5641	5 l/min.

M24N

DATE/TIME	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm	COMMENTS
7/05/95				
09:24				Start air surging @ 1.5 l/min
09:25	373	9	540	
09:30	1020	7	1558	
09:35	1160	7	1772	
09:40	1220	7	1864	
09:45	1270	7.25	1924	
09:50	1290	7	1971	Rate: 3 l/min; shut in till
10:16	1370	8	2038	10:14 hr
10:21	1335	7.5	2013	
11:21	1365	8	2031	Shut in.
13:02	1310	7	2002	Air surge for 10 min.

M24N continued

8/05/95				
08:50	1280	7.25	1943	Start air surging @ 3 l/min
08:58	1265	7	1933	
09:23	1310	7.25	1988	
10/05/95				
09:00	1170	9	1694	Start pumping with sub-
09:10	1120	9	1621	mersible @ 3 l/min
09:30	1150	10	1623	
09:50	1150	10	1623	
10:15	1240	11	1705	
10:45	1250	10	1764	
11:10	1250	11	1719	

M26B

DATE/TIME	E.C. (mS/cm)	TEMP. (^{o}C)	E.C. @ 25 ^{o}C (mS/cm	COMMENTS
29/04/95				Air pumping 10-20 l/min
17:30	122	7	186	Immediately after start
17:35	276	6	433	
17:50	355	7	542	
18:00	425	7	649	Shut in
30/04/95				
09:30	482	7	736	Start air pumping
10:00	520	8.5	763	
10:10	500	6.75	769	
10:20	530	8	788	
10:45	530	8	788	Stop air pumping
10:55				Install submersible pump
11:10	520	8	774	Pumping @ 11 l/min
12:00	500	8	744	

M27C

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
6/05/95				
14:49				Start air surging @ 12 l/min
14:50	133	9.75	189	
14:54	1580	9.5	2258	
14:56	1740	9	2520	
15:00	1900	9	2751	
15:05	1920	8.25	2838	
15:10	1930	8.25	2853	
15:15	1950	8.25	2882	Air surging @ 15-20 l/min
15:20	1950	7.5	2940	
15:25	1920	7.5	2895	Air surging @ 20-30 l/min
15:45	1930	7.75	2891	
16:30	1970	8	2931	
10/05/95				
11:30	1950	12	2615	Start pumping wih submer-
11:35	2000	12	2682	sible @ 6.6 l/min
12:35	2000	10	2822	
13:50	1880	10.25	2635	

M40B

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
30/04/95				
12:29				Start air pumping: 1-5 l/min
12:30	1220	12	1636	
12:40	2240	12	3005	
12:50	2600	11	3575	
13:00	3100	9.25	4460	Shut in till 14:45 hr
14:45	3400	10	4800	
15:00	4280	9.75	6080	
15:15	4610	9.25	6635	
15:30	5000	9.25	7195	
16:00	5100	9	7385	Install submersible pump
16:15	5000	8.75	7290	Pumping @ 1-2 l/min
16:30	5300	10.5	7385	
17:30	5100	8.5	7485	
17:45	5000	8	7440	
18:00	5000	7	7640	
18:30	5000	7	7640	
18:45	5000	6.75	7695	
19:00	5000	6.25	7795	Still producing sediment

M40B continued

1/05/95				Air surge piezometer and install submersible pump
07:45	5100	8.5	7487	Pumping @ 1.8 l/min
07:50				Increase to 2.3 l/min
08:10	5100	8	7589	
09:15	5100	8	7589	

M64

DATE	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm)	COMMENTS
26/04/95	625	4	1037	After pumping @ 1-2 l/min
27/04/95	700	4	1162	After bailing by hand: start
	680	3.5	1145	After bailing by hand: finish
28/04/95	700	4	1162	After bailing by hand
29/04/95	615	3.75	1028	After bailing by hand
17/05/95	600	6	941	Bailing, replacement of water column in piezometer 1.5x

M65

DATE	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm)	COMMENTS
27/04/95	102	4	169	Bailed dry and after recovery
	108	3	184	a/a
28/04/95	92	4.5	150	a/a
29/04/95	99	3	169	a/a

M66A

DATE/TIME	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm)	COMMENTS
27/04/95				
09:30				Start airlift pumping
10:00	1380	4.75	2242	10-20 l/min
10:05	1380	5.5	2195	
10:10	1300	5.5	2068	
10:15	1320	5.5	2100	
10:30	1300	5.25	2083	
10:45	1320	5	2130	
11:00	1320	5.25	2115	
11:20	1350	5.25	2163	
11:40	1380	5	2226	
12:00	1320	6	2071	Switch to submersible

M66A continued

15:00	1210	4.75	1966	pump; total volume pumped 1630 l.
3/05/95				
14:45				Install submersible
14:50	1020	11	1100	Pumping @ 3.2 l/min
15:15	1000	10.5	1395	
15:25	1080	11.5	1465	
15:35	1020	10	1439	
16:00	1020	11	1402	

M66B

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
27/04/95				
10:35	60	3	102	First bail
10:50	70	3.5	118	Bailed dry and after recovery
11:50	80	4	133	a/a
12:50	85	8.5	125	a/a
13:30	110	7	168	a/a
16:00	110	7	168	a/a
17:30	128	4	212	a/a
28/04/95	145	3.75	242	a/a
29/04/95	135	3.5	227	a/a

M67

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
28/04/95				
12:25				Install airlift pump
12:30	1120	7	1711	Pumping @ 10-20 l/min
12:45	1320	7	2017	
13:00	1410	7	2154	
13:30	1510	6.75	2323	
14:00	1650	7.25	2505	
14:30	1710	7	2613	
15:00	1750	7	2674	
15:30	1900	7.75	2846	
16:30	1820	7.5	2745	

M68

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
29/04/95				
14:20				Install airlift pump.
14:30	398	8.25	588	pumping @ 5-10 l/min
14:50	405	7	619	
15:00	400	7.5	603	
15:10	410	7	626	
15:20	402	6.25	627	Quit air lifting, install
15:30	393	5.5	625	submersible, pumping
15:45	435	6.25	678	@ 1 l/min
16:00	421	6.25	656	
16:45	421	6.25	656	

M69

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
1/05/95				
08:35				Start air surging
08:38	187	6.75	288	aprox: 8.5 l/min
08:48	303	6.25	472	
08:58	240	6.5	371	
09:08	218	6.5	337	Shut in
11:10				Start air surging
11:15	218	8.75	317	
11:30	193	7	295	
11:50	183	7	280	
12:00				Quit air surging, install submersible, start pumping: 8.5 l/min @ 13:05 hr
13:15	186	7.5	280	
14:00	183	7.5	276	
14:30	183	7.5	276	
15:30	176	7	269	Shut in
16:30				Start pumping @ 9.4 l/min
16:45	180	7.25	273	
17:30	176	6.5	272	Max. drawdown: 32.5 cm

M70A

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
2/05/95				
10:20	160	3	273	After 3 bails
10:35	190	6.25	296	Immediate after air surging
10:45	119	6.75	183	
10:55	122	6	191	
11:05	105	4.25	173	
11:15	108	6	169	
11:25	108	5	174	
11:35	99	4.25	163	Stop air surging
12:10	100	5.25	160	start air surging

M70B

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
2/05/95				piezometer bailed by hand
No of bails				
1	110	2		
5	55	1.25		

M70C

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
2/05/95				piezometer bailed by hand
No of bails				
?	62	2.75		

M71

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm)	COMMENTS
2/05/95				
12:30				Start air surging
13:00	60	60	97	

M72A

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
3/05/95				
11:58				Start air surging @ 1-5 l/min
12:00	620	11	852	
12:10	605	10	854	
12:20	620	10.25	869	
12:30	660	10	931	
12:40	700	10.5	975	
12:50	700	10.5	975	
13:00	780	11	1072	
13:10	820	10.5	1142	
13:20	810	9	1173	
13:30	850	9.25	1223	
13:40	880	9	1274	
13:50	890	9	1289	
14:00	910	9.25	1309	
;				

M72B

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
6/05/95				
08:25				Start air surging @ 1 l/min
08:30	2090	6.75	3215	
08:35	2160	6	3389	
08:40	2560	5.75	4045	
08:50	3120	5	5032	
09:35	3240	6.25	5050	Shut in from 09:35-09:40 hr
09:48	3220	6.25	5019	
11:25	3410	6.5	5280	
12:10	3475	6.75	5345	Increase rate to 1.5 l/min
13:15	3700	8	5505	
14:00	3530	7	5394	

M72C

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
6/05/95				piezometer bailed by hand
No of bails				
1	1090	7.25	1658	Approximate volume bailer:
2	2700	5.25	4325	= 1.1 liter.
3	4100	5	6613	
5	5000	4.5	8182	
7	5800	6.5	9040	
11	6100	7.75	9138	
14	6250	7.25	9488	
16	6100	7.25	9260	

M73

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
4/05/95				Air surging @ 23 l/min
14:45	255	9	369	Immediately after start
15:05	375	8.75	547	
15:15	337	8	501	
15:20	348	8	518	
15:30	345	7.5	520	
15:45	345	8	513	Increase air surging rate
16:00	343	7.25	521	to 36 l/min
16:15	418	8	622	
16:45	361	7.5	544	
17:15	375	7.5	565	
17:45	388	7.5	585	

M74

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
5/05/95				Air surging @ 5.5 l/min
16:25	72	8.75	105	Immediately after start
16:30	391	7.5	590	
16:35	775	7.25	1176	
16:40	860	7	1314	
16:45	910	7	1390	
16:55	990	6.5	1543	Increase air surging rate
17:05	930	6	1459	to 6.8-9 l/min.
17:15	1010	6	1586	
17:25	1020	6	1600	

M74 continued

9/05/95				
10:25				Submersible pump
10:30	1060	8.5	1556	@ 5 l/min
10:35	930	7.5	1402	
10:45	980	8	1458	
10:50	1000	8.25	1478	
10:55	990	7.5	1493	
11:00	980	7.5	1478	
11:05	990	7.5	1493	
11:10	990	7.5	1493	
11:15	990	7	1512	
11:45	1050	7	1604	
12:30	1050	7	1604	

M75

DATE/TIME	E.C. (mS/cm)	TEMP. (^{o}C)	E.C. @ 25 ^{o}C (mS/cm	COMMENTS
10/05/95				
14:45				Air surging @ 6 l/min
15:00	2700	11	3712	
15:05	2800	11	3850	
15:30	2600	11	3575	
15:50	2600	10	3669	
16:10	2620	11	3602	
16:45	2600	11.25	3553	
17:00	2580	10	3640	
17:15	2560	10	3612	

M76

DATE/TIME	E.C. (mS/cm)	TEMP. (^{o}C)	E.C. @ 25 ^{o}C (mS/cm	COMMENTS
9/05/95				
09:40				Air surging @ 1.25 l/min
09:45	800	7.75	1198	
09:55	1300	7.5	1960	
10:00	1945	7.25	2952	
11:30	2400	8	3571	
17:30	2580	8	3839	
18:30	2580	8	3839	

M77A

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
8/05/95				
16:54				Air surging @ 7.5 l/min
16:55	228	10	322	
17:00	278	7.5	419	Increase air surging rate
17:05	331	6.75	509	to 8.5 l/min
17:30	389	7	594	
17:35	378	6	593	
17:55	391	6.25	609	
18:00	372	5.5	592	
18:15	386	6	606	
18:30	390	5.5	620	
9/05/95				
07:58				Pumping with submersible
08:00	402	5	648	@ 8 l/min
08:10	430	5	693	
08:20	420	5	677	
08:50	412	6	646	
09:00	395	6	620	
09:10	407	5.9	643	
10:10	421	6.7	648	

M77B

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
8/05/95				piezometer bailed by hand
No of bails				
1	120	7.75	180	Approximate volume bailer:
3	123	6.5	190	= 1.1 liter.
8	110	6	172	
13	150	6	235	
23	152	5.5	242	
30	138	5.5	220	
40	143	5	231	
50	150	5	242	
60	148	6	232	
66	148	6	232	

M78A

DATE/TIME	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm	COMMENTS
10/05/95				
07:29				Start air surging @ 40-60
07:30	115	8	171	l/min
07:35	2400	8	3571	
07:40	2600	7	3973	
07:50	2700	7	4126	
07:55	2740	7	4187	
08:00	2750	7	4202	
08:05	2760	7	4217	
08:10	2780	7	4248	
08:20	2800	7	4278	
09:15	2650	7	4049	
09:35	2850	8	4240	
09:45	2850	8	4240	
10:20	2900	10	4091	
10:40	2850	9	4127	
11:40	2900	11	3987	
12:10	2990	11	4111	
12:30	2990	11	4111	
13:30	2850	9	4127	

M78B

DATE/TIME	E.C. (mS/cm)	TEMP. (°C)	E.C. @ 25 °C (mS/cm	COMMENTS
13/05/95				
11:49				Start air surging @ 10 l/min
11:50	280	5.5	445	
12:00	605	6	949	
12:20	800	3.5	1110	
12:50	800	3	1367	
13:10	880	5	1419	
13:20	910	5.25	1475	
13:50	900	4.75	1462	

M79

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
10/05/95				
13:55				Start air surging @ 40-60 l/min
14:00	2440	9	3533	
14:05	2440	7.5	3679	
14:15	2530	8	3764	
14:20	2520	7.5	3800	
14:30	2570	8	3824	
14:45	2530	8.75	3679	
15:20	2490	8	3705	
15:30	2400	8	3571	
16:15	2300	9	3330	
16:25	2200	8	3273	
16:40	2250	8	3348	

M80

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
11/05/95				
07:59				Start air surging @ 60 l/min
08:00	2340`	8	3482	
08:05	2280	7	3485	
08:15	2240	6.5	3469	
08:20	2250	6.5	3485	
08:25	2260	7	3453	
08:35	2280	7	3485	
08:40	2250	7	3438	
08:45	2240	7	3423	
08:50	2230	6.5	3453	
08:55	2240	7	3423	
09:00	2250	7	3438	
09:05	2260	7	3453	
09:10	2230	6.5	3453	

M81

DATE/TIME	E.C. (mS/cm)	TEMP. (^{o}C)	E.C. @ 25 ^{o}C (mS/cm	COMMENTS
13/05/95				
09:11				Start air surging @ 40-60
09:12	1820	5	2936	l/min
09:22	1760	5	2839	
09:32	1860	5	3000	
09:42	1850	5.5	2943	
09:52	1820	5.25	2916	
10:02	1820	5.5	2895	
10:12	1920	5.25	3075	
10:42	1850	5.75	2923	
11:12	1820	5.25	2915	

M82

DATE/TIME	E.C. (mS/cm)	TEMP. (^{o}C)	E.C. @ 25 ^{o}C (mS/cm	COMMENTS
13/05/95				
14:49				Start air surging @ 20-40
14:50	315	7	481	l/min
14:51	480	6.25	748	
15:10	410	5.25	657	
15:30	590	5	952	
16:10	640	5.75	1011	
16:40	690	5	1113	
18:00	750	5	1210	
14/05/95				
09:00	690	7	1054	
09:20	680	5	1097	
09:30	700	4.75	1137	
09:50	690	5	1113	Stop air surging
14:50	315	7	418	Start pumping @ 6-8 l/min
14:51	480	6.25	748	
15:10	410	5.75	648	
15:30	590	5	952	
16:10	640	5.75	1011	
16:40	690	5	1113	
18:00	700	5	1129	

M83A

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
13/05/95				
10:45				Start air surging 40-60 l/min
10:50	1760	5.25	2819	
11:10	1970	5.5	3134	
11:20	2040	6	3200	
11:40	2100	6	3295	
12:00	2130	7	3255	
12:20	2130	7	3255	
13:00	2180	8	3244	

M83B

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
13/05/95				
13:05				Start air surging 40-60 l/min
13:10	318	7	496	
13:40	215	9	311	
14:05	180	8	268	
15:05	180	8	268	

M85

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
12/05/95				piezometer bailed by hand
No of bails				
10	140	9	203	
20	175	8	260	

M86

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
12/05/95				piezometer bailed by hand
No of bails				
4	108	8	161	
15	102	7.5	154	

M87

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
12/05/95				piezometer bailed by hand
No of bails				
4	53	7	81	

M88

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
12/05/95				piezometer bailed by hand
No of bails				
4	46	6.75	71	

M89

DATE/TIME	E.C. (mS/cm)	TEMP. (^oC)	E.C. @ 25 ^oC (mS/cm	COMMENTS
12/05/95				piezometer bailed by hand
No of bails				
1	530	6	832	
4	510	5.75	806	
15	430	5.75	679	

APPENDIX D: STRATIGRAPHIC DESCRIPTIONS

ELECTRICAL CONDUCTIVITY DURING AIR HAMMER DRILLING

The electrical conductivity (E.C.) of the water produced during air hammer drilling was measured in M79, M80, M81 and M83A.

M79

Ground Elevation: 415.39 m

DATE	DEPTH (ft)	DEPTH (m)	E.C. (mS/cm)	TEMP. (^{o} C)	E.C. @ 25 ^{o} C (mS/cm)
9/05/95					
	15	4.57	200	17	238
	19	5.79	225	17	268
	24	7.31	215	15	268
	29	8.84	305	13	399
	37	11.28	440	10	621
	38	11.58	480	9	695
	39	11.89	570	9	825
	40	12.19	730	14	932
	43	13.11	730	14	932
	44	13.41	950	17	2984
	49	14.93	2450	16	2984
	52	15.85	2800	16	3410
	53	16.15	3200	16	3898
	54	16.46	3150	14	4023
	55	16.76	2950	15	3674
	57	17.37	3000	14	3831
	58	17.68	2990	12	4010

M80

Ground Elevation: 414.46 m

DATE	DEPTH (ft)	DEPTH (m)	E.C. (mS/cm)	TEMP. (^{o} C)	E.C. @ 25 ^{o} C (mS/cm)
10/05/95					
	10	3.05	189	11	260
	15	4.57	182	10	256
	20	6.10	230	10	324
	25	7.62	222	9	321
	30	9.14	335	9.5	478
	35	10.67	438	10	618
	40	12.19	860	9	1245
	45	13.72	1860	9	2693
	46	14.02	2000	10	2822
	47	14.32	2100	10	2963
	48	14.63	2130	10	3005
	50	15.24	2100	12	2945
	52	15.85	2250	13	2945
	53	16.15	2310	12.75	3042
	54	16.46	2280	11.5	3096
	55	16.76	2380	11.5	3232
	57	17.37	2430	12	3258
	59	17.98	2440	13	3193
	60	18.29	2580	9.5	3688

M81

Ground Elevation: 415.44 m

DATE	DEPTH (ft)	DEPTH (m)	E.C. (mS/cm)	TEMP. (^{o} C)	E.C. @ 25 ^{o} C (mS/cm)
10/05/95					
	15	4.57	300	17.5	352
	20	6.10	320	15	399
	25	7.62	370	15.5	456
	30	9.14	360	10.5	501
	35	10.67	470	11.75	634
	40	12.19	660	10.75	908
	43	13.11	890	11.75	1201
	45	13.72	980	9.5	1400
	47	14.32	1080	11	1485
	50	15.24	1580	9.25	2274
	53	16.15	2000	11.5	2716
	55	16.76	1900	9	2751
	59	17.98	1890	8.75	2755

M83

Ground Elevation: 416.61 m

DATE	DEPTH (ft)	DEPTH (m)	E.C. (mS/cm)	TEMP. (^{o} C)	E.C. @ 25 ^{o} C (mS/cm)
12/05/95					
	15	4.57	182	3	311
	20	6.10	198	3	338
	25	7.62	168	5.75	256
	30	9.14	163	6	256
	35	10.67	330	5.25	529
	40	12.19	1260	5.75	1990
	45	13.72	1760	5	2839
	46	14.02	1720	3.25	2919
	50	15.24	1980	3	3384
	51	15.54	2000	3	3418

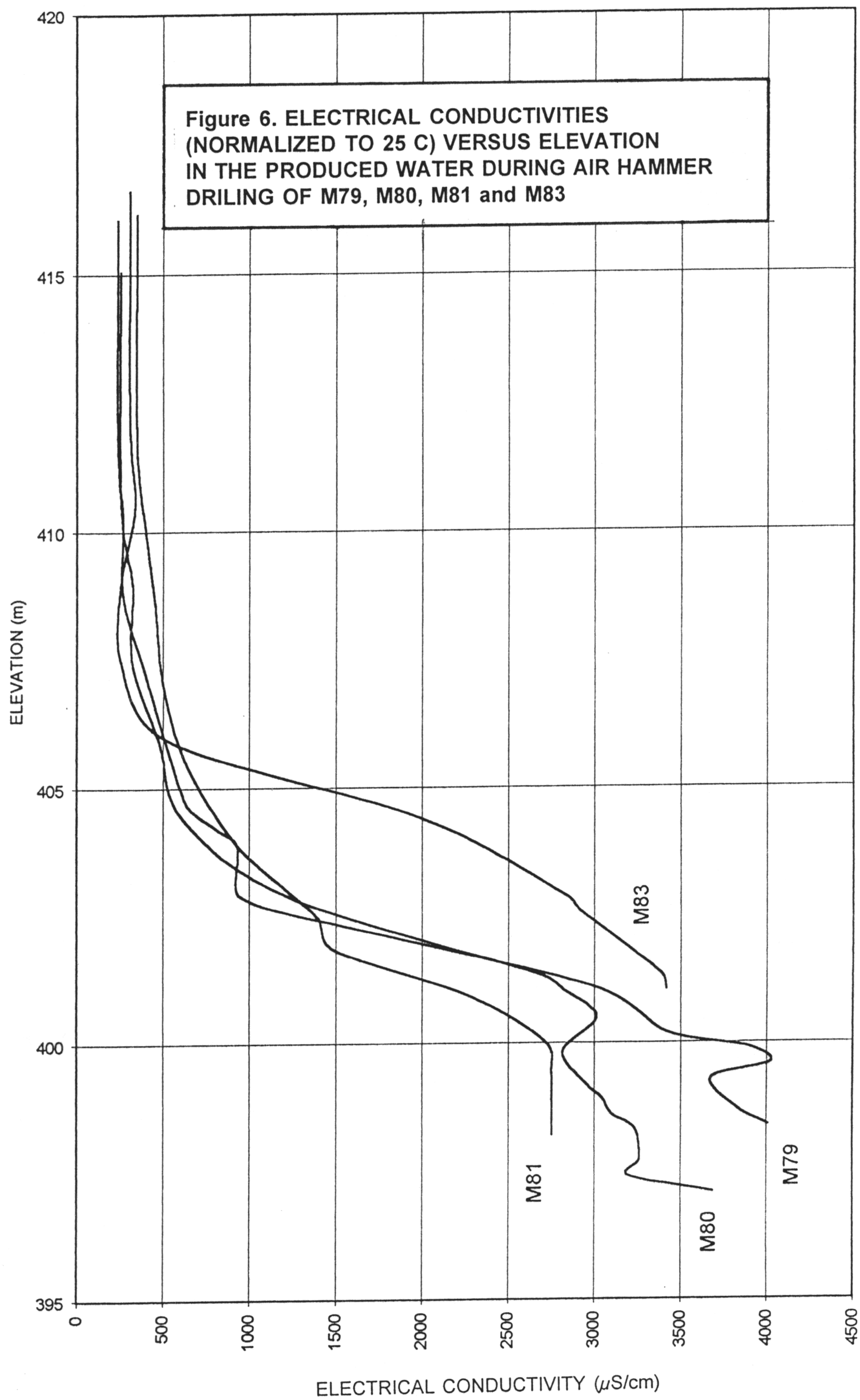


Figure 6. ELECTRICAL CONDUCTIVITIES (NORMALIZED TO 25 C) VERSUS ELEVATION IN THE PRODUCED WATER DURING AIR HAMMER DRILING OF M79, M80, M81 and M83
ELEVATION (m)
420
415
410
405
400
395
0
500
1000
1500
2000
2500
3000
3500
4000
4500
ELECTRICAL CONDUCTIVITY (µS/cm)
M83
M81
M80
M79

APPENDIX E: ELECTRICAL CONDUCTIVITY OF PRODUCED WATER DURING AIRHAMMER DRILLING

TESTHOLE INFORMATION, BEDROCK ELEVATION & PIEZOMETER CONSTRUCTION DETAILS, SOUTHBAY, ONTARIO: 1995

PIEZO. No:	GROUND ELEVATION (m)	TOTAL DEPTH TESTHOLE (m)		BEDROCK SURFACE (m)		PIEZOMETER CONSTRUCTION DETAILS (with respect to ground level) TOTAL LENGTH (m)	STICK UP (m)		TIP (m)		SCREEN BOTTOM (m)		SCREEN TOP (m)		TOP SANDPACK (m)		BOTTOM (m)		BENTONITE PELLETS TOP (m)		BENTONITE PELLETS BOTTOM (m)	
		measured	Elevation	measured	Elevation		measured	Elevation	measured	Elevation	measured	Elevation	measured	Elevation	measured	Elevation	measured	Elevation	measured	Elevation	measured	Elevation
5C	417.674	17.37	400.304	16.46	401.214	16.770	0.950	418.624	-15.820	401.854	-15.760	401.914	-14.310	403.364	-14.170	403.504	-14.170	403.504	-12.770	404.904	-9.140	408.534
24N	417.692	13.56	404.132	12.65	405.042	12.950	0.855	418.547	-12.095	405.597	-12.035	405.657	-11.385	406.307	-9.600	408.092	-9.600	408.092	-8.080	409.612	-6.100	411.592
26B	416.541	18.59	397.951	17.98	398.561	18.900	1.065	417.606	-17.835	398.706	-17.775	398.766	-16.405	400.136	-16.005	400.536	-16.005	400.536	-14.785	401.756		
27C	417.327	13.20	404.127	12.50	404.827	13.100	1.010	418.337	-12.090	405.237	-12.030	405.297	-10.620	406.707	-10.260	407.067	-10.260	407.067	-9.050	408.277	-5.790	411.537
40B	417.463	7.65	409.813	7.16	410.303	7.830	0.830	418.293	-7.000	410.463	-6.940	410.523	-6.270	411.193	-5.940	411.523	-5.940	411.523	-3.050	414.413	-0.610	416.853
64	415.965	4.72	411.245	3.81	412.155	4.560	0.755	416.720	-3.055	412.910	-2.995	412.970	-2.350	413.615	-2.135	413.830	-2.135	413.830	0.000	415.965		
65	416.662	3.66	413.002	2.74	413.922	3.070	0.980	417.642	-2.090	414.572	-2.030	414.632	-1.370	415.292	-1.210	415.452	-1.210	415.452	0.000	416.662		
66A	415.572	8.84	406.732	8.23	407.342	9.140	0.930	416.502	-8.210	407.362	-8.150	407.422	-6.690	408.882	-6.380	409.192	-6.380	409.192	-3.580	411.992	-0.910	414.662
66B	415.615	3.05	412.565			3.820	0.815	416.430	-3.005	412.610	-2.945	412.670	-2.320	413.295	-1.925	413.690	-1.925	413.690	-1.015	414.600	-0.910	414.705
67	417.169	7.31	409.859	6.55	410.619	7.480	0.880	418.049	-6.600	410.569	-6.540	410.629	-5.870	411.299	-5.460	411.709	-5.460	411.709	-2.170	414.999	-1.220	415.949
68	416.030	4.86	411.170	4.42	411.610	5.340	1.035	417.065	-4.305	411.725	-4.245	411.785	-3.585	412.445	-3.385	412.645	-3.385	412.645	-2.005	414.025	-1.220	414.810
69	418.580	12.19	406.390	11.43	407.150	12.190	0.930	419.510	-11.260	407.320	-11.080	407.500	-9.620	408.960	-9.140	409.440	-9.140	409.440	-8.530	410.050	-1.830	416.750
70A		10.82		10.36		11.430	1.180		-10.250		-10.190		-9.580		-8.120		-8.120		-7.520			
70B		5.34				6.030	0.690		-5.340		-5.290		-4.545		-4.270		-4.270		-3.670			
70C		4.11				4.710	0.620		-4.090		-4.030		-3.370		-2.900		-2.900		0.000			
71	415.224	4.72	410.504	4.27	410.954	5.345	0.935	416.159	-4.410	410.814	-4.350	410.874	-3.640	411.584	-3.165	412.059	-3.165	412.059	0.000	415.224		
72A	416.726	11.89	404.836	11.12	405.606	11.890	0.800	417.526	-11.090	405.636	-11.030	405.696	-9.655	407.071	-9.300	407.426	-9.300	407.426	-5.490	411.236	-3.050	413.676
72B	416.704	6.10	410.604			5.790	0.960	417.664	-4.830	411.874	-4.770	411.934	-3.390	413.314	-3.050	413.654	-3.050	413.654	0.000	416.704		
72C	416.711	1.52	415.191			2.005	0.600	417.311	-1.405	415.306	-1.345	415.366	-1.065	415.646	-0.950	415.761	-0.950	415.761	0.000	416.711		
73	415.385	14.17	401.215			10.670	0.875	416.260	-9.795	405.590	-9.735	405.650	-8.325	407.060	-7.905	407.480	-7.905	407.480	-7.505	407.880	-7.205	408.180
74	414.769	14.02	400.749	12.80	401.969	12.950	0.600	415.369	-12.350	402.419	-12.290	402.479	-11.670	403.099	-10.520	404.249	-10.520	404.249	-9.610	405.159	-5.500	409.269
75	417.865	19.81	398.055	18.74	399.125	19.870	0.630	418.495	-19.240	398.625	-19.180	398.685	-18.470	399.395	-18.360	399.505	-18.360	399.505	-17.600	400.265		
76	417.788	5.36	412.428			6.490	1.135	418.923	-5.355	412.433	-5.295	412.493	-4.635	413.153	-4.415	413.373	-4.415	413.373	-3.505	414.283	-2.435	415.353
77A	414.557	6.40	408.157	5.18	409.377	5.820	0.815	415.372	-5.005	409.552	-4.945	409.612	-4.205	410.352	-3.955	410.602	-3.955	410.602	-2.585	411.972	-0.300	414.257
77B	414.644	3.05	411.594			3.820	0.765	415.409	-3.050	411.594	-2.995	411.649	-2.245	412.399	-2.125	412.519	-2.125	412.519	0.000	414.644		
78A	420.426	24.69	395.736	24.08	396.346	23.770	0.825	421.251	-22.945	397.481	-22.885	397.541	-21.405	399.021	-21.185	399.241	-21.185	399.241	-20.425	400.001		
78B	420.442	15.39	405.052			15.390	0.810	421.252	-15.340	405.102	-15.280	405.162	-13.840	406.602	-13.100	407.342	-13.100	407.342	-12.800	407.642		
79	415.392	18.90	396.492	17.37	398.022	18.140	0.670	416.062	-17.460	397.932	-17.400	397.992	-15.950	399.442	-12.190	403.202						
80	414.462	21.18	393.282	19.35	395.112	19.810	0.600	415.062	-19.210	395.252	-19.150	395.312	-17.780	396.682	-12.190	402.272						
81	415.443	20.72	394.723	17.83	397.613	21.240	0.730	416.173	-20.510	394.933	-17.890	397.553	-16.480	398.963	-13.720	401.723						
82	418.896	20.42	398.476	19.20	399.696	19.810	0.620	419.516	-19.190	399.706	-19.130	399.766	-17.690	401.206	-16.150	402.746	-16.150	402.746	-15.770	403.126		
83A	416.608	17.68	398.928	15.54	401.068	18.480	0.590	417.198	-17.890	398.718	-15.730	400.878	-14.120	402.488	-12.190	404.418						
83B	416.574	5.26	411.314			6.100	0.860	417.434	-5.240	411.334	-5.170	411.404	-4.530	412.044	-4.400	412.174	-4.400	412.174	0.000	416.574		
85	417.446	4.57	412.876			5.330	0.790	418.236	-4.540	412.906	-4.480	412.966	-1.640	415.806	-1.210	416.236	-1.210	416.236	0.000	417.446		
86	418.936	7.62	411.316			6.860	0.720	419.656	-6.140	412.796	-6.080	412.856	-4.710	414.226	-4.270	414.666	-4.270	414.666	-2.740	416.196	0.610	419.546
87	417.334	1.52	415.814			2.230	0.770	418.104	-1.460	415.874	-1.400	415.934	-0.820	416.514	-0.610	416.724	-0.610	416.724	0.000	417.334		
88	416.776	4.57	412.206			4.570	0.910	417.686	-3.660	413.116	-3.600	413.176	-2.150	414.626	-0.910	415.866	-0.910	415.866	0.000	416.776		
89	416.482	4.57	411.912			4.570	0.900	417.382	-3.670	412.812	-3.610	412.872	-2.170	414.312	-1.830	414.652	-1.830	414.652	0.000	416.482		
90	416.397	2.11	414.287			2.915	0.810	417.207	-2.105	414.292	-2.045	414.352	-1.385	415.012	-1.210	415.187	-1.210	415.187	0.000	416.397		

ELLETS			BENTONITE GROUT				REMARKS
M (m)	TOP (m)		BOTTOM (m)		TOP (m)		
Elevation	measured	Elevation	measured	Elevation	measured	Elevation	
408.534	-5.330	412.344					Pellets bridged @ -9.14m.Also pellets from: -4.27m to surface
411.592	-5.490	412.202					Sand fron: -8.08 to -6.10 & -5.49 to -3.66m;Also pellets from -3.66m to surface
			-9.750	406.791	0.000	416.541	After placing 122cm of pellets on sandpack, pellets bridged @ -11.12m
411.537	-5.110	412.217					Sand fron: -9.35 to -5.79 & -5.11 to -3.07m;Also pellets from -3.07m to surface
416.853	0.000	417.463					Cuttings from -3.05 to -0.61 m
414.662	0.000	415.572					
414.705	0.000	415.615					
415.949	0.000	417.169					
414.810	0.000	416.030					
416.750	0.000	418.580	-5.790	412.790	-1.830	416.750	pellets bridged @ - 5.79m after 61cm placed on sandpack
			-7.520		0.000		
			-3.670		0.000		
413.676	0.000	416.726					
408.180	-6.895	408.490					Also pellets from: -2.785 to -0.495m
409.269	0.000	414.769	-9.610	405.159	-5.500	409.269	
			-17.200	400.665	0.000	417.865	Sand from: - 17.60 to -17.20m
415.353	-1.215	416.573					Sand from: - 3.51 to -2.43m; cuttings from: -1.21m to surface
414.257	0.000	414.557					Cuttings from: -2.58 to -0.30m
			-18.285	402.141	0.000	420.426	Pellets bridged @ -18.285m after 76cm placed on sandpack
			-12.190	408.252	0.000	420.442	
			-12.190	403.202	0.000	415.392	NOTE: natural pack to -12.19 m
			-12.190	402.272	0.000	414.462	NOTE: natural pack to -12.19 m
			-13.720	401.723	0.000	415.443	NOTE: natural pack to -13.72 m
			-9.750	409.146	0.000	418.896	Pellets bridged @ -9.75m after 38cm placed on sandpack
			-12.190	404.418	0.000	416.608	NOTE: natural pack to -12.19 m
419.546	0.000	418.936					Sand from: -2.74 to - 0.61m

TEST-HOLE No	GROUND ELEVATION (m)	TOTAL DEPTH TESTHOLE (m)		BEDROCK SURFACE (m)	
		measured	Elevation	measured	Elevation
TH1	416.195	4.57	411.625	3.50	412.695
TH2	417.515	4.57	412.945		
TH3	417.026	4.57	412.456		
TH4	416.546	6.55	409.996	6.55	409.996
TH5	417.629	3.66	413.969		
TH6	417.849	4.57	413.279		
TH7	417.411	4.57	412.841		
TH8	417.419	4.57	412.849		
TH9	417.642	4.57	413.072		