Waste Rock Pile and Tailings Covers for the Anvil Range Mining Complex

Projects 16(a) & 18(b)

Faro, Yukon, Canada

- DRAFT -

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DRAFT for REVIEW

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Table of Contents

List of Tables

List of Photos

List of Figures

List of Appendices

1 Introduction and Scope of Report

1.1 General Project Background

The Anvil Range Mining Complex (ARMC) – Integrated Comprehensive Abandonment and Reclamation Plan (ICAP) (RGC, 1996) presents the existing closure plan for the site, which is currently being revisited by SRK Consulting (SRK) under contract to Deloitte & Touche Inc., who is the Court appointed Interim Receiver for Anvil Range Mining Corporation who owned and operated the ARMC. This work is carried out as Project 19 – "Develop Faro/Grum/Vangorda Mine Area and Tailings Closure Alternatives". The ARMC consist of two mining areas; the Faro pit, and the Vangorda plateau, which in turn consist of the Grum and Vangorda pits. A general location map of the ARMC is presented in Figure 1.

One component of "Project 19" is the remediation of the 196 ha Rose Creek tailings impoundment at the Faro mine site, and the conglomerate of waste rock piles at the Faro (335 ha) and Vangorda plateau (59 ha Vangorda, and 148 ha Grum waste rock piles) sites. Some site conditions have changed since the development of the ICAP, and therefore no final site specific closure objectives have been set for these waste facilities in the development of the current closure plan.

The ICAP stated that the major concerns with the Rose Creek tailings impoundment was geochemical (related to meteoric water passing through the tailings mass), physical stability of the impoundment dam walls and overall erosion stability of the impoundment under extreme flood conditions for Rose Creek. The recommended closure alternative in the ICAP for the Rose Creek tailings impoundment was relocating most of the tailings to the Faro pit, and establishing a 3 m water cover over the remaining tailings. Tailings would be relocated from all three the impoundments (Original, Second and Intermediate) to bring the surface low enough such that with the intended 3 m water cover, the Intermediate dam would not have to be raised.

One alternative that was considered at the time the ICAP was prepared entailed not relocating any tailings to the Faro pit, but to establish a water cover over the tailings in the Intermediate impoundment and a composite soil cover (with a saturated layer) placed on the Original and Second impoundments. This alternative was not selected at the time, since it was believed that it could not achieve the closure goals set at the time within realistic costs. Specifically it was felt that the effectiveness of a saturated soil cover could not be demonstrated, and as a result adequate oxygen control could not be guaranteed.

The ICAP study identified geochemical concerns related to the predicted chemistry of drainage from the ARMC waste rock piles as the most significant closure issue. Therefore the primary closure objectives were to control surface drainage, and minimize infiltration. It was however felt that due to the lack of available low permeability cover soils and the cost of placing such a cover system that covering the Faro waste rock piles would not be practical. The closure plan for these waste rock piles therefore called for ensuring that surface drainage from the piles are contained, and treated. Also, it was felt that a minimum of surface re-contouring should be done, since pile stability is not really a concern, and re-contouring would expose fresh un-oxidized material, which could increase contaminant loads through surface drainage if these surfaces are allowed to oxidize. Under this scenario, infiltration would be minimized by ensuring that ponding is not allowed.

The Vangorda waste rock pile closure plan documented in the ICAP differs from the approach recommended at Faro. The plan which remained essentially unchanged from the original 1989 Water Licence Application calls for re-sloping of the waste rock pile to 2.5H:1V to allow for the placement of a 1 m thick compacted till cover. The final till cover would be re-vegetated as an erosion control measure, and all the remaining seepage would be collected and treated. This closure approach was also recommended for the Grum waste rock pile.

The ICAP study clearly identified the need to isolate the ARMC waste facilities to some extent due to the geochemical concerns associated with them. Soil covers was recommended as a possible solution for achieving such isolation, however there are differing opinions as to how effective soil covers would be. This project is intended to illustrate on a conceptual level, what could be achieved with soil covers at the ARMC. This study is not intended to present a cover solution, but rather illustrate what the issues are that are associated with placing soil covers on the ARMC waste facilities, and what the likely benefits and/or complications of such an action would be.

1.2 Primary ARMC Waste Issues

The ICAP study clearly demonstrated that the waste at the ARMC is not geochemically benign, and therefore appropriate closure protection measures need to be adopted. The primary geochemical issues are acid mine drainage associated with the sulphides in the host rock and associated leachable metals, particularly zinc. Acid generation is a natural process which takes place when the sulphide rich host rock is allowed to oxidize. For the oxidation to take place, there must be sufficient oxygen and water, and if the ambient temperature is conducive, acid generation will further be enhanced through bacteriological action. In order to control acid generation it is necessary to remove some or all of these components, and one way of doing this is to cover the waste.

Covers for the control of acid generation, can be categorized into three broad groups: (1) covers that prevent acid generation in the first place, (2) covers that prevent the physical migration of acidic leachate once it is generated, and (3) covers that neutralize acid and remove contaminants after they are produced. Covers can only prevent acid generation, if oxidation has not yet started, and it has been shown that water covers are the most effective in achieving this. Essentially these covers are oxygen barriers. Covers that prevent physical migration of acidic leachate are probably the most common, since they are applicable when acid generation has already started. These covers usually consist of infiltration barriers, in the form of physical covers. Neutralizing covers rest on the principle of introducing some foreign substance that would alter the chemistry of water infiltrating the waste and thus positively impact the leachate.

The Rose Creek tailings have been shown to have undergone significant surface oxidation, and therefore an oxygen barrier cover would not be useful. The primary objective of a cover for the Rose Creek tailings with respect to the geochemical issues would therefore be to minimize the mobilization of contaminants through infiltration control. Similarly, the ARMC waste rock piles have been oxidizing, and thus the use of oxygen barrier covers may not be the most appropriate. If however substantial re-handling of either tailings and/or waste rock is considered (including both relocation and re-contouring), it is conceivable that un-oxidized waste may appear on the final upper surface, and under such circumstances, it may be prudent to try and prevent further oxidation with the cover, in combination with limiting the infiltration which would mobilize contaminants within the oxidised waste.

Over and above these considerations, covers may be used on the waste rock piles to stabilize the surface against wind and water erosion, and to provide a stable growth media for re-vegetation. This in turn, may render the surface safe for access by wild animals (provided the vegetation is not subject to metal uptake).

1.3 Report Layout

The next section of this report presents a brief summary of the most basic cover concepts, and is intended to demonstrate some of the basic underlying principles when considering making use of covers as final closure tools. This section is certainly not an exhaustive description of cover theory, but rather presents the broad framework within which potential use of covers at the ARMC should be evaluated.

Section 3 of this report presents a summary of historic work that has been done at the ARMC with respect to covers. This information presents some of the best factual and anecdotal information with respect to cover performance at the site, which cannot be overlooked.

The success of any soil cover system depends on the type and availability of cover materials. Section 4 documents the characterization of potential cover materials at the ARMC based on detailed laboratory testing. This testing includes some tailings and waste rock testing as well. In our opinion material characterization using laboratory testing alone, is not sufficient, and Section 5 presents the results of in-situ material characterization carried out at the ARMC.

Section 6 provides a brief discussion about some of the cover constructability issues that will have to be faced at the ARMC. These issues include cover material availability, re-contouring requirements, vegetation sustainability, frost susceptibility and possible evaporite development.

The results of a scoping level numerical modeling program to evaluate potential cover effectiveness are presented in Section 7 of this report. This modeling is not fully calibrated, but is rather intended to illustrate what the likely performance criteria would be by placing covers at the ARMC, using the available materials.

The final section of this report documents some conclusions and recommendations with respect to making use of covers at the ARMC.

2 Basic Cover Concepts

2.1 Cover Objectives

Upon mine closure, current best management practice requires the placement of a cover onto most types of mine waste including tailings and waste rock piles. The objectives of these cover systems should be site specific, but generally include; (1) dust and erosion control, (2) chemical stabilization of acid forming waste (through control of oxygen ingress), (3) containment release control (through control of infiltration, or radiation), (4) provision of a growth medium for establishment of sustainable vegetation, and (5) providing access to wildlife and general aesthetics.

Cover objectives should not be arbitrarily chosen, before considering the overall site closure plan. For example, on a particular site, the waste may be contributing towards the site wide waste load, and therefore the logical conclusion might be that a low infiltration cover is required. However, the waste facility may only be contributing a small amount of the total waste load for the site, and to deal with all the rest, a water treatment plant may be required. Under such circumstances, the cover objective may be less stringent, since the treatment cost may be less than covering the waste with very little added benefit.

2.2 Cover Types

A successful cover design will achieve it's specific objectives by taking into account the site specific conditions that are impacting on the cover, i.e. climate, waste type, cover material availability, topography etc. Even though materials used to construct cover systems are never the same at different sites, there are five basic types of covers systems that are implemented; (1) water covers, "low permeability" covers, (3) capillary barrier covers, (4) store-and-release covers, and (5) reactive covers.

2.2.1 Water Covers

Water covers involve submerging the waste under water, typically by flooding a tailings impoundment or relocating the tailings/waste rock to an alternative storage basin, usually an open pit. The water cover significantly reduces the potential for oxygen to move into the tailings, providing protection against future oxidation of the mine waste. Water covers have often been used in Canada, and are best suited to climates where the climatic water balance is net positive (i.e. annual precipitation exceeds evaporation/evapotranspiration). Potentially there may however be problems with physical stability of the storage facility (i.e. tailings dams which were not designed as water retaining structures). Furthermore seepage from these facilities are usually increased due to the increased head, and if the seepage water quality is poor, then increased seepage means increased waste load.

Water covers work best if the waste management plan was designed from the outset, considering a water cover, and furthermore if the waste deposition was subaqueous. This has the advantage that stability issues are not a consideration, since the system ahs been designed accordingly, and no oxidation takes place, therefore limiting the potential for poor quality water.

Based on the diffusion coefficient of oxygen through water, it is accepted that under perfect conditions a minimum water cover of 1 m would be sufficient to prevent oxidation. In reality, since waste disposal facilities are large in size, wind induced wave action, and lake ice formation causes turbulence in the water which results in re-suspension of particles (typically fines, like those found in tailings impoundments), which in turn could result in poor quality surface water discharge through permanent spillways etc. To overcome this problem, water covers are generally designed such that there is always a clear column of water at the surface, which in many cases results in water covers between 3 and 5 m thick.

This type of cover has been suggested for the Rose Creek tailings, however the large elevation differences between the dams, requires either that some dams be raised substantially to completely flood the tailings, or that some tailings be relocated to allow smaller dams. Furthermore, the dams have not been designed as water retaining structures, and as a result, they may be unstable, if they are not upgraded substantially. Since the tailings have already oxidized to some depth, prevention of further oxidation is unlikely to provide much additional long-term geochemical stability. The increased seepage load that would be created by the constant head on the tailings, mobilizing the oxidation products, may make perpetual treatment more costly, than if the poor quality seepage can be minimized through shedding of runoff and limiting infiltration.

The only way the ARMC waste rock can be covered with water, would be to relocate all the waste rock to the three pits and flood them. First order cost estimates was prepared during the Scoping studies for relocating the waste rock to the pits, and due to the shear volumes this remediation alternative does not appear to have sufficient environmental benefit for the cost involved. The exposed waste rock has already underwent significant oxidation, and therefore submerging the rock to prevent further oxidation, may not be that beneficial at this time. Furthermore, the relocation would mobilize large amounts of contaminants, and expose further un-oxidized surfaces, which may increase the site wide load balance. Recent research has also shown that relocation of waste rock piles may not be the best solution.

2.2.2 "Low Permeability" Covers

Conventional infiltration-limiting cover systems rest upon the principle of providing a physical barrier to flow of meteoric water also called a "barrier cover". It typically consists of a low permeability (or low hydraulic conductivity) layer (generally clay or geosynthetic membrane), in combination with a number of other layers. This type of cover system requires protective soil layers to minimise deterioration of the low hydraulic conductivity layer due to desiccation, frost action, erosion, animal burrowing and/or plant rooting. Typically, complex cover systems of several layers and considerable depth (1 to 1.5 m thick) results. If the low hydraulic conductivity layer must also serve as an oxygen barrier then additional constraints apply, e.g. clay layers must remain tension-saturated.

These cover systems can be used in any climate system, provided that the appropriate protection layers are in place, and therefore the thickness of the covers often ultimately becomes the restricting factor. The performance of barrier covers is often quite difficult to measure, and as time progresses their efficiency often deteriorates, leading to a false sense of security. Low permeability covers tend to function best in areas that had a net positive climatic water balance, i.e. the annual precipitation exceeds the evaporation. Under such conditions, the compacted clay layers can remain saturated, and is stressed less through wet/dry cycles.

Although the ARMC experiences a net negative climatic water balance, i.e. annual evaporation exceeds precipitation, low-permeability barrier layer covers may be quite suitable for use on the ARMC waste rock piles. There is a significant amount of low-plasticity till available, which can be compacted to yield low saturated hydraulic conductivities (certainly much lower than the waste rock), and due to its low plasticity does not appear to be overly susceptible to wet/dry and freeze/thaw desiccation cracking. The silty nature of the till does however, allow the material to be quite susceptible to erosion, and as a result consideration may have to be given to providing some form of erosion protection layer.

Although the same reasoning would apply to the Rose Creek tailings impoundment, placing of compacted barrier layers require a stable foundation. The Rose Creek tailings impoundment contains primarily saturated unconsolidated silty-sands, which provides no bearing capacity for placing a compacted cover. This problem can be overcome by placing a cover in the winter when the tailings is frozen, but since sufficient cover cannot be placed to keep the underlying tailings frozen, settlement would occur, when the tailings does start to thaw. Whilst we cannot say with certainty how much settlement would occur, it would likely be substantial, resulting in a hummocky final surface, which will prevent runoff, and as a result increase infiltration. Furthermore, settling of the cover over the tailings, may result in a blended material, which may render the cover less efficient, and thus the initial cover may have to be thicker.

An additional potential problem with placing the fine-grained till cover directly onto the tailings surface, is that evaporates may continue to be wicked up through the cover unhindered, which in turn will contaminate surface runoff.

2.2.3 Capillary Barriers

An alternative method of creating a barrier cover, is to make use of the capillary barrier effect. This effect is created when a fine-textured material layer is placed over a coarse-textured material layer. The capillary barrier results when the underlying coarse material is drained (i.e. is unsaturated), thus possessing a hydraulic conductivity much lower that that of the overlying fine-textured material. The result is a low hydraulic conductivity layer that prevents downward movement of soil moisture from the upper fine-textured layer. This phenomenon ceases when the fine-textured material layer is close to full saturation and the negative pore-water condition at the interface of the two materials is less than the negative pore-water condition at which the hydraulic conductivity function of the two materials cross. In many cases this condition is generally near zero pressure (i.e. full saturation) due to the coarse-textured nature of the underlying material. At this point, the net percolation to the underlying waste will be a function of the saturated hydraulic conductivity of the fine-textured material, which in general is at least one-order of magnitude greater than "typical" compacted barrier layer materials, i.e. “low permeability” covers.

The capillary barrier cover system will therefore significantly reduce net percolation into the underlying mine waste as long as the entire cover profile remains unsaturated. However, it does not prevent the ingress of oxygen to the underlying waste unless provisions are made to maintain the soil moisture content of the overlying fine-textured layer near saturation.

The success of a capillary barrier layer system relies on the contrast between the two layers being used, and therefore the economic use thereof relies on the availability of suitable local materials. Often, it is possible to use the actual contrast between the waste materials and the cover material to use as the capillary break. These covers are best suited to environments where precipitation and evaporation is equally matched, however the thickness of the fine layer must be designed to ensure no seasonal breakthrough.

Capillary barrier covers may be a suitable cover system for the Rose Creek tailings impoundment. Waste rock could be used to provide an interim traffic surface on the tailings, on which a low permeability till cover could be placed. Although the till would provide the primary infiltration control, the contrast between the waste rock and the underlying tailings would provide a break against any upward migration of evaporates.

2.2.4 Store-and-Release Barriers

Store-and-release covers (also referred to as "water storage covers", or "evapotranspiration covers") consist of one or several layers, which are designed to maximise root penetration and soil moisture storage. These covers rely on the moisture retention and storage characteristics of the cover material to "store" infiltration for subsequent removal by evapotranspiration. Storage covers has to be designed in such a way that all incoming infiltration during the “wet” season can be stored within the root zone. Note that the root zone is not limited to the cover layer but may extend into the upper layers of the mine waste. In this case, the cover material would primarily serve as a medium for initiating plant growth and to avoid wind and water erosion of the underlying waste material.

Store-and-release covers are usually best suited to environments where the climatic water balance is net negative, i.e. annual evaporation exceeds infiltration. A limiting factor of this cover type is the thickness of the cover, which often has to be quite substantial to allow sufficient storage capacity of the wet season meteoric water.

The overall climatic water balance at the ARMC is well suited towards constructing store-and-release cover, however due freshet flows, it would be difficult to construct a cover that could “capture” the freshet and release it during the remainder of the summer.

2.2.5 Reactive Covers

Reactive covers normally refer to covers that include chemically active components. Broadly speaking, two types of such reactive covers are referred to; (1) covers where the reaction leads to consumption of oxygen and (2) covers where the reaction leads to formation of low permeability layers and/or barriers to oxygen diffusion.

Oxygen consuming covers can be either organic or inorganic. Organic covers, for example wood waste over an acid generating tailings impoundment have been shown to have good success, however the main complication with these kinds of waste is that they are not sustainable. The organic cover loses its ability to consume oxygen over time, and as a result become ineffective. Organic oxygen consuming covers, can be in the form of materials which has high neutralizing potential, and as a result, balance out the overall seepage waste load as a result of the buffering capacity.

The concept of deliberately placing reactive materials to create low-permeability covers, rest on the principal that two layers are placed in contact, each one being a reagent. Where these layers contact each other, the reactants will meet and combine to form a precipitate that fills the pores.

There does not appear to be any potential cover materials that would make for good reactive cover construction at the ARMC. Material can of course always be imported; however, this may be prohibitively expensive, given the vast areas that require covering.

3 Historic ARMC Cover Design Research

3.1 Introduction

There has been a number of cover/cover related studies carried out over the years at the ARMC. Some of these studies were well planned, executed and documented studies, whilst some were not. We have attempted to review all these studies and summarize the most important results and/or findings of these in this section of the report. Actual long-term cover performance monitoring does remain the only true standard against which to measure the effectiveness of a cover system, and therefore this study would not be complete if we do not make use of the information learned at the site.

3.2 ARMC Tailings Test Covers

Curragh Resources Inc. initiated a program of seven test plots on the Original Rose Creek tailings impoundment in the summer of 1997 and monitored them for five years (SRK, 1986). The purpose of these test plots were to test the effects of various cover types on Faro tailings, specifically their ability to inhibit acid generation in the tailings and reduce the transport rate of leached contaminants through the tailings.

The test facility, illustrated in Photo 1, consisted of six test plots (see Figure 2) and one designated site within the old tailings adjacent to the test plots. Five different cover types were investigated including; (1) shallow water cover, (2) till cover, (3) unsaturated composite cover, (4) saturated composite cover, and an (5) organic cover. The sixth test plot was a control plot of uncovered tailings, and the seventh site was uncovered old (in-situ) tailings. Details of the construction of the test facility, baseline chemical composition of the tailings and annual monitoring results are documented in a number of historic reports.

Photo 1: Tailings cover test facility on the Original impoundment of the Rose Creek tailings.

The test covers were constructed, to evaluate whether a cover could be constructed to limit oxidation of the underlying tailings through exclusion of oxygen, and by reducing bacteriological action by controlling the thermal regime through the cover. The efficiency of the test covers was measured by the covers effect on temperature and oxygen availability within the tailings mass. This in turn was used to determine the effect of the cover on the rate of sulphide oxidation and acid generation within the tailings mass.

Not surprising, the experiment results confirmed that the different covers did affect the oxidation processes of the tailings mass. The tailings in each test plot were shown to be generating acid, however only stage I chemical oxidation of the pyrite was occurring. Pore water chemistry however confirmed that the test plots were oxidizing at different rates.

The cover test program was not entirely successful due to a number of instrumentation failures, and the fact that the test design caused a different thermal regime than in the actual tailings impoundment. Furthermore meteoric water infiltrating through the covers were not measured and this made interpretation of the pore water chemistry difficult. However, it could be deduced that the composite covers were useful in acid prevention and/or migration. A review of the oxidation products indicated that the composite covers showed the greatest degree of oxidation retardation. The second most effective cover appeared to be the organic cover; however this was only in based on temperature control. Based on pore water chemistry the till cover appeared to be more effective than the organic cover. The till cover however had little effect on the temperature regime, therefore its affect on oxidation retardation is prescribed to oxygen control only.

Theoretically two of the most important factors that govern oxidation rates are temperature and oxygen availability. The composite covers were shown to significantly lower the underlying tailings temperature. The same was observed for the organic cover, although much more subdued than for the composite covers. The extent to which oxidation retardation was caused by temperature control as proposed to oxygen diffusion is not known.

Although it could be deducted that the composite covers were effective in reducing the oxidation rate in the underlying tailings, the long term effects could not be determined. After the five year test period, it was recommended that the cover monitoring be extended; however, this was never carried out.

Nicholson et al. (1996) documents the results of a numerical model which was used to estimate the release of zinc and other sulphide oxidation products to the local surface water environment from the Rose Creek tailings impoundment. The purpose of this modeling was to compare the relative differences in the water quality of the Rose Creek resulting from different decommissioning alternatives and the uncertainties within those alternatives.

The composite covers that were identified in the test plot program as the most efficient cover system were estimated to have a diffusion coefficient of 1 x 10^{-8} m^2/s over the long term to provide a minimum of protection from rapid sulphide oxidation. The modeling suggests that a more effective cover with a diffusion coefficient a factor of five lower than this, which resembles flooding of the tailings would be more desirable over the long term.

3.3 Partial Vangorda Waste Rock Pile Cover

When the Vangorda waste rock pile was designed, it was anticipated that it would be closed, by re-sloping to 3H:1V and placing a 3 m thick low permeability till cover, which would act as an infiltration and oxygen barrier. In 1993 SRK was appointed to design a closure cover for the Vangorda waste rock pile. A requirement of the design was that the waste rock pile could be reactivated in the event that mining would continue, and as such the design was not considered the final closure design. The soil cover requirement of 3 m till was however considered excessively onerous, and SRK ultimately designed a 2-layer, 2 m thick till cover. The bottom 1 m till was placed with a high degree of compaction, and the upper 1 m was only loosely compacted. SRK did not conduct any numerical modeling of the cover performance, but since there was not sufficient till to construct a 3 m cover, SRK argued that a 2 m cover would act very similar and any increased infiltration would not be significant. Furthermore, it was felt that this cover would shed most of the meteoric water as runoff. Finally, the re-sloping was done to 2.5H:1V, more as a result of survey errors by the contractor, than the intended design.

The design called for doing a small test section first to evaluate constructability of the cover. This test section would then be used to determine quality control measures for the rest of the project. This test section involved a 100 m wide section of re-sloped waste rock, and 50 m wide of till cover placed over the entire side slope length. Unfortunately, cover construction was halted at that time, and no further work continued.

The original cover design called for the final surface to be vegetated as an erosion protection measure, however due to the construction being halted, this was never done. Furthermore, since construction was halted prematurely, the final surface was not cross-graded perpendicular to the slope, and therefore runoff could flow unimpeded down the entire slope length.

This full scale test cover section has been in place for almost 10 years now. Dr. Maritz Rykaart, P.Eng., and Senior Geotechnical engineer from SRK conducted a visual inspection of the site in July 2003 and concluded that the cover has physically held up exceptionally well. There are numerous erosion gulleys on the cover; however the largest gulleys are less than 200 mm deep, with the majority being between 50 and 100 mm deep (with the exception of the lower section were a sharp slope break occurs). Photos 2 and 3 illustrate some of the gulleying on this cover. The till cover is a low plasticity clayey-silt, which is prone to erosion, and the amount of washed out material in the toe collection drain is evidence of the amount of the erosion that has occurred to date (See Photo 4). The amount of rilling and erosion could possibly have been limited if vegetation had established, and if the final surface was cross-rilled perpendicular to the slope to break the length of the flow path.

Photo 2: Erosion gullies on the 10 year old till cover on the Vangorda waste rock pile, as seen from the crest of the pile.

Photo 3: View of the 10 year old till cover on the Vangorda waste rock pile as seen from the base of the pile.

Photo 4: View of the collection drain at the toe of the till cover. Note the accumulated fines that have been washed off the slope.

There is no evidence of cracking of the cover, either due to freeze/thaw action or natural wetting and drying. Some minor vegetation spots have started to develop on the cover, mostly within the erosion gulleys (Photo 5). The original cover design called for the lower compacted till layer to be 98% Standard Proctor density, and the upper loose layer to be 95% Standard Proctor density. Actual construction quality control records show that both layers were in fact placed at densities between 95 and 100% Standard Proctor density. In-situ density tests by SRK in 2003 confirmed that the cover was in a state resembling 90% Standard Proctor density, which does suggest that natural weathering has taken place. This density state is however consistent with that observed on the Overburden dump, and is therefore likely the natural density state to which this material will revert irrespective of its initial compaction.

In-situ infiltration testing on the cover in September 2003, confirmed that the cover is in fact relatively in tact, and permeabilities of 2.5×10^{-4} to 6.5×10^{-5} cm/s (788 to 205 mm/year) was measured, both at surface and 1 m deep. Simple oxygen lances were installed through the cover by SRK in 2002, and the measured oxygen concentration results suggest that the cover is not acting as an effective oxygen barrier, however, that is most likely due to the cover not being saturated, a fact confirmed by shallow test pitting in the cover in September 2003.

Photo 5: Sparse natural vegetation starting to establish in the erosion gulleys on the 10 year old Vangorda waste rock pile till cover.

Further anecdotal information with respect to the cover performance, is paste pH and conductivity testing in the cover that was carried out in 2003. These results did not suggest any uptake contamination from the underlying waste rock, which could imply that there is no upward flux through the cover.

Although there is no firm data to support the how the cover is performing, it does appear reasonable, to suggest that the 2 m till cover is likely acting as an effective infiltration barrier, although it does not necessary act as an efficient oxygen barrier. Considering the fact that the permeability is between 788 and 205 mm/year, and the average annual precipitation at the site is 387 mm/year, and that the till profile appears to be unsaturated, it is likely that the till cover is performing as a store-and-release cover. Perhaps more importantly, the cover appears to have held up very well to weathering over the past 10 years.

3.4 Vangorda Waste Rock Pile Starter Berm

The Vangorda waste rock pile has a compacted till started dyke, with 2H:1V exposed side slopes. These till dykes have been constructed with similar till as that used for the Vangorda cover test section, and the remainder of till available on site for future cover construction. The performance of this started dyke with respect to resistance to long-term weathering and erosion has been exceptional, suggesting that the material would be a suitable cover material. This is further supported by the state of the Overburden dump, which consist primarily of till salvaged from the Grum pit development. This dump, which is at angle of repose, does not show excessive erosion problems, and there are substantial signs of natural vegetation establishing, which suggest that with some assistance the material may carry vegetation. These slopes are illustrated on Photo 6.

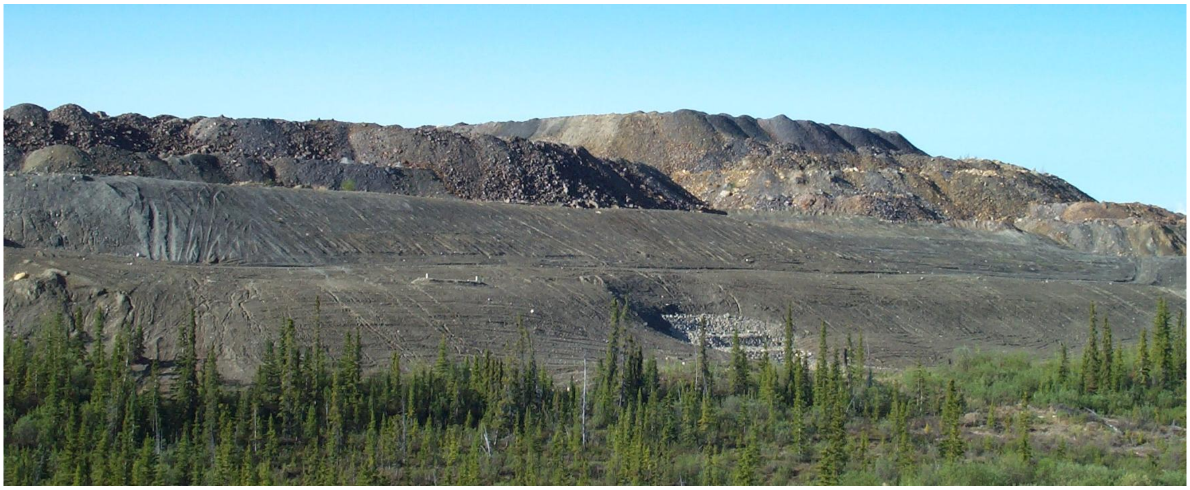

Photo 6: View of the Vangorda waste rock pile starter berm, which has been constructed from the same till that is available as a potential cover material.

3.5 Overburden Dump Re-sloping & Vegetation Trial

Curragh Resources did some experimenting with the Overburden dump till, to see what the materials ability would be for re-vegetation. They re-sloped a 200 m wide section of the dump to approximately 3H:1V and seeded the slope. No formal records exist of how and when this was done, however, the current condition of these slopes suggests, that vegetation could be successfully established on the till. This slope is illustrated in Photo 7.

There are substantial erosion rill present on the slope, again indicating the high erosion potential of the till material. It would however appear as if the final grading on the slope was not perpendicular to the slope thus creating preferential flow paths. This could be avoided in final cover construction.

Photo 7: View of re-sloped and re-vegetated slope on the Overburden dump. Note the abrupt edge of the vegetation, confirming that without active seeding, natural re-vegetation potential is low.

3.6 Summary of Historical Information

There has been a fair amount of work done at the ARMC which have relevance when evaluating the potential use of soil covers for covering the waste facilities. This work has varied from the formal test cover program on the Rose Creek tailings impoundment, to ad-hoc construction, anecdotal information and visual observations. The most relevant findings can be summarized as follows:

- Although the Rose Creek test cover program was not entirely conclusive, the results did suggest that the composite covers were the most effective in slowing down the oxidation rate to the underlying tailings – this was however only based on temperature control.

- As far, as pore water chemistry was concerned, the till cover appeared to function the best, however this cover did nothing to control the temperature regime.

- From the tests cover program, it could be deduced that the composite covers were the most effective in reducing the oxidation rate to the underlying tailings, the long-term effects could not be determined, especially since no measurements of meteoric and drainage fluxes were made at the site.

- Follow-up work by Nicholson et al. (1996) suggested that although the composite covers used in the test cover program, were deemed to be successful, a more effective long-term cover would have to have a diffusion coefficient which equals that resembled by a water cover.

- The 10-year old, 2 m thick till cover test section on the Vangorda waste rock pile suggest that the till is performing well as a final cover. Although it is rilled through water erosion, damage through freeze/thaw and wetting/drying cycles seems limited. Limited oxygen measurements beneath the cover suggest that the cover is not a good oxygen barrier, and this fact was confirmed by test-pitting which confirmed that the till cover profile was almost complete dry. Permeability and density tests, however, confirmed that the saturated permeability of the cover is between 2.5×10^{-4} to 6.5×10^{-5} cm/s, even though the density has reduced to approximately 90% Standard Proctor, as opposed to the constructed density which exceeded 95% Standard Proctor. Vegetation was never established on the cover, and natural re-vegetation has not occurred in 10 years, suggesting that some initial amendment would be required.

- A re-vegetation trial on the Overburden dump, confirmed that with some initial involvement, vegetation can be established, and sustained on the till covers. There is however no details on what the program involved.

4 Cover Materials (Source & Testing)

4.1 Introduction

A soil cover design, which would achieve a specific objective for a given site, would be quite simple if no consideration had to be given to what potential cover material would be economically and environmentally viable. The challenge lies in matching the cover design objectives with the available materials, and coming up with a design that would work in synergy. This section describes the properties of all potential cover materials at the ARMC.

4.2 Borrow Sources (Haul Distances)

SRK conducted a borrow source investigation in 2003 (SRK, 2003) to explore various potential borrow areas in the vicinity of the ARMC for use as cover materials and erosion protection. The investigation included a compilation of existing geological information for the site which was used to select locations for excavating 60 shallow test pits, which were profiled and selectively sampled for basic geotechnical testing (grain size and plasticity).

The borrow source investigation identified four primary sources of material; silts and medium plasticity clays (present in the form of till deposits), silty sands to sandy gravels (present in the glaciofluvial deposits), coarse-grained rock (for use as rip-rap), and organics. These borrow sites are scattered throughout the mine site, as illustrated on Figures 3 and 4, and the economical use of these borrow sources as potential cover materials would be dependant of the haul distances to the waste facilities.

For the purpose of this study, haul distances between the waste facilities and the borrow sources were calculated using the latest site mapping (2003 aerial photography). These haul distances are summarized in Table 1 and are based on the maximum distance between the most likely development area of each borrow site and the center of the waste facility as measured along the existing network of roads on the site.

Table 1: Summary of potential cover material volumes & haul distances

Material Type	Source (Location)	Estimated Volume (Million m^3)	Calculated Maximum Haul Distance (km)			
			Rose Creek Tailings	Faro Waste Rock Pile	Grum Waste Rock Pile	Vangorda Waste Rock Pile
Till	Grum overburden dump	8.00	18.9	18.1	3.8	4.9
	Vangorda overburden dump	0.40	19.6	18.8	4.5	2.9
	Haul road	0.72	5.6	4.7	12.3	14.8
	Rose Creek haul road	0.80	5.7	10.5	19.4	21.9
	Faro tailings	1.70	4.7	9.5	18.4	20.9
Galcio-fluvial	Haul road	0.15	5.6	4.7	12.3	14.8
	Moose pond	0.45	18.7	17.9	3.6	2.9
	Grum creek	0.20	18.7	17.9	3.6	2.8
	Vangorda/Grum back road	0.10	19.8	19.0	4.7	4.2
	Upper Vangorda creek	0.50	20.4	19.6	5.3	4.3
	Rose creek	1.40	6.7	11.4	20.4	22.8
Organics	East of Vangorda dump	0.075–0.15	20.4	19.6	5.3	4.3
	Faro west	0.05–0.075	6.0	10.8	19.7	22.2

The borrow source investigation estimated the volume of potential cover materials primarily based on the aerial extent of the deposits. The depth of the deposits was estimated based on local anecdotal knowledge of the area as opposed to actual deep drilling results. Based on these estimates, there is approximately 11.62 million cubic meters of till material, 2.8 million cubic meters of glaciofluvial material and between 0.125 to 0.225 million cubic meters of organics.

4.3 Laboratory Testing Program

4.3.1 Introduction

The evaluation of the effectiveness of a soil cover rests on a detailed assessment of the unsaturated geotechnical properties of the waste and potential cover material. Representative samples of the waste and potential cover materials were collected by SRK in June 2003, specifically for testing of these properties. This section presents the detailed results of this testing program.

4.3.2 Sample Collection, Shipping & Testing Requirements

Field samples were collected for laboratory testing by Dr. Maritz Rykaart, P.Eng. a Senior Geotechnical Engineer from SRK Vancouver, on June 10 and 11, 2003. Eight samples were collected with one sample each of the tailings (beach tailings from the Original impoundment) and waste rock (re-handled waste rock from the re-contoured slopes on the Vangorda waste rock pile), two samples containing glaciofluvial deposits, and the remaining four were till samples. The sample locations were identified in the field using a hand-held GPS, and Table 2 lists the complete information regarding each sample. The sample locations are marked on Figures 5 and 6, and Photos 8 through 15 illustrate what the sample location looked like.

Table 2: Details of waste and potential cover samples collected in June 2003

Sample No.	GPS Coordinate[1]		Sample Type (classified for general identification)
	Easting (m)	Northing (m)	
SRK-03-C01	593,781	6,902,291	Till
SRK-03-C02	593,017	6,904,626	Till
SRK-03-C03	584,776	6,912,652	Glaciofluvial
SRK-03-C04	581,020	6,914,323	Till
SRK-03-C05	579,171	6,915,071	Glaciofluvial
SRK-03-C06	580,257	6,914,564	Till
SRK-03-C07	583,228	6,912,905	Tailings
SRK-03-C08	593,749	6,902,441	Waste Rock

1. Coordinates based on hand-held GPS readings using UTM NAD 27 in zone 8V.

Photo 8: SRK-03-C01, till sample from the Vangorda waste rock pile cover. The sample excluded material that exceeded 50 mm (2”) in size.

Photo 9: SRK-03-C02, till sample from the top of the Overburden dump. The sample excluded material that exceeded 50 mm (2") in size.

Photo 10: SRK-03-C03, glaciofluvial sample from north fork haul road borrow area. The sample excluded material that exceeded 50 mm (2") in size.

Photo 11: SRK-03-C04, till sample from Rose Creek haul road borrow area. The sample excluded material that exceeded 50 mm (2”) in size.

Photo 12: SRK-03-05, glaciofluvial sample from Rose Creek west pit borrow area. The sample excluded material that exceeded 50 mm (2”) in size.

Photo 13: SRK-03-C06, till sample from road cut opposite main Rose Creek tailings dam. The sample excluded material that exceeded 50 mm (2”) in size.

Photo 14: SRK-03-C07, surface beach tailings from the Original impoundment at Rose Creek tailings.

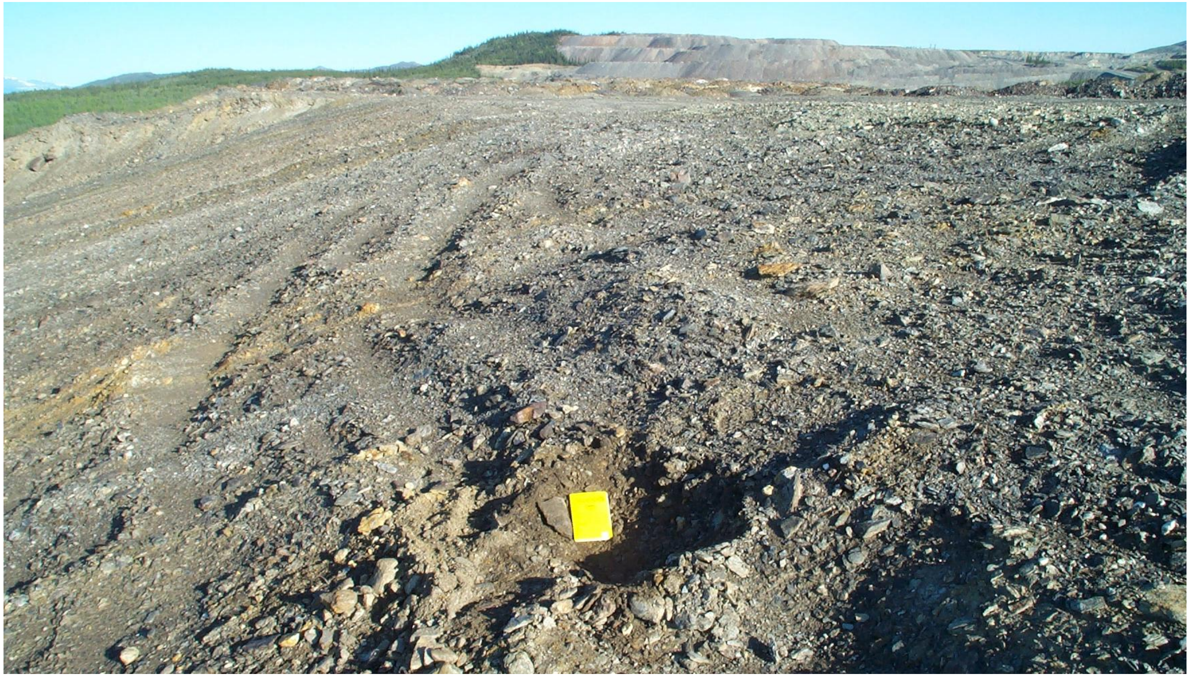

Photo 15: SRK-03-C08, re-handled waste rock from Vangorda waste rock pile. The sample excluded material that exceeded 50 mm (2") in size.

Samples SRK-03-C01 through SRK-03-C06 was collected in four Ziploc bags (each weighing approximately 5 kg), and samples SRK-03-C07 and SRK-03-C08 was collected in two standard soil sample bags (each weighing approximately 10 kg). Each set of sample bags was then placed in individual plastic 5-gallon pails for shipping to the laboratory. All samples were from shallow hand-dug test pits, using a shovel, as shown in Photos 8 through 15.

The samples were transported by road from the ARMC to Whitehorse on June 11, 2003. From here they were road shipped by a commercial freight company to MDH Engineered Solutions Corp. (MDH) in Saskatoon. MDH confirmed arrival of the samples at their laboratory on June 18, 2003. At the time of testing, this was the only laboratory in Canada that could carry out the specialized unsaturated soils testing that was required.

SRK specified a list of tests that MDH was to carry out on the collected samples. This list is presented in Table 3 below. The complete laboratory results were presented to SRK on October 31, 2003 in the form of a Laboratory Testing Report (MDH, 2003) attached as Appendix A. The results of the materials property testing is summarized in the following sections.

Table 3: List of laboratory testing carried out by MDH

Sample No.	Atterberg Limits	Specific Gravity[1]	Grain size	Standard Proctor	SWCC[2]	Consolidation	Hydraulic Conductivity
SRK-03-C01	Yes	<#4 #4 – 3/8” 3/8” – 2”	Sieve & Hydrometer	4-inch mould	300 mm & 64 mm	No test	Falling head
SRK-03-C02	Yes	<#4 #4 – 3/8” 3/8” – 2”	Sieve & Hydrometer	4-inch mould	64 mm	No test	Falling head
SRK-03-C03	Yes	<#4 #4 – 3/8”	Sieve & Hydrometer	6-inch mould	300 mm & 64 mm	No test	Constant head
SRK-03-C04	Yes	<#4 #4 – 3/8”	Sieve & Hydrometer	4-inch mould	64 mm	No test	Falling head
SRK-03-C05	Yes	<#4 #4 – 3/8”	Sieve & Hydrometer	4-inch mould	64 mm	No test	Falling head & Constant head
SRK-03-C06	Yes	<#4 #4 – 3/8”	Sieve & Hydrometer	4-inch mould	64 mm	No test	Falling head
SRK-03-C07	Yes	<#4 #4 – 3/8”	Sieve & Hydrometer	No test	64 mm	Yes	Falling head
SRK-03-C08	Yes	<#4 #4 – 3/8”	Sieve & Hydrometer	No test	300 mm	No test	Constant head

1. Specific gravity testing was carried out using the different size fractions noted here.
2. Soil Water Characteristic Curves (SWCC).

4.3.3 Atterberg Limits

Atterberg limits tests were attempted on all eight samples. According to the Unified Soil Classification System (UCS), based on plasticity alone, three of the till samples were classified as inorganic clays of low to medium plasticity (CL). The remaining five samples, including one till sample, two glaciofluvial and one each tailings and waste rock samples was all classified as being non-plastic. The complete Atterberg limits results are presented in Table 4.

Table 4: Summary of Atterberg limits results

Sample No.	Material Type	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
SRK-03-C01	Till	23.0	14.5	8.5
SRK-03-C02	Till	23.8	13.9	9.9
SRK-03-C04	Till	19.4	16.8	2.6
SRK-03-C06	Till	Non-plastic		
SRK-03-C03	Glaciofluvial	Non-plastic		
SRK-03-C05	Glaciofluvial	Non-plastic		
SRK-03-C07	Tailings	Non-plastic		
SRK-03-C08	Waste Rock	Non-plastic		

4.3.4 Specific Gravity

Specific gravity tests were conducted on each sample using three size fractions. The till and glaciofluvial samples measured consistent values of between 2.68 and 2.73, with no significant variance between different size fractions. This value is typical of normal silica material. The waste rock measured a specific gravity of between 2.85 and 2.88, and again the difference between the size fractions was not significant. The slightly higher specific gravity is representative of the sulphides present in the waste rock. The finer fraction of the tailings had a measured value of 3.46, which is consistent with sulphide tailings. The complete results are summarized in Table 5.

Table 5: Summary of specific gravity results

Sample No.	Material Type	<#4 Sieve (4.75 mm)	#4 Sieve – 3/8”	3/8” – 2”
SRK-03-C01	Till	2.70	2.73	2.72
SRK-03-C02	Till	2.69	2.68	2.72
SRK-03-C04	Till	2.69	2.71	No test
SRK-03-C06	Till	2.68	2.70	No test
SRK-03-C03	Glaciofluvial	2.68	2.70	No test
SRK-03-C05	Glaciofluvial	2.68	2.70	No test
SRK-03-C07	Tailings	3.46	No test	No test
SRK-03-C08	Waste Rock	2.88	2.85	No test

4.3.5 Particle-Size Analysis

Particle-size analysis was carried out on all eight samples, and included both sieve and hydrometer testing, to measure the full envelope of the fines. Table 6 list the major size fractions of each sample, and the final UCS designation assigned to each sample (inclusive of the limits results). Figure 7 presents a summary of all these curves.

It should be noted that the sampling of till, glaciofluvial and waste rock was specifically biased to select materials smaller than 50 mm (2”). This bias when sampling the till material should not significantly affect the representativeness of the data, since the overriding majority of this material is less than 4.75 mm in size. The glaciofluvial results may be less representative, since there are clearly significant amounts of cobbles and boulders in these deposits. These cobbles and boulders can however be easily screened, and it is likely that the materials represented by the testing would be a material that could practically be manufactured. Photos 16, 17 and 18 illustrates the heterogeneity of the till and glaciofluvial material.

Photo 16: A typical exposed till slope. Note the well-rounded cobles and boulders contained in the soil matrix, which is not included in the laboratory sampling and testing.

Photo 17: The first of two typical exposed glaciofluvial deposits. In these deposits, there are horizontal boulder layers present, which can be easily screened out.

Photo 18: The second of two typical exposed glaciofluvial deposits. In these deposits, there are much less cobbles and boulders, and when present they are mixed throughout the matrix.

A visual inspection of the waste rock piles would lead one to conclude that the waste rock sample tested during this study would not be representative (Photo 19). Whilst this may be true, we specifically selected a sample on the re-sloped Vangorda waste rock pile for testing. If soil covers are to be used, it is a reasonable assumption that waste rock surfaces must be re-sloped. Re-sloping of these highly weathered waste rock piles, would result in the finer material represented by the testing. Furthermore, the amount of cobbles and boulders that are present after such grading and weathering, will remain in the matrix, but is less likely to dominate flow.

Photo 19: The waste rock can be anything from clay size particles to boulders.

Table 6: Summary of grain-size distribution results

Sample No.	Material Type	Gravel Content (>4.75 mm) (%)	Sand Content (0.075 mm - 4.75 mm) (%)	Fines Content (<0.075 mm) (%)	UCS
SRK-03-C01	Till	16	34	50	CL (sandy-clay)
SRK-03-C02	Till	16	37	47	SC (clayey-sand)
SRK-03-C04	Till	19	43	38	SC (clayey-sand)
SRK-03-C06	Till	0	71	29	SM (silty-sand)
SRK-03-C03	Glaciofluvial	40	60	0	GP (poorly graded gravel-sand mixture)
SRK-03-C05	Glaciofluvial	16	78	6	GP (poorly graded gravel-sand mixture)
SRK-03-C07	Tailings	0	70	30	SM (silty-sand)
SRK-03-C08	Waste Rock	49	39	12	GW (well graded gravel-sand mixture)

4.3.6 Standard Proctor Compaction Test

The potential cover materials were subjected to Standard Proctor compaction testing. The results of these tests are summarized in Table 7 below.

Table 7: Summary of Standard Proctor compaction test results

Sample No.	Material Type	Maximum Dry Density (kg/m^3)	Optimum Water Content (%)
SRK-03-C01	Till	2,072	9.9
SRK-03-C02	Till	2,045	10.0
SRK-03-C04	Till	2,120	7.4
SRK-03-C06	Till	2,087	8.4
SRK-03-C03	Glaciofluvial	2,195	6.9
SRK-03-C05	Glaciofluvial	2,065	8.5

4.3.7 Consolidation Test

A consolidation test was performed on the tailings sample (SRK-03-C07). The results of this test are summarized in Table 8. The sample was slurried into the consolidation ring and the initial moisture content was 19.2% for an initial dry density of 2,391 kg/m^3, at a void ratio of 0.44.

Table 8: Summary of consolidation test results

Pressure (kPa)	Void Ratio	Coefficient of Consolidation, c_v (cm^2/s)
13.9	0.44	3.39×10^{-5}
29.3	0.44	1.34×10^{-4}
64.2	0.44	2.25×10^{-5}
131.9	0.43	3.21×10^{-5}
267.6	0.42	5.69×10^{-5}
607.8	0.40	1.11×10^{-4}
1204.7	0.38	7.07×10^{-5}
2426.5	0.36	8.59×10^{-5}
4866.6	0.32	4.35×10^{-5}

4.3.8 Saturated Hydraulic Conductivity Test

Falling head and constant head hydraulic conductivity tests was conducted on select samples. Sample SRK-03-05 was subjected to both a falling head and constant head test for quality assurance purposes. The complete hydraulic conductivity results are summarized in Table 9. All samples were prepared to 95% Standard Proctor density.

Table 9: Summary of laboratory hydraulic conductivity tests

Sample No.	Material Type	Test Type	Water content (%)	Dry Density (kg/m^3)	Hydraulic Conductivity (cm/s)
SRK-03-C01	Till	Falling Head	15.9	1,966	1.28×10^{-7}
SRK-03-C02	Till	Falling Head	14.8	1,932	1.09×10^{-7}
SRK-03-C04	Till	Falling Head	14.2	2,025	3.25×10^{-6}
SRK-03-C06	Till	Falling Head	14.8	1,967	2.48×10^{-6}
SRK-03-C03	Glaciofluvial	Constant Head	8.0	2,095	1.13×10^{-3}
SRK-03-C05	Glaciofluvial	Falling Head	-	2,011	3.81×10^{-5}
SRK-03-C05	Glaciofluvial	Constant Head	10.0	2,019	4.98×10^{-5}
SRK-03-C07	Tailings	Falling Head	15.4	2,676	1.16×10^{-5}
SRK-03-C08	Waste Rock	Constant Head	8.0	1,852	5.11×10^{-3}

4.3.9 Soil-Water Characteristic Curve Test

Soil water characteristic curve (SWCC) tests were carried out on all the samples using the pressure plate technique for the suction range below 1,500 kPa and the vapour extraction technique for suctions higher than this. Two samples; one till and one glaciofluvial sample were subjected to both the standard test method (63 mm sample diameter) which consists of screening out the size fraction less than 4.75 mm, and full size fraction using 300 mm diameter Tempe cells. The complete laboratory results are presented in Figure 8.

The numerical code RETC was used to fit curves to the laboratory data, using the van Genuchten formulation. The most representative curves for all samples are presented on Figures 9, 10 and 11, and the representative van Genuchten parameters for these curves are listed in Table 10.

Table 10: Summary of van Genuchten parameters for SWCC's

Sample No.	Material Type	θ_r (%)[1]	θ_s (%)[2]	K_s (cm/sec)[3]	a[4]	n[4]	p[4]
SRK-03-C01	Till	20.8	27.8	1.46×10^{-7}	0.007	1.314	0.5
SRK-03-C01 – large test	Till	17.8	28.7	1.46×10^{-7}	11.782	1.137	0.5
SRK-03-C02	Till	10.8	27.0	1.52×10^{-7}	0.003	1.154	0.5
SRK-03-C04	Till	0.0	26.0	3.61×10^{-6}	0.071	1.073	0.5
SRK-03-C06	Till	0.0	26.2	2.67×10^{-6}	0.002	1.411	0.5
SRK-03-C03	Glaciofluvial	0.0	22.8	1.15×10^{-3}	0.011	1.350	0.5
SRK-03-C03 – large test	Glaciofluvial	0.0	23.1	1.15×10^{-3}	0.293	1.222	0.5
SRK-03-C05	Glaciofluvial	0.0	24.6	4.49×10^{-5}	0.008	1.406	0.5
SRK-03-C07	Tailings	8.0	38.0	1.31×10^{-5}	0.012	2.103	0.5
SRK-03-C08	Waste Rock	0.0	36.1	5.54×10^{-3}	0.327	1.225	0.5

1. Residual volumetric moisture content.
2. Saturated volumetric moisture content.
3. Saturated hydraulic conductivity.
4. Curve fit parameters.

RETC applies a best-fit SWCC curve to the laboratory data, however in some cases these curve fits were not representative of the sample characteristics. Figures 12 to 15 present the results of four SWCC tests where we manually adjusted the curve fit. In all these cases the base case RETC curve resulted in a steep SWCC with a higher Air Entry Value (AEV) than suggested by the data, and lower saturated volumetric moisture content. If we forced the curve fit to pass through the laboratory measured saturated volumetric moisture content, the AEV became less than suggested by the data points, and to steep in the medium suction range. In these cases we therefore opted to ignore the high suction range data points and used a best-fit through the low to medium range data points. This was deemed representative, since the availability of moisture and the primary infiltration characteristics of these materials will be governed by matric suction and hydraulic conductivity in the low suction ranges, as opposed to the high suction ranges.

Two samples were subjected to both the standard test method, and a large-scale SWCC test. The large scale test was designed to yield more representative results for samples with substantial amounts of particles larger than 4.75 mm. The large scale till sample (Figure 16) showed a very low AEV (less than 0.1 kPa); however the curve suggests that the sample has a dual porosity with another AEV at approximately 200 kPa. The small scale-sample showed a more distinct AEV at approximately 10 kPa, however, the high suction data points again suggested dual porosity with another AEV at approximately 1,000 kPa.

The difference between the large and small-scale test on the glaciofluvial sample (Figure 17) was similar with the large cell indicating a lower AEV than the small cell. These results can be explained in terms of the greater drainage characteristics of the larger particles present in the large cells.

The determination of the saturated volumetric water content (θ_s), for each SWCC was a direct outcome of the test, whilst the determination of the AEV, the residual matric suction (ψ_r) and the residual moisture content (θ_r) for each test was carried out using the construction technique proposed by Fredlund and Xing (1994), using the van Genuchten curves presented in Figures 9, 10 and 11. Table 11 list these properties for each of the tested samples.

Table 11: Summary of soil water characteristic curve results

Sample No.	Material Type	θ_s (%)	AEV (kPa)	θ_r (%)	ψ_r (kPa)
SRK-03-C01	Till	27.8	10.0	3,000	6.0
SRK-03-C01 – large test	Till	28.7	0.1	3,000	4.0
SRK-03-C02	Till	27.0	20.0	3,000	6.0
SRK-03-C04	Till	26.0	1.0	3,000	4.0
SRK-03-C06	Till	26.2	20.0	3,000	3.0
SRK-03-C03	Glaciofluvial	22.8	3.0	3,000	2.0
SRK-03-C03 – large test	Glaciofluvial	23.1	0.1	3,000	4.0
SRK-03-C05	Glaciofluvial	24.6	3.0	3,000	2.0
SRK-03-C07	Tailings	38.0	3.0	3,000	4.0
SRK-03-C08	Waste Rock	36.1	0.1	3,000	3.0

4.3.10 Unsaturated Hydraulic Conductivity

The unsaturated hydraulic conductivity curves for each of the samples were developed from the SWCC data using a number of empirical formulations. The saturated hydraulic conductivity value for each sample was taken initially from the laboratory data as presented in the previous section. Later adjustments were made to these curves based on in-situ saturated hydraulic conductivity measurements (see next section of this report). The corresponding unsaturated hydraulic conductivity curves are presented in Figures 18 to 21 for each of the material types tested.

4.4 Summary of Cover Materials

The borrow source investigation estimated the volume of potential cover materials primarily based on the aerial extent of the deposits. The depth of the deposits was estimated based on local anecdotal knowledge of the area as opposed to actual deep drilling results. Based on these estimates, there is approximately 11.62 million cubic meters of till material, 2.8 million cubic meters of glaciofluvial material and between 0.125 to 0.225 million cubic meters of organics.

The most abundant potential cover material is the till deposits. The till is predominantly silicatious, having a specific gravity of 2.7, and is predominantly well graded sandy-clay (CL) to clayey-sand (SC) with a plasticity index between 2 and 10. This material generally has 20% gravel content with the sand fraction between 34 and 43%, and a fines content of 38 to 50%. One of the tested till samples were a non-plastic silty-sand (SM), consisting of zero gravel content, 71% sand and 29% fines.

Standard Proctor compaction suggests a maximum dry density of between 2,072 and 2,120 kg/m^3 is achievable at moisture contents ranging between 7.4 and 10%. Falling head permeability results on samples compacted to 95% Proctor density showed results that ranged between 2.5 x 10^{-6} and 1.3 x 10^{-7} cm/sec (7.9 to 0.4 mm/year).

The well-graded nature of the till, together with the fines content suggests that the material would be a good “barrier-type” cover material. The SWCC’s of the tested samples suggest AEV’s between 1 and 20 kPa, however, the data suggest that there may be a dual porosity in the material, with a secondary AEV value of approximately 1,000 kPa. This means that although the till does allow some rapid de-saturation, the fines have a large potential to retain moisture, and therefore act as a saturated barrier cover, provided sufficient moisture is available.

The glaciofluvial deposits are also silica based, sharing the same specific gravity value of 2.7 as the till. The material can however be classified as poorly graded gravel-sand mixtures with an abundance of sand and gravel and virtually no fines. Compaction results showed similar maximum dry densities and moisture contents as observed for the till material, however the 95% Proctor saturated permeabilities illustrates the effects of the fine sands, varying between 1.1 x 10^{-3} and 5 x 10^{-5} cm/sec (3,469 to 158 mm/yr).

The water retention properties of the glaciofluvial material is less complex than the till, showing a fairly steep curve, with AEV’s around 10 kPa for standard Tempe cells tests. The large Tempe cell test suggests that the AEV of the sample as a whole is closer to 1 kPa. Based on these results it is likely to expect that the glaciofluvial material would be less suitable to use as a barrier cover than the till material.

5 In-Situ Material Property Testing

5.1 Introduction

Laboratory testing is an important component in characterizing potential cover materials; however, natural soils exhibit a large degree of heterogeneity and therefore in-situ material property testing becomes invaluable when trying to predict cover performance.

In order to develop some understanding regarding the in-situ permeability and density of the materials under consideration at the ARMC, SRK excavated a number of shallow test pits in September 2003. These test pits and the area immediately surrounding the test pits were subjected to in-situ infiltration tests (using a single ring infiltrometer and/or Guelph permeameter), and density tests (sand-cone replacement tests).

In addition to these tests pits a number of shallow thermistors were installed into the various potential cover materials to allow us to measure the depth of the active zone.

5.2 Field Program

The field program was carried out by Dr. Maritz Rykaart, P.Eng., a Senior Geotechnical Engineer and Mr. Joe Pun, E.I.T, a Junior Engineer, both from SRK in Vancouver. The field program was carried out between September 8 and 19, 2003.

A total of 16 thermistors was installed and seven test pits was excavated, around which a total of 28 single ring infiltrometer tests was conducted, seven Guelph permeameter tests and 19 sand-cone replacement tests. The test locations are marked on Figures 5 and 6, and the details of each test pit location is also listed in Table 12.

Test pits were excavated using a CAT-235B excavator supplied by the ARMC, complete with skilled operators.

Table 12: Details of the test pit locations for conducting in-situ property testing

Location	Test Pit ID	GPS Coordinates[1]	
		Easting (m)	*Northing (m)*
Vangorda Overburden Dump	VA-OD-TP01	593,152	6,904,689
Vangorda Embankment Till	VA-ET-TP01	593,663	6,902,864
Vangorda Re-sloped Till Cover	VA-CT-TP01	593,774	6,902,416
Vangorda Re-sloped Waste Rock Piles	VA-WR-TP01	593,719	6,902,451
Vangorda Glaciofluvial Deposits[1]	VA-GF-TP01	584,816	6,912,522
Faro Slime Tailings	FA-TS-TP01	582,167	6,913,155
Faro Beach Tailings	FA-TB-TP01	583,409	6,912,613

1. Co-ordinates based on hand-held GPS readings using UTM NAD 27 in zone 8V.
2. This sample was incorrectly labelled as being on the Vangorda property – it is actually at Faro.

5.3 Thermistor String Installation

Shallow thermistor strings were installed into the ground, through potential cover materials and into the tailings, to start to gather a data base of information with respect to the depth of the active zone.

Thermistor strings were proposed to be installed at all test pit locations (three, 5-meter thermistor strings at each of the Vangorda test pits and four 6-meter strings at Faro tailings) excluding the re-sloped Vangorda till cover and waste rock pile area. The installation technique however prevented some installations from being completed, and field adjustments were made. Table 13 lists the final locations of all the thermistors.

All thermistors, except for those on Rose Creek tailings were installed by pushing down a 50 mm diameter steel pipe, 1 m shorter than the thermistor string, into the profile with the bucket of an excavator. A specially manufactured metal drive-point tip was first placed at the base of the pipe to ensure that the pipe does not fill with soil, and assist in penetration of the pipe. Once the pipe was completely pushed in, the thermistor string was placed into the pipe, before slowly pulling the pipe out again using the excavator. The drive-point tip and the thermistor string remained in the hole. The hole was then backfilled around the thermistor to ensure that it stayed in place. The Rose Creek tailings thermistors was installed using a 50 mm diameter hand auger

The thermistor strings were ordered from RST Instruments Ltd. with 12 strings in 5 meter lengths and four strings in 6 meter lengths. All thermistor strings were designed to have beads positioned at 1.5, 2.0, 2.5, 3.0, 4.0, and 5.0 meters below the nominal ground surface (with 1 m stick-up), while the 6 meter lengths thermistor strings have one extra bead positioned at 6.0 meter beneath normal ground surface. They were each constructed with open-ended wires at the above-ground end to allow hand-held devices for data collection in relation to each bead. Photo 20 illustrates completed thermistor installations in the till and on the Rose Creek tailings.

A hand-held digital thermometer (model 866C from Omega Technologies) was used to collect temperature data from the installed thermistor strings. Up to two sets of data were collected after the thermistor strings were installed. Details of the collected data are presented in Appendix B-6, together with the complete thermistor calibration data sheets. The second set of readings confirmed that the strings are reaching equilibrium, and more data will be completed during the later winter and spring of 2004.

Table 13: Details of Installed thermistors strings

Location	Therm. No. (Serial #)	Date Installed	GPS Coordinate[1]		Depth of Beads from Ground Surface (m)
			Easting (m)	*Northing (m)*	
Overburden Dump	TS-04 (23262-4)	10-Sep-03	593,174	6,904,639	0.05, 040, 0.90, 1.40, 2.40, 3.40
	TS-06 (23262-6)	10-Sep-03	593,158	6,904,668	0.05, 0.50, 1.00, 1.50, 2.50, 3.50
Vangorda Embankment Till	TS-08[2] (23262-8)	10-Sep-03	593,668	6,902,65	0.05, 0.55, 1.05, 1.55, 2.55, 3.55
	TS-09 (23262-9)	11-Sep-03	593,652	6,9028,54	0.10, 0.60, 1.10, 1.60, 2.60, 3.60
	TS-10 (23262-10)	10-Sep-03	593,688	6,9028,70	0.05, 0.20, 0.30, 0.80, 1.80, 2.80
	TS-11 (23262-11)	11-Sep-03	593,638	6,9028,44	0.05, 0.55, 1.05, 1.55, 2.55, 3.55
Vangorda Glaciofluvial Deposits	TS-01 (23262-1)	15-Sep-03	584,823	6,9124,38	0.05, 0.36, 0.86, 1.36, 2.36, 3.36
	TS-02 (23262-2)	15-Sep-03	584,908	6,9125,54	0.05, 0.10, 0.15, 0.20, 0.50, 1.50
	TS-03 (23262-3)	15-Sep-03	584,835	6,9124,57	0.05, 0.23, 0.73, 1.23, 2.23, 3.23
	TS-05 (23262-5)	15-Sep-03	584,774	6,9125,13	0.05, 0.10, 0.53, 1.03, 2.03, 3.03
Faro Tailings	TS-07 (23262-7)	12-Sep-03	583,173	6,9125,10	0.05, 0.45, 0.95,1.45, 2.45, 3.45
	TS-12 (23262-12)	12-Sep-03	582,194	6,9131,97	0.50, 1.00, 1.50, 2.00, 3.00, 4.00
	TS-13 (23262-13)	12-Sep-03	583,105	6,9128,51	0.05, 0.15, 0.25, 0.75, 1.75, 2.75, 3.75
	TS-14 (23262-14)	12-Sep-03	583,206	6,9129,36	0.50, 1.00, 1.50, 2.00, 3.00, 4.00, 5.00
	TS-15 (23262-15)	12-Sep-03	582,235	6,9131,27	0.05, 0.15, 0.25, 0.55, 1.55, 2.55, 3.55
	TS-16 (23262-16)	12-Sep-03	582,894	6,9126,96	0.05, 0.25, 0.75, 1.25, 2.25, 3.25, 4.25

1. Co-ordinates based on hand-held GPS readings using UTM NAD 27 in zone 8V.
2. GPS Location not exact - estimated from neighboring installed thermistor locations.

Photo 20: Examples of the thermistor installations on (1) Rose Creek tailings and (2) Vangorda waste rock pile starter dyke till.

5.4 Single Ring Infiltrometer Tests

Single ring infiltrometer tests were used to obtain an in-situ measurement of the saturated hydraulic conductivity of the potential cover soils and the waste.

The infiltrometers measured approximately 60 cm in diameter and 30 cm in height, and was constructed from 44-gallon steel drums. The test is performed by placing the infiltrometer on a relatively level surface, then pushing/driving the ring into the ground for at least 5 to 10 cm. The ring is then filled with water to a predetermined height, and the rate of water loss is recoded over time to second lower predetermined level. The water level is topped-up, and the process is repeated until a constant rate of water loss is observed. If leakage was observed around the outer edge of the infiltrometer during the test, some fine soils was used as backfill against the edge, and if this could not contain the leakage, the test was abandoned. Photo 21 illustrates tests being conducted.

Many of the tests required at the ARMC were on the side slopes, which does not allow for testing using the ring infiltrometer. In these locations an area measuring approximately 100 cm x 100 cm was excavated by hand using geological picks and shovels to allow a flat platform to perform the test on. Similarly, where infiltrometer tests were conducted in the bottom of test pits, a flat platform was prepared for placing the test

The infiltration measured from the ring infiltrometers were analyzed to convert it to an equivalent saturated hydraulic conductivity, using the procedure developed by Bouwer et al. (1999). Summarized results of the ring-infiltrometer tests are presented in Table 14 and the complete field data sheets are presented in Appendix B-1.

Table 14: Summarized results of the single ring infiltration tests

Test Site	Test Pit ID	Date Tested	Location	Test No.	In-Situ Saturated Hydraulic Conductivity, K_{fs} (cm/sec)
Vangorda Overburden Dump	VA-OD-TP1	9-Sep-03	Bottom of Test Pit	SR-01	2.31×10^{-4}
			Surface	SR-02	1.49×10^{-4}
Vangorda Re-sloped Embankment Till	VA-ET-TP1	10-Sep-03	Bottom of Test Pit	SR-01	2.25×10^{-4}
			Surface	SR-02	3.14×10^{-5}
				SR-03	3.16×10^{-5}
				SR-04	5.63×10^{-5}
Vangorda Re-sloped Till Cover	VA-CT-TP1	11-Sep-03	Bottom of Test Pit	SR-01	2.48×10^{-4}
			Surface	SR-02	1.94×10^{-5}
				SR-03	6.42×10^{-5}
				SR-04	5.73×10^{-5}
Vangorda Re-Sloped Waste Rock Dump	VA-WR-TP1	12-Sep-03	Bottom of Test Pit	SR-01	1.68×10^{-3}
			Surface	SR-02	1.23×10^{-5}
				SR-03	9.23×10^{-5}
				SR-04	4.85×10^{-4}
				SR-05	4.38×10^{-4}
Vangorda Glaciofluvial Deposits	VA-GF-TP1	13-Sep-03	Surface (loosened)	SR-01	2.84×10^{-3}
				SR-04	4.64×10^{-3}
			Surface (compacted)	SR-02	1.39×10^{-5}
				SR-03	9.92×10^{-5}
Faro Slime Tailings	FA-TS-TP1	14-Sep-03	Surface	SR-01	8.61×10^{-8}
				SR-02	4.08×10^{-6}
				SR-03	3.01×10^{-5}
				SR-04	9.15×10^{-8}
				SR-05	1.92×10^{-6}
Faro Beach Tailings	FA-TB-TP1	17-Sep-03	Surface	SR-01	1.58×10^{-3}
				SR-02	1.51×10^{-3}
				SR-03	1.58×10^{-3}
				SR-04	1.88×10^{-3}

Photo 21: Sloped test site showing 3 ring infiltrometers being used for testing.

5.5 Guelph Permeameter Tests

Additional in-situ infiltration tests were conducted using a Guelph permeameter. The Guelph permeameter differs from the ring infiltrometer in that it is essentially a constant head as opposed to a falling head permeability test, and its area of influence is substantially smaller than the ring infiltrometer. The Guelph permeameter is therefore more suited to finer grained, fairly homogeneous material, such as the tailings.

Although the till is a good candidate for using the Guelph permeameter in terms of its fines content, the large gravel fraction therein makes for quite random results, which may not necessarily be representative. For this reason, only a limited amount of Guelph permeameter testing was completed.

The complete field data sheets are included in Appendix B-2, and Table 15 summarizes the results of the Guelph permeameter tests. Photo 22 illustrates a Guelph permeameter test being conducted adjacent to a ring infiltrometer test.

Table 15: Summary of Guelph permeameter test results

Test Site	Date Tested	Test No.	Location	Depth of Well Hole	Effective Saturated Hydraulic Conductivity, K_{fs} (cm/sec)
Vangorda Overburden Dump	9-Sep-03	GP-01	Up-slope of SR-02	20cm	2.62×10^{-4}
Vangorda Embankment Till	10-Sep-03	GP-01	Nearby SR-02	20cm	4.85×10^{-4}
		GP-02	Nearby SR-01	20cm	4.35×10^{-3}
Faro Beach Tailings	18-Sep-03	GP-01-1	Nearby SR-03	20cm	3.86×10^{-3}
	19-Sep-03	GP-01-2		50cm	1.77×10^{-3}
		GP-02-1	Nearby SR-04	20cm	4.40×10^{-3}
		GP-02-2		50cm	1.93×10^{-3}

Photo 22: Test site showing a ring infiltrometer and Guelph permeameter.

5.6 In-Situ Density Tests

The sand cone test method (ASTM D1556 with 6-inch cone and Ottawa sand) was used to determine the in-situ density of the potential cover soils and waste at various locations.

The experiments were performed by first preparing a level surface (approximately 30 cm x 30 cm) at each designated location, for placing the base plate. The sand-cone replacement test was then conducted, and the in-situ sand weights were determined on site using the scale in the water laboratory at the Faro main gate.

The wet samples was preserved and shipped to EBA Engineering in Whitehorse for moisture content determination. Table 16 presents a summary of the test results, and the complete data sheets are presented in Appendix B-3.

Table 16: Summary of the in-situ density test results

Test Site	Date Tested	Test No.	Location	In-Situ Dry Density (g/cm^3)
Vangorda Re-sloped Till Cover	11-Sep-03	SC-01	Surface - sloped	1.91
		SC-02	Surface - sloped	2.05
	15-Sep-03	SC-03	Surface - sloped	1.75
		SC-04	Surface - sloped	1.63
Vangorda Embankment Till	16-Sep-03	SC-01	Surface - sloped	1.61
		SC-02	Surface - sloped	1.46
		SC-03	Surface - sloped	1.32
Vangorda Overburden Dump		SC-01	Surface - sloped	1.75
		SC-02	Surface - sloped	1.85
		SC-03	Surface - sloped	1.70
Vangorda Glaciofluvial Deposits		SC-01	Surface - flat	1.89
		SC-02	Surface - flat	2.06
		SC-03	Surface - flat	2.09
Faro Slime Tailings	14-Sep-03	SC-01	Surface - flat	1.66
		SC-02	Surface - flat	1.78
		SC-03	Surface - flat	1.91
Faro Beach Tailings	17-Sep-03	SC-01	Surface - flat	1.43
		SC-02	Surface - flat	1.34
		SC-03	Surface - flat	1.43

5.7 Conductivity and pH Sampling

Samples were collected at all test pits at various depths for conductivity and pH testing. The samples were mixed with distilled water in a 1:1 volume ratio to form a paste composition for testing using calibrated hand-held instruments. For low range conductivity samples (0 – 1,999µS), hand held instruments (model TDSTestr 40 from Oakton Instruments) and (model pHTestr 3 from Oakton Instruments) were used for conductivity and pH testing respectively. Conversely, for the higher range conductivity samples (>1,999µS), a different instrument (model pH/Cond 340i from WTW Wissenschaftlich-Technische Werkstätten GmbH & Co. KG) was used for both conductivity and pH testing.

Different sampling procedures were conducted at different test pit locations. For samples collected at the Rose Creek tailings impoundment, a hand auger was used to obtain samples at 50 cm intervals from the surface down to a maximum depth of 500 cm. Alternatively for all the actual test pits, samples were collected, at 1 m intervals, from the surface. Detailed results from the laboratory testing are presented in Appendix B-5.

5.8 In-Situ Moisture Content

Samples were collected at various depths of all test pits to determine the in-situ moisture content of the materials before and after the single ring infiltrometer tests. A hand auger was used to obtain a dry soil profile of samples (15 cm intervals from the surface down to a maximum depth of 60 cm) before the infiltration tests. Subsequently after each test, a wet surface sample was collected. A minimum of one set of dry and wet samples were obtained at each test pit where single ring infiltrometer tests were conducted. The samples were kept in air-tight containers and were sent to EBA Engineering in Whitehorse for moisture content determination. The results are provided in the laboratory report from EBA Engineering in Appendix B-4. A summary of the collected sample locations, date, quantities and depths is outlined in Table 17 below.

Table 17: Details of in-situ moisture content samples collected

Test Pit Site	Date Collected	Location (Single Ring Infiltration Test No.)	Quantity & Depths (cm below ground surface)
Vangorda Overburden Dump	9-Sep-03	SR-01	dry profile (0, 15, 30, 45, 60)
			wet profile (0, 15, 30, 45, 60)
		SR-02	dry profile (0, 15, 30, 45, 60)
			wet profile (0, 15, 30, 45, 60)
Vangorda Embankment Till	10-Sep-03	SR-01	dry profile (0, 15, 30, 45, 60)
			wet profile (0, 15, 30)
		SR-02	dry profile (0, 15, 30, 45, 60)
Vangorda Till Cover	11-Sep-03	SR-02	dry profile (0, 15)
			wet surface sample
Vangorda Waste Rock Dump	12-Sep-03	SR-01	wet surface sample
		SR-03	dry profile (0, 15)
			wet surface sample
		SR-04	wet surface sample
Vangorda Glaciofluvial	13-Sep-03	SR-01	dry profile (0, 15, 30, 45, 60)
			wet surface sample
Faro Slime Tailings	14-Sep-03	SR-01	dry profile (0, 15, 30, 45, 60)
			wet surface sample
Faro Beach Tailings	17-Sep-03	SR-03	dry profile (0, 15, 30, 45, 60)
			wet surface sample

5.9 Summary of In-Situ Testing Results

The in-situ permeability results confirmed that the field hydraulic conductivity of the till is between 1.5×10^{-4} and 6.4×10^{-5} cm/sec (473 to 202 mm/year), which is between 1 and 2 orders of magnitude more permeable than the laboratory results. Similarly, the in-situ permeability of the glaciofluvial material is approximately 9.9×10^{-5} cm/sec (312 mm/year) for the compacted traffic surfaces and 2.8

x 10^{-3} cm/sec (8,830 mm/year) for the looser unconsolidated sections. These results are quite consistent with the laboratory results.

The in-situ density results for the till, suggest substantially lower densities than the 95% Proctor density tested in the laboratory, which may be part of the reason for the higher permeabilities measured in the field.

The tailings and waste rock samples measured conductivities in the milli-Siemens range, whilst all the potential cover materials measured conductivities in the micro-Siemens range. He most important conclusion with regard to these results are the fact that the Vangorda waste rock pile till cover, does not appear to be impacted by contaminants that are present in the underlying waste rock. There is no definitive gradient of increased conductivities close to the waste rock contact, suggesting that upward fluxes are negligible, if present at all. This is further confirmed by the past pH results which show the waste rock to have a consistent paste pH of 5.1 to 5.9, whilst the till cover has a consistent paste pH between 7.4 and 7.7.

The embankment till did show the highest conductivities in natural materials, and these higher conductivities were associated with lower paste pH values ranging between 5.7 and 6.9. This result cannot be immediately explained.

The tailings conductivities were consistently high, and the paste pH varied between 1.6 and 5.2, with a near consistent pattern of increasing pH with depth.

6 Cover Constructability

6.1 General

Whilst it may be possible to design a cover capable of achieving specific target infiltration or oxygen ingress rates, these designs can only be realized if they can in fact be implemented. This section attempts to highlight some of the difficult construction issues that must be dealt with at the ARMC. Suitable engineering solutions can be found for each of the aspects discussed here, however it is likely that it would invoke a cost premium, which may not be acceptable.

6.2 Re-Sloping Requirements for Waste Rock Piles

As stated previously, the ICAP study recommended that re-contouring of the Faro waste rock pile be limited to areas where there is not positive surface drainage. At the time it was felt that re-contouring would disturb the existing oxidized surface waste rock and uncover more un-oxidized material. On the contrary, the ICAP did recommend re-contouring of the Vangorda and Grum waste rock piles, prior to covering them with a till cover.

For the purpose of this report we have calculated the amount of waste rock material that would have to be moved if all the waste rock piles at the ARMC were to be re-contoured to have positive drainage (i.e. top slopes flattened to remove voids and graded at 1%) and maximum side slopes of 2.5H:1V. This slope angle was considered to be the maximum that would still allow for safe and efficient placement of a soil cover, should it be required.

Our analysis of re-contouring earthworks volume are conservative, since we have only accounted for re-contouring of side slopes that are not bordering on an open pit, and we have used typical representative sections to conduct the calculations.

Based on these estimates, re-contouring of the Faro waste rock pile would require moving 3.1 million cubic meters of material, or approximately 2.4% of the 129 million cubic meters of material contained in this conglomerate of piles. The Grum waste rock pile would require re-contouring to the tune of 0.42 million cubic meters of material, or 1.8% of the 23.6 million cubic meters contained in the waste rock pile. At the Vangorda waste rock pile, approximately 0.6 million cubic meters of material would have to be re-handled for re-contouring, which would be equal to 1.8% of the total waste rock pile volume of 32.5 million cubic meters of material.

The re-sloping would also have an impact on the final surface areas of the waste rock piles that would be exposed, and that would have to be covered. These surface areas are summarized in Table 18. Based on these calculations, we have also determined that there would no areas where the re-sloping of the waste rock piles would cause problems with respect to encroaching on streams or cadastral boundaries. The current toe-lines of the main waste rock piles and the anticipated toe-lies after re-sloping are presented on Figures 22a and 22b.

Table 18: Summary of waste rock pile surface areas

Waste Rock Pile	Footprint surface area (ha)			3D surface area (ha)	
	Before re-sloping		After resloping[2]	Before re-sloping[1]	After re-sloping[3]
	ICAP	Revised[1]			
Faro	335	347	357	370	381
Grum	128	148	153	154	159
Vangorda	43	59	59	62	62

1. Surface areas calculated based on latest air photography.
2. Surface area calculated based on estimated new footprint due to re-contouring.
3. Arbitrary correction of 3% based on increased footprint.

6.3 Volume of Cover Material/Borrow Area Rehabilitation

Based on the areas of each of the waste rock piles that would require covering (602 ha in total), each 50 cm layer of cover would require 3.01 million cubic meters of cover material. This is 8% more than the total volume of glaciofluvial material available on site, and about 26% of the estimated volume of till. Also, it is evident that there is no way that sufficient organic material could ever be harvested to cover these areas. If all the glaciofluvial material was used, it would mean that there would be vast areas of currently undisturbed ground that would have to be rehabilitated in addition to the waste facilities. Using till as a cover material therefore would appear to be the only viable option considering the vast volumes required.

The Rose Creek tailings impoundment covers a surface area of approximately 196 ha, consisting of 42 ha of the Original impoundment, 55 ha of the Secondary impoundment and the remaining 99 ha in the Intermediate impoundment. Covering this surface area with a 50 cm layer of cover would require 1.96 million cubic meters of material.

Based on these numbers, if all the ARMC waste areas were to be covered with till only, there would be sufficient material to use a cover of 150 cm thick. Alternatively, if everything was to be covered in glaciofluvial material only, the maximum cover thickness would be 50 cm.

6.4 Vegetation Season

The till cover test section at the Vangorda waste rock pile has been in place for almost 10 years, and although the design called for this cover to be vegetated, this was never done after construction. Subsequently this slope has been left to nature to vegetate, and it is evident that this has not occurred. There is practically no signs of natural vegetation on this area, suggesting, that if a positive attempt is not made to vegetate a till cover, then vegetation would not happen naturally.

The apparent vegetation trial at the Overburden dump, which is of similar till material than at the Vangorda test cover trial area, confirm that vegetation will grow, if some initial stimulation is achieved.

6.5 Tailings Trafficability

Access onto the soft slimes of the Rose Creek tailings impoundment, for the purposes of cover placement would be problematic due to the saturated unconsolidated nature of particularly the slimes sections of the tailings impoundments. This aspect has been confirmed by anecdotal information from persons familiar with the tailings impoundment. Placing any cover materials onto these tailings areas would result in settlement of the cover material into the tailings, effectively creating a new blended material type. This in itself may not be a detrimental result; however it would be difficult to predict the performance of such a cover system. Furthermore, it is likely that a substantially thicker cover could be required if substantial settlement does occur.

6.6 Frost Penetration Studies

The extreme temperatures experienced at the ARMC poses a unique set of challenges for the long-term integrity of a soil cover. Freeze-thaw cycles can result in break-up of the soil matrix, which would impact the permeability and diffusion coefficient of the cover. Anecdotal information from the site suggest that the ground freezes to between 1 m and 3 m deep, depending on site specific conditions, and therefore any cover design should consider this affect.

The tailings test cover trials conducted between 1995 and 1999 measured temperature profiles through the covers and into the tailings. The results from this study showed how the cover materials acted as insulators for the underlying waste to varying degrees depending on the cover material properties. Some of the cover variants would have been expected to be physically impacted by cyclic freeze-thaw cycles, particularly the low plasticity till cover, however there is no documented evidence that any degradation had occurred. Similarly the till cover section of the Vangorda waste rock pile which had been in place for almost 10 years does not show any signs of degradation through cyclic freeze-thaw, suggesting that the available cover materials at the ARMC would not be particularly susceptible to this form of desiccation.

The thermistors installed as part of this study will assist in determining the likely frost penetration depth of the potential cover materials, which may lead to alternate suggestions.

6.7 Evaporites

One potential problem associated with covering any mine waste is evaporites. This will occur when contaminants (salts) are wicked to the surface through capillary action driven by evaporation. These evaporites results in contamination of surface water that runs over these surfaces, as well as potentially restricting the establishment of vegetation. This problem is greater in fine grained waste, i.e. the tailings slimes, however in finely weathered waste rock this can also occur. There is visual evidence of evaporates on the Rose Creek tailings impoundment, and since there is a definitive upward flux of moisture during the summer months it is likely that any fine grained cover could in the long term be carriers of these evaporates. It would thus be necessary to possibly incorporate some form of capillary break for any soil cover on the tailings.

There are only isolated pockets of evaporites visible on the Anvil Range waste rock piles. These evaporates are normally only present in areas where water ponds after precipitation and where the surface is comprised of fines that have accumulated in these low lying areas. The test cover section of the Vangorda waste rock pile show no signs of evaporites being present, even after being in place for almost 10 years, and being fairly fine grained. This suggests that long-term evaporite problems at the waste rock piles are probably not an issue. This is a fact supported by the paste pH and conductivity measurements, which showed no sign of increased salinity in the cover.

7 Scoping Level Numerical Modeling

7.1 Introduction

Other than pilot-scale field testing, the only viable way to evaluate the effectiveness of any particular soil cover to achieve the closure objectives is through the use of numerical modeling. Scoping level numerical modeling was carried out to determine the likely range of performance parameters that can be achieved by placing soil covers over the Rose Creek tailings impoundment and the ARMC waste rock piles. Likely cover configurations was selected and modelled, based on the available cover materials, and the performance of these configurations were measured and evaluated in terms of the potential cover objectives, i.e. moisture and/or oxygen control, freeze-thaw protection, shedding runoff, evapotranspiration capacity etc.

The numerical modeling conducted is not calibrated with actual long term field performance data; however, the input parameters does reflect field measured soil properties which will allow a level of confidence sufficient for this level of study.

The numerical modeling was conducted with the SoilCover model. SoilCover is a mechanistic one-dimensional, transient, finite element coupled heat and water transfer (liquid and vapour) model that implements the physically based method described by Wilson et al. (1994) for predicting the exchange of moisture between the atmosphere and a soil surface. The coupling of the soil profile to the atmosphere is accomplished using a modified Penman formulation developed by Wilson (1990) and Wilson et al. (1994) that allows for the calculation of evaporation from a saturated or an unsaturated surface.

7.2 Model Setup

7.2.1 Mesh Generation

Two different mesh sizes were created for simulations for the waste rock covers and the tailings covers. Mesh for waste rock cover profiles had a depth of 10 meters, while the mesh for tailings cover profiles had a depth of 7 m. These profile depths were based on some sensitivity analysis runs, and were selected to ensure a minimum boundary effect impact.

The base temperature was kept constant at 4^oC in all simulations, while the initial surface temperature was set equal to 0^oC for all the simulations. The top temperature was chosen to coincide with the beginning of the spring thaw, while the bottom temperature was chosen to be 6 degrees warmer than the mean annual temperature. The algorithms in SoilCover were used to calculate the daily ground temperatures for all simulations. Initial moisture conditions for each profile was set by means of matric suction for the tailing cover simulations and by water content for waste rock cover simulations and is discussed in a subsequent section.

7.2.2 Material Properties

The material properties required defining the SoilCover model is presented in this section. These properties are tailings soil water characteristic curves, unsaturated hydraulic conductivity functions, saturated hydraulic conductivity, thermal conductivity- and volumetric specific heat functions. The material properties are for the waste rock, till, glaciofluvial, coarse and fine tailings. The general properties, porosity, specific gravity and saturated permeability used for each material are summarized in the Table 19, and these values were selected based on the laboratory and field testing programs.

Table 19: Summary of material properties used in SoilCover modeling

Material	Porosity	Specific Gravity	Saturated Permeability (cm/s)
Waste Rock	0.361	2.86	1.7×10^{-3}
Till	0.262	2.70	2.7×10^{-6}
Glaciofluvial	0.246	2.70	1.0×10^{-4}
Coarse Tailings	0.380	2.93[a]	2.0×10^{-3}
Fine Tailings	0.419	2.93[a]	1.0×10^{-6}
Slimes	0.419	2.93[a]	1.0×10^{-8}

a. This value should be 3.14; it does not impact the results significantly.

7.2.3 Soil Water Characteristic Curves

Points from the fitted van Genuchten SWCC's presented in Section 3 of this report were entered into the SoilCover model for each material. SoilCover uses the Fredlund and Xing (1996) method to develop a SWCC for use in calculations. The corresponding SWCC's that were used in the modeling is presented in Figure 23.

7.2.4 Unsaturated Hydraulic Conductivity Functions

Suction and relative permeability data is generated using the method developed by Fredlund et al. (1994). The method produces a relative permeability function. The actual permeability for any given suction is equal to the relative permeability multiplied by the saturated coefficient of permeability (SoilCover, 1997). Figure 24 presents the unsaturated relative hydraulic conductivity function for each material used in the modeling.

7.2.5 Thermal Conductivity & Specific Heat Functions

SoilCover generates a thermal conductivity function by specifying an overall weighted quartz percentage in the soil using the Johansen (1975) method. The function describes the amount of heat which flows through a unit area of soil, in a unit time, under a unit gradient (SoilCover, 1997). The values were entered using the typical values listed in the SoilCover manual and are listed in Table 20.

SoilCover also generates a volumetric specific heat function, by specifying a mass specific heat for each soil, using the de Vries method (1953). The function describes the amount of stored heat required to change the temperature of a unit volume ($1m^3$) by one degree Celsius (SoilCover, 1997). The values were entered using the typical values listed in the SoilCover manual and are listed in Table 20.

Table 20: Summary of thermal conductivity and volumetric specific heat constants

Material	% Quartz (dec.)	Solids Specific Heat (J/Kg-C)
Waste Rock	0.9	850
Till	0.8	800
Glaciofluvial	0.8	800
Coarse Tailings	0.9	850
Fine Tailings	0.9	850
Slimes	0.9	850

7.2.6 General Boundary Conditions

The site data criteria used in the SoilCover model were kept constant for all the simulations. The temperature and humidity lags (entered in hours) were set to zero. The latitude of the Faro site was entered as 62.25 degrees north.

All the simulations was done without making use of the soil freezing facility in SoilCover, and all simulations did not consider the presence of any vegetation.

Separate initial conditions were used for the waste rock simulations and the tailings simulations. For the waste rock simulations, profiles were created that varied linearly with a saturated water content at the surface to a volumetric water content of 16% at the bottom of the ten meter profile. For the tailings simulations, profiles were created that varied linearly from a suction of 50 kPa at the surface, to a suction of 0 kPa at the bottom of the 7 m profile. The 0 kPa suction signifies the water table. A sensitivity analysis showed that the depth to the water table had little to no effect on the modelled infiltration.

The water content and suction profiles at the end of year 1 simulations were then used as the initial condition for the start of year 2 simulations, which was used to evaluate results.

7.2.7 Climate Data

Available climate data included daily maximum, minimum and mean temperatures, as well as daily rainfall, snowfall and precipitation data at the Faro airport weather station for the years from 1978 to

2000. The start and end date for the simulations were chosen as March 18th and October 25th of any particular year, which corresponds to the dates where the average maximum daily temperatures were above zero. For the remaining portion of the year, the ground is assumed to be frozen and no infiltration would occur.

Precipitation

A representative year for precipitation data was chosen to be 1995 as both the yearly rainfall (220 mm) and total precipitation (301 mm) was close to the annual rainfall average (215 mm) and total precipitation average (314 mm). For wet year precipitation data, the average of the three wettest years on record for the Faro airport from 1978 to 2000 were used (1991, 1993 and 2000). Figure 25 presents the daily rainfall used in the simulations for an average year.

Precipitation data was modified to account for the elevation difference between the airport and the mine site. Correlating the data between the Faro airport (717 m) and the ARMC weather station (1160 m) found that the precipitation increased by 18 mm per 100 m gained in elevation. Using an average top of dump elevation of 1200 m, gave an average precipitation total of 387 mm per year.

In order to simulate the spring snow melt, eighty percent of the total precipitation from Oct. 26th to March 17th was assumed to be present as snow on day one of the simulations. 3 mm of this total was then assumed to melt each day over the daylight hours of 10:00 to 16:00 until gone, which for an average year corresponded to 22 days. The remaining daily precipitation would occur over a 24 hr period on any given day.

Air Temperature

Daily maximum and minimum temperatures entered in all average year SoilCover simulations were from average daily data at the Faro Airport from 1978 to 2000. For wet year temperature data, the average temperatures of the wettest three years were used. Daily air temperatures used are shown in Figure 26.

Relative Humidity

Relative humidity data for the Faro area was scarce. The humidity data used was based on June and December average relative humidity data for Mayo, Yukon, found on the Government of Yukon website (http://www.gov.yk.ca/depts/eco/stats/annual/enviro.pdf). Monthly averages were derived by varying the data linearly from a maximum and minimum of 84% and 82% in December to the maximum and minimum of 75% and 44% in June. The monthly relative humidity values used are presented on Figure 27.

Evaporation

Lake Evaporation at Faro was determined to be 490 mm by Gartner Lee in the 2004 to 2008 Water License Renewal Report. A monthly breakdown of the Lake Evaporation was found in the SRK Report 60635 “Down Valley Tailings Impoundment Decommissioning Plan”, April 1991. The monthly Lake Evaporation data used was for Whitehorse, Yukon, and the actual numbers used in the SoilCover modeling is presented in Figure 28.

7.3 Modeling Results

7.3.1 Tailings Covers

The base case against which the numerical modeling results were evaluated, were the uncovered tailings, as it exists currently. The tailings properties vary greatly in the tailings impoundment, from coarse beach tailings to slimes. Furthermore the phreatic level within the tailings impoundment varies greatly, from being right at the surface at the ponds, to being as far down as 10 m in some areas. Rykaart (2002) illustrated that site specific spatial surface flux boundary functions can be developed for tailings profiles such as these, which would allow for rigorous calculation of surface fluxes anywhere on the tailings surface. This was not attempted for this project; however, the same modeling principal was adopted, which calls for modeling generalized tailings profiles; in the case of Rose Creek tailings, a coarse and a fine tailings profile, and using varying depths to the water table. The model simulations confirmed that the most representative base case results for the uncovered tailings could be presented with two simulations of coarse (beach) and fine tailings using a phreatic level of 7 m below surface.

Appropriate cover configurations were selected based on available materials and the minimum cover layer thickness was arbitrarily set at 50 cm. Both single and multilayer covers were considered (see Figures 29a through d). The primary objective of the tailings cover was minimization of infiltration, however there are a number of secondary objectives which are also vitally important; (1) erosion protection on the surface (to possibly allow for flood routing of the Rose Creek over the covered tailings), (2) providing a capillary break to minimise the potential of surface evaporites, and (3) to maximize surface runoff if infiltration cannot be minimized. The ICAP study suggested a number of cover alternatives, and for completeness those cover configurations have also been evaluated in this study. Table 21 presents a list of the final model runs selected for evaluation and discussion, and Figures 29a through d provides simple diagrams illustrating these covers.

Tailings settlement due to consolidation is considered to be the primary challenge in the success of any cover system. Anecdotal information suggest that, other than for the Original impoundment, the bulk of the Rose Creek tailings impoundment consist of saturated unconsolidated material, which if loaded with a cover will undergo significant settlement. It may thus be necessary to construct a traffic layer first, and after settlement has taken place, to construct a low-permeability cover. Since there is a shortage of suitable cover materials on site, we have assumed that waste rock could be used as a cover material, specifically to fill this bulk requirement.

Table 21: Summary of tailings cover simulations

Cover Profile	Full Simulation Period (Precipitation = 387 mm)					Freshet Only (P = 83 mm)		
	Runoff (mm)	Evap-oration (mm)	Infil-tration (mm)	Flux at Top of Tailings [1] (mm)	Flux at Top of Tailings [1] (%)	Infil-tration (mm)	Flux at Top of Tailings[1] (mm)	Flux at Top of Tailings [1] (%)
Uncovered Tailings								
Uncovered fine tailings	60	277	28	---	7%	28	---	34%
Uncovered coarse tailings	0	280	92	---	24%	62	---	75%
Single Layer Covers								
1m Till on Fine Tailings	40	293	38	-33	-9%	36	-22	-27%
1m Till on Coarse Tailings	26	280	64	-64	-17%	45	-28	-34%
1m Waste Rock on Fine Tailings	120	185	66	-6	-2%	62	0	0%
1m Waste Rock on Coarse Tailings	119	187	65	-1.5	0%	62	0	0%
1m Glacial/Fluvial on Fine Tailings	0	336	35	-38	-10%	62	-23	-28%
1m Glacial/Fluvial on Coarse Tailings	0	269	101	-103	-27%	62	-30	-36%
2.0m Waste Rock, 5m Fine Tailings	122	185	64	0	0%	62	0	0%
2m Waste Rock, 5m Coarse Tailings	119	186	65	0	0%	62	0	0%
Two-Layer Covers								
0.5m Waste Rock, 0.5m Till on Fine Tailings	119	185	67	-38	-10%	62	-1	-1%
0.5m Waste Rock, 0.5m Till on Coarse Tailings	116	186	68	-36	-9%	62	-1	-1%
0.5m Till, 1m Waste Rock on Fine Tailings	57	293	21	0	0%	24	0	0%
0.5m Till, 1m Waste Rock on Coarse Tailings	56	294	21	0	0%	24	0	0%
0.5m Till, 1m Glacial/Fluvial on Fine Tailings	67	285	19	0	0%	17	0	0%
0.5m Till, 1m Glacial/Fluvial on Coarse Tailings	75	286	10	0	0%	24	0	0%
1m Till, 1m Waste Rock, 5m Fine Tailings	49	297	25	0	0%	30	0	0%
1m Till, 1m Waste Rock, 5m Coarse Tailings	48	299	24	0	0%	29	0	0%
Three-Layer Covers								
0.5m Waste Rock, 0.5m Till, 0.5m Slime on Fine Tailings	119	185	67	0	0%	62	0	0%
0.5m Waste Rock, 0.5m Till, 0.5m Slime on Coarse Tailings	117	187	67	-1	0%	62	0	0%
1m Waste Rock, .5m Till, .5m Waste Rock on Fine Tailings	133	182	56	0	0%	62	0	0%
1m Waste Rock, .5m Till, .5m Waste Rock on Coarse Tailings	119	188	65	-1	0%	62	0	0%
1m Waste Rock, 1m Till, 1m Waste Rock on Fine Tailings	107	189	76	0	0%	62	0	0%
1m Waste Rock, 1m Till, 1m Waste Rock on Coarse Tailings	119	186	65	0	0%	62	0	0%

1. For uncovered tailings a positive flux, implies a flux into the tailings, but for covered tailings, a negative flux implies flux through the cover into the underlying waste.

Providing a stable surface covering for the tailings surface, which would allow routing of the Rose Creek over the covered tailings will require armouring of some kind, most likely Rip-Rap. For the purpose of the modeling carried out here, we have used waste rock as the armouring, however in reality waste rock cannot be used since it is not geochemically benign. Furthermore it should be borne in mind that clean Rip-Rap would have fewer fines than the modeled waste rock.

The uncovered fine tailings allows approximately 7% overall infiltration with 34% of the snowmelt reporting as infiltration. Surface runoff constitutes 16% of the water balance. In contrast the coarse uncovered tailings allows 24% overall infiltration, with 75% of the snowmelt infiltration, whilst there is no reported runoff. Currently, although local runoff can occur on the Rose Creek tailings, all this runoff is collected and contained on the impoundment, however, to allow more representative modeling we need to consider what occur on a more micro-scale.

One meter thick single layer covers, of either till, glaciofluvial material or waste rock, did result in a reduced infiltration, however, these single layer covers performed less effective than the multilayer covers, with both 100 cm thick till and glaciofluvial covers proving almost no barrier against infiltration. A 100 cm thick waste rock cover (using the same waste rock as used for the waste rock modeling) provided the best results, reducing infiltration to less than 2%. At first glance these results may seem counterintuitive, however the close similarity of the water retention characteristics of the tailings and the till and glaciofluvial materials, results in their poor performance as cover materials over the tailings. The waste rock however, performs best, since it is effectively acting as a surface capillary break, and since it contains enough fines, it allows the stored moisture to be evaporated during the summer season. This fact is further emphasized by the simulation of a 200 cm thick waste rock cover, which suggest even less infiltration.

All the multilayer covers evaluated performed well, with the model predicting no overall infiltration through the cover, and surface runoff varying between 12% and 34% depending on what material is used as the upper layer. From a practical point of view, based on these modeling results a cover of waste rock only seems reasonable. This would achieve all the closure objectives, however if the waste rock used to construct the cover is not geochemically benign it is likely that it would have to be covered with till or glaciofluvial material. Therefore a 1 m thick waste rock cover acts as a traffic surface and capillary break together with a thin glaciofluvial and/or till layer should be a good cover, reducing infiltration to a minimum.

7.3.2 Waste Rock Piles

The base case against which the numerical modeling results were evaluated for covers over the waste rock piles, were the uncovered waste rock. It was however assumed that the waste rock piles would have to be re-contoured extensively to allow placement of the cover, as had occurred at the cover test section on the Vangorda waste rock pile. For this reason, the uncovered waste rock profile model simulations were based on those material properties. It should be noted that the ARMC waste rock appears to be highly susceptible to environmental weathering, and re-handling of this weathered waste results in a well graded mixture of gravel-sand-silt mixture, as opposed to the poorly graded segregated boulders that is commonly observed on the side slopes. Modeling results of the final runs are presented in Table 22 and on Figure 30.

Table 22: Summary of waste rock pile cover simulations

Cover Profile	Full Simulation Period (Precipitation = 387 mm)					Freshet Only (P = 83 mm)		
	Runoff (mm)	Evap-oration (mm)	Infil-tration (mm)	Flux at Top of Tailings [1] (mm)	Flux at Top of Tailings [1] (%)	Infil-tration (mm)	Flux at Top of Tailings[1] (mm)	Flux at Top of Tailings [1] (%)
Uncovered Waste Rock								
10m Waste Rock	80	199	92	----	24%	62	----	75%
10m Waste Rock (Ksat 10^1 less permeable)	165	163	44	----	11%	62	----	75%
10m Waste Rock (Ksat 10^1 more permeable)	6	234	131	----	34%	61	----	73%
Covered Waste Rock								
0.5m Till, 9.5m Waste Rock	62	296	14	-17	-4%	22	-23	-28%
0.5m Till (Ksat 10^1 more Permeable); 9.5m Waste Rock	0	347	2.5	3.3	1%	62	-4	-5%
0.5m Till (Ksat 10^1 Less Permeable); 9.5m Waste Rock	131	222	17	2	1%	15	2	2%
0.5m Glacial/Fluvial, 9.5m Waste Rock	0	348	23	-18	-5%	62	-33	-40%
1.0m Till	48	299	24	-20	-5%	30	-24	-29%
1.0m Glacial/Fluvial, 9m Waste Rock	0	370	1	-3	-1%	62	-14	-17%
1.5m Till , 8.5m Waste Rock	47	298	26	-24	-6%	32	-23	-28%
1.5m Glacial/Fluvial, 8.5m Waste Rock	0	382	-10	4	1%	62	-4	-5%
2.0m Till, 8.0m Waste Rock	45	296	30	-28	-7%	33	-21	-25%
2m Glacial/Fluvial, 8m Waste Rock	0	375	-4	4	1%	62	-1	-1%

1. For uncovered waste rock a positive flux, implies a flux into the tailings, but for covered waste rock, a negative flux implies flux through the cover into the underlying waste.

Depending on the choice of saturated hydraulic conductivity, it is likely that the range of infiltration for uncovered waste rock (whether on side slopes or flat surfaces) would be between 11 and 34% of the annual total precipitation. Noteworthy, is the fact that approximately 75% of the 83 mm snowmelt results in infiltration, which has the resultant effect, that during the summer months there is between 0% and 29% infiltration. The uncovered waste rock is also prone to approximately 2% and 43% surface runoff, depending on the range of material properties selected.

In order to be able to compare cover effectiveness using different theoretical cover configurations, a constant waste rock profile was selected as a base case for the uncovered waste rock. This base case presents 24% overall infiltration (75% infiltration of the snowmelt with 12% infiltration for the remaining year) and 21% surface runoff.

Cover configurations were selected based on the available cover materials, and the minimum layer thickness considered was 50 cm. Only homogeneous layer covers was considered, i.e. till or glaciofluvial material only. The primary cover objective was set at minimizing infiltration through the cover. Therefore fluxes immediately below the cover was reported for comparison to the base uncovered waste rock case.

The model simulations clearly showed that placing a cover (varying between 50 cm and 200 cm) over the bare waste rock would reduce the overall infiltration to between 0% and 7% depending on the type (till or glaciofluvial material) and thickness of the cover. Also, the snowmelt period infiltration was reduced with the application of a cover to between 1% and 40%.

Interestingly, the glaciofluvial material appears to be a better cover with respect to minimizing infiltration. As the cover thickness increases from 50 cm to 200 cm in 50 cm increments for the till and glaciofluvial materials, the till cover overall infiltration increases from 4% to 7%, whilst the glaciofluvial cover overall infiltration reduces from 5% to 0%. The corresponding snowmelt infiltrations for these materials reduce from 28% to 25% for the till covers and from 40% to 5% for the glaciofluvial material.

The till cover sheds runoff, at a rate of between 16% and 12%, depending n the cover thickness, whilst the glaciofluvial cover does not allow any runoff to occur.

8 Conclusions

This report documents preliminary work to determine that could be achieved with soil covers at the ARMC, both with respect to the waste rock piles and the Rose Creek tailings impoundment. The main conclusions of this study can be summarized as follows:

- There is no benign waste on the ARMC; both the Rose Creek tailings and the waste rock piles are acid generating to various degrees, and both have leachable metals. It is therefore unlikely that the waste facilities can be left without doing some form of mitigation, e.g. isolating the waste through the use of covers. All the waste has however already undergone significant surface oxidation, and therefore it is unlikely that a cover design objective should be prevention of oxidation. More realistically, a cover design objective should be minimizing infiltration through shedding clean runoff and appropriate barrier systems.

- Historically, there has been some formal cover research carried out on cover performance on the Rose Creek tailings impoundment. The cover design at that time was geared towards preventing oxidation through controlling oxygen ingress and promoting freezing conditions. Although, the 5-year monitoring results were not conclusive they did suggest that oxidation rates could be slowed down through placement of covers. Further follow-up work by Nicholson et al. (1996), however recommended that only a permanent water cover would yield a sustainable oxygen barrier.

- The 10-year old, 2 m thick till cover test section on the Vangorda waste rock pile suggest that the till is performing well as a final cover. Although it is rilled through water erosion, damage through freeze/thaw and wetting/drying cycles seems limited. Limited oxygen measurements beneath the cover suggest that the cover is not a good oxygen barrier, and this fact was confirmed by test-pitting which confirmed that the till cover profile was almost complete dry. Permeability and density tests, however, confirmed that the saturated permeability of the cover is between 2.5×10^{-4} to 6.5×10^{-5} cm/s, even though the density has reduced to approximately 90% Standard Proctor, as opposed to the constructed density which exceeded 95% Standard Proctor. Vegetation was never established on the cover, and natural re-vegetation has not occurred in 10 years, suggesting that some initial amendment would be required.

- The borrow source investigation estimated the volume of potential cover materials primarily based on the aerial extent of the deposits. Based on these estimates, there is approximately 11.62 million cubic meters of till material, 2.8 million cubic meters of glaciofluvial material and between 0.125 to 0.225 million cubic meters of organics.

- Detailed laboratory and in-situ testing was carried out on all the potential cover materials and the tailings and waste rock. These tests confirmed that in all likelihood the till and glaciofluvial materials would be suitable for use in constructing covers. Neither of these materials are the ideal material, and the successful use thereof will depend on a suitable designed and tested "Engineered" cover.

- Constructing covers on the ARMC will be challenging due to the re-sloping requirements needed. Preliminary estimates for re-sloping the waste rock piles to 2.5H:1V suggest re-contouring of the Faro waste rock pile would require moving 3.1 million cubic meters of material, or approximately 2.4% of the 129 million cubic meters of material contained in this conglomerate of piles. The Grum waste rock pile would require re-contouring to the tune of 0.42 million cubic meters of material, or 1.8% of the 23.6 million cubic meters contained in the waste rock pile. At the Vangorda waste rock pile, approximately 0.6 million cubic meters of material would have to be re-handled for re-contouring, which would be equal to 1.8% of the total waste rock pile volume of 32.5 million cubic meters of material.

- Tailings trafficability remains a primary concern when considering the successful placement and performance of a cover system on Rose Creek tailings. This problem could likely be overcome by placing the cover in the winter when the tailings is frozen; however, the tailings will eventually thaw and settlement will occur.

- Evaporites can bee seen on the surface of the Rose Creek tailings, and on isolated areas of the waste rock piles. Based on the observed performance of the till cover on the Vangorda waste rock pile, we do not expect evaporates to be an issue when dealing with the waste rock, however it is expected to be a problem when considering tailings covers.

- The numerical modeling, confirmed that the available cover materials could be applied such that infiltration fluxes can be reduced, in many cases substantially. The modeling suggest that it is conceivable that for the waste rock piles, a tailings cover of 50 cm thick, would reduce overall infiltration to the underlying waste rock by more than 75%, and by increasing this thickness infiltration may become negligible. For the tailings impoundment, it would appear as if the most likely cover scenario would involve placing a traffic layer of 100 cm of waste rock, and then cladding this with either till or glaciofluvial material. This would reduce the infiltration to the tailings substantially.

Based, on our current understanding of the issues relating to covers for the ARMC waste facilities, we would recommend that the following action items be considered in the next Phase of the project:

- A study on the re-vegetation potential of the till should be initiated. It is clear from the work carried out at the Overburden dump and at the Vangorda waste rock pile test cover section that natural re-vegetation of the till is unlikely to occur, but that with some human intervention sustainable vegetation is likely. Although these observations are undisputed, good factual information that would support specification of a suitable species mix, and re-vegetation procedure has not been developed.

- The tailings trafficability tests described during the Scoping studies stage should be carried out. This study involves constructing actual full-scale test pads on the tailings surface. Such test pads may measure approximately 25 x 25 m each, and would comprise of a number of potential cover variants, including glaciofluvial material and/or geotextiles or combinations thereof. The pads will be placed using techniques similar to those that would be adopted for full scale construction (i.e. winter construction). Prior to placing such pads and immediately following construction, detailed surveys of the surrounding tailings surface and pad surfaces will be conducted. Follow-up surveys will be conducted in the following year, once the tailings have had a chance to thaw. As a follow-up to test pad studies, test pits will be excavated into these test pads approximately one year after initial placement to physically measure the blending of the pad material and tailings. The purpose of these test pads will be to determine how much settlement is likely to occur, and thus how thick the initial traffic layer should be. Naturally, covering 196 ha of tailings with 50 cm of rock as opposed to 100 cm makes a big difference in construction cost.

- Consideration should be given to constructing a full-scale test cover facility, to evaluate the performance of various thicknesses of till covers. Again, this would be to confirm whether there could be a cost saving when we consider covering 602 ha of waste rock piles. The proposed test facility would involve up to three test pads, with till covers ranging in thickness from 50 cm to 150 cm. Each of these test pads will be instrumented with a continuous data logger and instruments to measure matric suction and moisture content in the profiles. In addition such a station would be included on the existing Vangorda waste rock pile cover. Consideration would also be given to actual surface runoff measurement to calibrate numerical modeling.

- Another round of numerical modeling should be carried out, this time specifically focussing on potential cover configurations that might be implemented.

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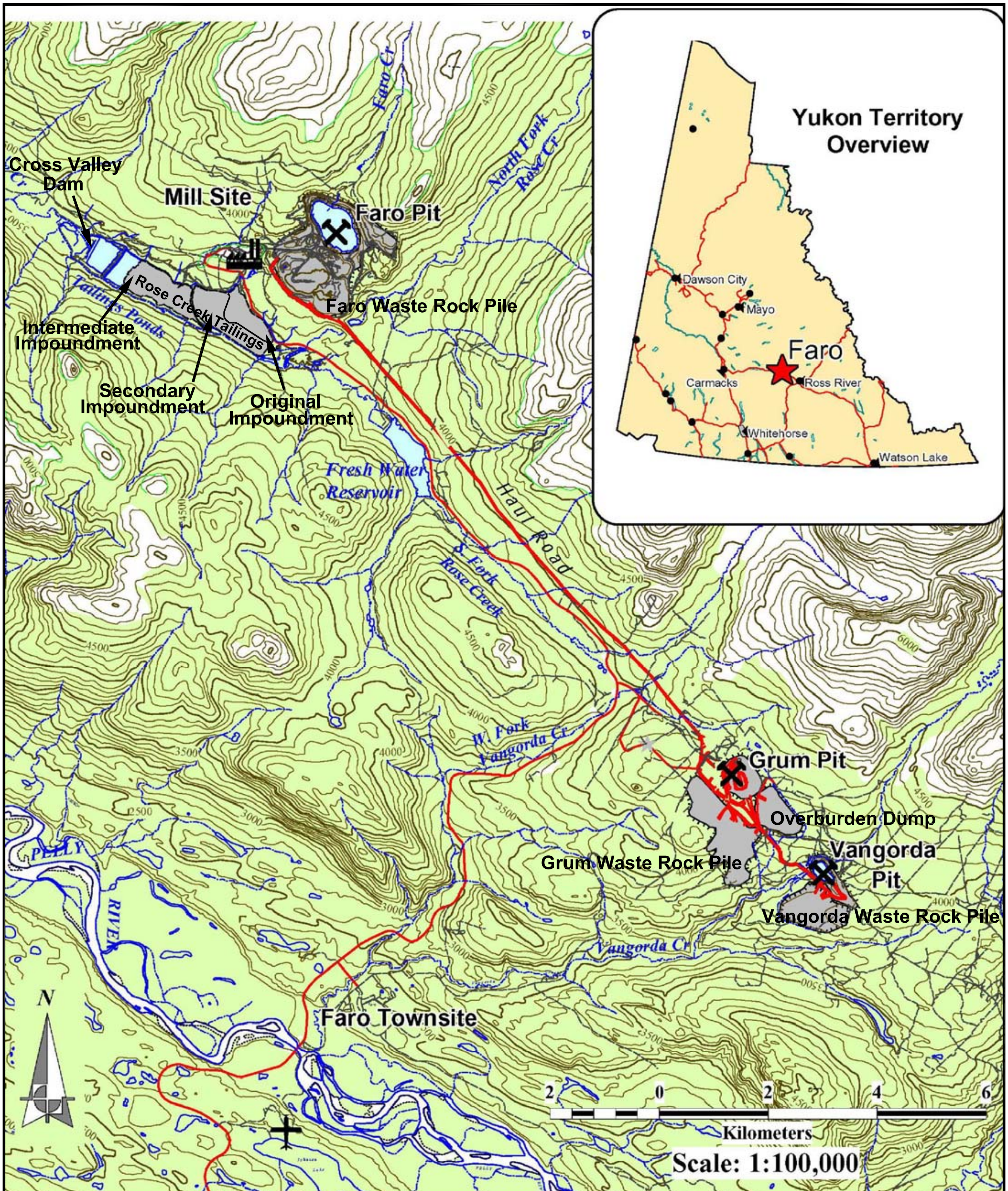

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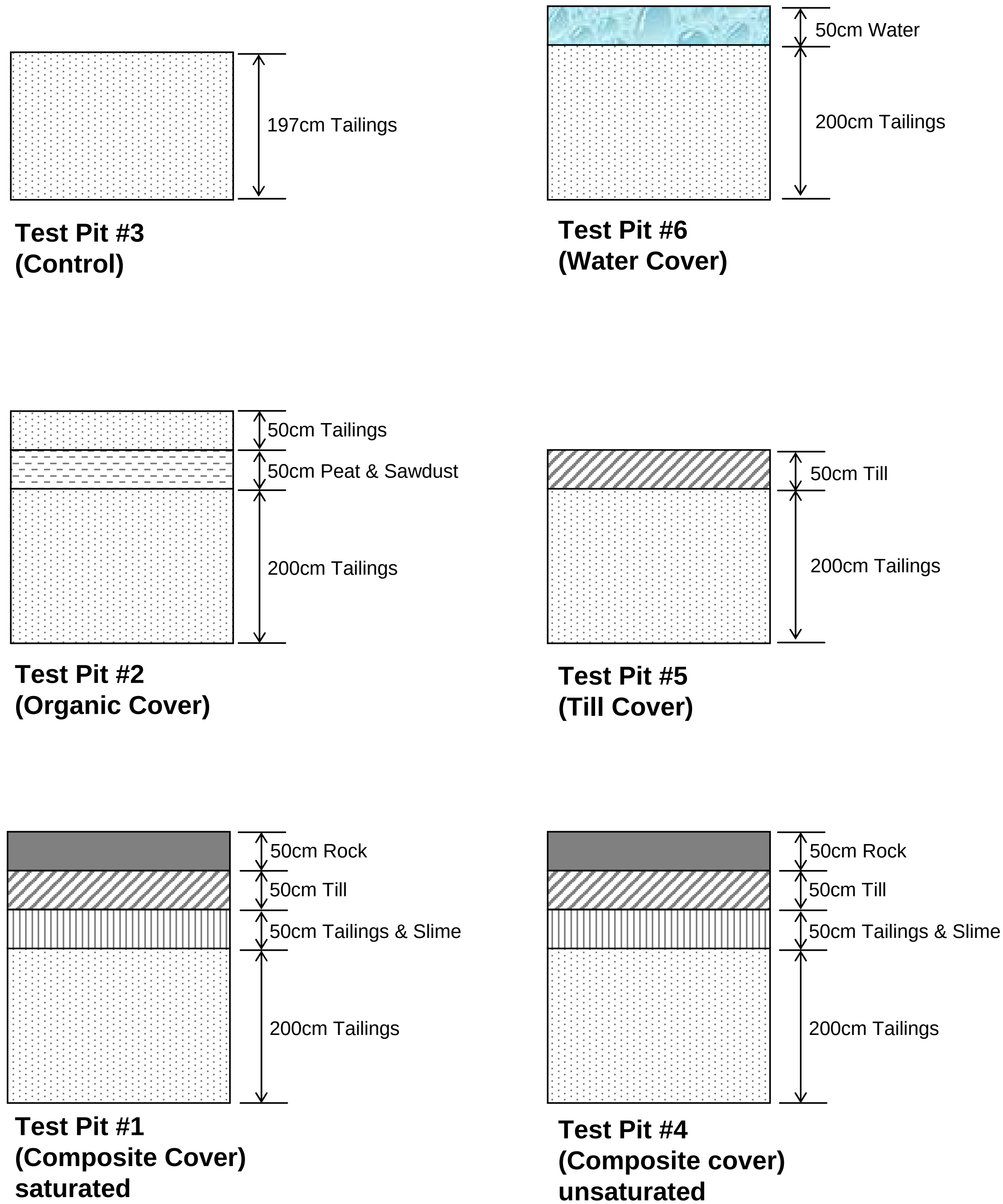
Anvil Range Mining Complex

Location Map

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	J.H.P.	1



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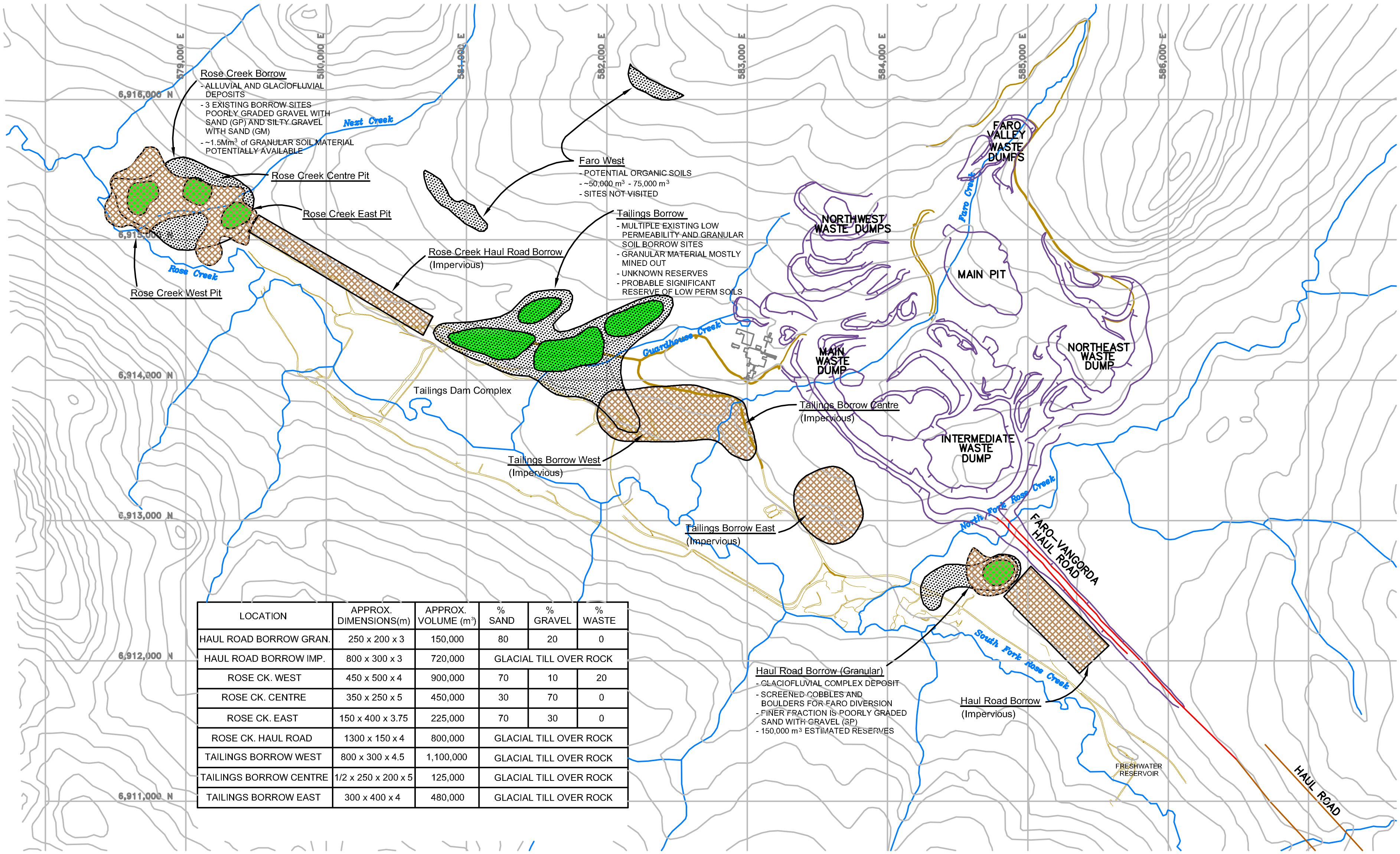
Anvil Range Mining Complex

Rose Creek Tailings Impoundment Test Covers

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.26	February 2004	EMR	2



LOCATION	APPROX. DIMENSIONS(m)	APPROX. VOLUME (m^3)	% SAND	% GRAVEL	% WASTE
HAUL ROAD BORROW GRAN.	250 x 200 x 3	150,000	80	20	0
HAUL ROAD BORROW IMP.	800 x 300 x 3	720,000	GLACIAL TILL OVER ROCK		
ROSE CK. WEST	450 x 500 x 4	900,000	70	10	20
ROSE CK. CENTRE	350 x 250 x 5	450,000	30	70	0
ROSE CK. EAST	150 x 400 x 3.75	225,000	70	30	0
ROSE CK. HAUL ROAD	1300 x 150 x 4	800,000	GLACIAL TILL OVER ROCK		
TAILINGS BORROW WEST	800 x 300 x 4.5	1,100,000	GLACIAL TILL OVER ROCK		
TAILINGS BORROW CENTRE	1/2 x 250 x 200 x 5	125,000	GLACIAL TILL OVER ROCK		
TAILINGS BORROW EAST	300 x 400 x 4	480,000	GLACIAL TILL OVER ROCK		

EXISTING QUARRY OR BORROW
POTENTIAL QUARRY OR BORROW
AREA IDENTIFIED BY BOND
MINE INFRASTRUCTURE
EXISTING ACCESS ROAD

0 500 1000 Metres

FILE REF: FIG-3.dwg

REFERENCE
BOND, J.D. (OPEN FILE 1999-10)
SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE (105K/3&6 W), CENTRAL YUKON TERRITORY

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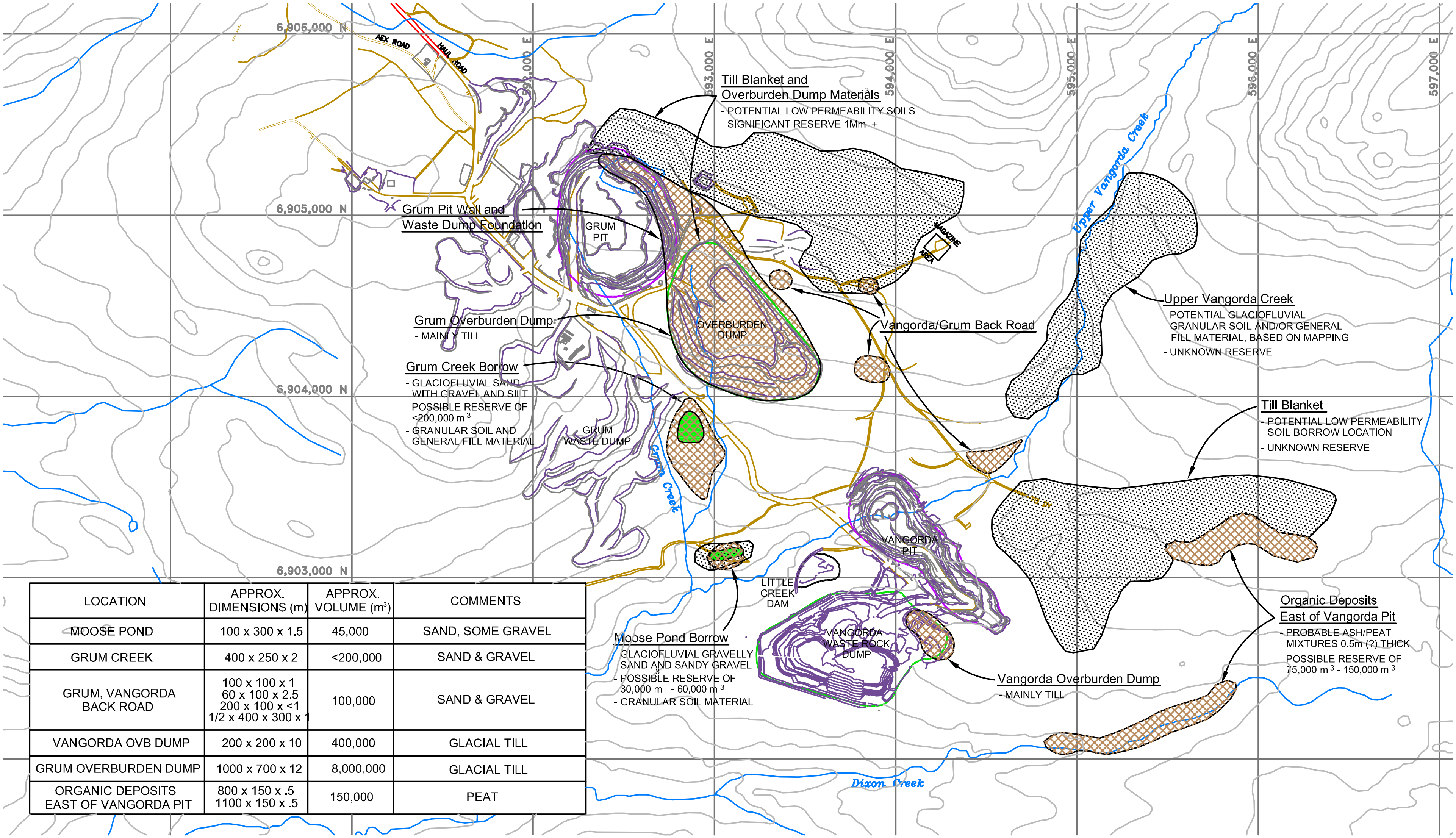
Anvil Range Mining Complex

Borrow Source Locations – Faro Mine

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	J.H.P.	3



LOCATION	APPROX. DIMENSIONS (m)	APPROX. VOLUME (m³)	COMMENTS
MOOSE POND	100 x 300 x 1.5	45,000	SAND, SOME GRAVEL
GRUM CREEK	400 x 250 x 2	<200,000	SAND & GRAVEL
GRUM, VANGORDA BACK ROAD	100 x 100 x 1 60 x 100 x 2.5 200 x 100 x <1 1/2 x 400 x 300 x 1	100,000	SAND & GRAVEL
VANGORDA OVB DUMP	200 x 200 x 10	400,000	GLACIAL TILL
GRUM OVERBURDEN DUMP	1000 x 700 x 12	8,000,000	GLACIAL TILL
ORGANIC DEPOSITS EAST OF VANGORDA PIT	800 x 150 x .5 1100 x 150 x .5	150,000	PEAT

EXISTING QUARRY OR BORROW
POTENTIAL QUARRY OR BORROW
AREA IDENTIFIED BY BOND
MINE INFRASTRUCTURE
EXISTING ACCESS ROAD

0 500 1000 Metres

REFERENCE
BOND, J.D. (OPEN FILE 1999-10)
SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE (105K/3&6 W), CENTRAL YUKON TERRITORY

FILE REF: FIG-3.dwg

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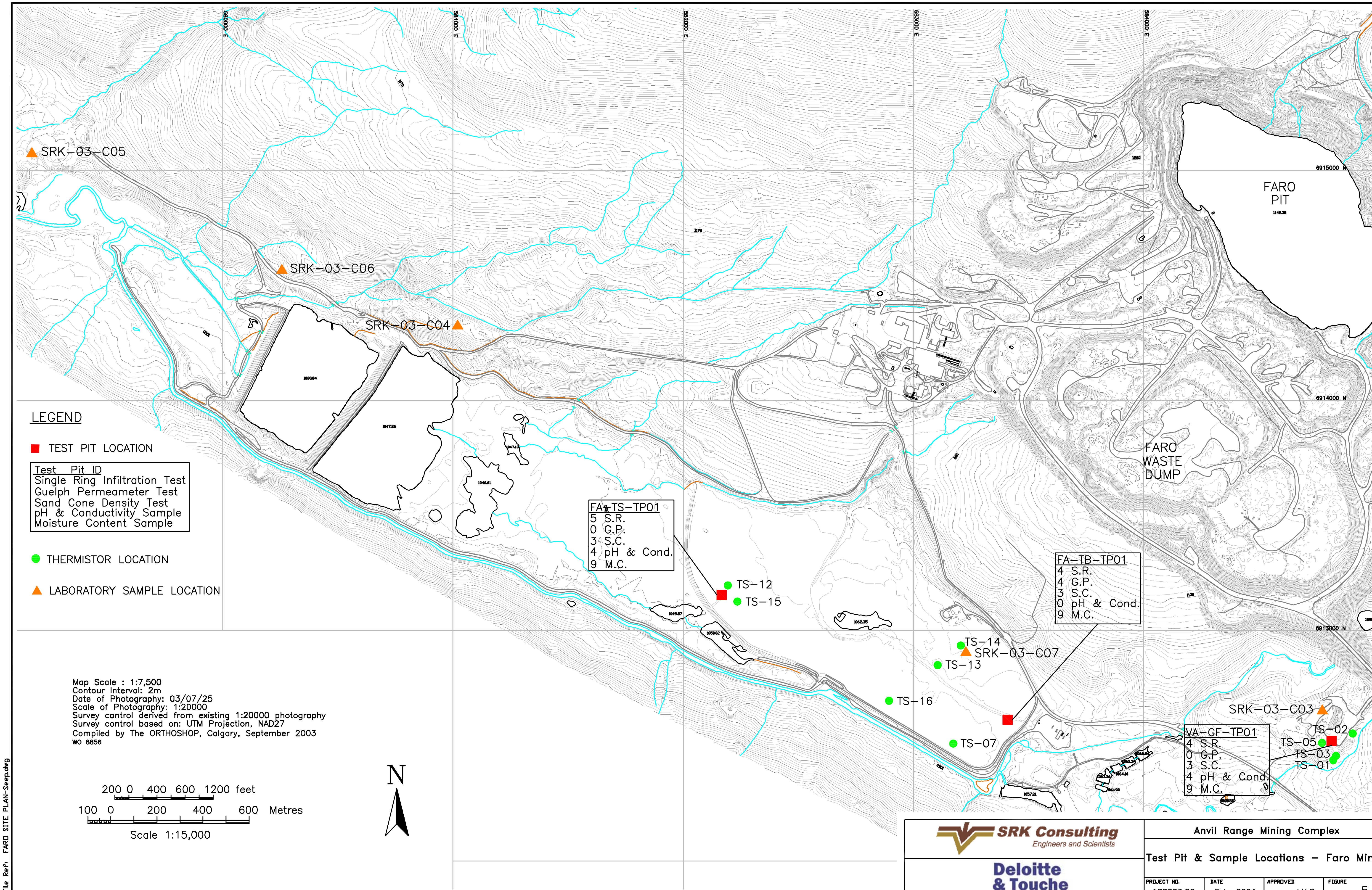
Anvil Range Mining Complex

Borrow Source Locations – Vangorda Plateau

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	J.H.P.	4


SRK-03-C05
SRK-03-C06
SRK-03-C04
SRK-03-C07
SRK-03-C03
FARO PIT
FARO WASTE DUMP
FA-TS-TP01
5 S.R.
0 G.P.
3 S.C.
4 pH & Cond.
9 M.C.
FA-TB-TP01
4 S.R.
4 G.P.
3 S.C.
0 pH & Cond.
9 M.C.
VA-GF-TP01
4 S.R.
0 G.P.
3 S.C.
4 pH & Cond.
9 M.C.
TS-12
TS-15
TS-14
TS-13
TS-16
TS-07
TS-02
TS-05
TS-03
TS-01
580000 E
581000 E
582000 E
583000 E
584000 E
6915000 N
6914000 N
6913000 N
LEGEND
TEST PIT LOCATION
Test Pit ID
Single Ring Infiltration Test
Guelph Permeameter Test
Sand Cone Density Test
pH & Conductivity Sample
Moisture Content Sample
THERMISTOR LOCATION
LABORATORY SAMPLE LOCATION
Map Scale : 1:7,500
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856
200 0 400 600 1200 feet
100 0 200 400 600 Metres
Scale 1:15,000
N
File Ref: FARO SITE PLAN-Seep.dwg
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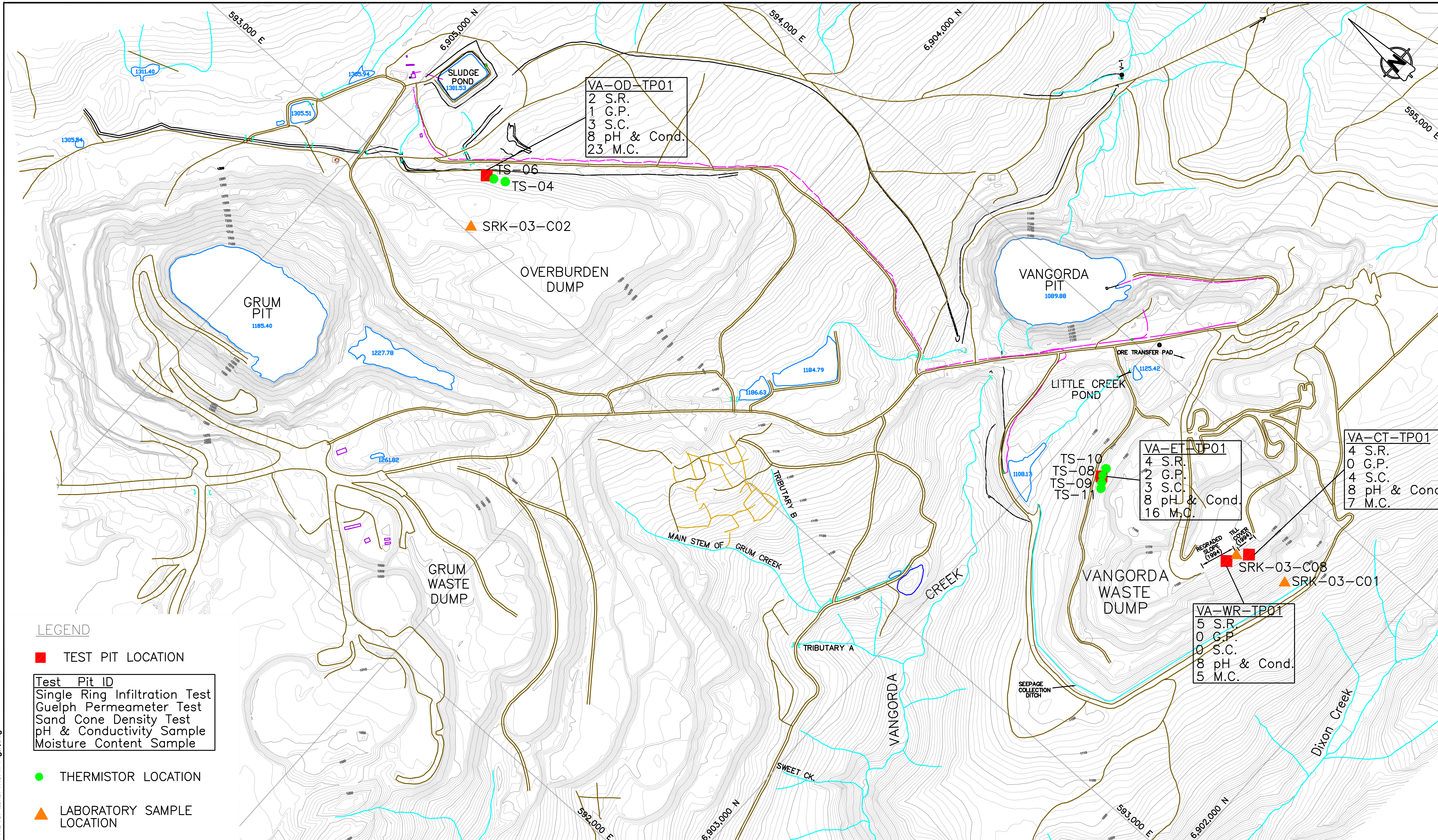
Deloitte & Touche
Anvil Range Mining Complex
Test Pit & Sample Locations – Faro Mine
PROJECT NO. 1CD003.26
DATE Feb. 2004
APPROVED J.H.P.
FIGURE 5



File Ref: site_plan_Thermistor(11x17Therm-Fig1).dwg

Map Scale: 1:2500
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

0 100 200 300 400 500 600 700 800 900 1000m
Scale 1:10,000

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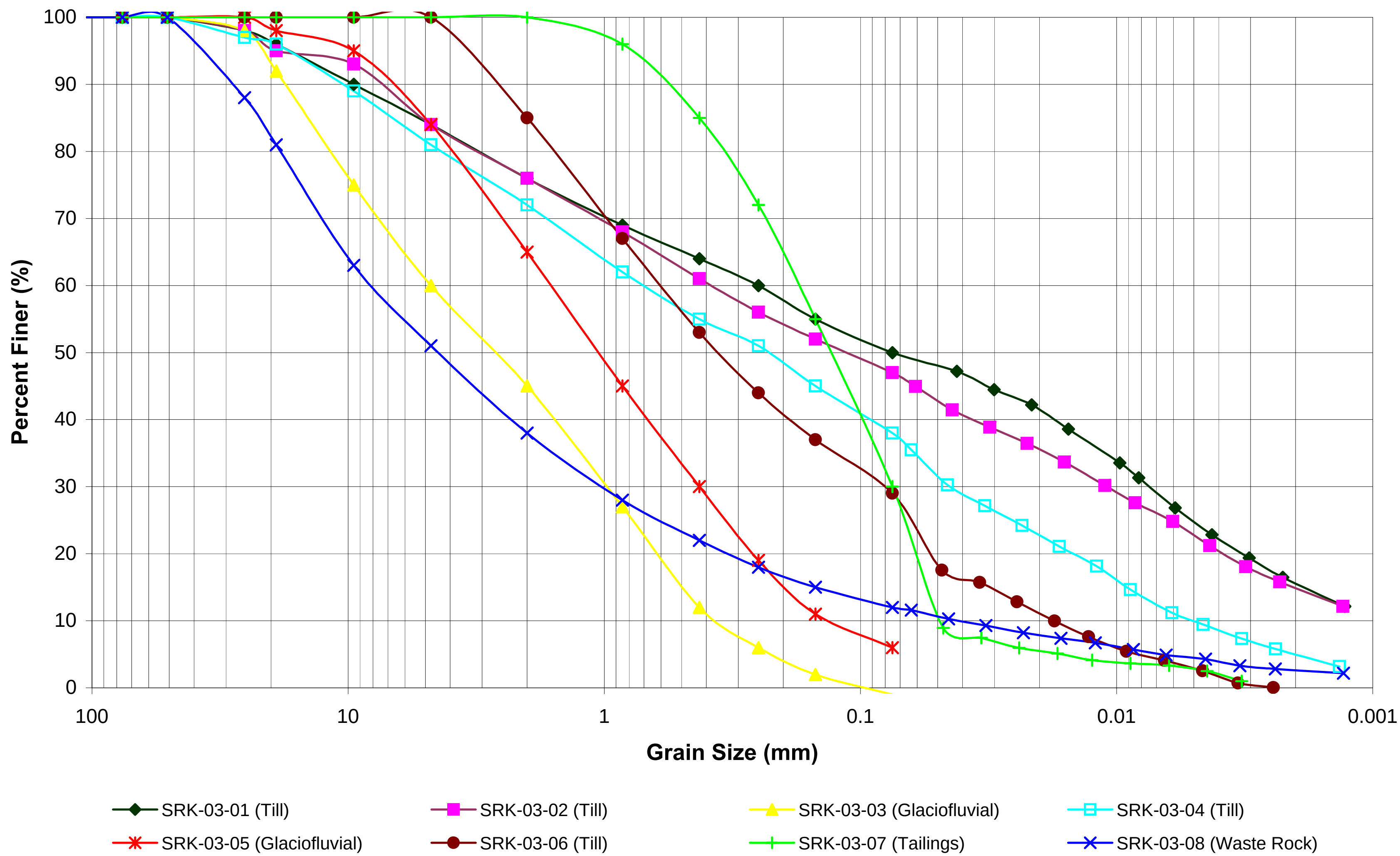
Anvil Range Mining Complex

Test Pit & Sample Locations – Vangorda Plateau

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	J.H.P.	6



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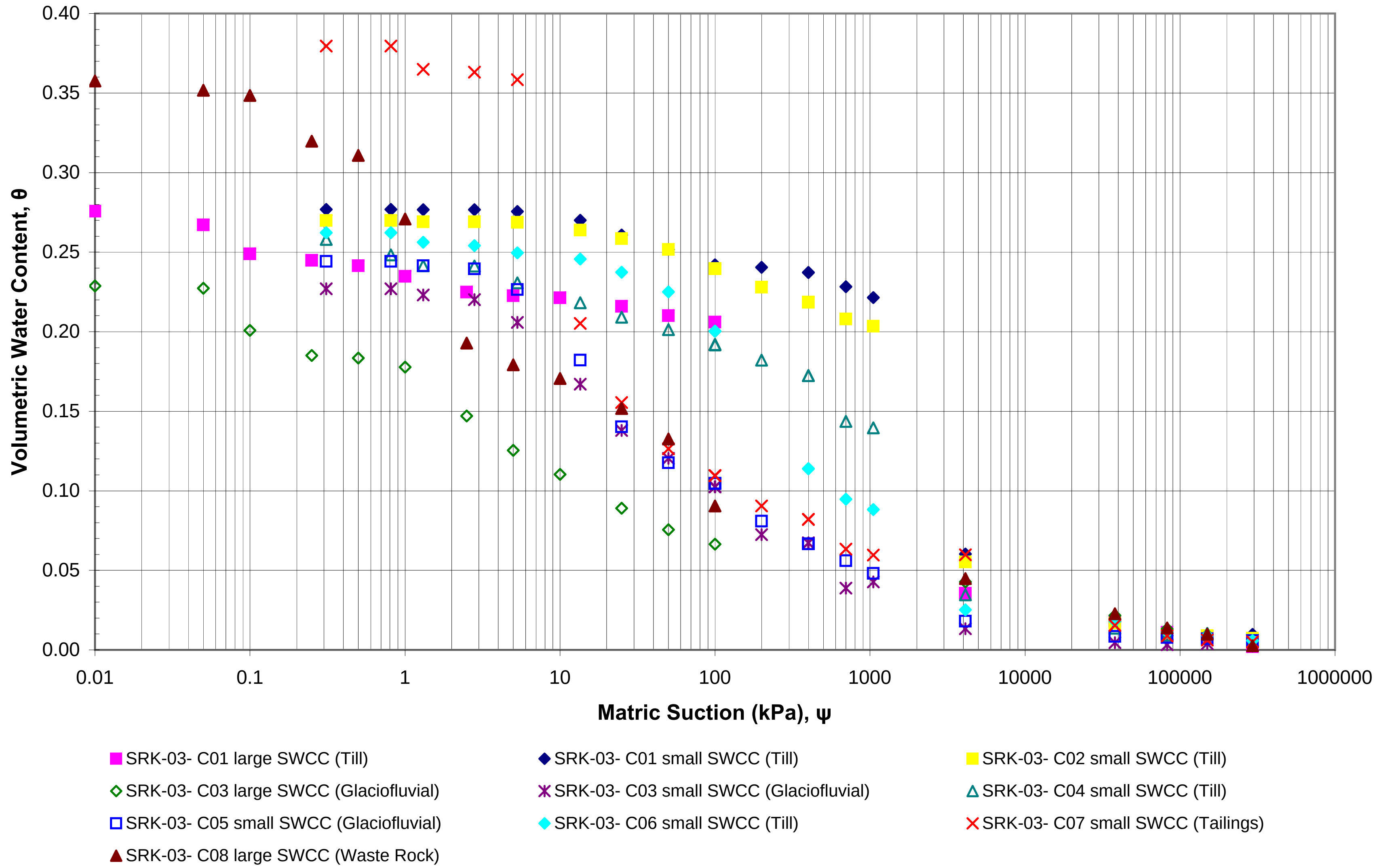
Anvil Range Mining Complex

Particle Size Distribution Curves

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	7



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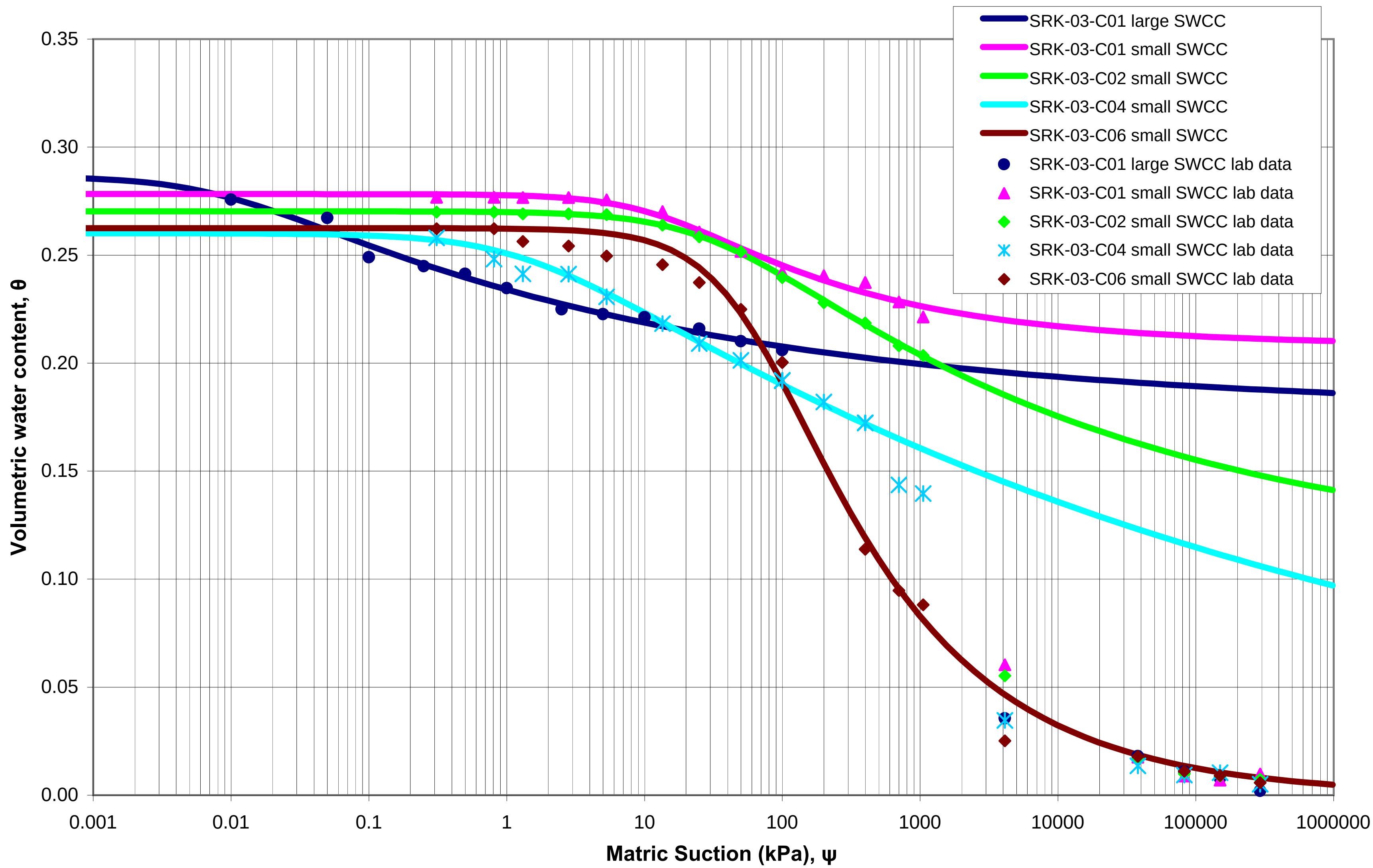
Anvil Range Mining Complex

Soil Water Characteristic Curve Data

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	8

Report Figures.xls, SWCC



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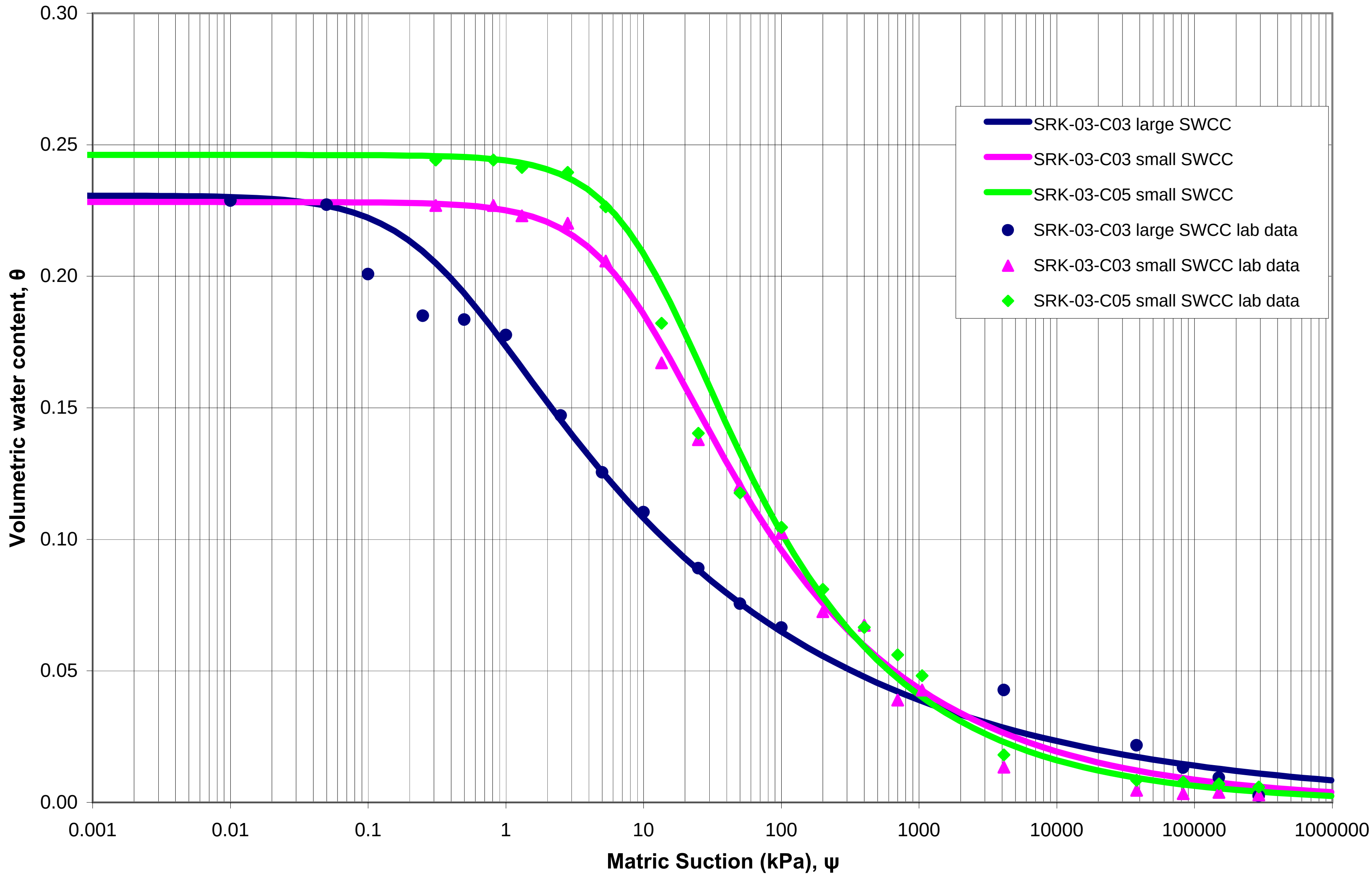
Anvil Range Mining Complex

Soil Water Characteristic Curves (Till Material)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	9



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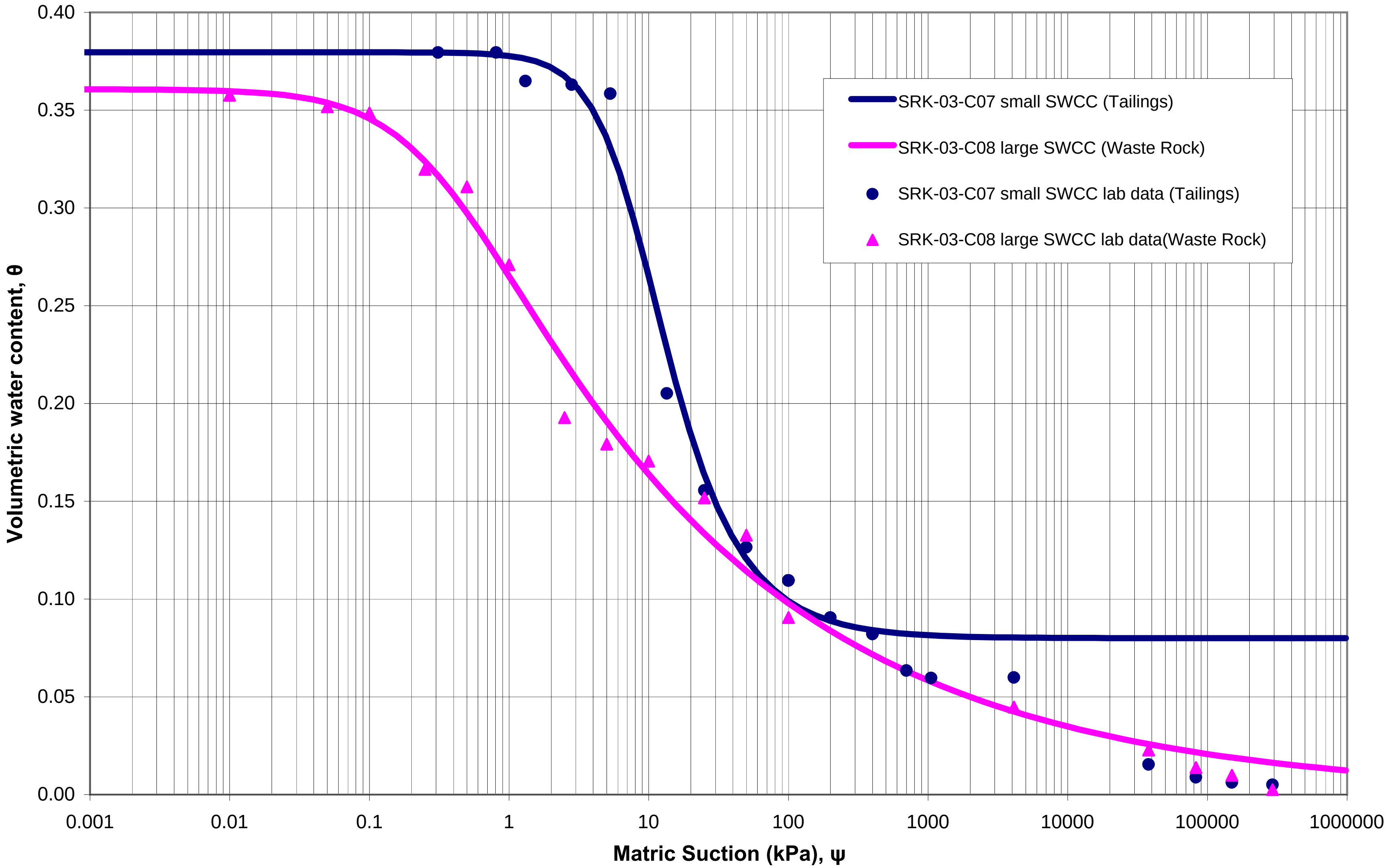
Anvil Range Mining Complex

Soil Water Characteristic Curves (Glaciofluvial Material)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	10



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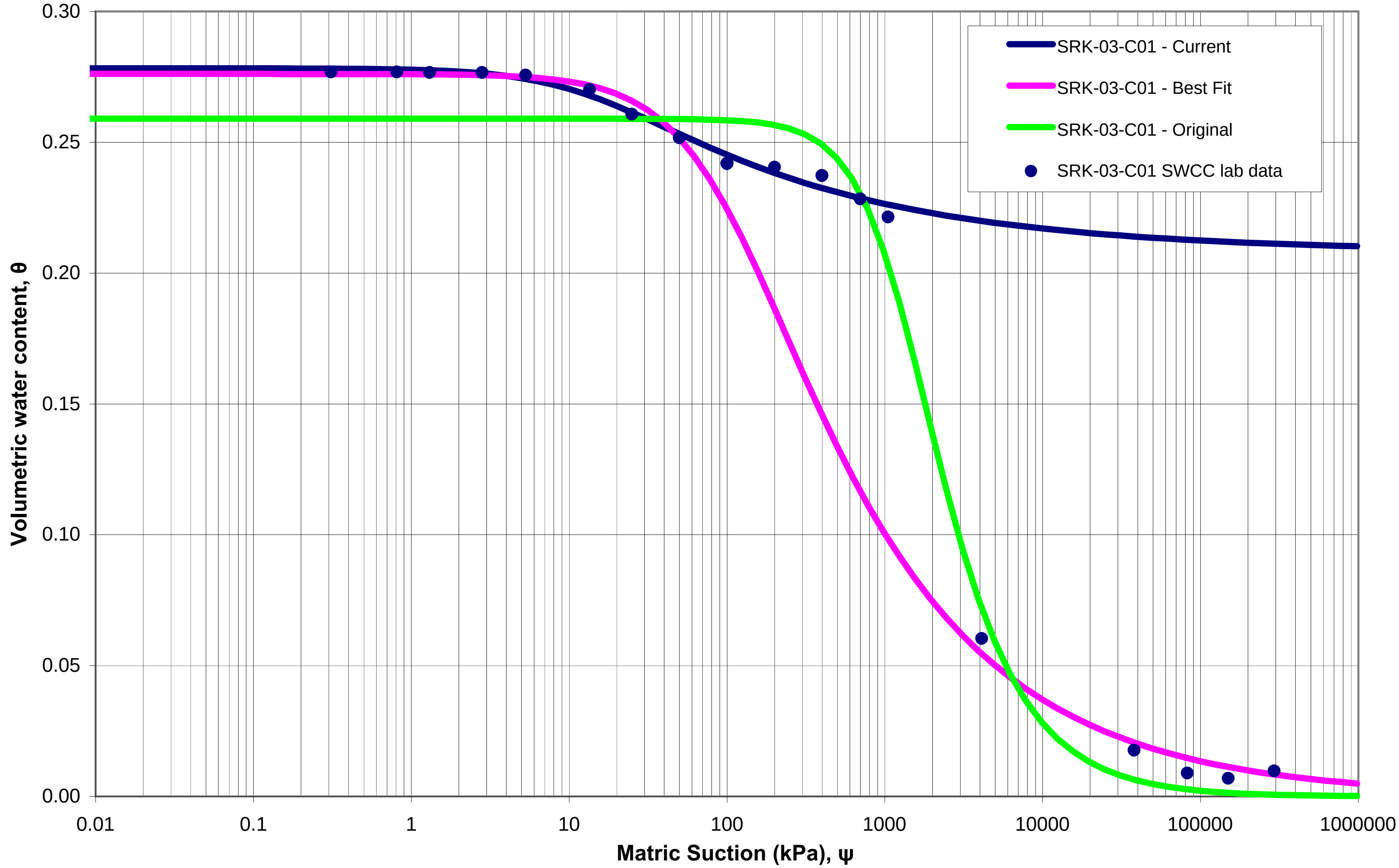
Anvil Range Mining Complex

Soil Water Characteristic Curves (Waste Rock & Tailings)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	11



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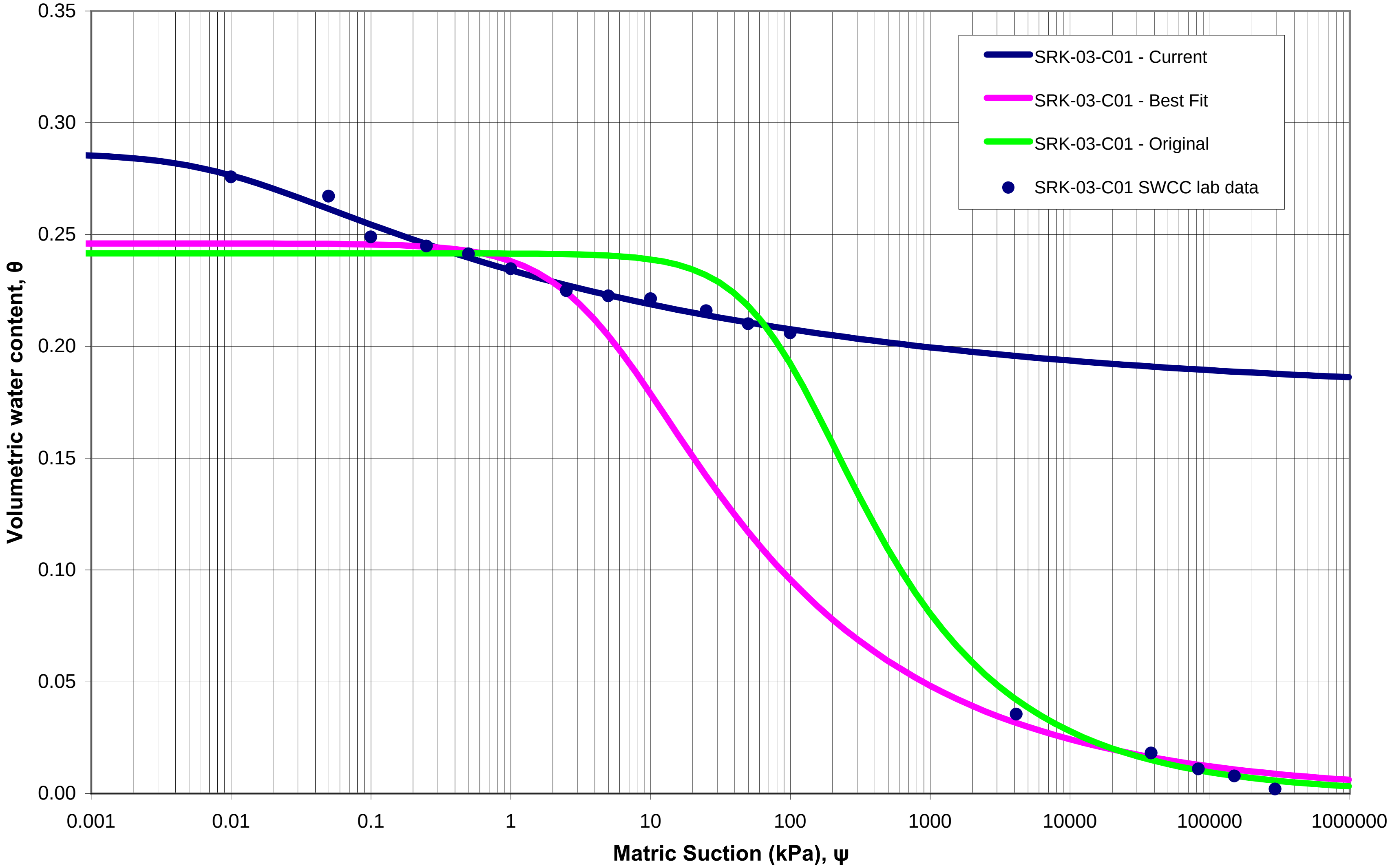
Anvil Range Mining Complex

Soil Water Characteristic Curves (Till, SRK-03-C01, Standard Tempe Cell)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	12



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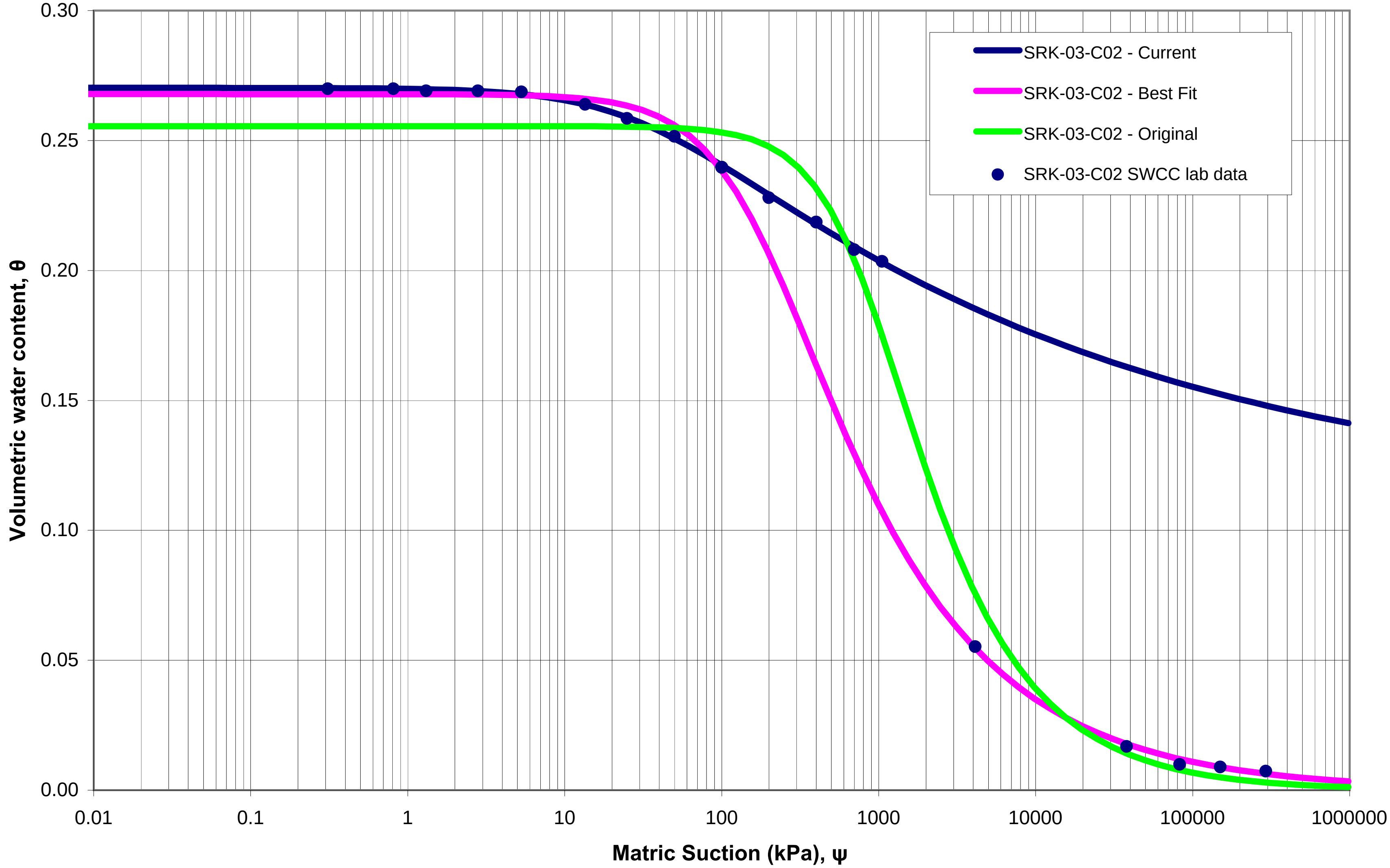
Anvil Range Mining Complex

Soil Water Characteristic Curves (Till, SRK-03-C01, Large Tempe Cell)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	13

Report Figures.xls, Tail-end fit (C01 large)



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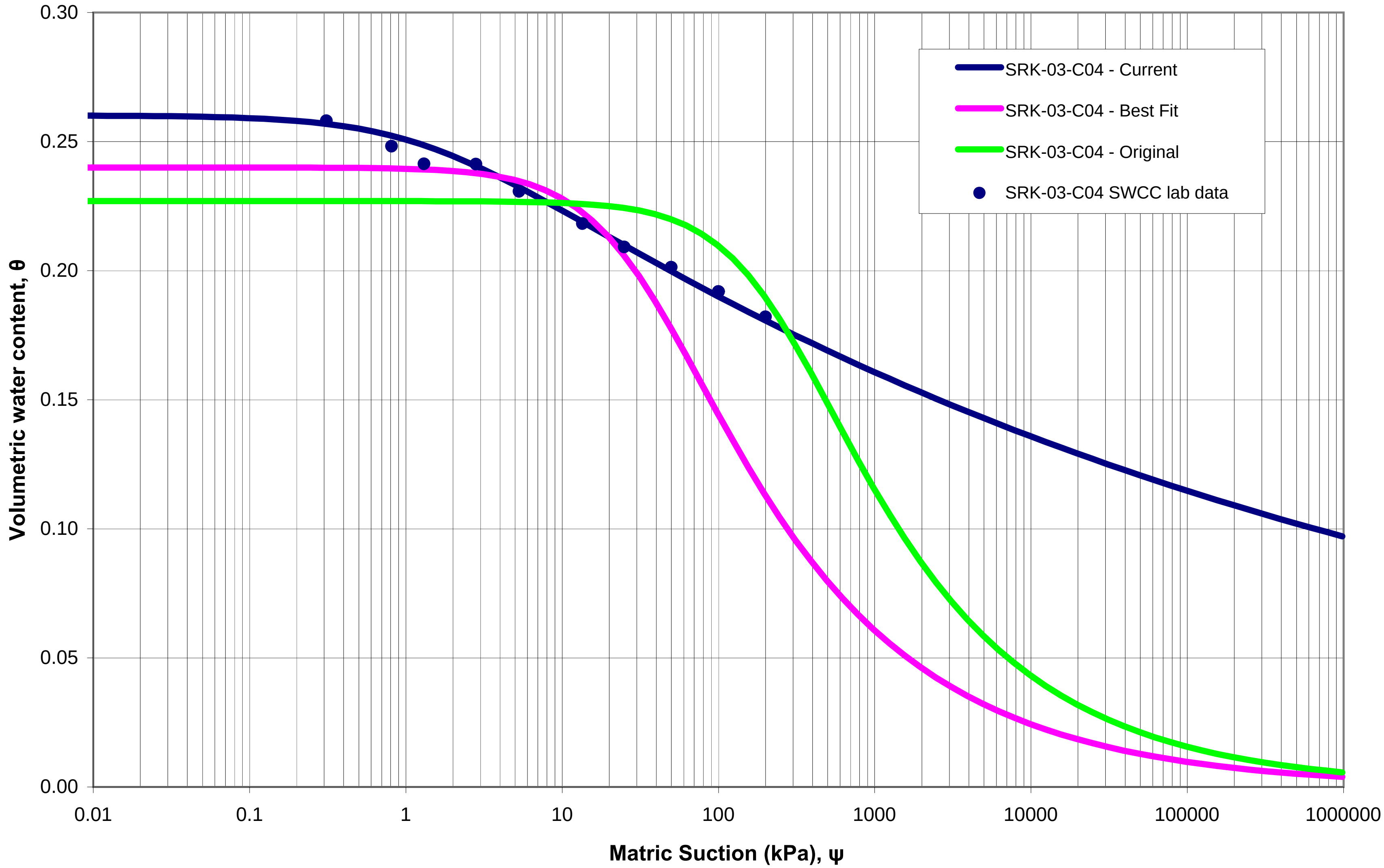
Anvil Range Mining Complex

Soil Water Characteristic Curves (Till, SRK-03-C02, Standard Tempe Cell)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	14



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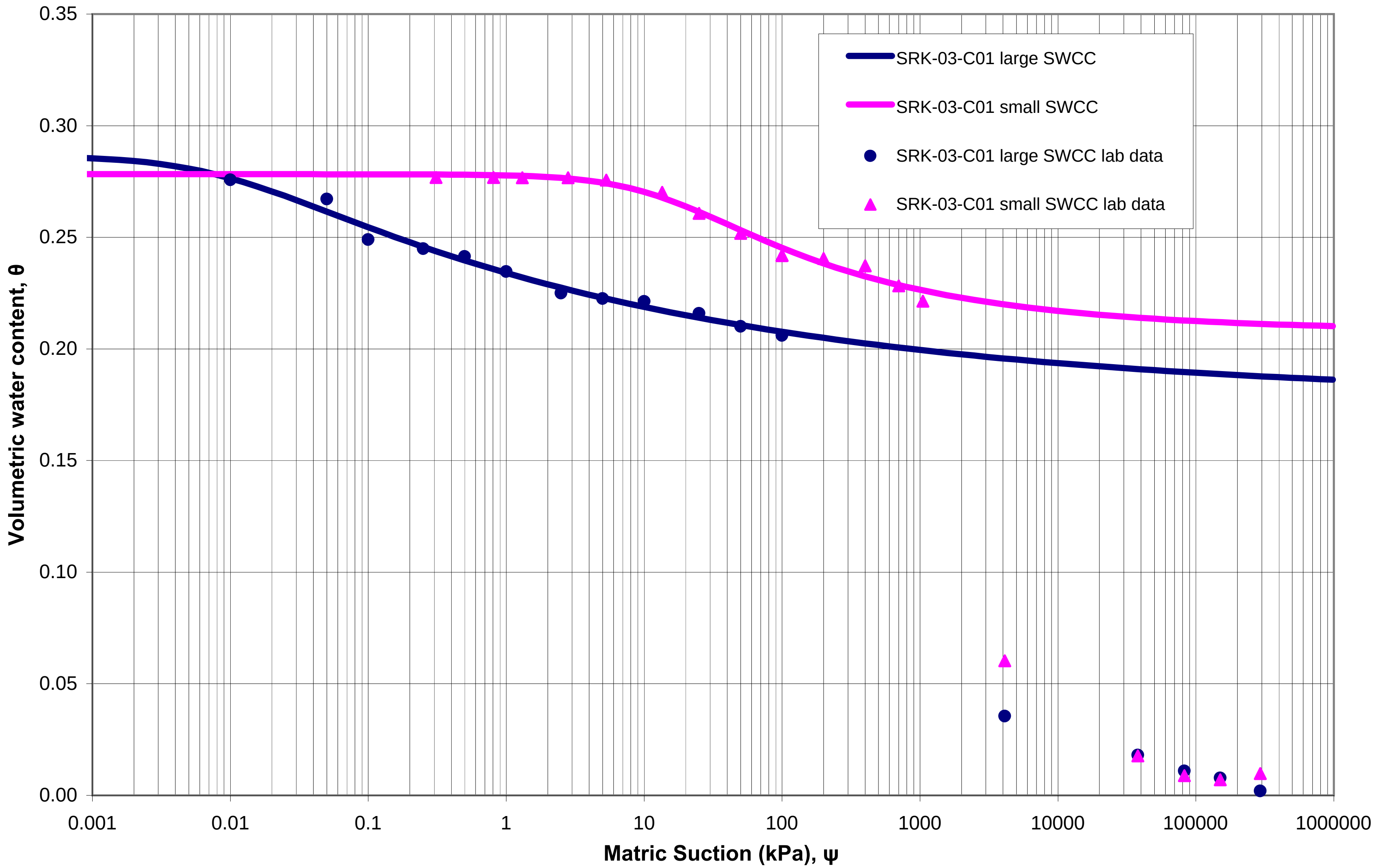
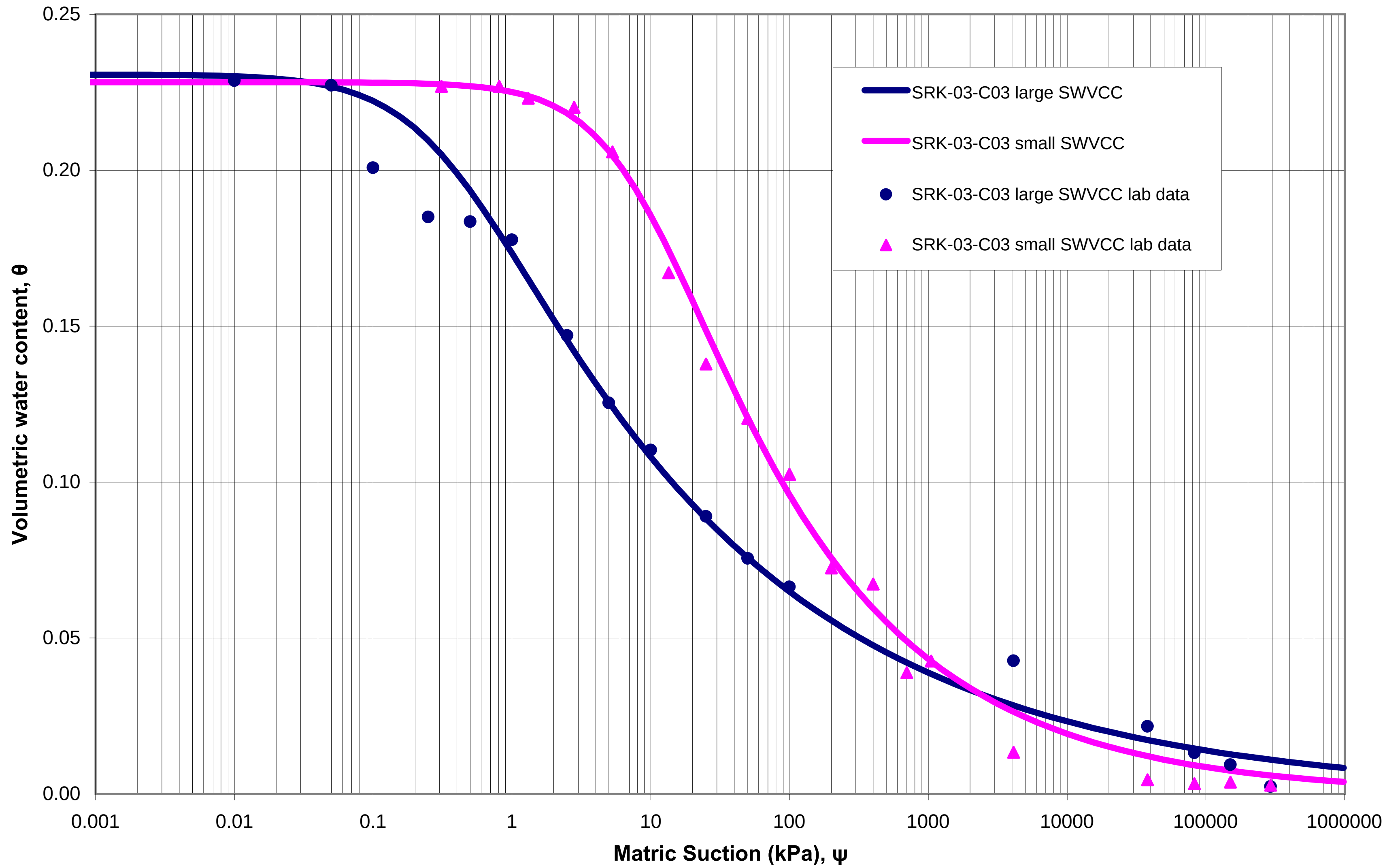
Anvil Range Mining Complex

Soil Water Characteristic Curves
(Till, SRK-03-C04, Standard Tempe Cell)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	15



SRK Consulting *Engineers and Scientists*	Anvil Range Mining Complex			
Deloitte & Touche	**Soil Water Characteristic Curves (Till, SRK-03-C01)**			
	PROJECT 1CD003.26	DATE Feb. 2004	APPROVED E.M.R.	FIGURE 16



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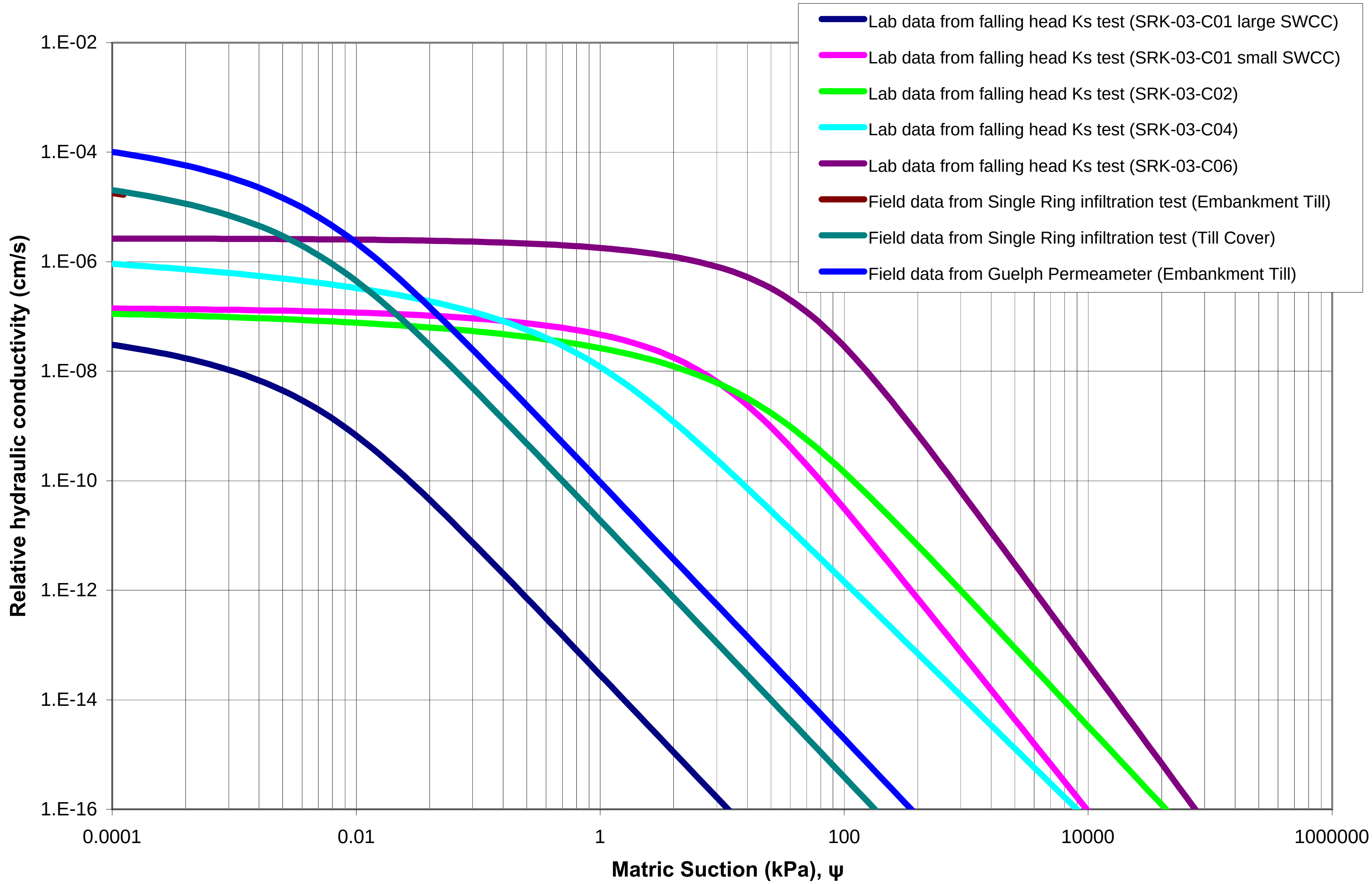
Anvil Range Mining Complex

Soil Water Characteristic Curves (Glaciofluvial, SRK-03-C03)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	17



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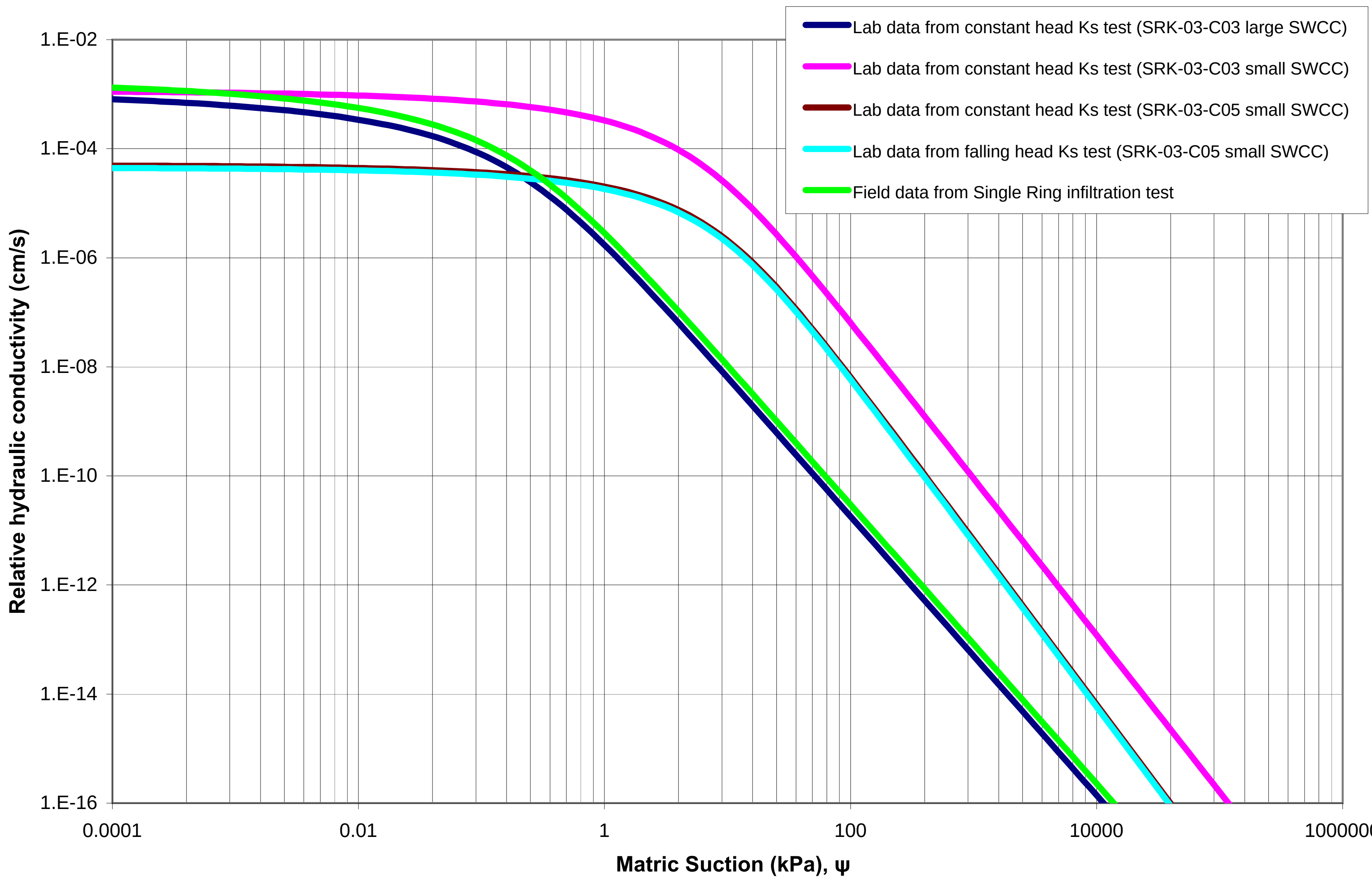
Anvil Range Mining Complex

Unsaturated Hydraulic Conductivity Curves (Till Material)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	18



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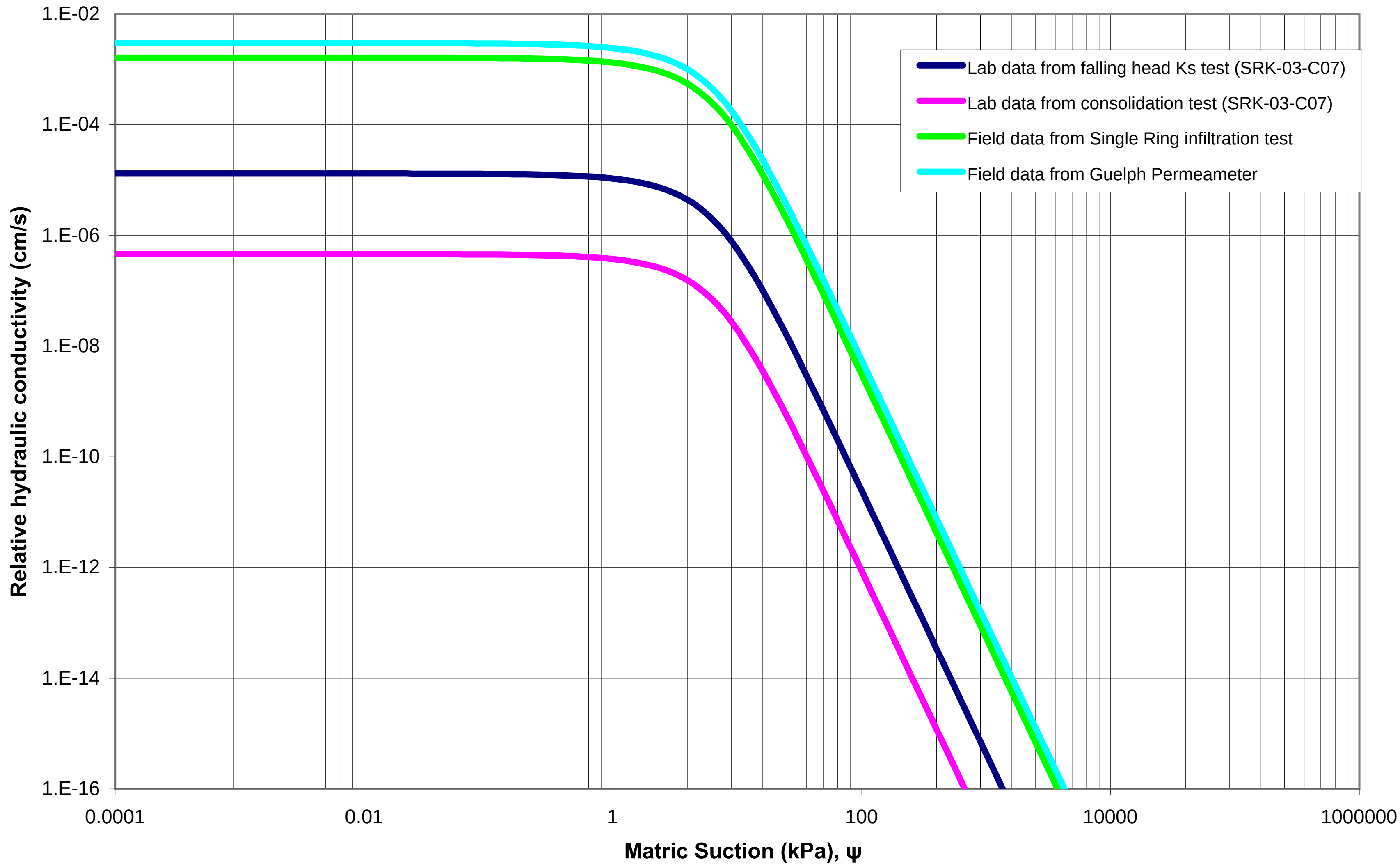
Anvil Range Mining Complex			
Unsaturated Hydraulic Conductivity Curves (Glaciofluvial Material)			
PROJECT 1CD003.26	DATE Feb. 2004	APPROVED E.M.R.	FIGURE 19



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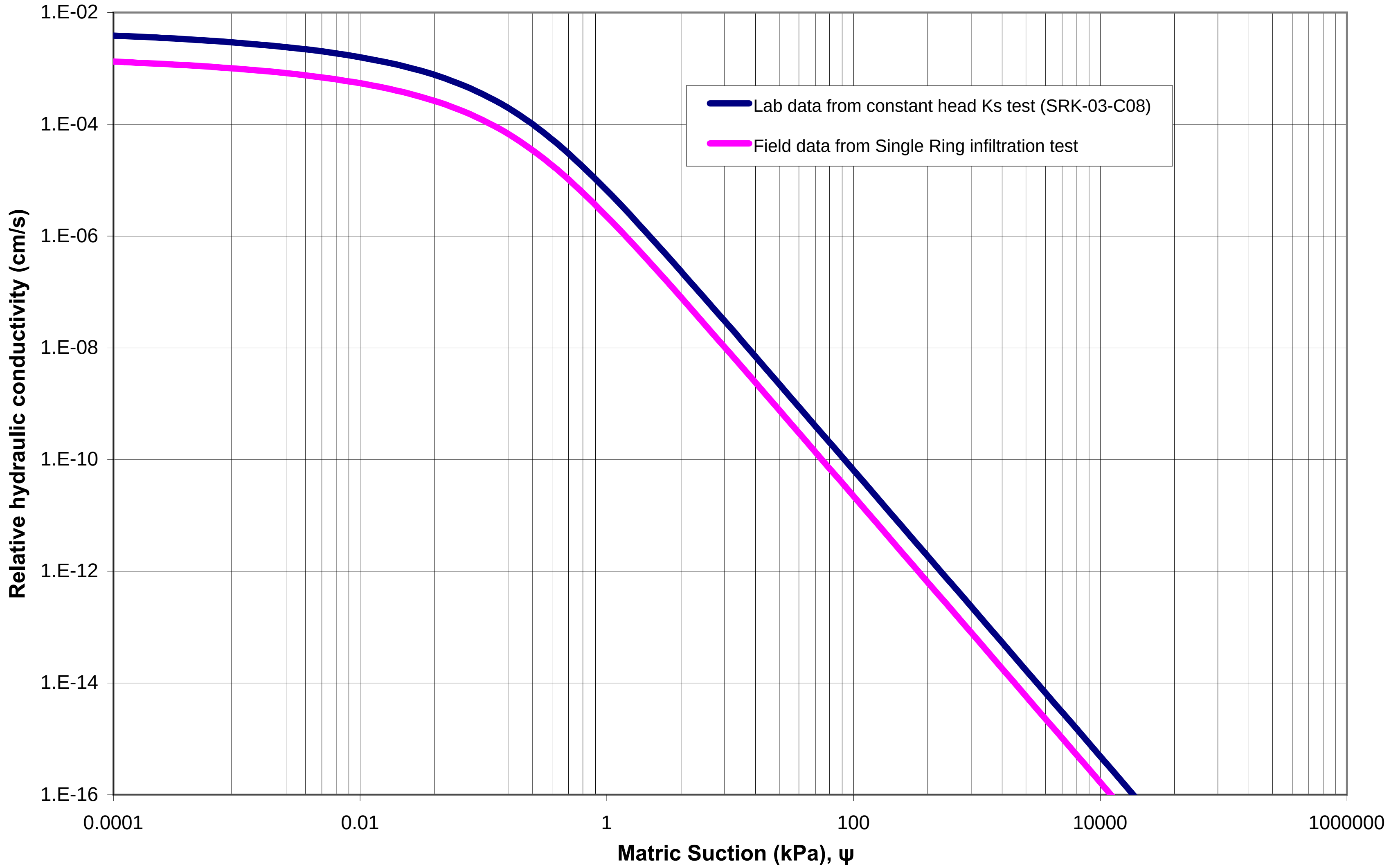
Anvil Range Mining Complex

Unsaturated Hydraulic Conductivity Curves (Tailings)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	20



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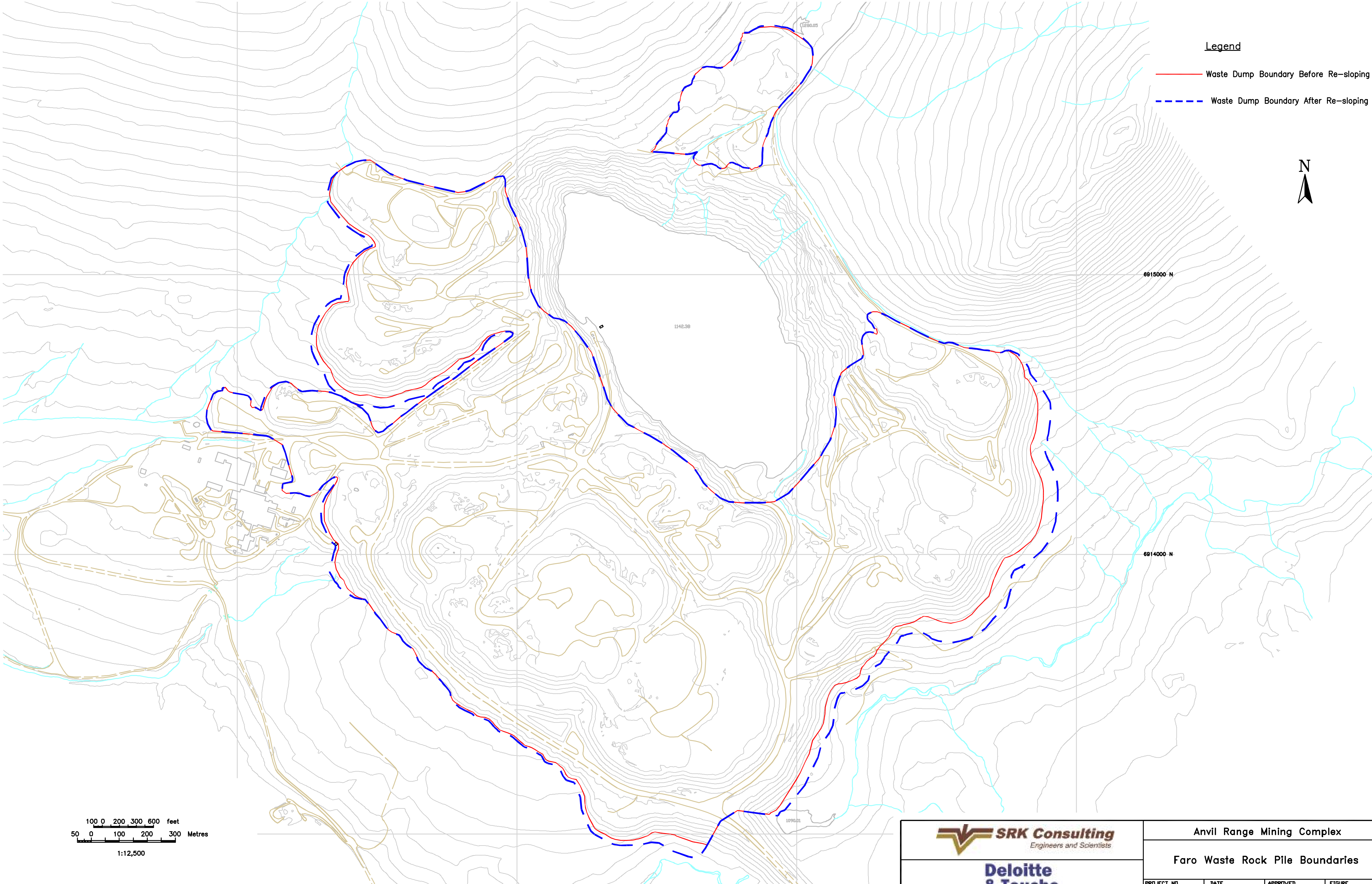
Anvil Range Mining Complex

Unsaturated Hydraulic Conductivity Curves (Waste Rock)

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	21



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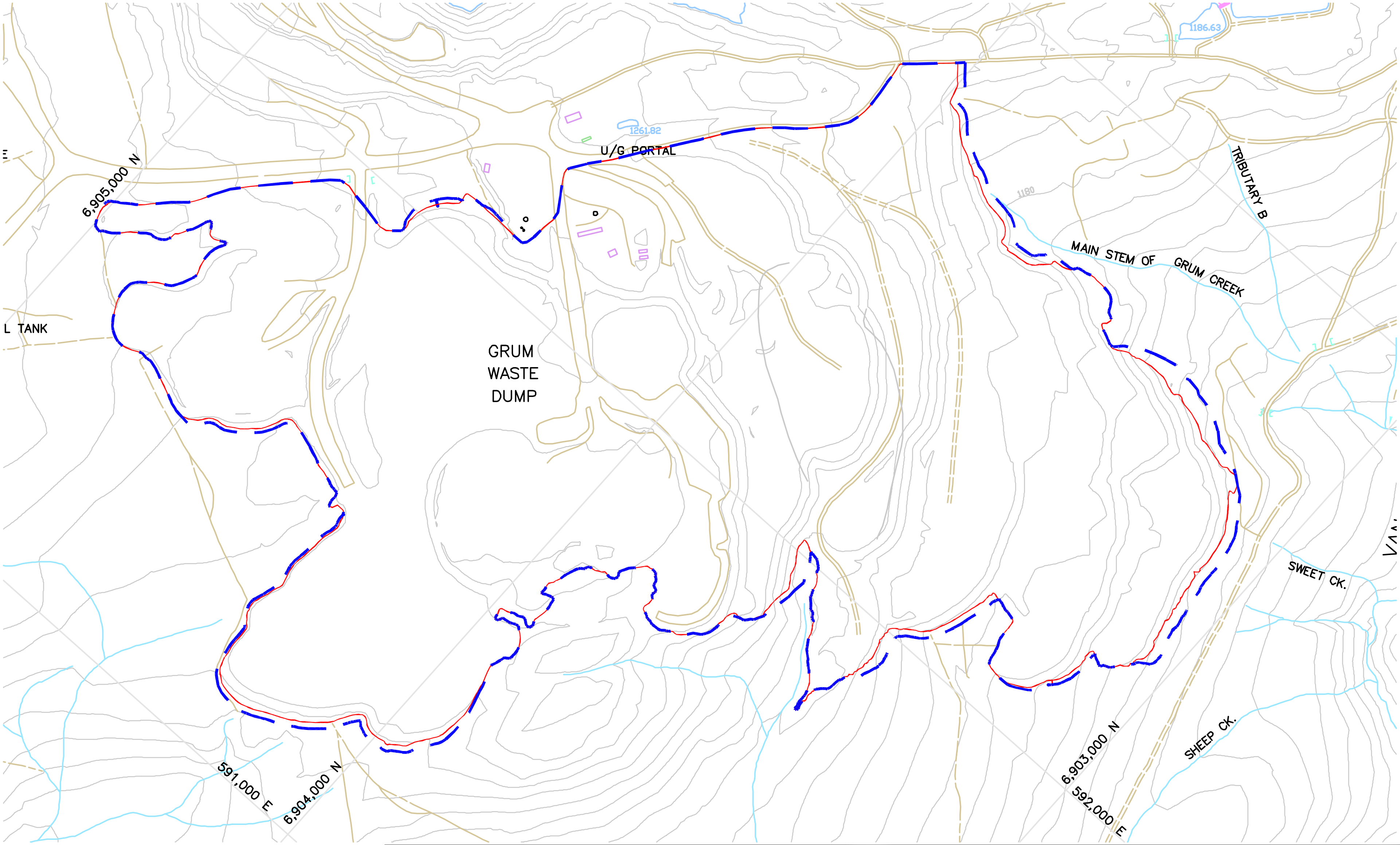
Anvil Range Mining Complex

Faro Waste Rock Pile Boundaries

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	J.H.P.	22a

File Ref: 2003 SITE PLAN-photo.dwg



Legend

Waste Dump Boundary Before Re–sloping

Waste Dump Boundary After Re–sloping

0 25 50 75 100 125 150 175 200 225 250m

Scale 1:10,000

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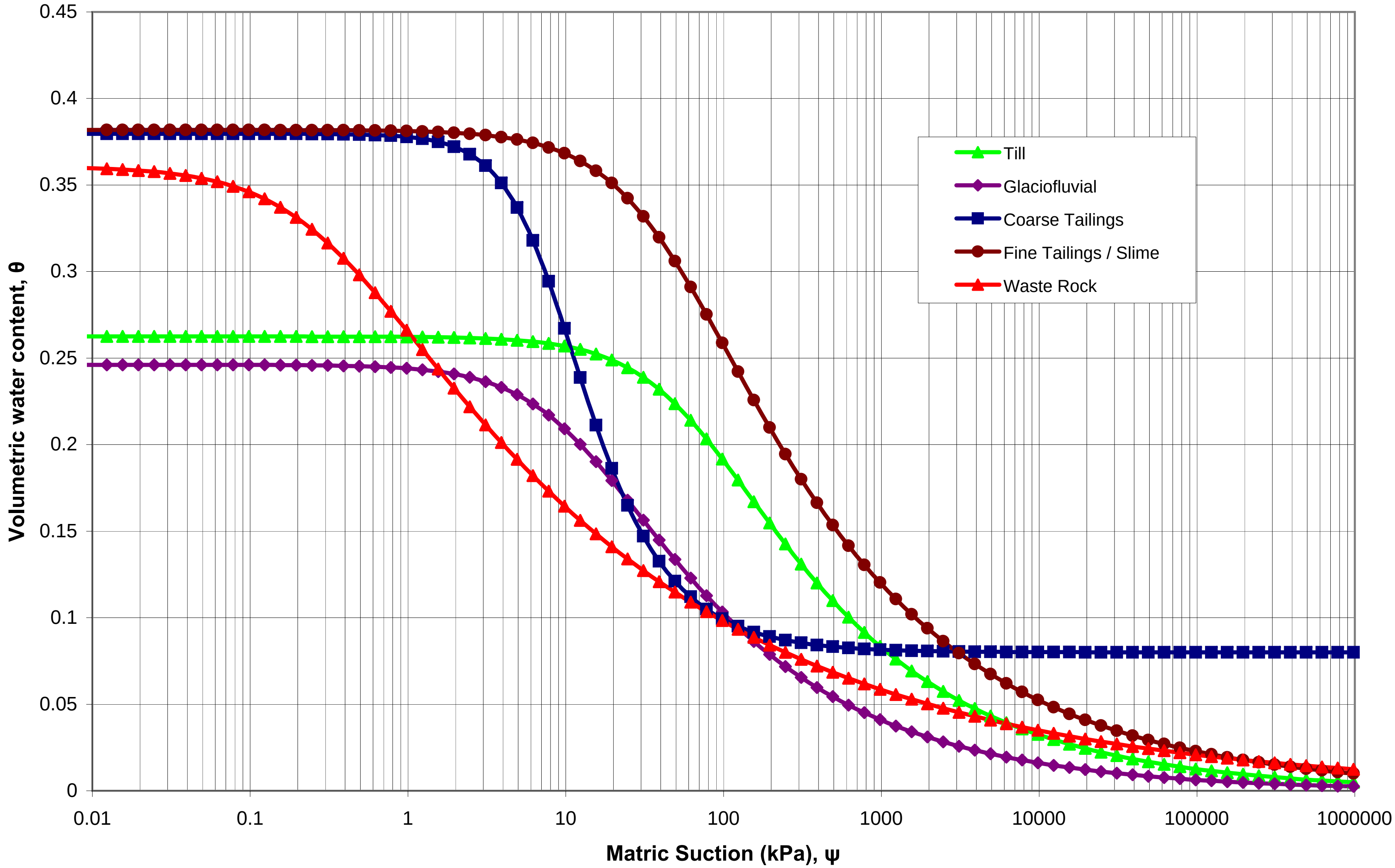
Anvil Range Mining Complex

Grum Waste Rock Pile Boundaries

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	J.H.P.	22b

Dwg Ref: Regional Loc Map.dwg



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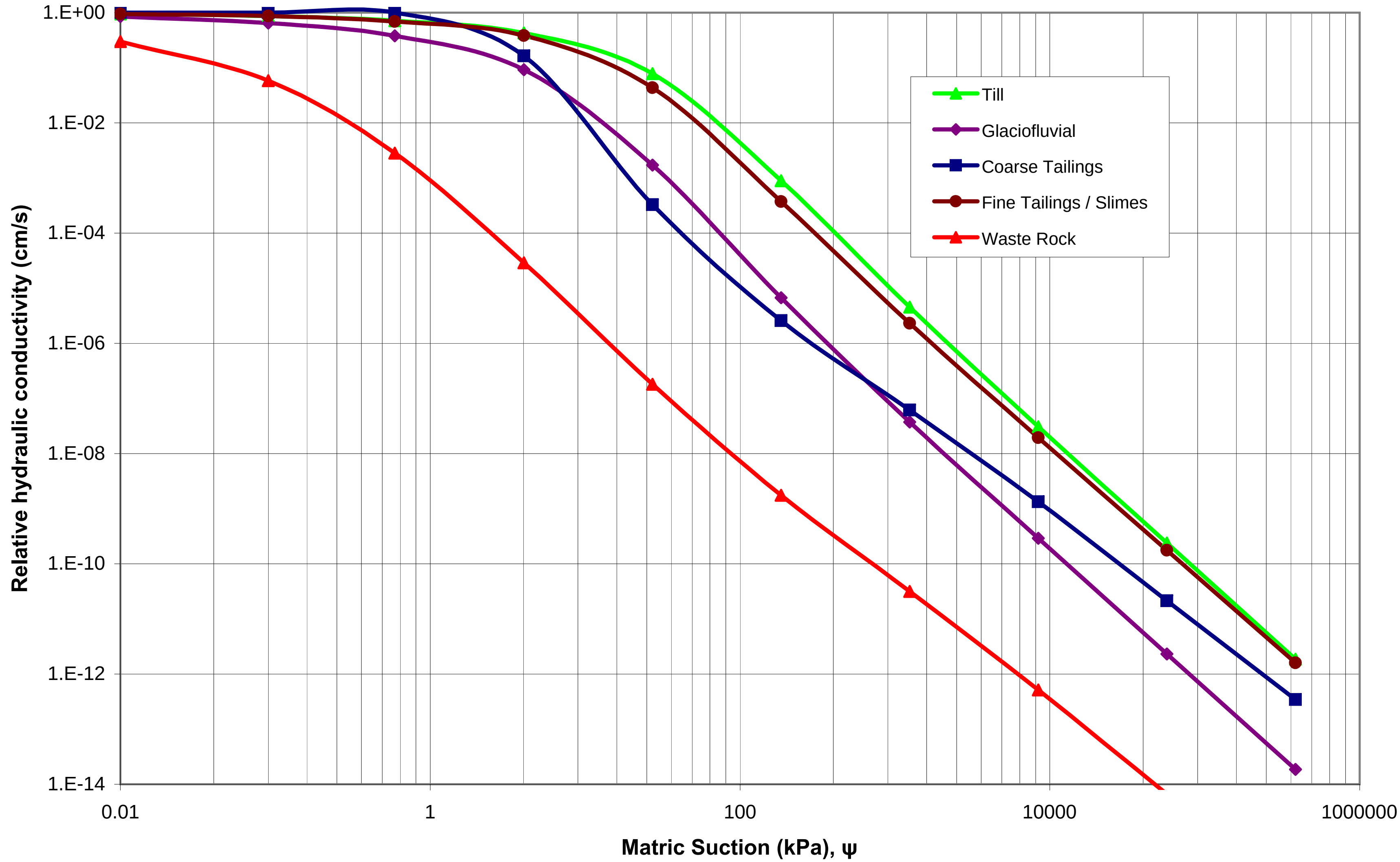
Anvil Range Mining Complex

Soil Water Characteristic Curves Used in SoilCover Modeling

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	23

Report Figures.xls, SWCC-model



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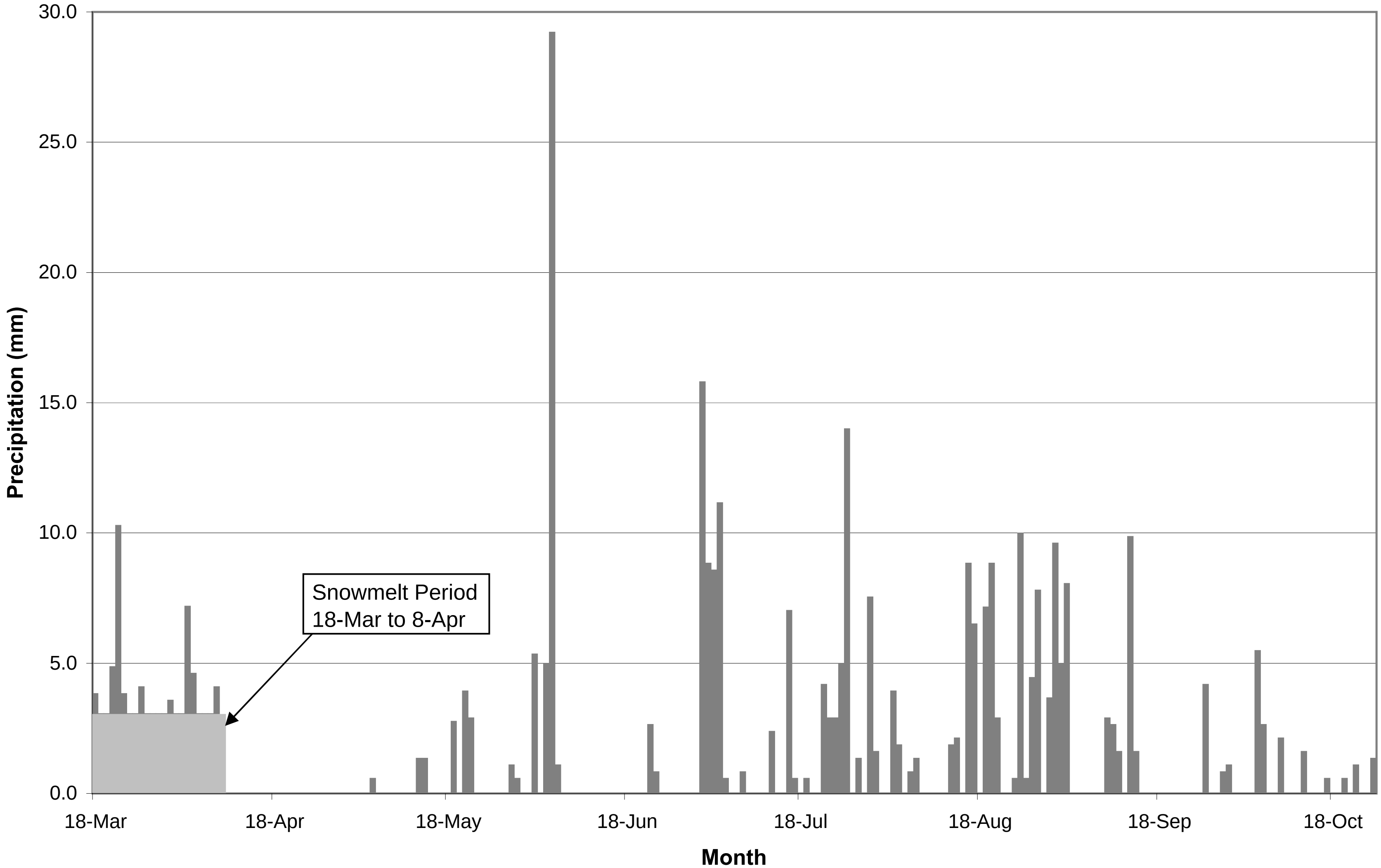
Anvil Range Mining Complex

Relative Unsaturated Hydraulic Conductivity Curves Used in SoilCover Modeling

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	24



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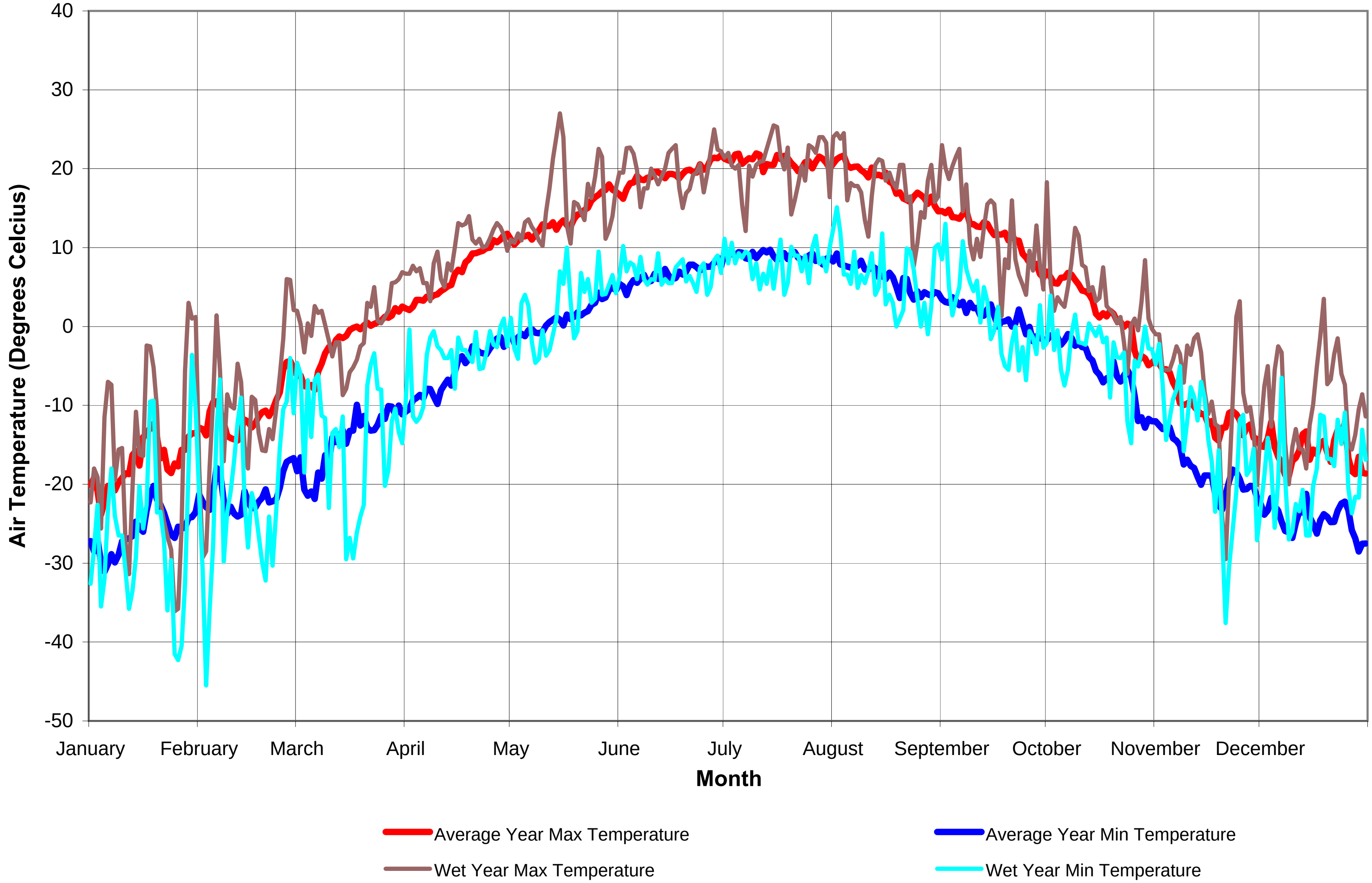
Anvil Range Mining Complex

Average Yearly Precipitation Used in SoilCover Modeling

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	25



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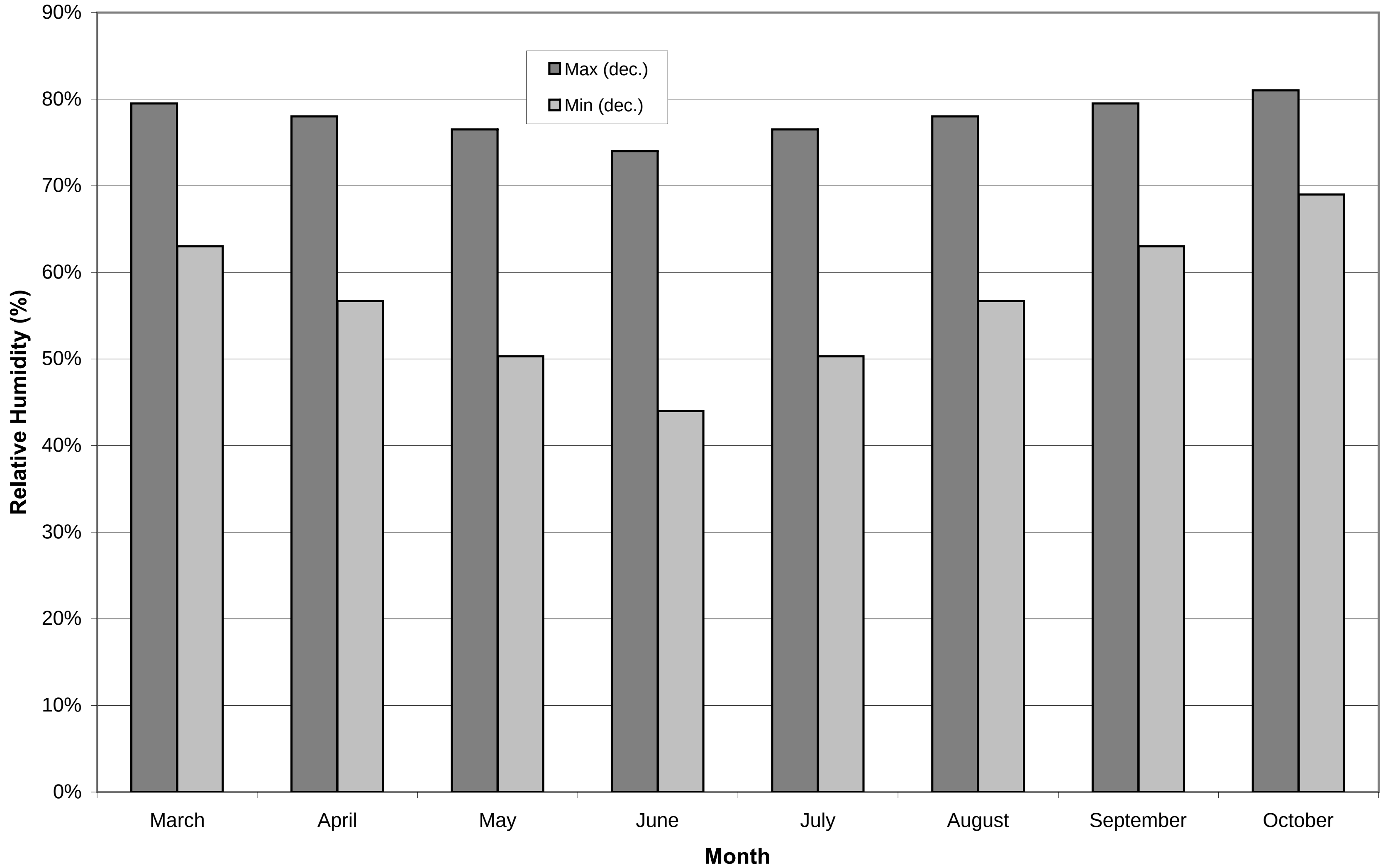
Anvil Range Mining Complex

Annual Air Temperatures Used in SoilCover Modeling

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	26



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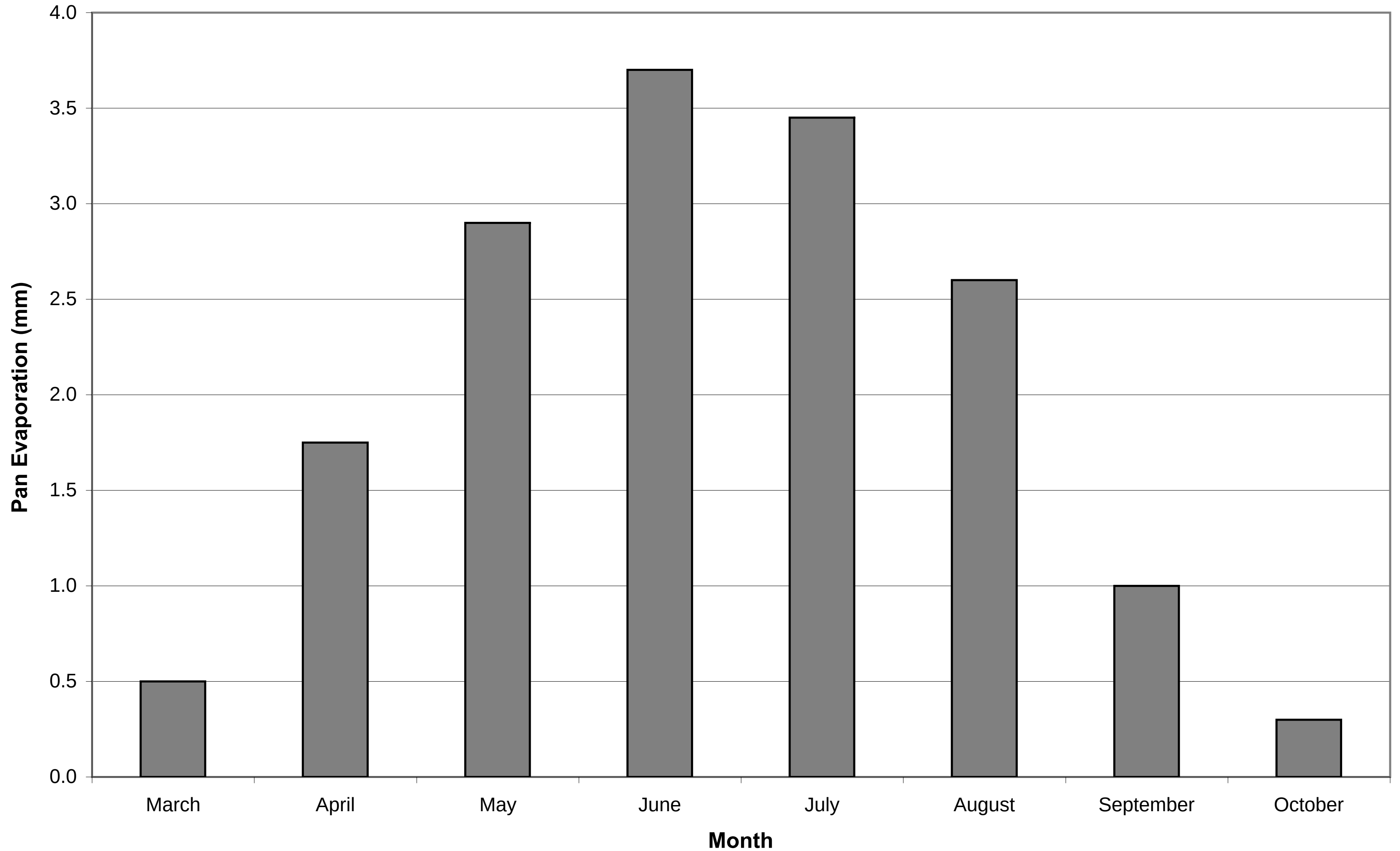
Anvil Range Mining Complex

Average Relative Humidity Used in SoilCover Modeling

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	27



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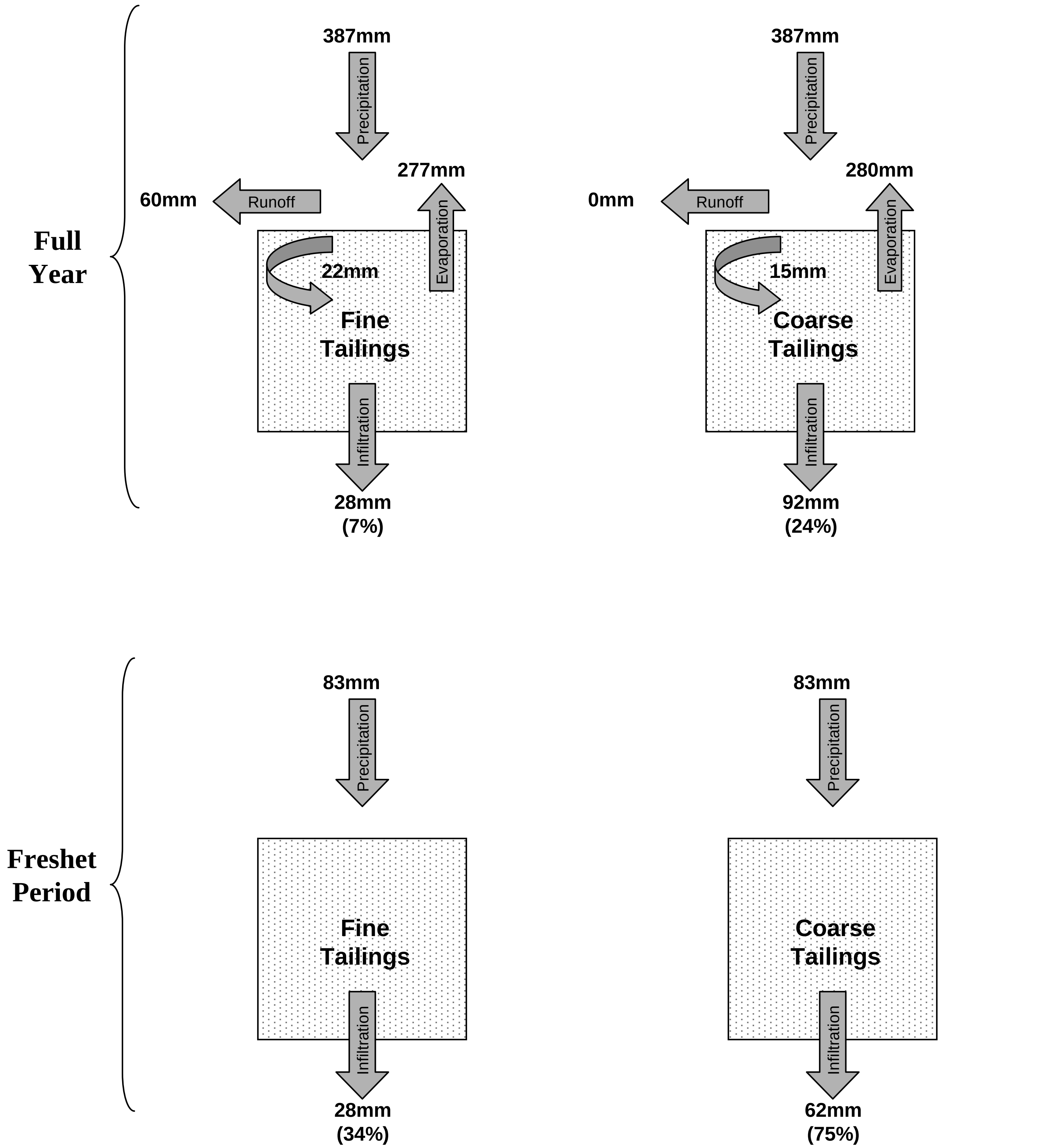
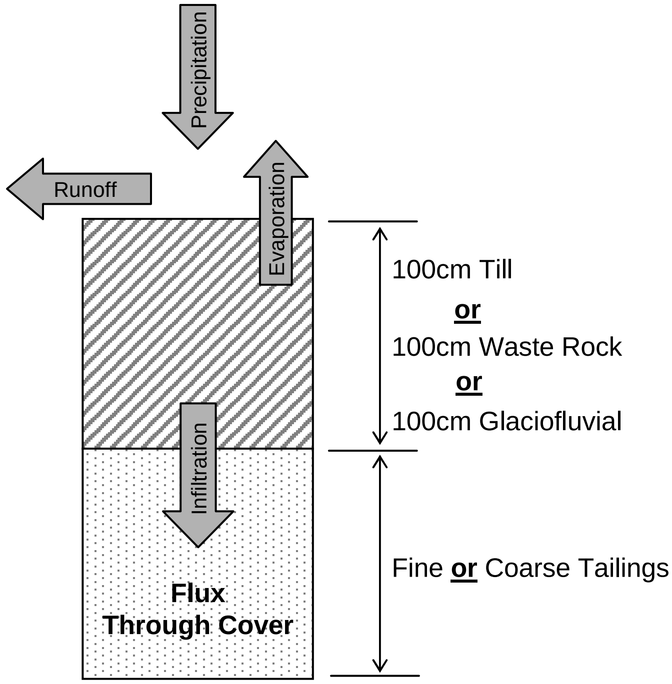
Anvil Range Mining Complex

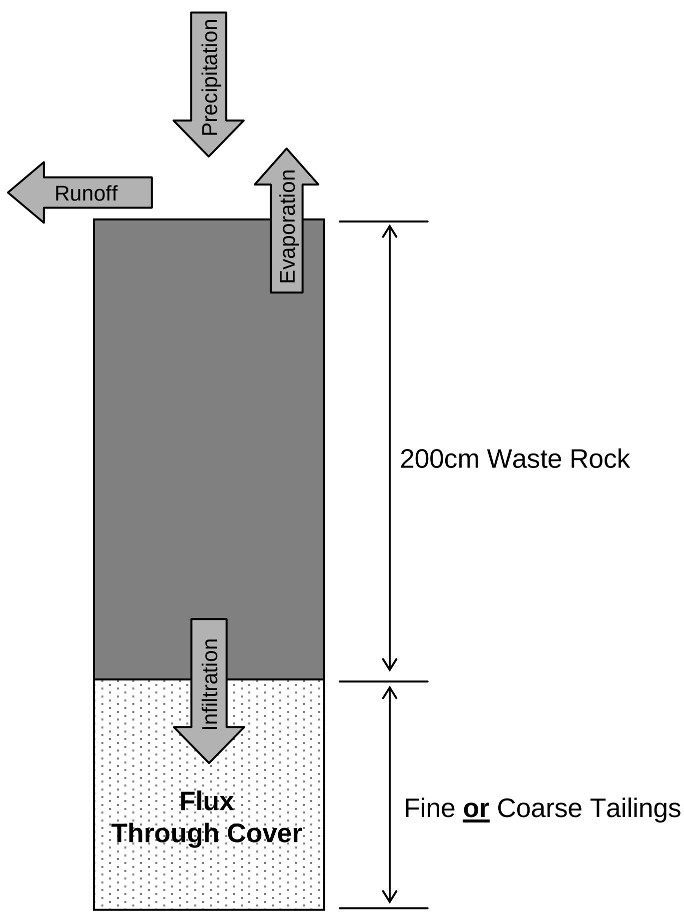
Average Evaporation Used in SoilCover Modeling

PROJECT	DATE	APPROVED	FIGURE
1CD003.26	Feb. 2004	E.M.R.	28



SRK Consulting Engineers and Scientists	Anvil Range Mining Complex			
Deloitte & Touche	**Tailings Profiles Uncovered Tailings**			
	PROJECT: 1CD003.26	DATE: February 2004	APPROVED: EMR	FIGURE: **29a**





SRK Consulting
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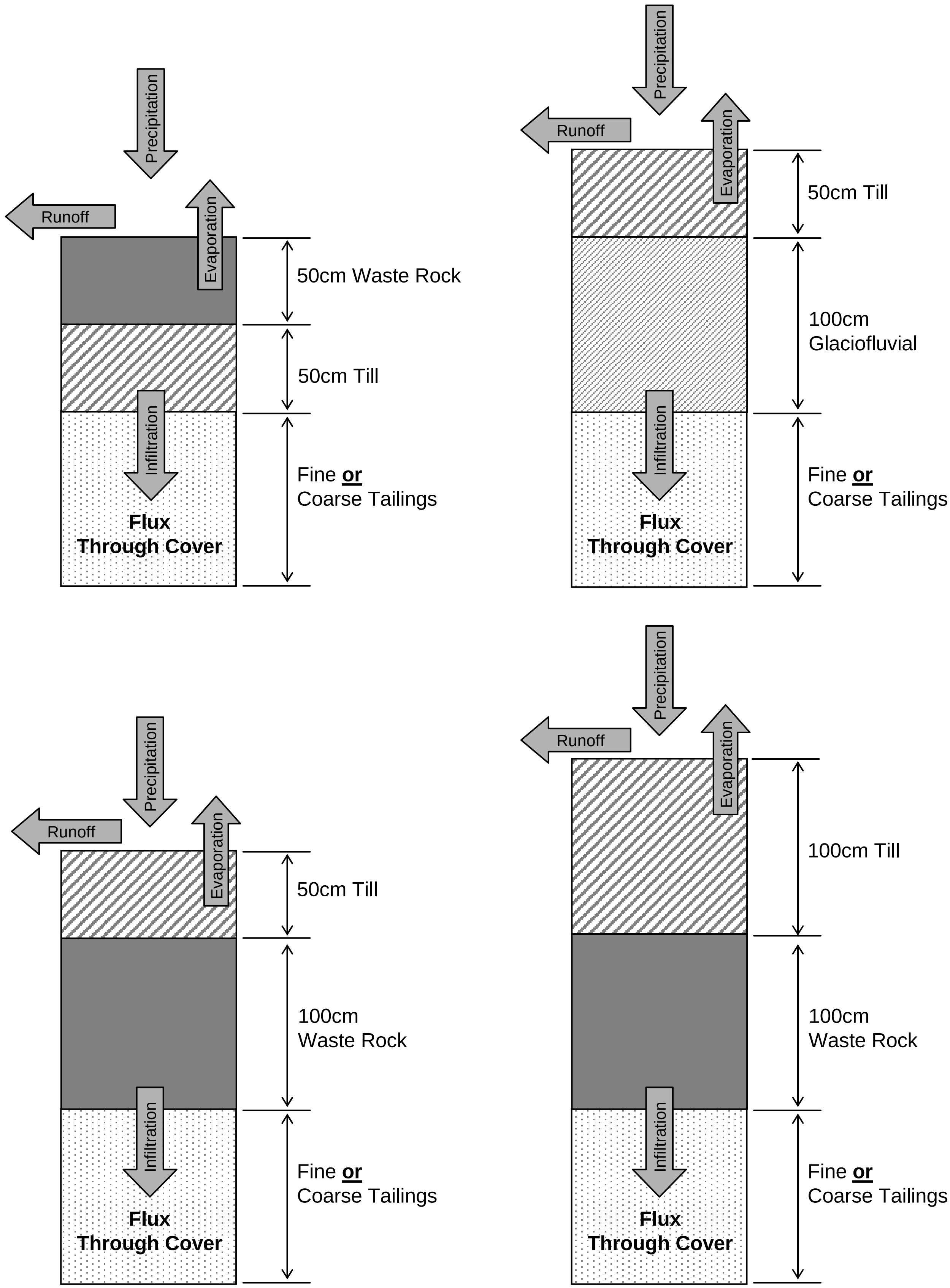
Anvil Range Mining Complex

Tailings Profiles
Single-layer Tailings Covers

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.26	February 2004	EMR	**29b**



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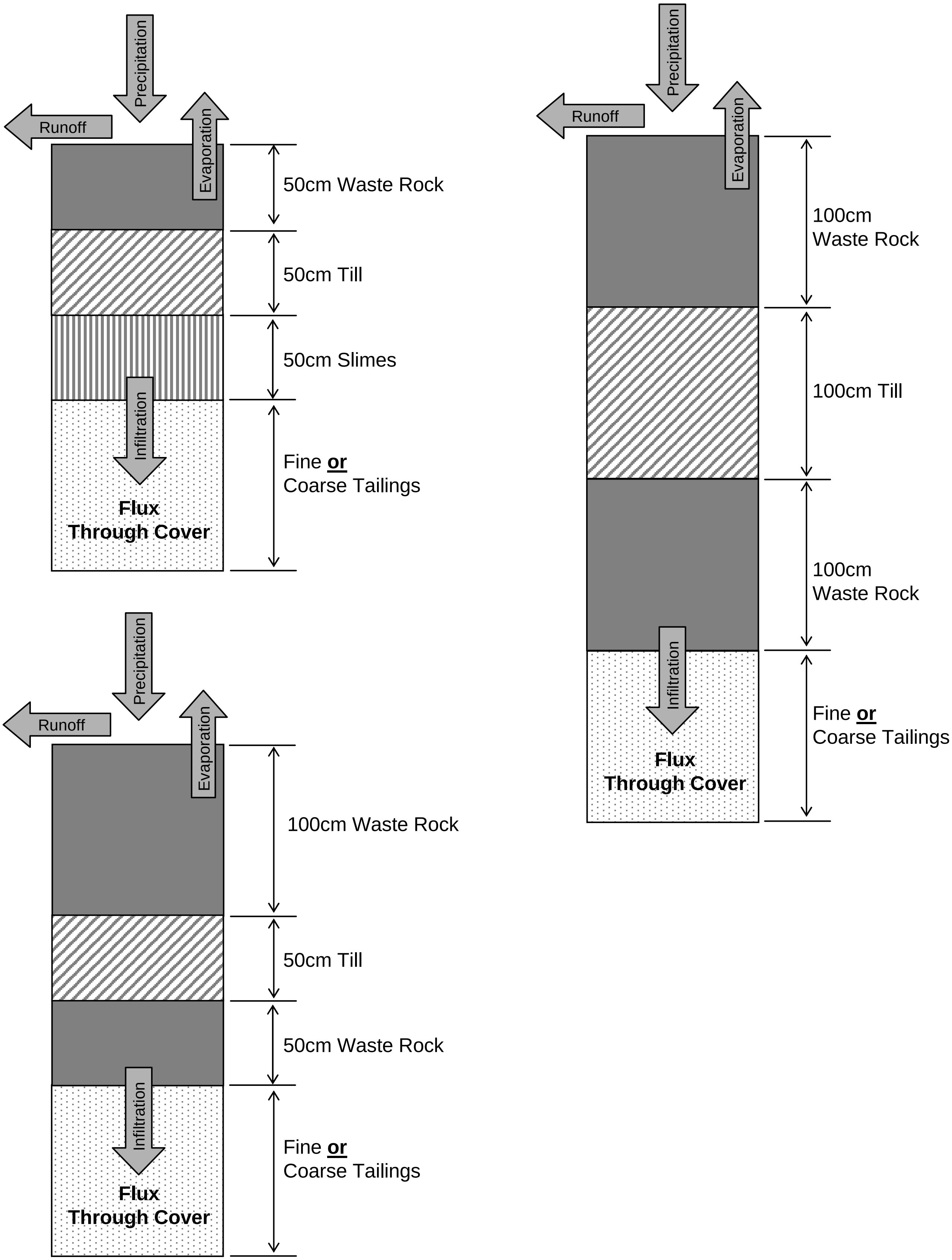
Anvil Range Mining Complex

Tailings Profiles
Two-layer Tailings Covers

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.26	February 2004	EMR	29c



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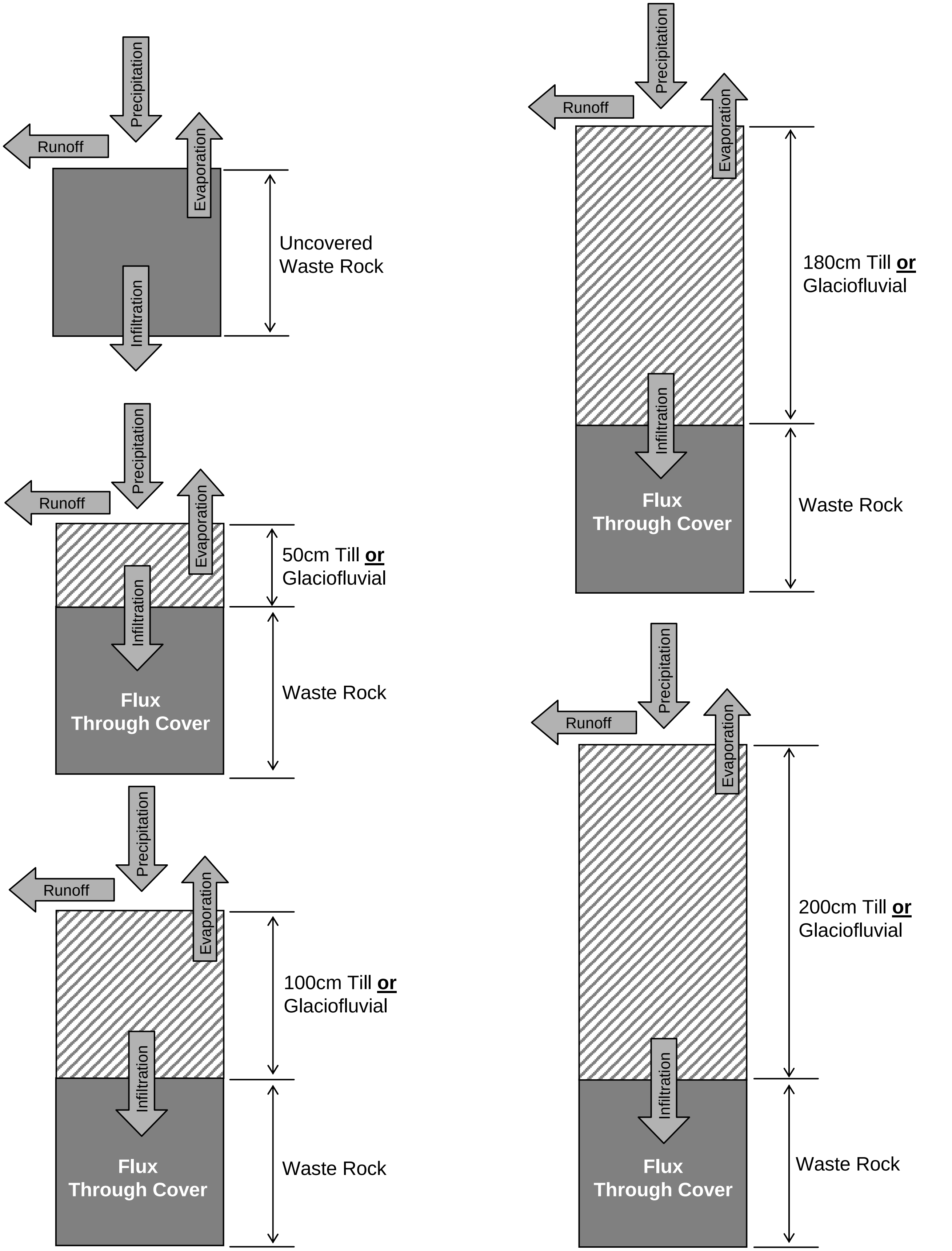
Anvil Range Mining Complex

Tailings Profiles
Three-layer Tailings Covers

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.26	February 2004	EMR	**29d**



SRK Consulting
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Deloitte & Touche

Anvil Range Mining Complex

Waste Rock Cover Profiles

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.26	February 2004	EMR	30

Appendix A

MDH Engineering Laboratory Report

HEAD OFFICE: 232-111 Research Drive, Saskatoon, SK, S7N 3R2 Telephone: (306) 934-7527 Fax: (306) 934-7528
LABORATORY: #1-320 Jessop Avenue, Saskatoon, SK, S7N 1Y6 Telephone: (306) 955-2735 Fax: (306) 651-3676

October 31, 2003

Dr. Maritz Rykaart, P.Eng.
Senior Geoenvironmental Engineer
SRK Consulting
Suite 800, 1066 West Hastings Street
Vancouver, BC
Canada V6E 3X2

Dear Dr. Rykaart:

Re: Geotechnical Laboratory Testing for Faro Mine Project, White Horse

This letter presents the results of a laboratory testing program conducted on materials from the Faro Mine in White Horse. MDH Geotechnical Laboratories conducted this testing program for SRK Consulting in Vancouver.

On June 18, 2003, eight 5-gallon pails of materials were received at MDH Geotechnical laboratories. The pails were labeled:

1. SRK-03-C01 (consists of 4 Ziploc bags of sandy till)
2. SRK-03-C02 (consists of 4 Ziploc bags of sandy till with some gravels)
3. SRK-03-C03 (consists of 4 Ziploc bags of glaciofluvial sand)
4. SRK-03-C04 (consists of 4 Ziploc bags of till)
5. SRK-03-C05 (consists of 4 Ziploc bags of glaciofluvial sand)
6. SRK-03-C06 (consists of 4 Ziploc bags of till)
7. SRK-03-C07 (consists of 2 bags of tailings)
8. SRK-03-C08 (consists of 2 bags of weathered waste rocks).

Instructions were received from SRK consulting to combine the individual bags in each pail to form eight samples for the laboratory testing program.

Laboratory Testing Program

The testing program is presented in Table 1 below.

Materials	Atterberg Limits	Specific gravity	Grain size	Standard Proctor	SWCC	Consolidation	Hydraulic Conductivity
SRK-03-C01	Yes	<#4 #4– 3/8” 3/8”-2”	Mech & hydrometer	4-inch mold	300-mm 64-mm		Falling head
SRK-03-C02	Yes	<#4 #4– 3/8” 3/8”-2”	Mech & hydrometer	4-inch mold	64-mm		Falling head
SRK-03-C03	Yes	<#4 #4– 3/8”	Mech & hydrometer	6-inch mold	300-mm 64-mm		Constant head
SRK-03-C04	Yes	<#4 #4– 3/8”	Mech & hydrometer	4-inch mold	64-mm		Falling head
SRK-03-C05	Yes	<#4 #4– 3/8”	Mech & hydrometer	4-inch mold	64-mm		Falling head & Constant head
SRK-03-C06	Yes	<#4 #4– 3/8”	Mech & hydrometer	4-inch mold	64-mm		Falling head
SRK-03-C07	Yes	<#4 #4– 3/8”	Mech & hydrometer		64-mm	Max Press. 4866 kPa	Falling head
SRK-03-C08	Yes	<#4 #4– 3/8”	Mech & hydrometer		300-mm		Constant head

Atterberg Limits

The Atterberg limits tests were conducted as per ASTM D 4318.

The Atterberg limits tests determine the water contents at which the materials were in the plastic and liquid ststes. The plastic limit is determined by the water content at which the soil begins to exhibit plastic behaviour and the liquid limit is determined by the water content at which the soil is at the boundary between the semi-liquid and plastic states. The plasticity index is the water content over which the soil behaves in a plastic manner. Numerically, plastic index is the difference between the liquid limit and the plastic limit.

Atterberg limits are conducted on fine-grained materials only. The Atterberg limits are used to characterize the fine-grained fraction of soils and are used to correlate with engineering behavior such as compressibility, permeability, compactibility, shrink-swell, water retention and shear strength.

Atterberg limits tests were attempted on all eight materials. Five out of the eight materials turned out to be non-plastic. These non-plastic materials are SRK-03-C03, SRK-03-C05, SRK-03-C06, SRK-03-C07 and SRK-03-C08. Results of the Atterberg limits tests are presented in Appendix I.

Specific Gravity

Specific gravity tests were conducted for fine-grained materials as well as for coarse aggregates. Specific gravity tests for the fine-grained materials were conducted on materials passing the #4 sieve (4.75-mm) as per ASTM D 854. Specific gravity tests for the coarse aggregates were conducted on materials larger than the #4 sieve as per ASTM C 127. For the specific gravity tests on the coarse aggregates, the materials were divided into two size groups, namely; #4 to 3/8" and 3/8" to 2'.

The specific gravity is required for calculating phase relationships.

Results of the specific gravity tests are presented in Appendix II.

Grain-size Distribution

Grain-size analyses were conducted as per ASTM D 422.

Wash sieve analyses were conducted on material larger than the #10 sieve (2.00-mm) and hydrometer analyses were conducted on material smaller than the #10 sieve. Results from the wash sieve analyses and hydrometer analyses were combined to provide the grain-size distribution curves. Results from the wash sieve analyses and hydrometer analyses are presented in Appendix III.

Standard Proctor Tests

Standard Proctor tests were conducted as per ASTM D 698.

The standard Proctor tests establish the relationship between water content and dry density of soils compacted in a 4 or 6-inch (101.6 or 152.4-mm) diameter mold using a 5.5-lbf (24.4-N) hammer dropped from a height of 12 inches (305 mm), producing a compactive effort of 12,400 ft-lb/ft3 (600 kN-m/m3).

Standard Proctor tests were conducted on six of the eight materials. These six materials were SRK-03-C01, SRK-03-C02, SRK-03-C03, SRK-03-C04 SRK-03-C05 and SRK-03-C06. Only one Standard Proctor test on material SRK 03-CO3 was conducted using a 6-inch mold due to the amount of oversize materials. The remainder of the materials were tested using a 4-inch mold.

Results of the standard proctor tests are presented in Appendix IV.

Soil-Water Characteristic Curve Tests

The pressure plate technique and the vapor extraction technique were used in the soil-water characteristic curve tests. The pressure plate technique was used for suction values up to the wilting point (i.e., 15-bar pressure). The vapor extraction technique was used for suction values greater than the wilting point.

Pressure Plate Apparatus

MDH Geotechnical Laboratories have three models of pressure plate apparatuses. These are 1.) 300mm diameter pressure plate cells suitable for testing waste rock materials with maximum particle size of 60mm (Figure 1), 2.) small pressure cells suitable for fine-grained and sand-size materials passing the #4 sieve (4.75mm) (Figure 2), and 3.) a large conventional pressure plate extractor from Soil Moisture commonly used by agricultural soil scientists. The large conventional pressure plate extractor from Soil Moisture is suitable only for testing fine-grained material and cannot be used for testing coarse-grained materials like waste rocks.

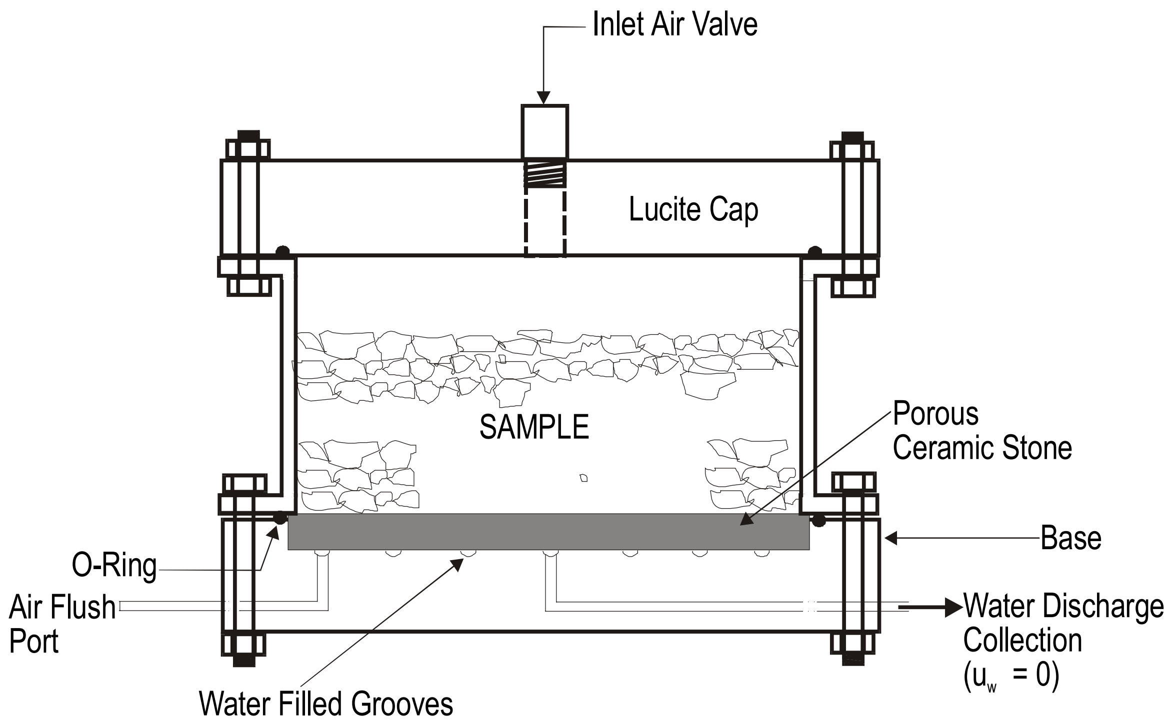


Figure 1 – Large pressure plate cell suitable for testing waste rocks with maximum particle size of 60mm.

Testing in this program were conducted using the small pressure plate cells for suction values up to 100 kPa and the conventional large pressure plate extraction for suction values from 200 kPa to 1500 kPa.

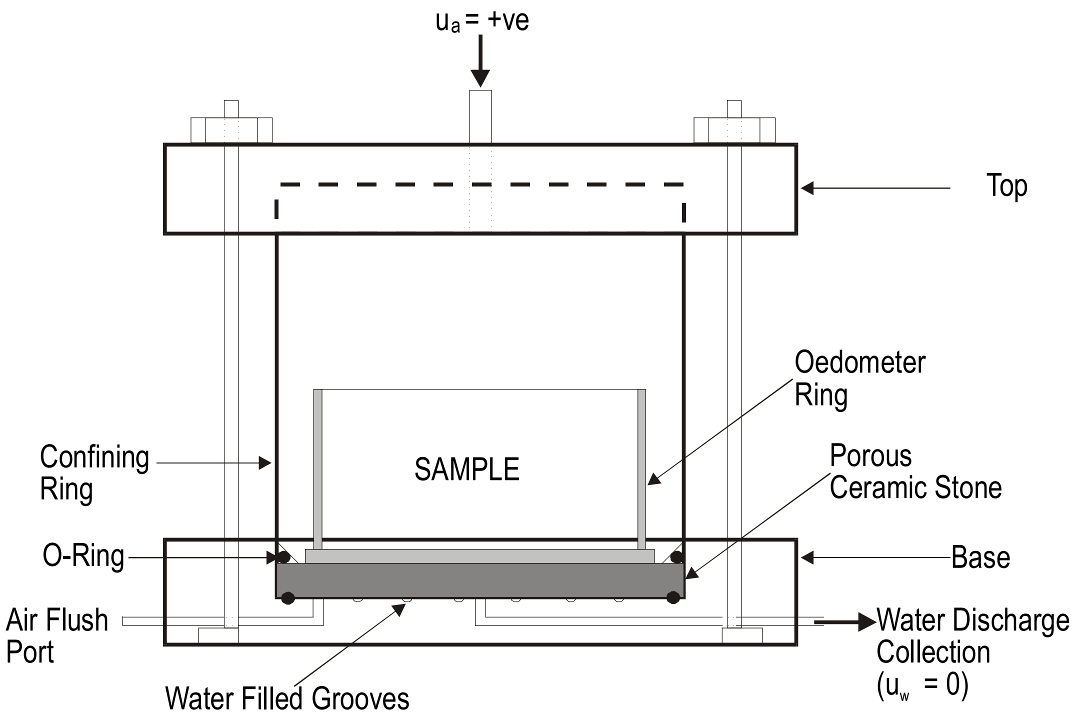


Figure 2 – Schematic diagram of small pressure plate cell.

Specimen Preparation

64-mm diameter specimens were used for the soil-water characteristic curve tests using the small pressure plate cells and the conventional large pressure plate extractor. The specimens were prepared using steel consolidometer rings with a diameter of 64mm and a height of 30mm.

The test specimens were prepared by tamping materials at its as-received water content condition into the steel consolidometer rings to 95% standard Proctor density.

Slurry test specimens were prepared in the following manner. Each slurry sample was first thoroughly mixed using an electric mixer for about 5 minutes. The thoroughly mixed slurry was allowed to settle overnight. Excess water was decanted and a test specimen was obtained by pressing the steel oedometer ring into the settled slurry.

The ringed-test specimens were then mounted into the small pressure plate cells (Figure 2) for soil-water characteristic curve tests. The high air-entry ceramic disks of the pressure plate cells were saturated prior to use.

Test Procedure

The soil-water characteristic curve tests conducted in this program were strictly desorption tests. Adsorption tests were not conducted. The tests specimens were saturated prior to starting the desorption process.

Specimens prepared from consolidated slurries were assumed saturated. Compacted specimens were saturated in the pressure plate cells by applying a water head to the bottom of the specimen. This was accomplished using a water column attached to the base of the pressure plate cell. Wetting from the bottom allowed air to escape easily through the surface of the specimen. During the saturation process, the pressure plate cell was vented to the atmosphere.

Suction was initially applied to the soil specimens by means of a water column. A 1-m long flexible tubing was attached to the outlet port of the pressure plate cell. The flexible tubing was completely filled with water to ensure a continuous water phase to the soil specimen. A negative water head was applied to the water in the soil specimen by maintaining the water level in the flexible tubing at the required distance below the surface of the soil specimen. The flexible tubing was capped with a septum and vented using a hypodermic needle. Suction equilibrium was attained in the soil specimen when water ceased to drain from the soil. At each suction equilibrium stage, the entire pressure plate cell system was weighed. In this manner, water that was extracted from the soil specimen can be accurately tracked. The water column was used for extracting water from the specimen up to a suction value of 5 kPa (negative 50 cm head). The water head was measured with reference to the surface of the specimen. The height of the specimen was about 30mm and there would be a suction difference of about 0.3 kPa between the top and bottom of the specimen.

The tests were continued beyond 5kPa using an air pressure supply for controlling suction in the soil specimen. On achieving suction equilibrium at 100 kPa, the test specimens were transferred into the conventional large pressure plate extractor for continuation of testing up to 1500 kPa.

The pressure plate tests used the axis-translation technique. In the axis-translation technique, the air and water pressures within the soil specimens were both translated to ensure that the water within the soil measurement systems remained at a positive value. In this test program, the water pressures were maintained near atmospheric condition for the tests that were conducted using an air supply system. Using the axis-translation technique, it is then possible to apply suction greater than 100 kPa without the problem of cavitation of the water phase within the measurement system. The applied suction being equal to the difference between the air and water pressure.

At the completion of the pressure plate test, the volume-mass properties of each test specimen were determined. From the volume-mass data obtained at the end of the test, the volumetric and gravimetric water contents of the soil specimens corresponding to each suction equilibrium condition were computed by accounting for the amount of water that was lost from the soil at each stage.

Vapor Extraction Using Desiccators

For obtaining the soil-water characteristic curves at suctions greater than the wilting point, the vapor extraction technique was used. The vapor extraction tests were conducted using desiccators containing saturated salt solutions. The salt solutions and their corresponding suction values are presented in Table 2.

Table 2 – Saturated salt solutions and equivalent total suctions.

DESICCATOR	SALT	TEMPERATURE (^oC)	RELATIVE HUMIDITY (%)	EQUIVALENT TOTAL SUCTION (kPa)
A	Lithium Chloride ($LiCl_2.H_2O$ + $LiCl_2.2H_2O$)	20	11.5	2.93×10^5
B	Magnesium Chloride ($MgCl_2.6H_2O$)	20	33.0	1.50×10^5
C	Magnesium Nitrate ($Mg(NO_3)_2.6H_2O$)	20	54.3	8.26×10^4
D	Sodium Chloride (NaCl)	20	75.5	3.80×10^4
E	Potassium Sulphate	20	97.0	4.12×10^3

Small samples from each of the ten material types were placed in each of the above five desiccators at the start of the testing program. The samples were kept in the desiccators until the pressure plate tests were nearing completion, a period of over six weeks in this case. Typically, a period of two to three weeks was required for the specimens in the desiccators to attain equilibrium. The equilibrium conditions were checked by weighing the specimens. Constant weight over two weighing period would confirm equilibrium condition. The water contents of each sample on attaining vapor equilibrium were then determined.

Results of the large diameter (300-mm) and small diameter (64-mm) soil-water characteristic curve tests are presented in Appendix V-a and V-b, respectively.

Consolidation Test

Consolidation test was conducted on tailings material SRK-03-CO7 as per ASTM D 2435. The test was conducted to a maximum pressure of 4866 kPa. Results of the consolidation tests performed on SRK-03-C07 are presented in Appendix VI.

Hydraulic Conductivity Tests

Falling head hydraulic conductivity tests were conducted on materials SRK-03-C01, SRK-03-C02 SRK-03-C04, SRK-03-C05, SRK-03-C06 and SRK-03-C07.

Constant head tests were conducted on materials SRK-03-C03 and SRK-03-C08. Constant head test was also repeated for material SRK-03-C05, and the results checked out well with the falling head test results.

Details on the constant head and falling head tests can be found in "Liu & Evett, 1984, SOIL PROPERTIES: Testing, Measurement, and Evaluation, Prentice-Hall, New Jersey ".

Results of the falling head and constant head tests are presented in Appendix VII-a and VII-b, respectively.

Closure

The tests conducted in this program were requested by Dr. Maritz Rykaart of SRK Consulting, Vancouver. This report was prepared exclusively for SRK Consulting, Vancouver.

We trust this report meets your present needs. Please contact the undersigned if you have any questions, or if we can be of further assistance.

Respectfully submitted

MDH Geotechnical Laboratories

Julian Gan, M.Sc., P.Eng.
Laboratories Manager

APPENDIX I

Atterberg Limits Tests Results

MDH ENGINEERED SOLUTIONS

ATTERBERG LIMITS

Project: Faro Mine
Location: Whitehorse, Yukon
SRK Consulting
Technician: SO Date: 22-Jul-03

Sample: SRK-03-C01

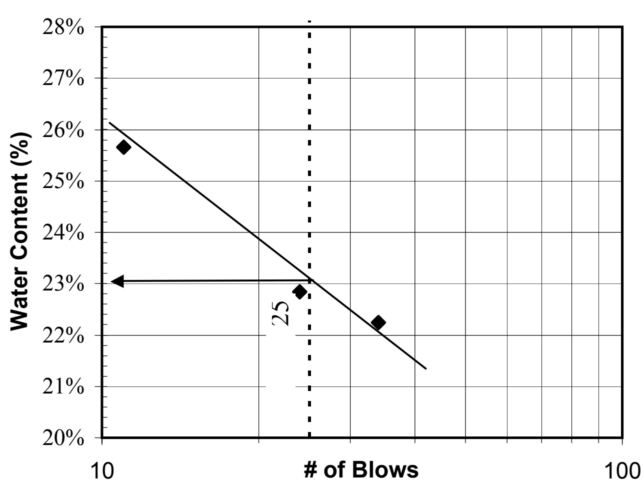
Plastic Limit

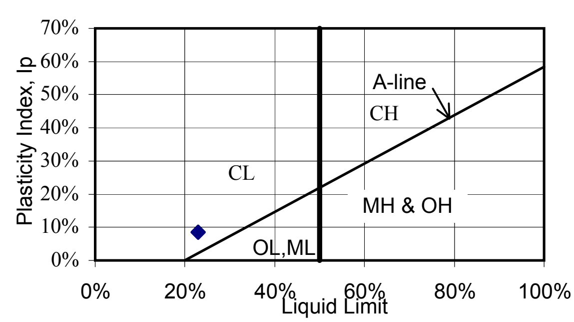
Tare #	A11	A2					
Tare Wt, g	13.41	13.16					
Wet + Tare, g	21.11	19.25					
Dry + Tare, g	20.13	18.48					
M%	14.6%	14.5%		Average:	14.5%		

Liquid Limit

# of Blows	11	24	34				
Tare #	A15	A6	A14				
Tare Wt, g	13.65	13.33	13.52				
Wet + tare, g	28.49	28.12	30.39				
Dry + tare, g	25.46	25.37	27.32				
M%	25.7%	22.8%	22.2%				

Plastic Limit: 14.5%
Liquid Limit: 23.0%
Plasticity Index: 8.5%
Classification: CL





Comments:

ATTERBERG LIMITS

MDH ENGINEERED SOLUTIONS

Project: Faro Mine
Location: Whitehorse, Yukon
SRK Consulting
Technician: SO Date: 22-Jul-03

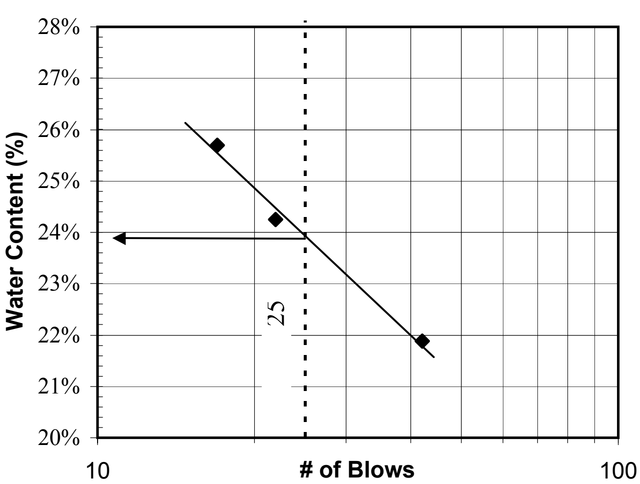
Sample: SRK-03-C02

Plastic Limit

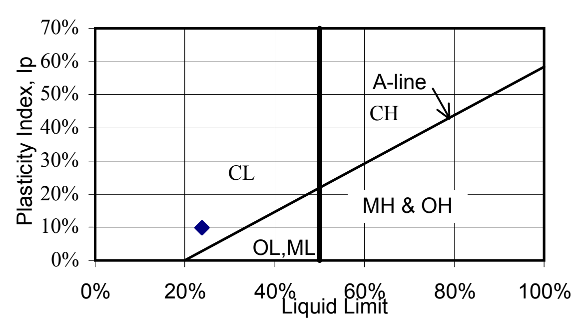
Tare #	A5	A4					
Tare Wt, g	13.45	13.50					
Wet + Tare, g	19.6	20.43					
Dry + Tare, g	18.85	19.58					
M%	13.9%	14.0%		Average:	13.9%		

Liquid Limit

# of Blows	42	22	17				
Tare #	A8	A3	A11				
Tare Wt, g	13.50	13.74	13.35				
Wet + tare, g	30.71	27.78	26.95				
Dry + tare, g	27.62	25.04	24.17				
M%	21.9%	24.2%	25.7%				



Plastic Limit: 13.9%
Liquid Limit: 23.8%
Plasticity Index: 9.9%
Classification: CL



Comments:

MDH ENGINEERED SOLUTIONS	ATTERBERG LIMITS
	Project: Faro Mine
	Location: Whitehorse, Yukon
	SRK Consulting
	Technician: SO Date: 22-Jul-03

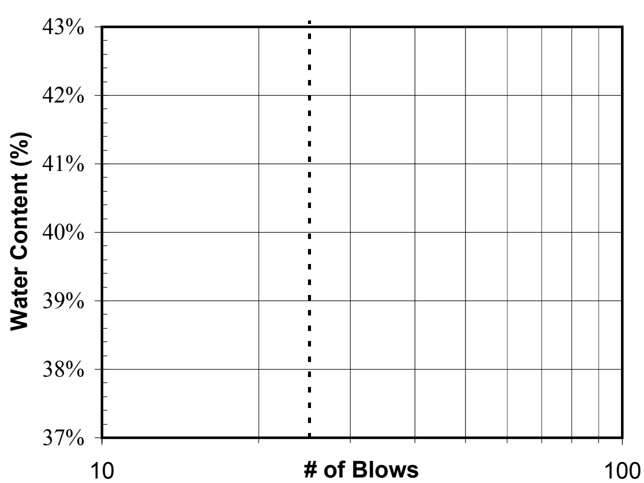
Sample: SRK-03-C03

Plastic Limit

Tare #							
Tare Wt, g							
Wet + Tare, g							
Dry + Tare, g							
M%	#DIV/0!	#DIV/0!		Average:	#DIV/0!		

Liquid Limit

# of Blows							
Tare #							
Tare Wt, g							
Wet + tare, g							
Dry + tare, g							
M%	#DIV/0!	#DIV/0!	#DIV/0!				

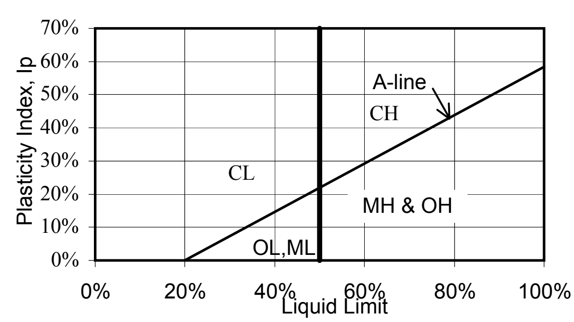


Plastic Limit: #DIV/0!

Liquid Limit:

Plasticity Index: #DIV/0!

Classification:



Comments: Material would not roll - all sand. Material classified as NONPLASTIC

ATTERBERG LIMITS

MDH ENGINEERED SOLUTIONS

Project: Faro Mine
Location: Whitehorse, Yukon
SRK Consulting
Technician: SO   Date: 22-Jul-03

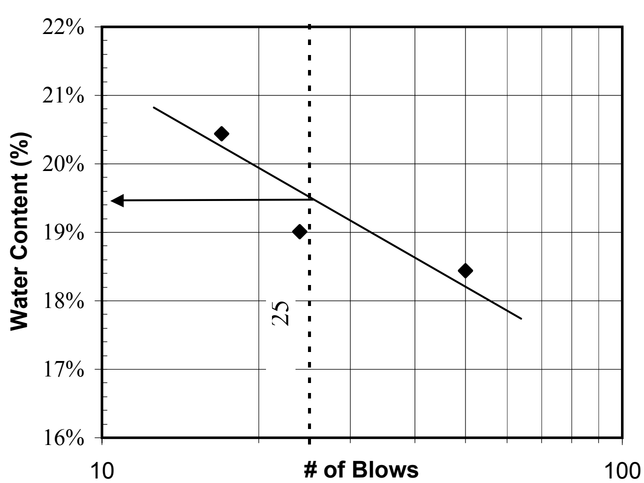
Sample: SRK-03-C04

Plastic Limit

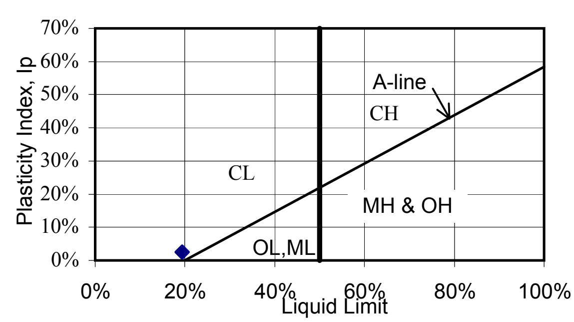
Tare #	A13	A9					
Tare Wt, g	13.37	13.42					
Wet + Tare, g	19.91	22.27					
Dry + Tare, g	18.97	20.99					
M%	16.8%	16.9%		Average:	16.8%		

Liquid Limit

# of Blows	17	24	50				
Tare #	A12	A7	A24				
Tare Wt, g	13.59	13.50	13.12				
Wet + tare, g	31.68	35.91	29.37				
Dry + tare, g	28.61	32.33	26.84				
M%	20.4%	19.0%	18.4%				



Plastic Limit: 16.8%
Liquid Limit: 19.4%
Plasticity Index: 2.6%
Classification: CL



Comments:

ATTERBERG LIMITS

Project: Faro Mine

Location: Whitehorse, Yukon

SRK Consulting

Technician: SO   Date: 22-Jul-03

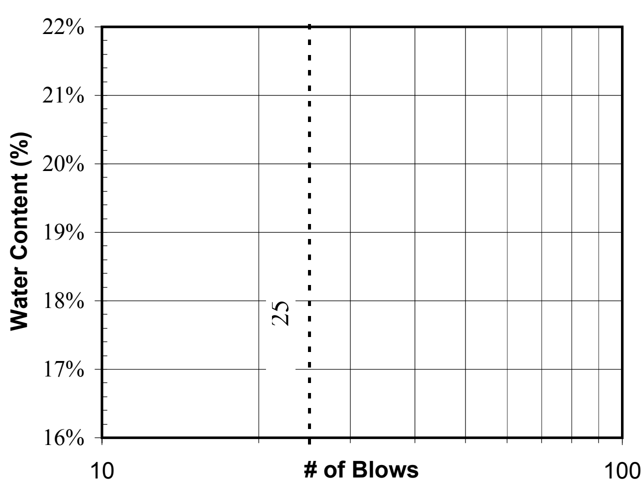
Sample: SRK-03-C05

Plastic Limit

Tare #							
Tare Wt, g							
Wet + Tare, g							
Dry + Tare, g							
M%	#DIV/0!	#DIV/0!		Average:	#DIV/0!		

Liquid Limit

# of Blows							
Tare #							
Tare Wt, g							
Wet + tare, g							
Dry + tare, g							
M%	#DIV/0!	#DIV/0!	#DIV/0!				

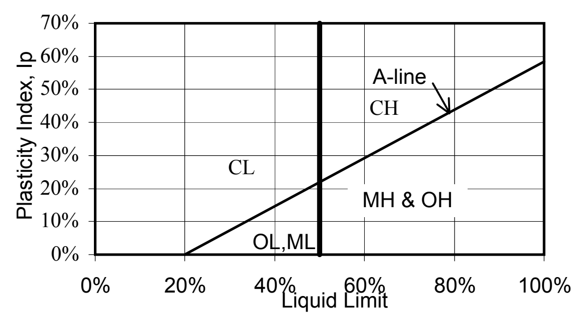


Plastic Limit: #DIV/0!

Liquid Limit:

Plasticity Index: #DIV/0!

Classification:



Comments: Material would not roll - too sandy - soil classified as NONPLASTIC

ATTERBERG LIMITS

MDH ENGINEERED SOLUTIONS

Project: Faro Mine
Location: Whitehorse, Yukon
SRK Consulting
Technician: SO   Date: 22-Jul-03

Sample: SRK-03-C06

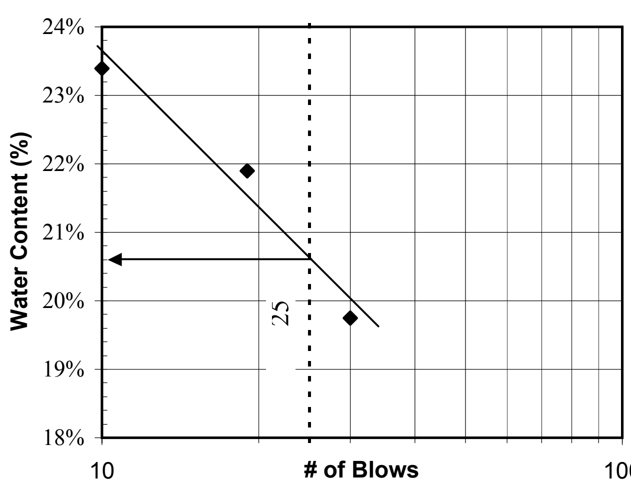
Plastic Limit

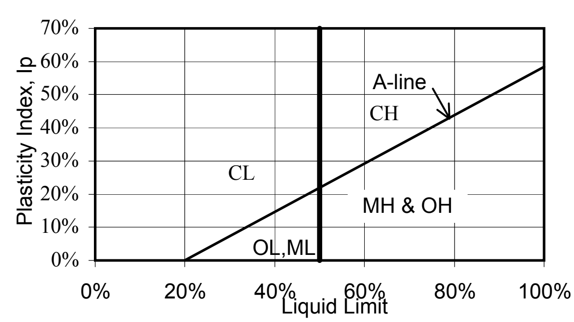
Tare #	A31	A19					
Tare Wt, g	13.57	13.54					
Wet + Tare, g	20.08	19.36					
Dry + Tare, g	18.89	18.33					
M%	22.4%	21.5%		Average:	21.9%		

Liquid Limit

# of Blows	10	19	30				
Tare #	A30	A29	A25				
Tare Wt, g	13.17	13.38	13.60				
Wet + tare, g	31.00	31.08	32.52				
Dry + tare, g	27.62	27.90	29.40				
M%	23.4%	21.9%	19.7%				

Plastic Limit: 21.9%
Liquid Limit: 20.6%
Plasticity Index: -1.3%
Classification:





Comments: Material barely rolled - too sandy - soil classified as NONPLASTIC

MDH ENGINEERED SOLUTIONS

ATTERBERG LIMITS

Project: Faro Mine
Location: Whitehorse, Yukon
SRK Consulting
Technician: SO Date: 22-Jul-03

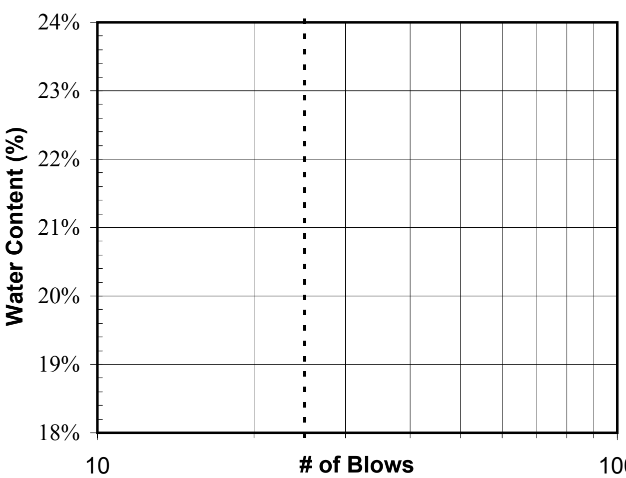
Sample: SRK-03-C07

Plastic Limit

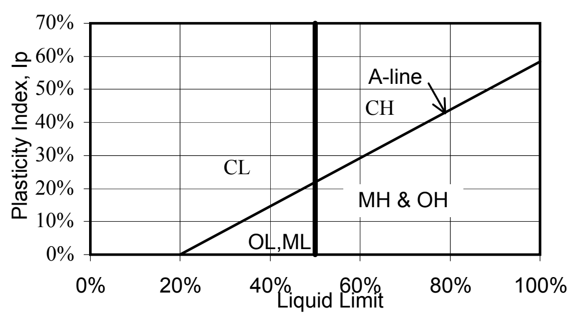
Tare #							
Tare Wt, g							
Wet + Tare, g							
Dry + Tare, g							
M%	#DIV/0!	#DIV/0!		Average:	#DIV/0!		

Liquid Limit

# of Blows							
Tare #							
Tare Wt, g							
Wet + tare, g							
Dry + tare, g							
M%	#DIV/0!	#DIV/0!	#DIV/0!				



Plastic Limit: #DIV/0!
Liquid Limit:
Plasticity Index: #DIV/0!
Classification:



Comments: Material would not roll - too sandy - soil classified as NONPLASTIC

MDH ENGINEERED SOLUTIONS

ATTERBERG LIMITS

Project: Faro Mine
Location: Whitehorse, Yukon
SRK Consulting
Technician: SO Date: 22-Jul-03

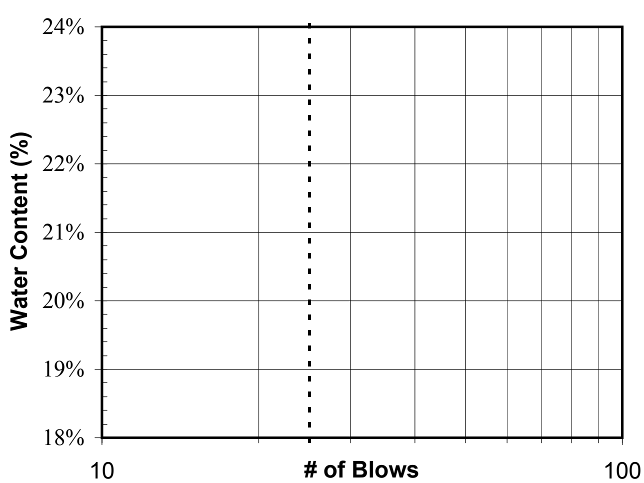
Sample: SRK-03-C08

Plastic Limit

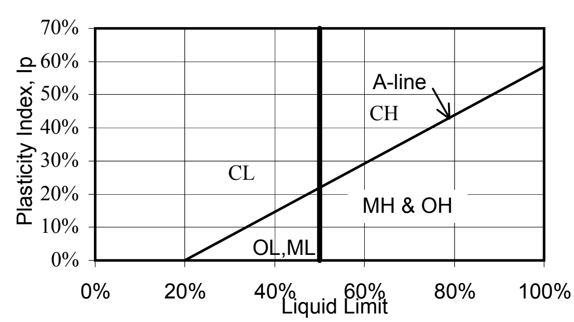
Tare #							
Tare Wt, g							
Wet + Tare, g							
Dry + Tare, g							
M%	#DIV/0!	#DIV/0!		Average:	#DIV/0!		

Liquid Limit

# of Blows							
Tare #							
Tare Wt, g							
Wet + tare, g							
Dry + tare, g							
M%	#DIV/0!	#DIV/0!	#DIV/0!				



Plastic Limit: #DIV/0!
Liquid Limit:
Plasticity Index: #DIV/0!
Classification:



Comments: Material would not roll - too sandy - soil classified as NONPLASTIC

APPENDIX II

Specific Gravity Results

SPECIFIC GRAVITY DETERMINATION FOR COARSE AGGREGATE - ASTM C 127

ENGINEERED SOLUTIONS

Project: SRK Consulting
Location: Faro Mine, WhiteHorse
Date: 14-Jul-03

Computation for Bulk Specific Gravity — **Sample: SRK-03-C01**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)		263.86	92.22	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)		265.85	93.39	
Weight of Saturated Sample in Water, *C* (g)		166.85	58.42	
Bulk Specific Gravity, G_s =B/(B-C)		2.69	2.67	
Apparent Specific Gravity, G_{as} = A/(A-C)		2.72	2.73	2.70

Computation for Bulk Specific Gravity — **Sample: SRK-03-CO2**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)		263.86	107.12	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)		265.85	108.24	
Weight of Saturated Sample in Water, *C* (g)		166.85	67.08	
Bulk Specific Gravity, G_s =B/(B-C)		2.69	2.63	
Apparent Specific Gravity, G_{as} = A/(A-C)		2.72	2.68	2.69

Computation for Bulk Specific Gravity — **Sample: SRK-03-CO3**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)			215.25	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)			217.60	
Weight of Saturated Sample in Water, *C* (g)			135.61	
Bulk Specific Gravity, G_s =B/(B-C)			2.65	
Apparent Specific Gravity, G_{as} = A/(A-C)			2.70	2.68

Comments:

MDH ENGINEERED SOLUTIONS

SPECIFIC GRAVITY DETERMINATION FOR COARSE AGGREGATE - ASTM C 127

Project: SRK Consulting
Location: Faro Mine, WhiteHorse
Date: 14-Jul-03

Computation for Bulk Specific Gravity — **Sample: SRK-03-C04**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)			108.16	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)			109.72	
Weight of Saturated Sample in Water, *C* (g)			68.18	
Bulk Specific Gravity, G_s =B/(B-C)			2.64	
Apparent Specific Gravity, G_{as} = A/(A-C)			2.71	2.69

Computation for Bulk Specific Gravity — **Sample: SRK-03-CO5**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)			148.02	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)			150.87	
Weight of Saturated Sample in Water, *C* (g)			93.15	
Bulk Specific Gravity, G_s =B/(B-C)			2.61	
Apparent Specific Gravity, G_{as} = A/(A-C)			2.70	2.68

Computation for Bulk Specific Gravity — **Sample: SRK-03-CO6**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)			155.73	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)			158.70	
Weight of Saturated Sample in Water, *C* (g)			98.07	
Bulk Specific Gravity, G_s =B/(B-C)			2.62	
Apparent Specific Gravity, G_{as} = A/(A-C)			2.70	2.68

Comments:

MDH ENGINEERED SOLUTIONS

SPECIFIC GRAVITY DETERMINATION FOR COARSE AGGREGATE - ASTM C 127

Project: SRK Consulting
Location: Faro Mine, WhiteHorse
Date: 14-Jul-03

Computation for Bulk Specific Gravity — **Sample: SRK-03-C07**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)			108.16	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)			109.72	
Weight of Saturated Sample in Water, *C* (g)			68.18	
Bulk Specific Gravity, G_s =B/(B-C)			2.64	
Apparent Specific Gravity, G_{as} = A/(A-C)			2.71	3.46

Computation for Bulk Specific Gravity — **Sample: SRK-03-C08**

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)			167.43	
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)			170.19	
Weight of Saturated Sample in Water, *C* (g)			108.71	
Bulk Specific Gravity, G_s =B/(B-C)			2.77	
Apparent Specific Gravity, G_{as} = A/(A-C)			2.85	2.88

Computation for Bulk Specific Gravity

Soil	> 2"	3/8" - 2"	#4 - 3/8"	<#4
Weight of Oven-Dry Sample in Air, *A* (g)				
Weight of Saturated-Surface-Dry Sample in Air, *B* (g)				
Weight of Saturated Sample in Water, *C* (g)				
Bulk Specific Gravity, G_s =B/(B-C)				
Apparent Specific Gravity, G_{as} = A/(A-C)				

Comments:

APPENDIX III

Grain Size Distribution Results

GRAIN SIZE DISTRIBUTION

	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	98
	3/4"	19.1	96
	3/8"	9.5	90
	# 4	4.75	84
	# 10	2.00	76
	# 20	0.850	69
	# 40	0.425	64
	# 60	0.250	60
	# 100	0.150	55
	# 200	0.075	50
		0.0584	50.8
		0.0420	47.2
		0.0301	44.4
		0.0215	42.2
		0.0154	38.6
		0.0097	33.6
		0.0082	31.3
		0.0059	26.8
		0.0042	22.8
		0.0030	19.4
		0.0022	16.5
		0.0013	12.1

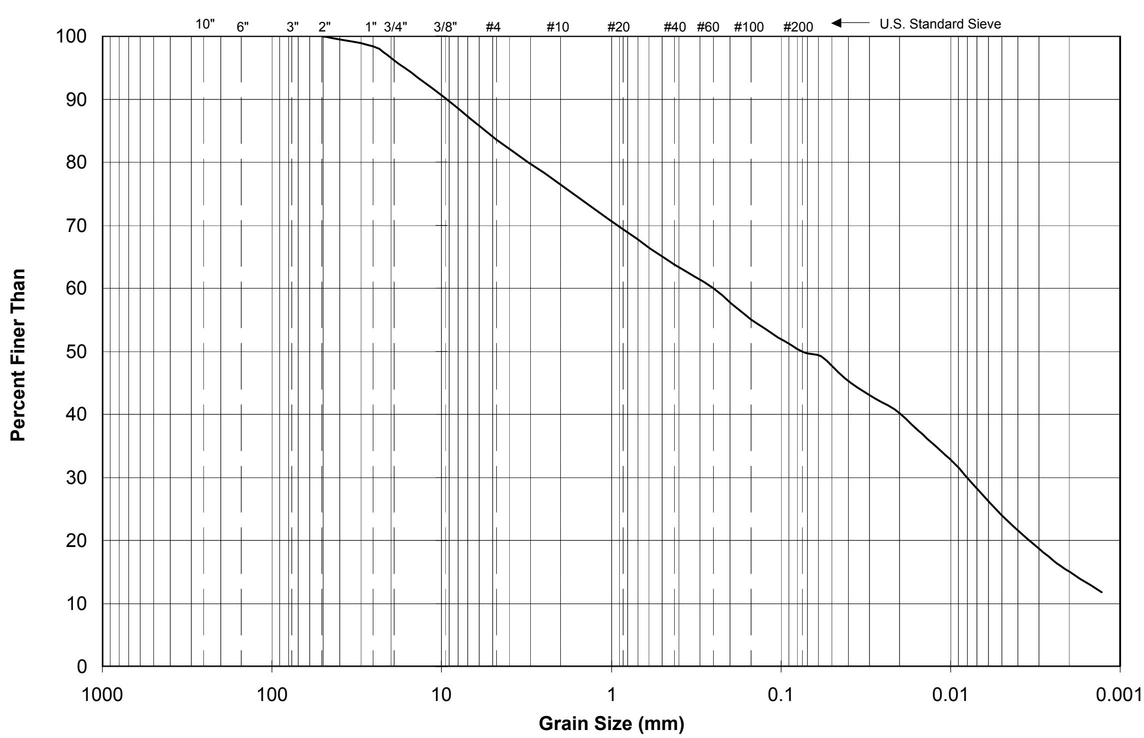
MDH ENGINEERED SOLUTIONS

PROJECT: Faro Mine
LOCATION: Whitehorse, Yukon
SITE: SRK Consulting
SAMPLE: SRK-03-C01
DATE: 25-Jul-03

COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	16
% SAND	34
% FINES (SILT, CLAY)	50



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

MDH ENGINEERED SOLUTIONS

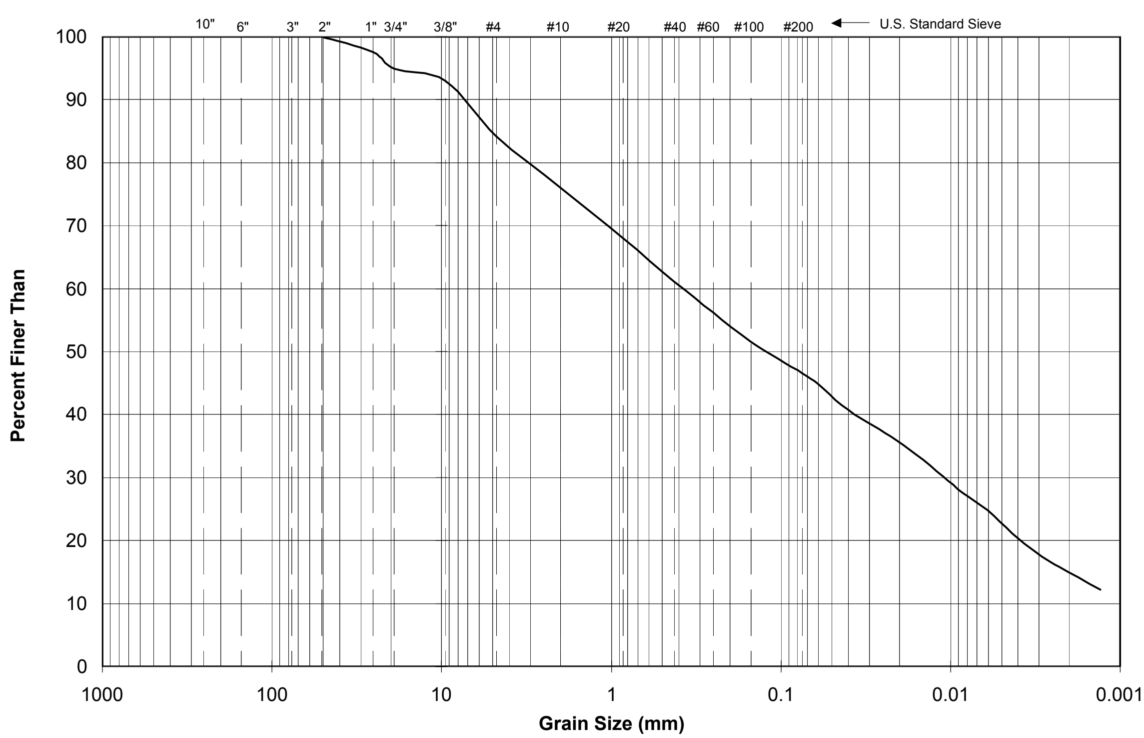
	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	98
	3/4"	19.1	95
	3/8"	9.5	93
	# 4	4.75	84
	# 10	2.00	76
	# 20	0.850	68
	# 40	0.425	61
	# 60	0.250	56
	# 100	0.150	52
	# 200	0.075	47
		0.0610	44.9
		0.0437	41.5
		0.0313	38.9
		0.0223	36.4
		0.0160	33.7
		0.0111	30.2
		0.0085	27.6
		0.0060	24.8
		0.0043	21.2
		0.0031	18.1
		0.0023	15.8
		0.0013	12.2

PROJECT: Faro Mine
LOCATION: Whitehorse, Yukon
SITE: SRK Consulting
SAMPLE: SRK-03-C02
DATE: 25-Jul-03

COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	16
% SAND	37
% FINES (SILT, CLAY)	47



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

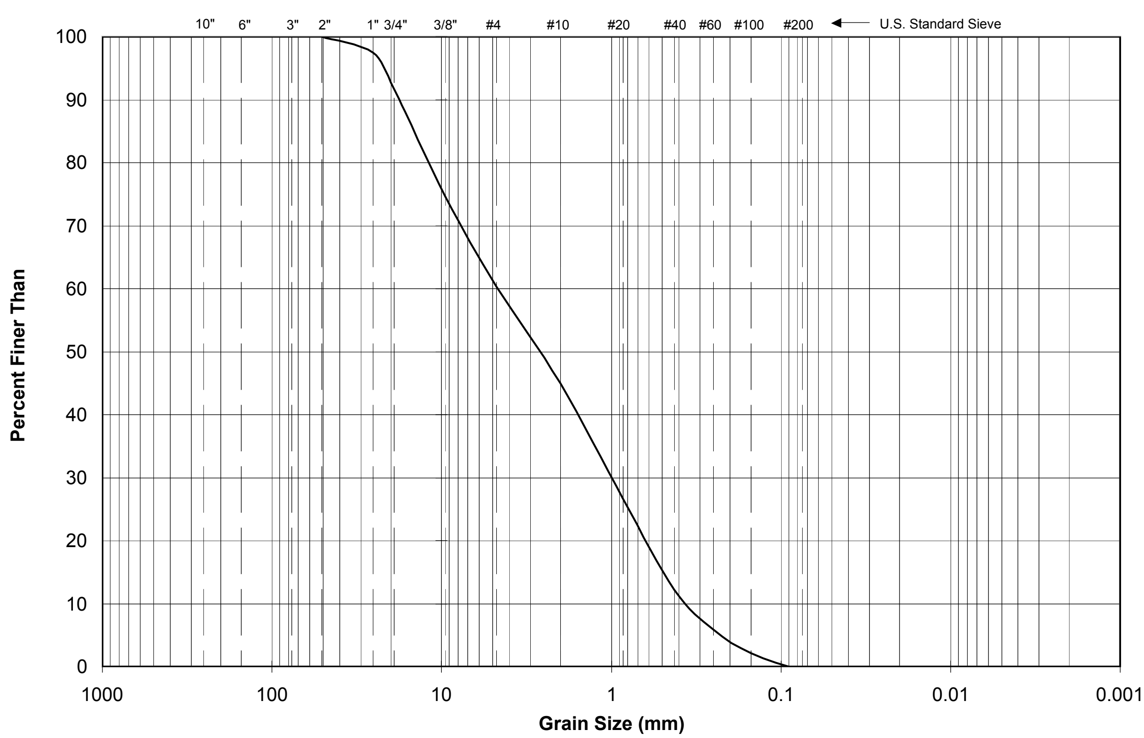
	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	98
	3/4"	19.1	92
	3/8"	9.5	75
	# 4	4.75	60
	# 10	2.00	45
	# 20	0.850	27
	# 40	0.425	12
	# 60	0.250	6
	# 100	0.150	2
	# 200	0.075	-1

ENGINEERED SOLUTIONS

PROJECT: Faro Mine
LOCATION: Whitehorse, Yukon
SITE: SRK Consulting
SAMPLE: SRK-03-C03
DATE: Jul 3-03
COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	40
% SAND	60
% FINES (SILT, CLAY)	



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

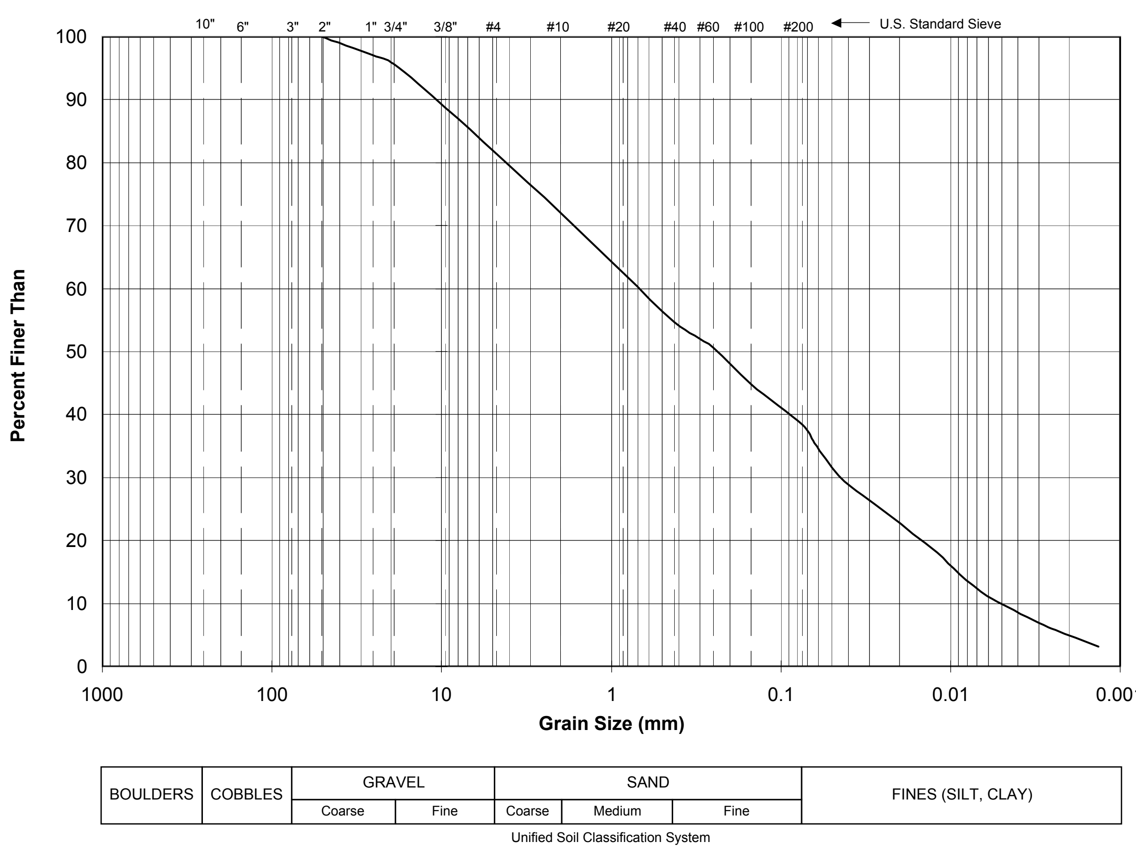
	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	97
	3/4"	19.1	96
	3/8"	9.5	89
	# 4	4.75	81
	# 10	2.00	72
	# 20	0.850	62
	# 40	0.425	55
	# 60	0.250	51
	# 100	0.150	45
	# 200	0.075	38
		0.0634	35.5
		0.0457	30.3
		0.0327	27.1
		0.0234	24.2
		0.0167	21.1
		0.0120	18.1
		0.0088	14.7
		0.0061	11.2
		0.0046	9.5
		0.0032	7.3
		0.0024	5.8
		0.0013	3.2

MDH ENGINEERED SOLUTIONS

PROJECT: Faro Mine
LOCATION: Whitehorse
SITE: SRK Consulting
SAMPLE: SRK-03-C04
DATE: 25-Jul-03
COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	19
% SAND	43
% FINES (SILT, CLAY)	38



GRAIN SIZE DISTRIBUTION

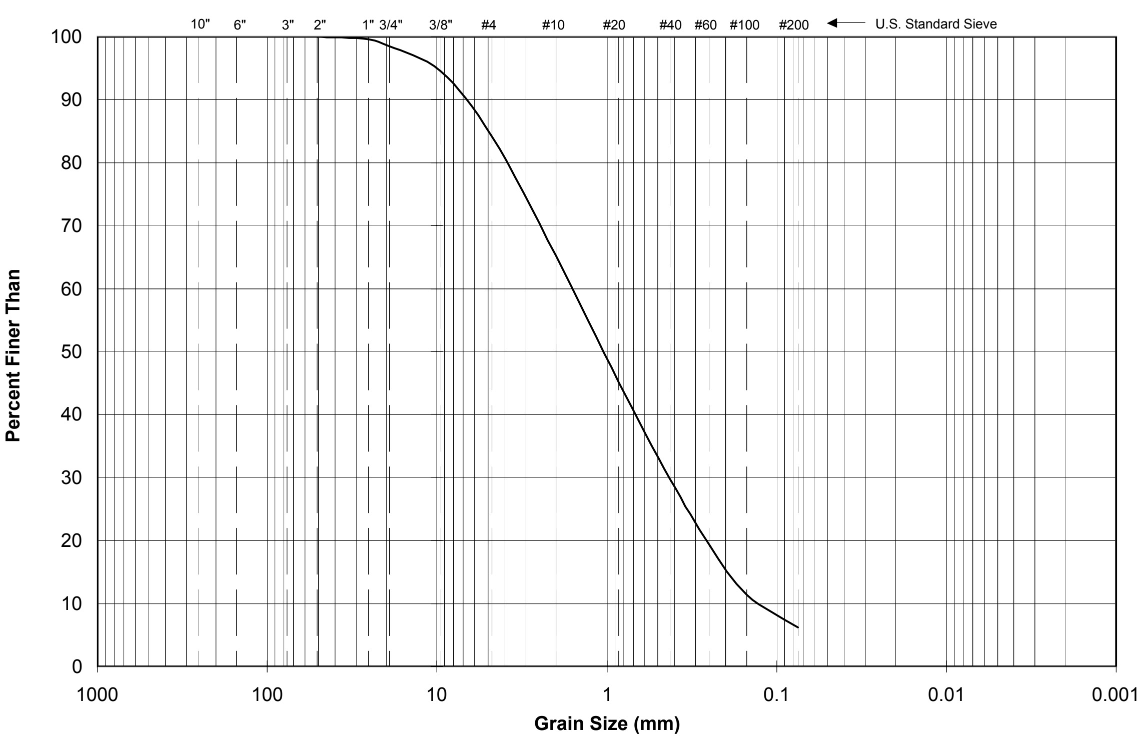
	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	98
	3/8"	9.5	95
	# 4	4.75	84
	# 10	2.00	65
	# 20	0.850	45
	# 40	0.425	30
	# 60	0.250	19
	# 100	0.150	11
	# 200	0.075	6

ENGINEERED SOLUTIONS

PROJECT: SRK Consultants
LOCATION:
SITE: Faro Mine, Whitehorse
SAMPLE: SRK-030-C05
DATE: Jul-3-03
COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	16
% SAND	78
% FINES (SILT, CLAY)	6



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

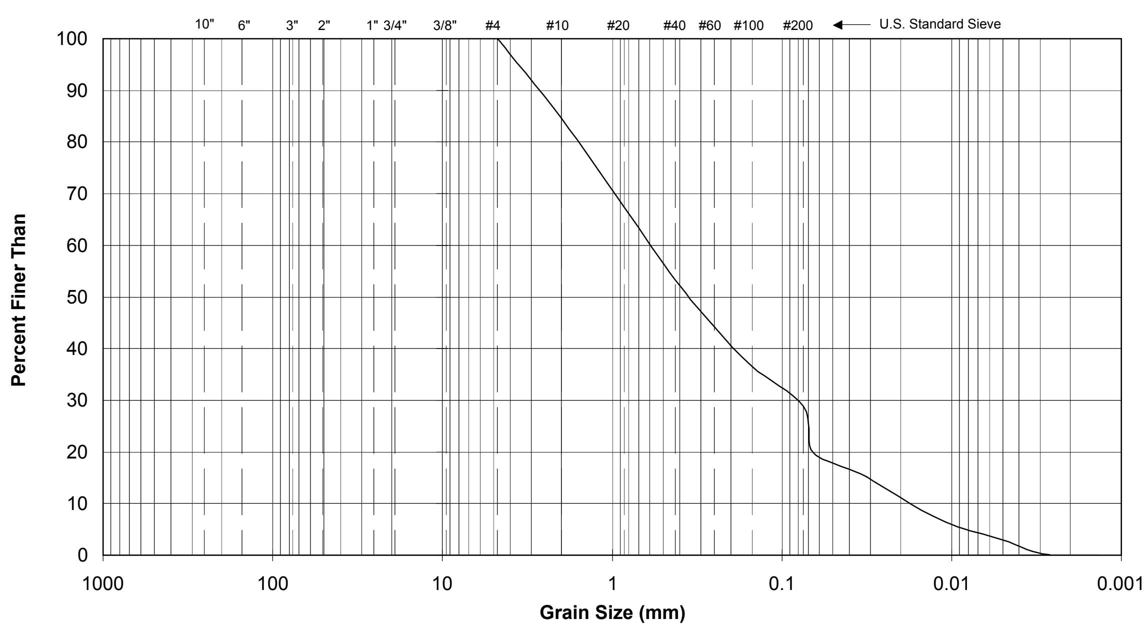
	Sieve	Diameter (mm)	% Finer
Mechanical:	15"	381.0	100
	14"	355.6	100
	13"	330.2	100
	12"	304.8	100
	11"	279.4	100
	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	100
	# 10	2.00	85
	# 20	0.850	67
	# 40	0.425	53
	# 60	0.250	44
	# 100	0.150	37
	# 200	0.075	29
Hydrometer:		0.0673	20.4
		0.0481	17.6
		0.0342	15.7
		0.0245	12.8
		0.0175	10.0
		0.0129	7.6
		0.0091	5.4
		0.0065	4.1
		0.0046	2.6
		0.0034	0.7
		0.0024	0.0
		0.0014	

MDH ENGINEERED SOLUTIONS

PROJECT: Faro Mine
Whitehorse, Yukon
SRK Consulting
SAMPLE: SRK-03-C06
DATE: 22-Jul-03
COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	
% SAND	71
% FINES (SILT, CLAY)	29



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Course	Fine	Course	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

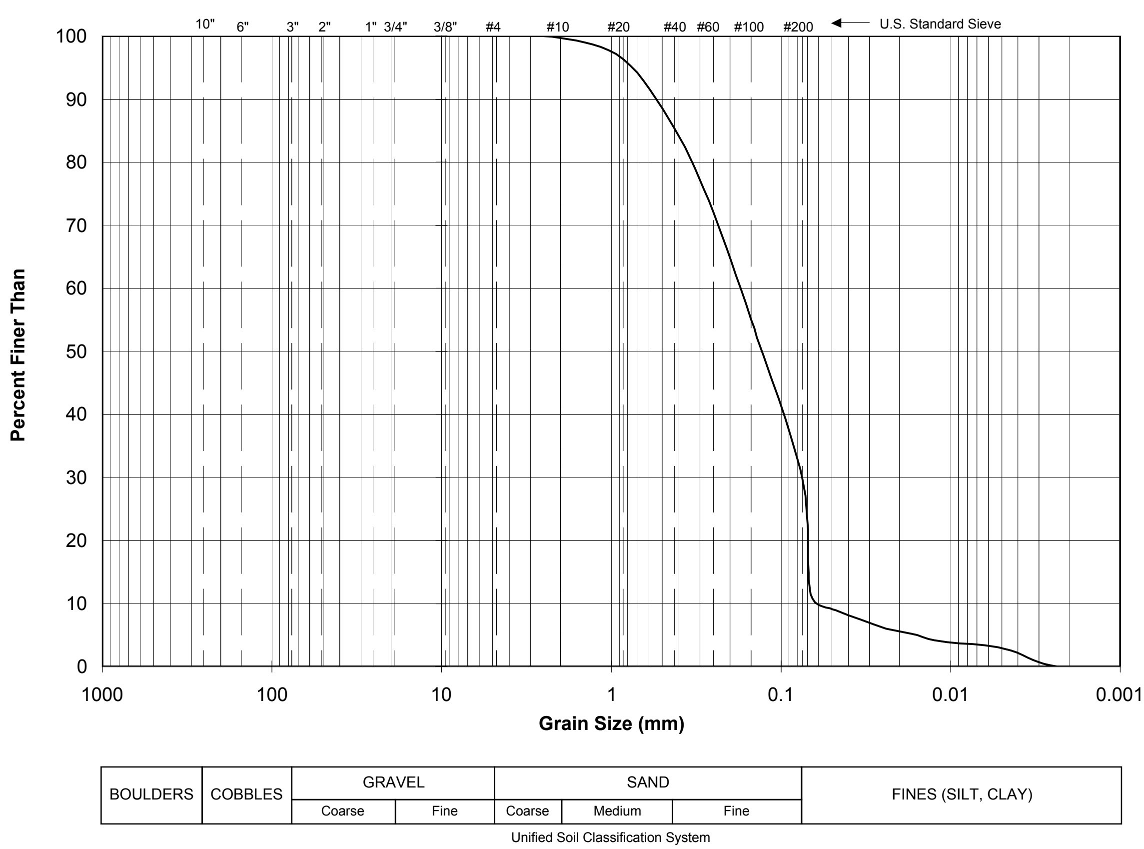
	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	100
	# 10	2.00	100
	# 20	0.850	96
	# 40	0.425	85
	# 60	0.250	72
	# 100	0.150	55
	# 200	0.075	30
		0.0666	11.4
		0.0475	8.9
		0.0338	7.5
		0.0240	6.0
		0.0170	5.1
		0.0125	4.1
		0.0088	3.7
		0.0062	3.3
		0.0044	2.5
		0.0033	1.0
		0.0024	
		0.0013	

MDH ENGINEERED SOLUTIONS

PROJECT: Faro Mine
LOCATION: Whitehorse
SITE:
SAMPLE: SRK-03-C07
DATE: 25-Jul-03
COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	
% SAND	70
% FINES (SILT, CLAY)	30



GRAIN SIZE DISTRIBUTION

MDH ENGINEERED SOLUTIONS

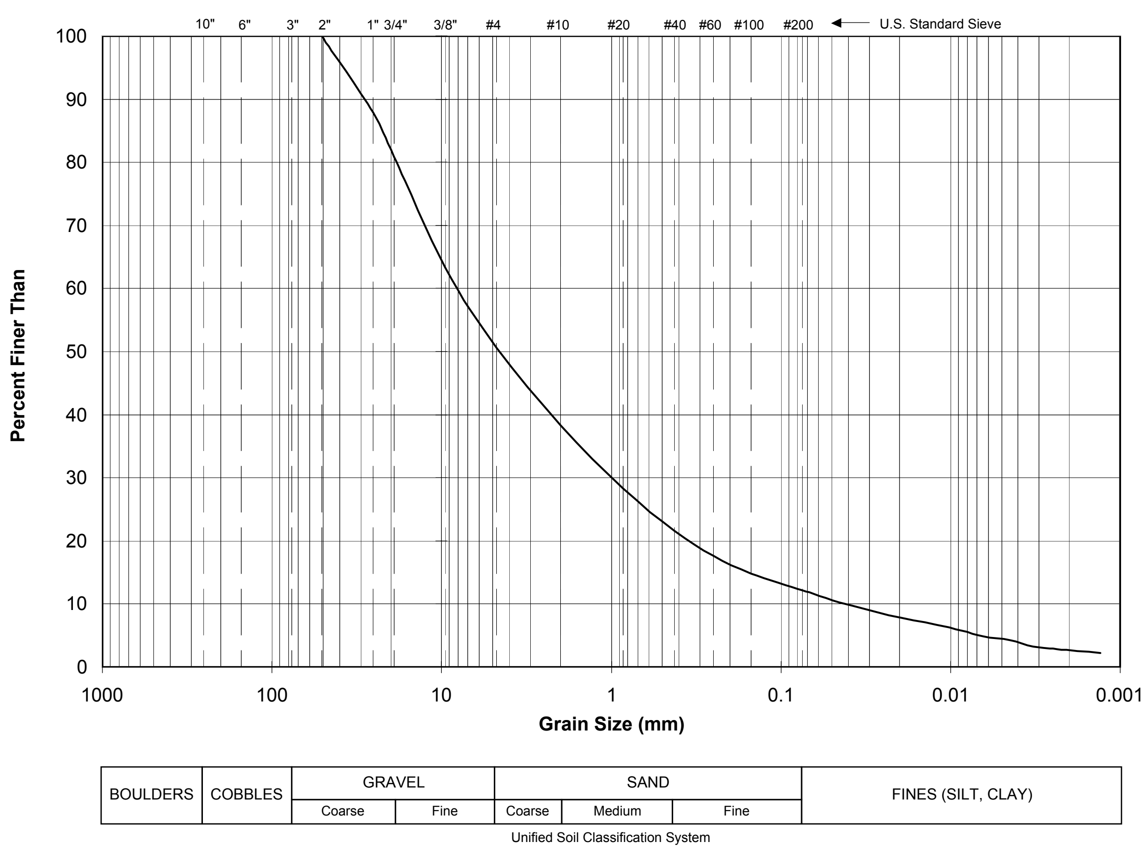
PROJECT: Faro Mine
LOCATION: Whitehorse
SITE:
SAMPLE: SRK-03-C08
DATE: 10-Jul-03

COMMENTS:

	Sieve	Diameter (mm)	% Finer
Mechanical:	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	88
	3/4"	19.1	81
	3/8"	9.5	63
	# 4	4.75	51
	# 10	2.00	38
	# 20	0.850	28
	# 40	0.425	22
	# 60	0.250	18
	# 100	0.150	15
	# 200	0.075	12
		0.0633	11.6
		0.0453	10.3
		0.0324	9.3
		0.0231	8.2
		0.0165	7.4
		0.0121	6.7
		0.0086	5.7
		0.0064	4.9
		0.0045	4.3
		0.0033	3.3
		0.0024	2.8
		0.0013	2.2

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	49
% SAND	39
% FINES (SILT, CLAY)	12



APPENDIX IV

Standard Proctor Tests Results

COMPACTION TEST

MDH ENGINEERED SOLUTIONS

PROJECT: M453
Faro Mine
Whitehorse, Yukon

SAMPLE: SRK 03-C01

DATE: 10-Jul-03

Test Results:

Water Content: (%)	Dry Density (kg/m^3)
6.8	1987
8.7	2057
10.3	2070
11.4	2011
13.0	1958

Maximum dry density: **2072** kg/m^3
Optimum water content: **9.9** %

Results corrected for oversized material?
yes

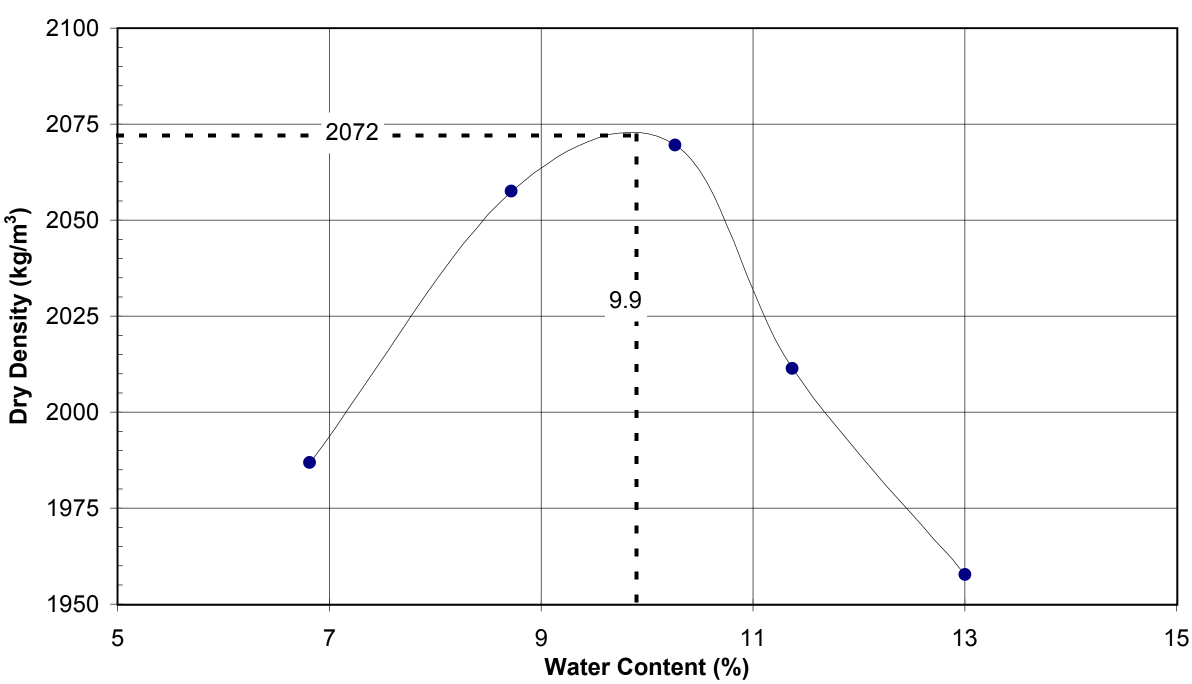
Test Details:

Effort:	Standard	
Procedure used:	A	
Diameter of mold:	101	mm
Compacted material less than:	4.75	mm in diameter
Method of preparation:	dry	

Oversize Correction Data (if applicable):

Percentage oversize fraction:	21.0	%
Specific gravity:	2.50	(assumed)

Comments:



COMPACTION TEST

MDH ENGINEERED SOLUTIONS

PROJECT: Faro Mine
Whitehorse

SAMPLE: SRC 03 C02
DATE: 3-Jul-03

Test Results:

Water Content: (%)	Dry Density (kg/m^3)
6.6	1870
8.2	1978
9.8	2048
11.4	1999
13.1	1934

Maximum dry density: **2045** kg/m^3
Optimum water content: **10.0** %

Results corrected for oversized material?
yes

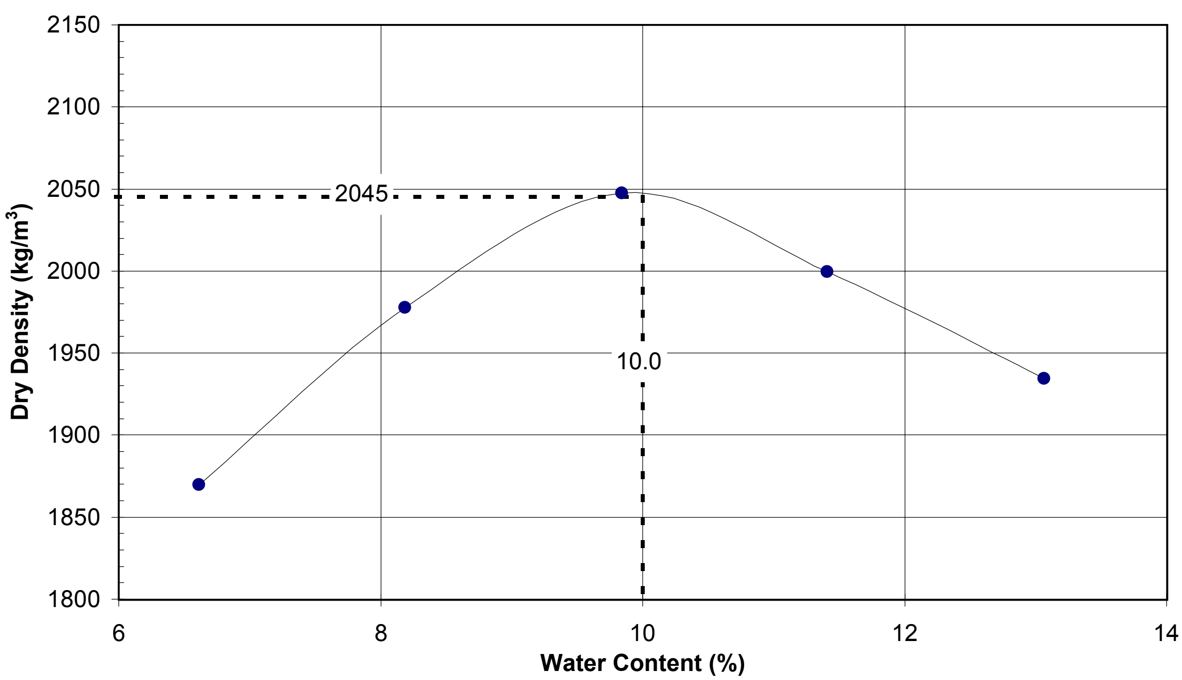
Test Details:

Effort:	Standard	
Procedure used:	A	
Diameter of mold:	101	mm
Compacted material less than:	4.75	mm in diameter
Method of preparation:	dry	

Oversize Correction Data (if applicable):

Percentage oversize fraction:	17.3	%
Specific gravity:	2.50	(assumed)

Comments:



MDH ENGINEERED SOLUTIONS

COMPACTION TEST

PROJECT: M453
Faro Mine
Whitehorse, Yukon
SAMPLE: SRK 03-C03
DATE: 11-Jul-03

Test Results:

Water Content: (%)	Dry Density (kg/m^3)
1.9	2129
3.5	2157
5.5	2183
7.2	2193
8.4	2144

Maximum dry density: **2195** kg/m^3
Optimum water content: **6.9** %

Results corrected for oversized material?
yes

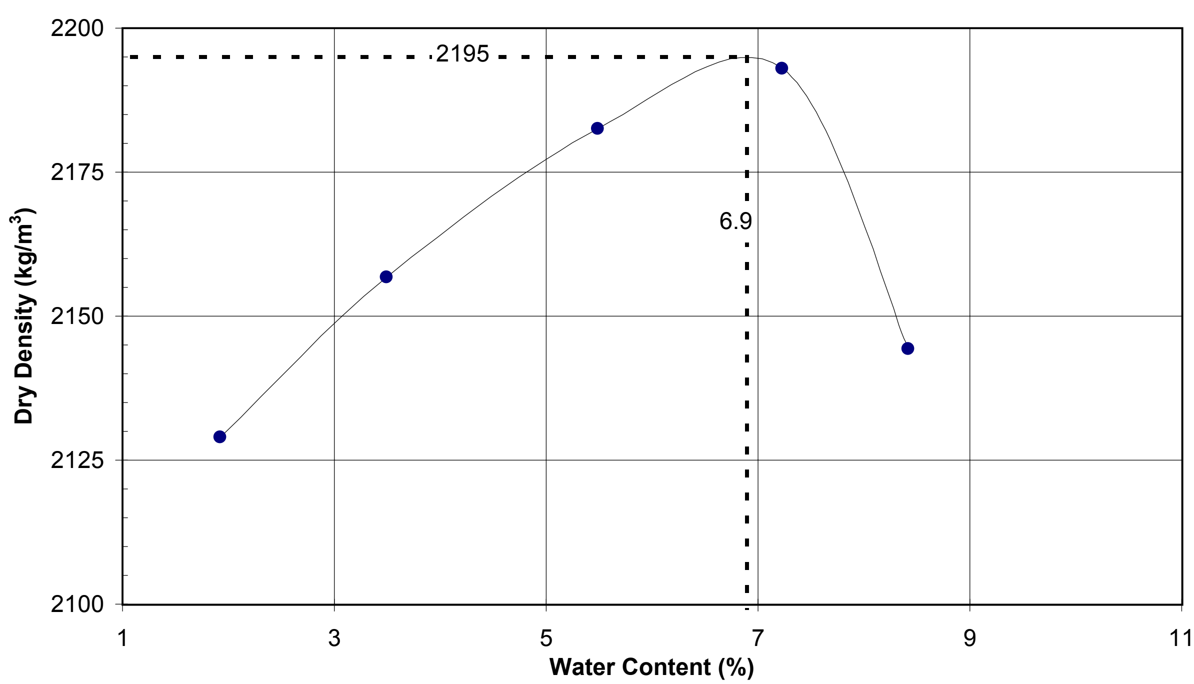
Test Details:

Effort:	Standard	
Procedure used:	C	
Diameter of mold:	152	mm
Compacted material less than:	19.1	mm in diameter
Method of preparation:	dry	

Oversize Correction Data (if applicable):

Percentage oversize fraction:	6.0	%
Specific gravity:	2.50	(assumed)

Comments:



COMPACTION TEST

MDH ENGINEERED SOLUTIONS

PROJECT: Faro Mine
Whitehorse

SAMPLE: SRK-03-C04
DATE: 10-Jul-03

Test Results:

Water Content: (%)	Dry Density (kg/m^3)
4.8	2033
6.3	2102
7.6	2117
9.4	2057
11.0	1992

Maximum dry density: **2120** kg/m^3
Optimum water content: **7.4** %

Results corrected for oversized material?
N/A

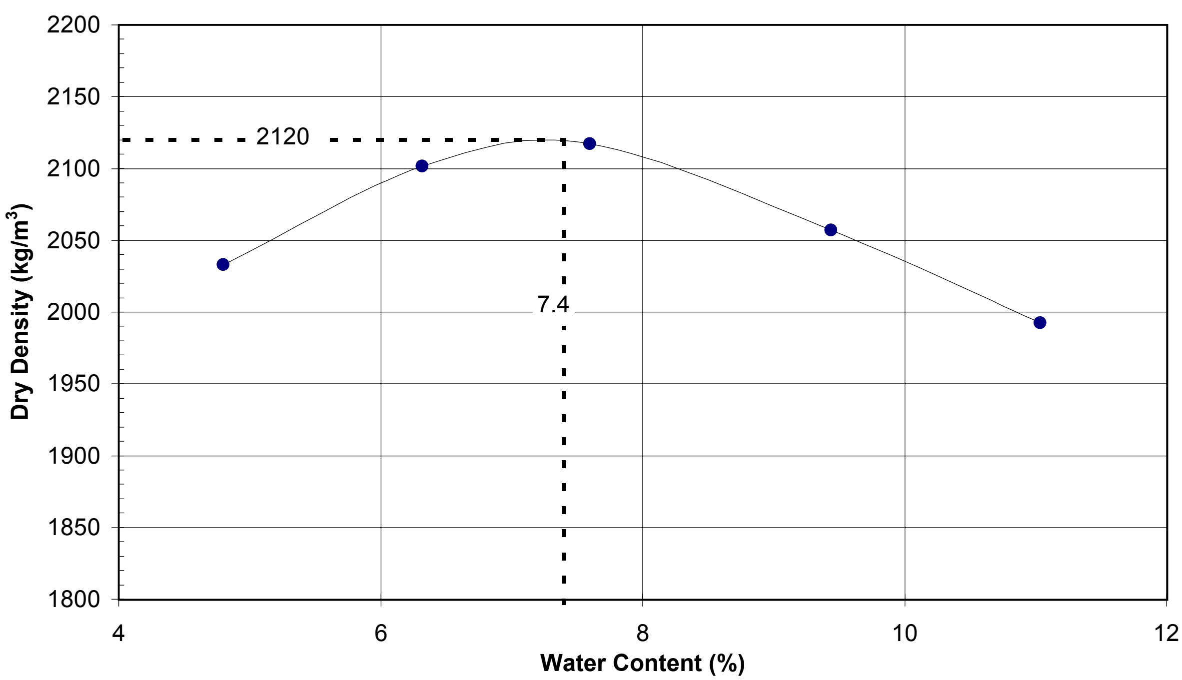
Test Details:

Effort:	Standard	
Procedure used:	A	
Diameter of mold:	101	mm
Compacted material less than:	4.75	mm in diameter
Method of preparation:	dry	

Oversize Correction Data (if applicable):

Percentage oversize fraction:	20.0	%
Specific gravity:	2.50	(assumed)

Comments:



MDH ENGINEERED SOLUTIONS

COMPACTION TEST

PROJECT: M453
Faro Mine
Whitehorse, Yukon
SAMPLE: SRK 03-C05
DATE: 8-Jul-03

Test Results:

Water Content: (%)	Dry Density (kg/m^3)
5.3	2024
6.9	2040
8.3	2065
10.0	2040
12.3	1931

Maximum dry density: **2065** kg/m^3
Optimum water content: **8.5** %

Results corrected for oversized material?
yes

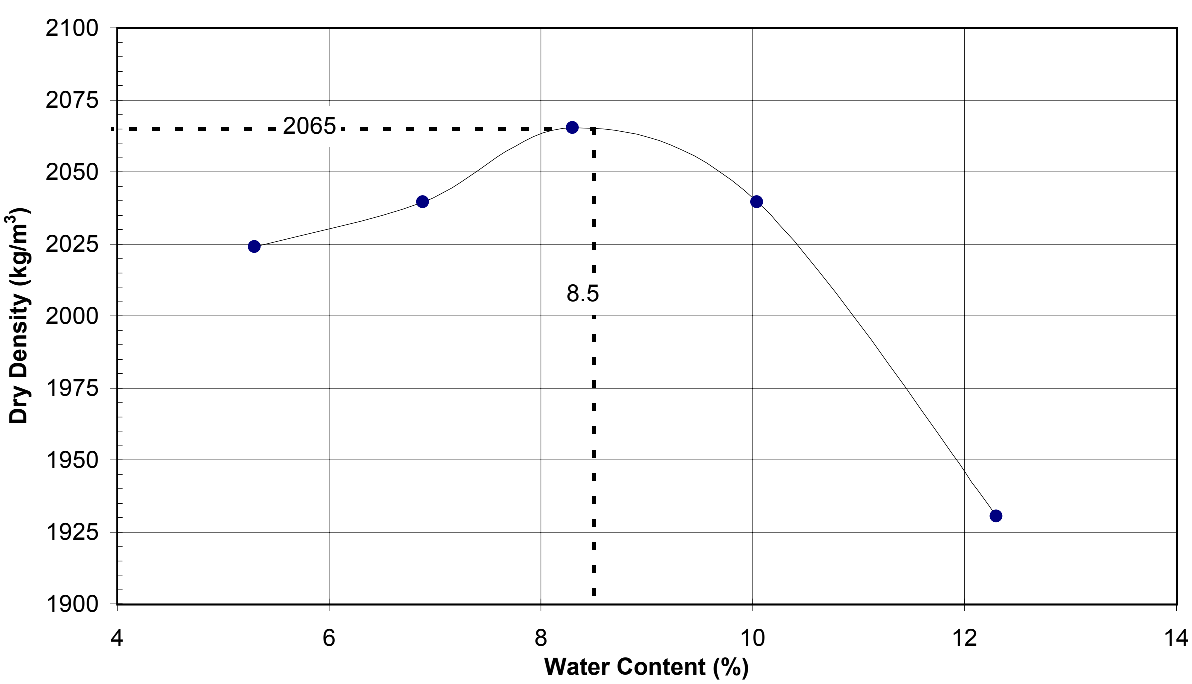
Test Details:

Effort:	Standard	
Procedure used:	A	
Diameter of mold:	101	mm
Compacted material less than:	4.75	mm in diameter
Method of preparation:	dry	

Oversize Correction Data (if applicable):

Percentage oversize fraction:	13.0	%
Specific gravity:	2.50	(assumed)

Comments:



COMPACTION TEST

PROJECT:	M453
	Faro Mine
	Whitehorse, Yukon
SAMPLE:	SRK 03-C06
DATE:	10-Jul-03

Test Results:

Water Content: (%)	Dry Density (kg/m^3)
5.1	2051
6.6	2069
8.4	2087
9.6	2061
11.2	2011

Maximum dry density: **2087** kg/m^3

Optimum water content: **8.4** %

Results corrected for oversized material?
yes

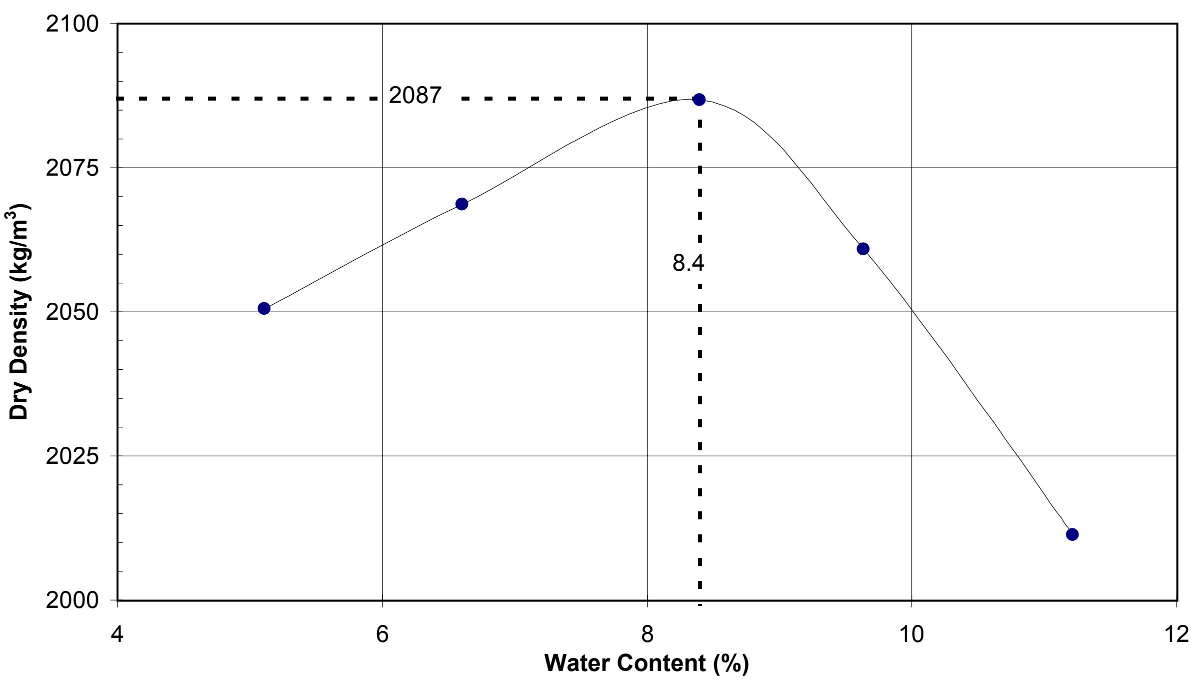
Test Details:

Effort:	Standard	
Procedure used:	A	
Diameter of mold:	101	mm
Compacted material less than:	4.75	mm in diameter
Method of preparation:	dry	

Oversize Correction Data (if applicable):

Percentage oversize fraction:	21.0	%
Specific gravity:	2.50	(assumed)

Comments:



APPENDIX V-a

Large Diameter (300-mm) SWCC Tests Results

M.D. Haug & Associates Ltd.

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants, Vancouver
Location: Faro Mine, Whitehorse
Date: 23-Jul-03

Sample: SRK-03-C01 @1.968 Mg/m^3 @ 10.5%

	Elevation of water column below top of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content		Notes
Large Pressure Plate cell	0	0	0.01	67801		0	1894.0	0.138	0.276		
	0.5	0	0.05	67742		59	1835.0	0.133	0.267		
	1	0	0.1	67617		184	1710.0	0.124	0.249		
	2.5	0	0.25	67589		212	1682.0	0.122	0.245		
	5	0	0.5	67565		236	1658.0	0.120	0.241		
	10	0	1	67519		282	1612.0	0.117	0.235		
	25	0	2.5	67452		349	1545.0	0.112	0.225		
	50	0	5	67436		365	1529.0	0.111	0.223		
	0	10	10	67427		374	1520.0	0.110	0.221		
	0	25	25	67390		411	1483.0	0.108	0.216		
	0	50	50	67350		451	1443.0	0.105	0.210		
	0	100	100	67322		479	1415.0	0.103	0.206		

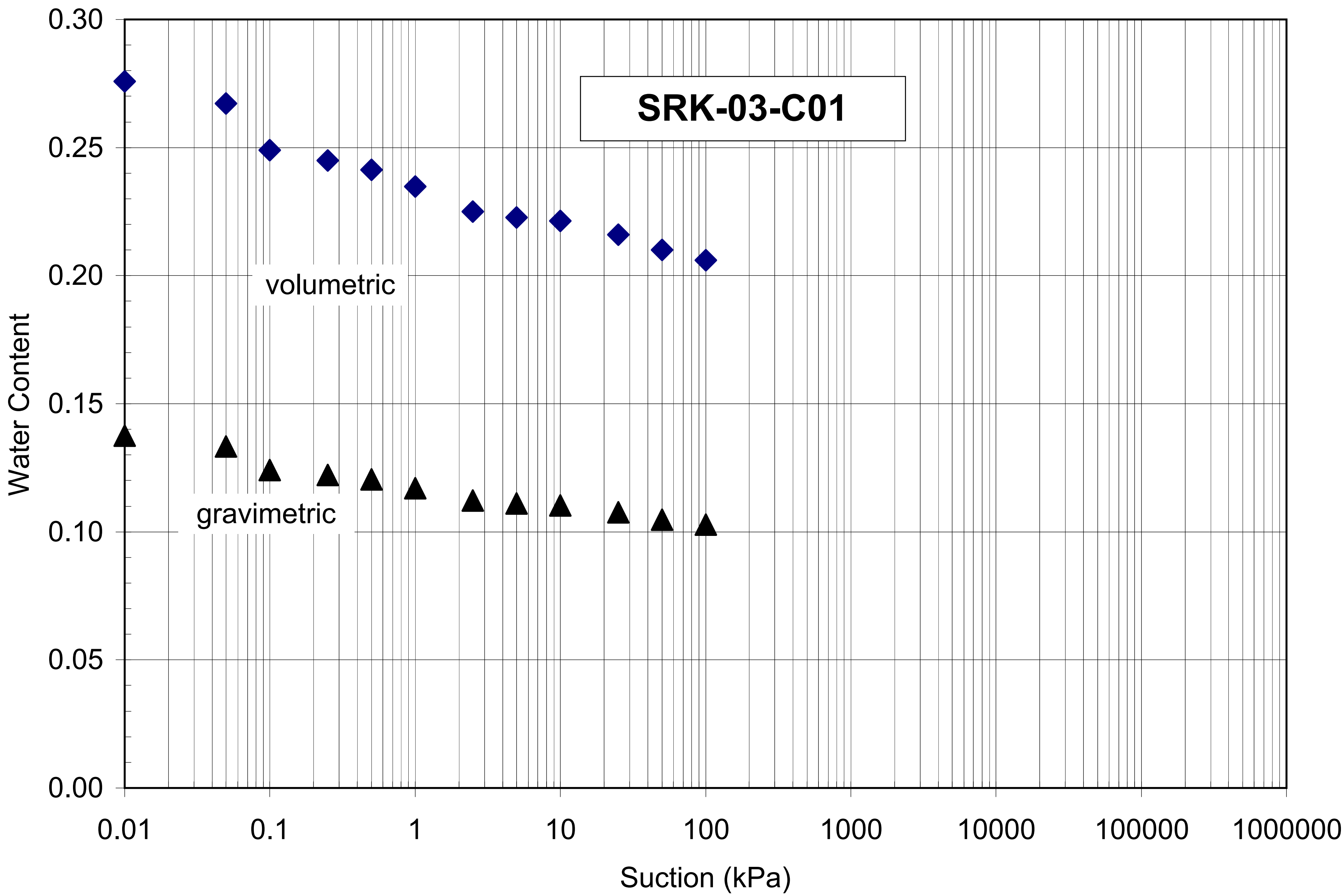
Dessicator Tests

Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)	Suction (kPa)					Gravimetric water content	Volumetric water content
4.282	4.189	0.627	4120					0.026	0.03552
4.086	4.042	0.722	38000					0.013	0.01803
3.123	3.103	0.622	82600					0.008	0.01097
4.066	4.048	0.918	150000					0.006	0.00782
4.288	4.283	0.917	293000					0.001	0.00202

Final water content determination

	Tare #1	Tare #2	Total
Weight of tare (g)	965	644	1609
Tare + soil wet (g)	11040	5756	16796
Tare + soil dry (g)	10076	5305	15381
Weight of dry soil (g)	9111	4661	13772
Weight of water in soil (g)	964	451	1415
Water content			10.3%

Dimensions of specimen	**Initial**
Diameter of specimen (mm)	305.00
Height of specimen (mm)	94.00
Volume of specimen (cc)	6868.7
Dry density of specimen (kg/m^3)	2005.04



SRK-03-C01
volumetric
gravimetric
Water Content
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.01
0.1
1
10
100
1000
10000
100000
1000000
Suction (kPa)

M.D. Haug & Associates Ltd.

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants, Vancouver
Location: Faro Mine, Whitehorse

Date: 23-Jul-03

Sample: SRK-03-C03 @2.085 Mg/m^3 @ 7.5%

	Elevation of water column below top of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content		Notes
Large Pressure Plate cell	0	0	0.01	67598		0	1663.0	0.110	0.229		
	0.5	0	0.05	67587		11	1652.0	0.109	0.227		
	1	0	0.1	67395		203	1460.0	0.097	0.201		
	2.5	0	0.25	67280		318	1345.0	0.089	0.185		
	5	0	0.5	67269		329	1334.0	0.088	0.183		
	10	0	1	67227		371	1292.0	0.085	0.178		
	25	0	2.5	67004		594	1069.0	0.071	0.147		
	50	0	5	66847		751	912.0	0.060	0.125		
	0	10	10	66737		861	802.0	0.053	0.110		
	0	25	25	66582		1016	647.0	0.043	0.089		
	0	50	50	66484		1114	549.0	0.036	0.076		
	0	100	100	66418		1180	483.0	0.032	0.066		

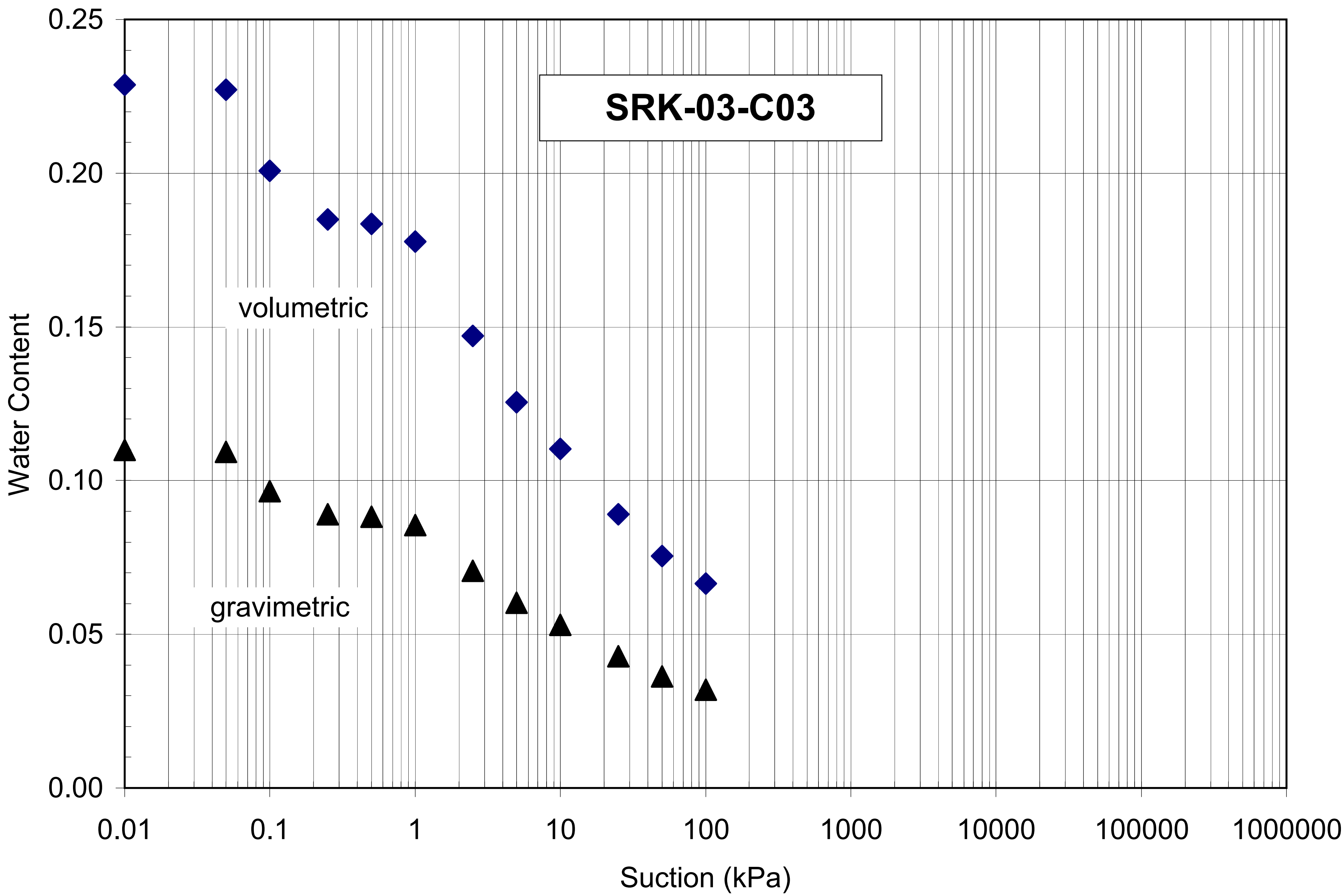
Dessicator Tests

Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)	Suction (kPa)					Gravimetric water content	Volumetric water content
4.282	4.189	0.627	4120					0.026	0.04269
4.086	4.042	0.722	38000					0.013	0.02167
3.123	3.103	0.622	82600					0.008	0.01318
4.066	4.048	0.918	150000					0.006	0.0094
4.288	4.283	0.917	293000					0.001	0.00243

Final water content determination

	Tare #3	Tare #4	Total
Weight of tare (g)	960	624	1584
Tare + soil wet (g)	10886	6296	17182
Tare + soil dry (g)	10581	6118	16699
Weight of dry soil (g)	9621	5494	15115
Weight of water in soil (g)	305	178	483
Water content			3%

Dimensions of specimen	**Initial**
Diameter of specimen (mm)	305.00
Height of specimen (mm)	99.50
Volume of specimen (cc)	7270.6
Dry density of specimen (kg/m^3)	2078.93


SRK-03-C03
volumetric
gravimetric
Water Content
0.25
0.20
0.15
0.10
0.05
0.00
0.01
0.1
1
10
100
1000
10000
100000
1000000
Suction (kPa)

M.D. Haug & Associates Ltd.	SOIL-WATER CHARACTERISTIC CURVE
	Project: SRK Consultants, Vancouver
	Location: Faro Mine, Whitehorse
	Date: 23-Jul-03

Sample: SRK-03-C08

	Elevation of water column below top of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content		Notes
Large Pressure Plate cell	0	0	0.01	54434		0	2639.0	0.197	0.358		
	0.5	0	0.05	54391		43	2596.0	0.193	0.352		
	1	0	0.1	54367		67	2572.0	0.192	0.349		
	2.5	0	0.25	54155		279	2360.0	0.176	0.320		
	5	0	0.5	54089		345	2294.0	0.171	0.311		
	10	0	1	53794		640	1999.0	0.149	0.271		
	25	0	2.5	53218		1216	1423.0	0.106	0.193		
	50	0	5	53118		1316	1323.0	0.099	0.179		
	0	10	10	53054		1380	1259.0	0.094	0.171		
	0	25	25	52915		1519	1120.0	0.083	0.152		
	0	50	50	52774		1660	979.0	0.073	0.133		
	0	100	100	52463		1971	668.0	0.050	0.091		

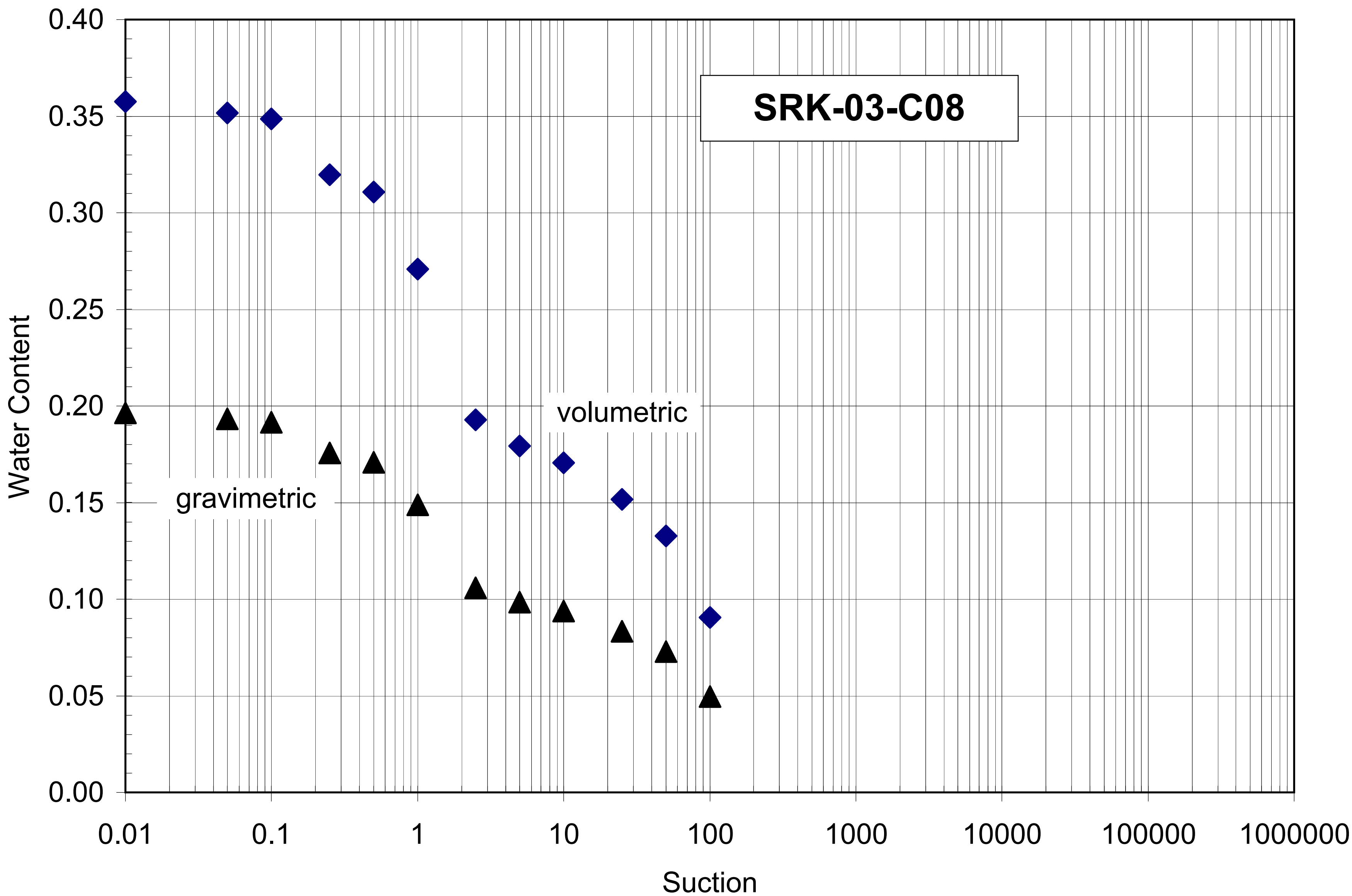
Dessicator Tests

Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)	Suction (kPa)					Gravimetric water content	Volumetric water content
4.282	4.189	0.627	4120					0.026	0.04476
4.086	4.042	0.722	38000					0.013	0.02272
3.123	3.103	0.622	82600					0.008	0.01382
4.066	4.048	0.918	150000					0.006	0.00986
4.288	4.283	0.917	293000					0.001	0.00255

Final water content determination

	Tare #5	Tare #6	Total
Weight of tare (g)	623	622	1245
Tare + soil wet (g)	7345	7997	15342
Tare + soil dry (g)	7030	7644	14674
Weight of dry soil (g)	6407	7022	13429
Weight of water in soil (g)	315	353	668
Water content			5%

Dimensions of specimen	**Initial**
Diameter of specimen (mm)	305.00
Height of specimen (mm)	101.00
Volume of specimen (cc)	7380.2
Dry density of specimen (kg/m^3)	1819.6


SRK-03-C08
Water Content
Suction
volumetric
gravimetric
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.01
0.1
1
10
100
1000
10000
100000
1000000

APPENDIX V-b

Small Diameter (64-mm) SWCC Tests Results

MDH ENGINEERED SOLUTIONS

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants
Location: Faro Mine, Whitehorse
Date: 10-Aug-03

Sample: SRK-03-CO1

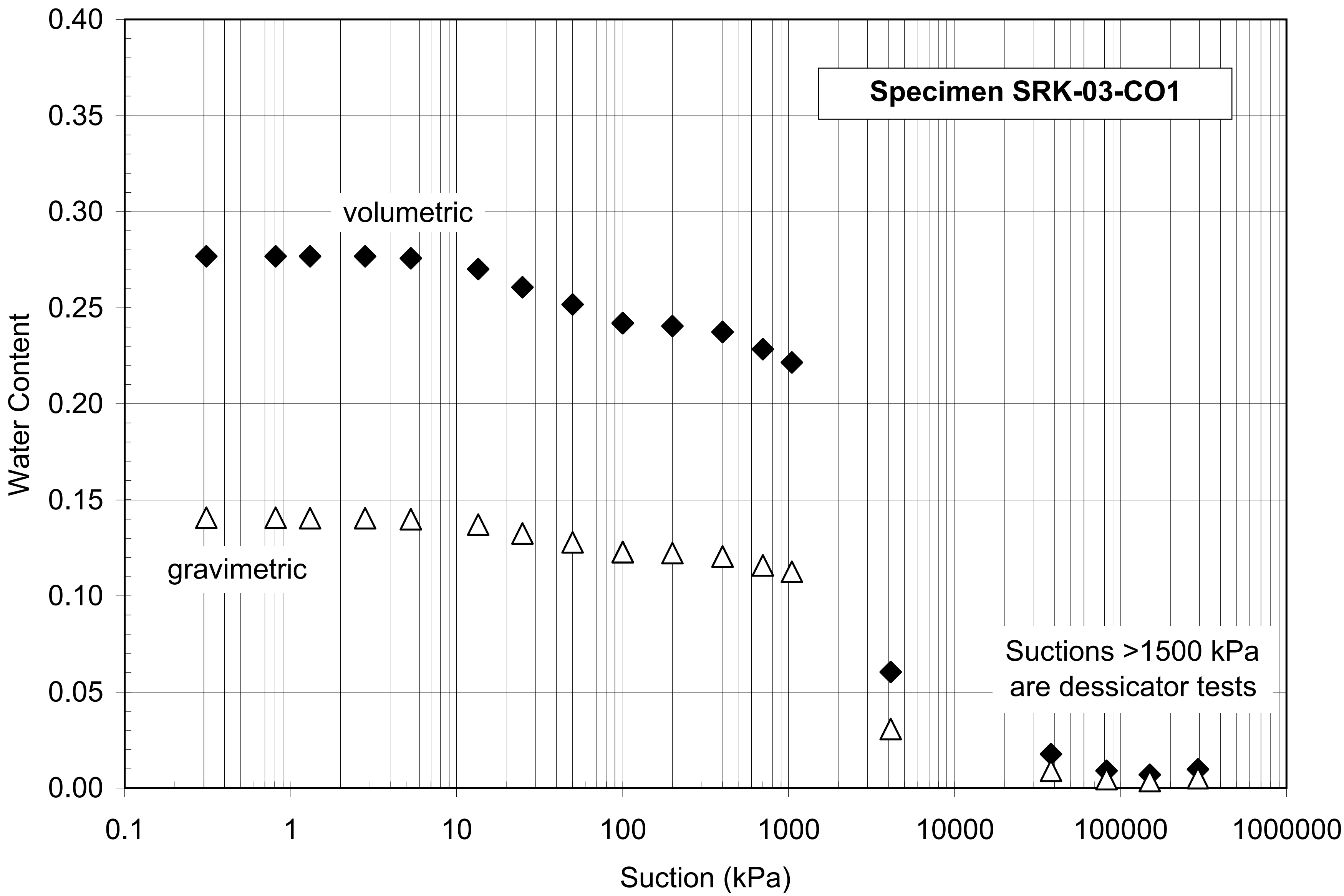
	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)		
1-Bar Stone	0	0	0.31	393.364	85.637	0.000	27.608	0.141	0.277	1.022		
	5	0	0.81	393.364	85.637	0.000	27.608	0.141	0.277	1.022		
	10	0	1.31	393.350	85.637	0.014	27.594	0.141	0.277	1.022		
	25	0	2.81	393.350	85.637	0.014	27.594	0.141	0.277	1.022		
	50	0	5.31	393.244	85.637	0.120	27.488	0.140	0.276	1.018		
	0	13.5	13.5	392.696	85.637	0.668	26.940	0.137	0.270	0.997		
	0	25	25	391.760	85.637	1.604	26.004	0.132	0.261	0.963		
	0	50	50	390.864	85.637	2.500	25.108	0.128	0.252	0.930		
	0	100	100	389.879	85.637	3.485	24.123	0.123	0.242	0.893		
	0	100	100	389.879	85.637	3.485	24.123	0.123	0.242	0.893		
	0	100	100	389.879	85.637	3.485	24.123	0.123	0.242	0.893		
	0	100	100	389.879	85.637	3.485	24.123	0.123	0.242	0.893		
5-Bar Stone	0	100	100	440.146	136.110	3.485	24.123	0.123	0.242	0.893		
	0	200	200	440.011	136.110	3.620	23.988	0.122	0.241	0.888		
	0	400	400	439.687	136.110	3.944	23.664	0.121	0.237	0.876		
15-Bar Stone	0	400	400	303.473	0.000	3.944	23.664	0.121	0.237	0.876		
	0	700	700	302.578	0.000	4.839	22.769	0.116	0.228	0.843		
	0	1050	1050	301.891	0.000	5.526	22.082	0.112	0.221	0.818		

Desiccator tests	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)		Gravimetric water content	Volumetric water content		
	4120	3.909	3.811	0.631		0.031	0.06031		
	38000	4.714	4.680	0.910		0.009	0.01765		
	82600	3.626	3.613	0.746		0.005	0.00887		
	150000	3.302	3.293	0.762		0.004	0.0070		
	293000	3.914	3.899	0.893		0.005	0.00977		

Final water content determination

Weight of ring (g)	83.42
Weight of tare (g)	115.246
Tare + ring + soil wet (g)	417.118
Tare + ring + soil dry (g)	395.036
Weight of dry soil (g)	196.370
Weight of water in soil (g)	22.082
Specific gravity, G_s	2.70

Dimensions of specimen	**Initial**	
Diameter of specimen (mm)	64.00	
Height of specimen (mm)	31.00	
Volume of specimen (cc)	99.74	
Dry density of specimen (kg/m^3)	1968.8	
Volume of solids (cc)	72.73	
Porosity	0.271	


Specimen SRK-03-CO1
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water Content
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1
1
10
100
1000
10000
100000
1000000
Suction (kPa)

SOIL-WATER CHARACTERISTIC CURVE

MDH ENGINEERED SOLUTIONS

Project: SRK Consultants
Location: Faro Mine, Whitehorse
Date: 10-Aug-03
Sample: SRK-03-CO2

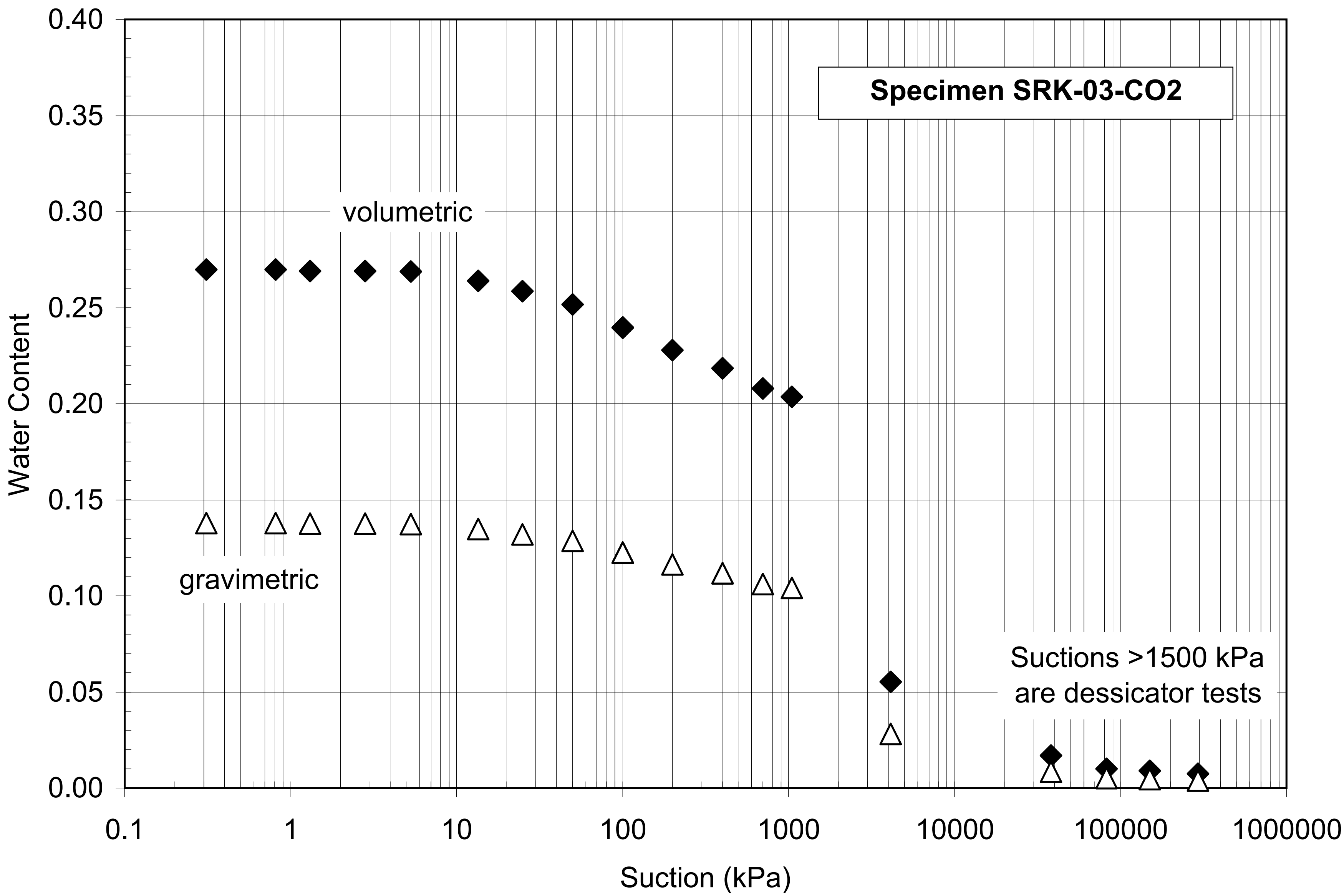
	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)
1-Bar Stone	0	0	0.31	440.546	135.253	0.000	26.902	0.138	0.270	0.991
	5	0	0.81	440.546	135.253	0.000	26.902	0.138	0.270	0.991
	10	0	1.31	440.468	135.253	0.078	26.824	0.137	0.269	0.988
	25	0	2.81	440.466	135.253	0.080	26.822	0.137	0.269	0.988
	50	0	5.31	440.431	135.253	0.115	26.787	0.137	0.269	0.986
	0	13.5	13.5	439.950	135.253	0.596	26.306	0.135	0.264	0.969
	0	25	25	439.411	135.253	1.135	25.767	0.132	0.258	0.949
	0	50	50	438.728	135.253	1.818	25.084	0.129	0.252	0.924
	0	100	100	437.534	135.253	3.012	23.890	0.122	0.240	0.880
	0	100	100	437.534	135.253	3.012	23.890	0.122	0.240	0.880
	0	100	100	437.534	135.253	3.012	23.890	0.122	0.240	0.880
	0	100	100	437.534	135.253	3.012	23.890	0.122	0.240	0.880
5-Bar Stone	0	100	100	442.500	140.295	3.012	23.890	0.122	0.240	0.880
	0	200	200	441.333	140.295	4.179	22.723	0.116	0.228	0.837
	0	400	400	440.396	140.295	5.116	21.786	0.112	0.219	0.802
15-Bar Stone	0	400	400	300.059	0.000	5.116	21.786	0.112	0.219	0.802
	0	700	700	299.006	0.000	6.169	20.733	0.106	0.208	0.763
	0	1050	1050	298.559	0.000	6.616	20.286	0.104	0.203	0.747

Desiccator tests	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)	Gravimetric water content	Volumetric water content
	4120	4.985	4.871	0.823	0.028	0.05526
	38000	4.207	4.179	0.909	0.009	0.0168
	82600	3.803	3.787	0.621	0.005	0.00992
	150000	5.197	5.177	0.752	0.005	0.00887
	293000	4.694	4.680	0.920	0.004	0.00731

Final water content determination

Weight of ring (g)	83.154
Weight of tare (g)	115.409
Tare + ring + soil wet (g)	413.961
Tare + ring + soil dry (g)	393.675
Weight of dry soil (g)	195.112
Weight of water in soil (g)	20.286
Specific gravity, G_s	2.69

Dimensions of specimen	**Initial**
Diameter of specimen (mm)	63.85
Height of specimen (mm)	31.13
Volume of specimen (cc)	99.69
Dry density of specimen (kg/m^3)	1957.2
Volume of solids (cc)	72.53
Porosity	0.272


Specimen SRK-03-CO2
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water Content
Suction (kPa)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.1
1
10
100
1000
10000
100000
1000000

SOIL-WATER CHARACTERISTIC CURVE

MDH ENGINEERED SOLUTIONS

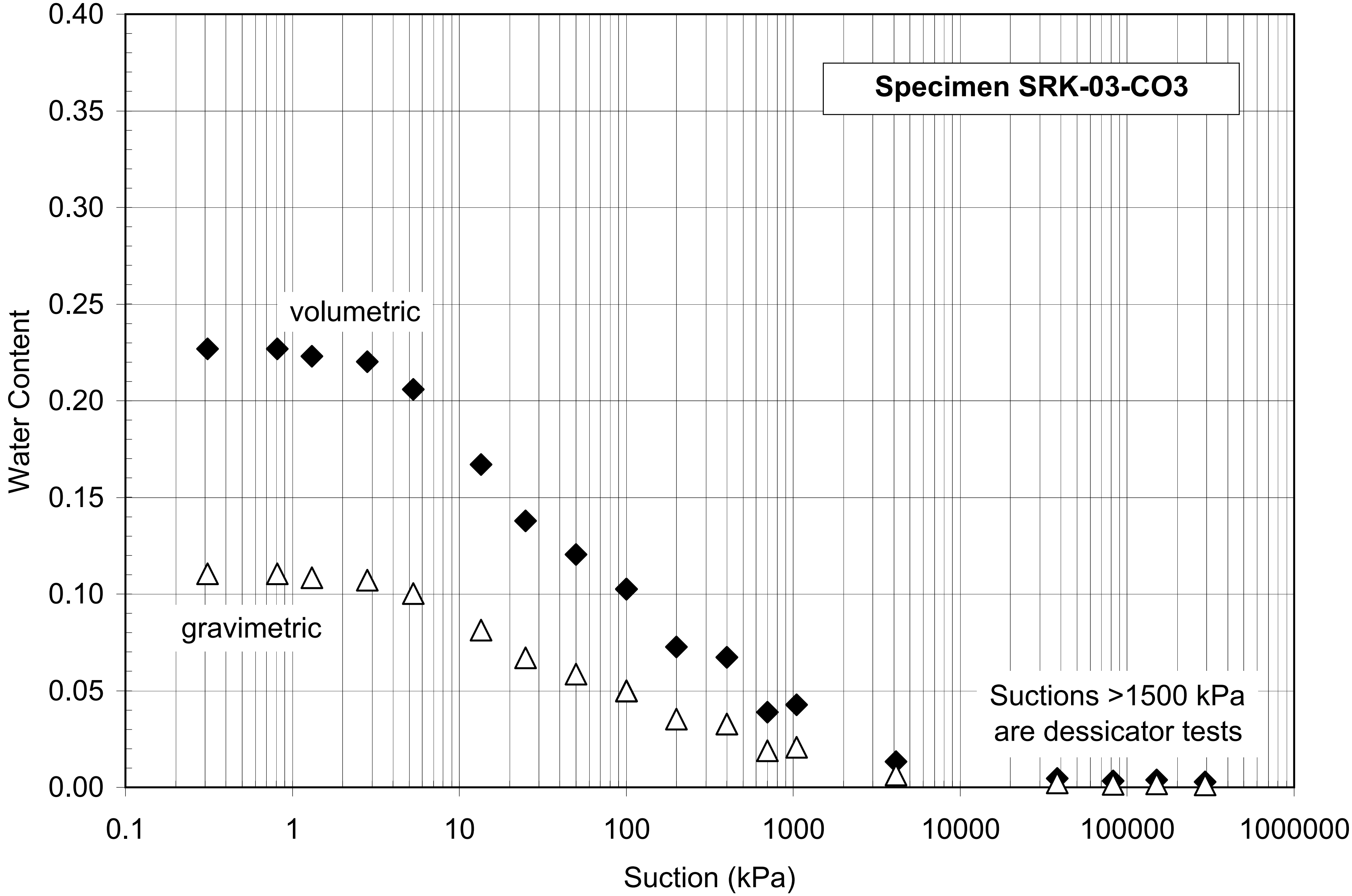
Project: SRK Consultants
Location: Faro Mine, Whitehorse
Date: 10-Aug-03
Sample: SRK-03-CO3

	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)		
1-Bar Stone	0	0	0.31	389.072	85.066	0.000	22.280	0.110	0.227	0.973		
	5	0	0.81	389.072	85.066	0.000	22.280	0.110	0.227	0.973		
	10	0	1.31	388.691	85.066	0.381	21.899	0.109	0.223	0.957		
	25	0	2.81	388.408	85.066	0.664	21.616	0.107	0.220	0.944		
	50	0	5.31	387.003	85.066	2.069	20.211	0.100	0.206	0.883		
	0	13.5	13.5	383.199	85.066	5.873	16.407	0.081	0.167	0.717		
	0	25	25	380.333	85.066	8.739	13.541	0.067	0.138	0.591		
	0	50	50	378.619	85.066	10.453	11.827	0.059	0.120	0.517		
	0	100	100	376.855	85.066	12.217	10.063	0.050	0.102	0.440		
	0	100	100	376.855	85.066	12.217	10.063	0.050	0.102	0.440		
	0	100	100	376.855	85.066	12.217	10.063	0.050	0.102	0.440		
	0	100	100	376.855	85.066	12.217	10.063	0.050	0.102	0.440		
5-Bar Stone	0	100	100	430.337	138.926	12.217	10.063	0.050	0.102	0.440		
	0	200	200	427.394	138.926	15.160	7.120	0.035	0.073	0.311		
	0	400	400	426.881	138.926	15.673	6.607	0.033	0.067	0.289		
15-Bar Stone	0	400	400	287.888	0.000	15.673	6.607	0.033	0.067	0.289		
	0	700	700	285.101	0.000	18.460	3.820	0.019	0.039	0.167		
	0	1050	1050	285.471	0.000	18.090	4.190	0.021	0.043	0.183		

Desiccator tests	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)		Gravimetric water content	Volumetric water content		
	4120	4.359	4.337	0.932		0.006	0.01336		
	38000	3.898	3.891	0.748		0.002	0.00461		
	82600	4.542	4.536	0.785		0.002	0.00331		
	150000	3.939	3.933	0.718		0.002	0.00386		
	293000	3.676	3.672	0.771		0.001	0.00285		

Final water content determination	
Weight of ring (g)	79.493
Weight of tare (g)	268.843
Tare + ring + soil wet (g)	554.310
Tare + ring + soil dry (g)	550.120
Weight of dry soil (g)	201.784
Weight of water in soil (g)	4.19
Specific gravity, G_s	2.68

Dimensions of specimen	Initial	
Diameter of specimen (mm)	63.50	
Height of specimen (mm)	31.00	
Volume of specimen (cc)	98.19	
Dry density of specimen (kg/m^3)	2055.1	
Volume of solids (cc)	75.29	
Porosity	0.233	


Specimen SRK-03-CO3
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water Content
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1
1
10
100
1000
10000
100000
1000000
Suction (kPa)

MDH ENGINEERED SOLUTIONS

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants
Location: Faro Mine, Whitehorse
Date: 10-Aug-03
Sample: SRK-03-CO4

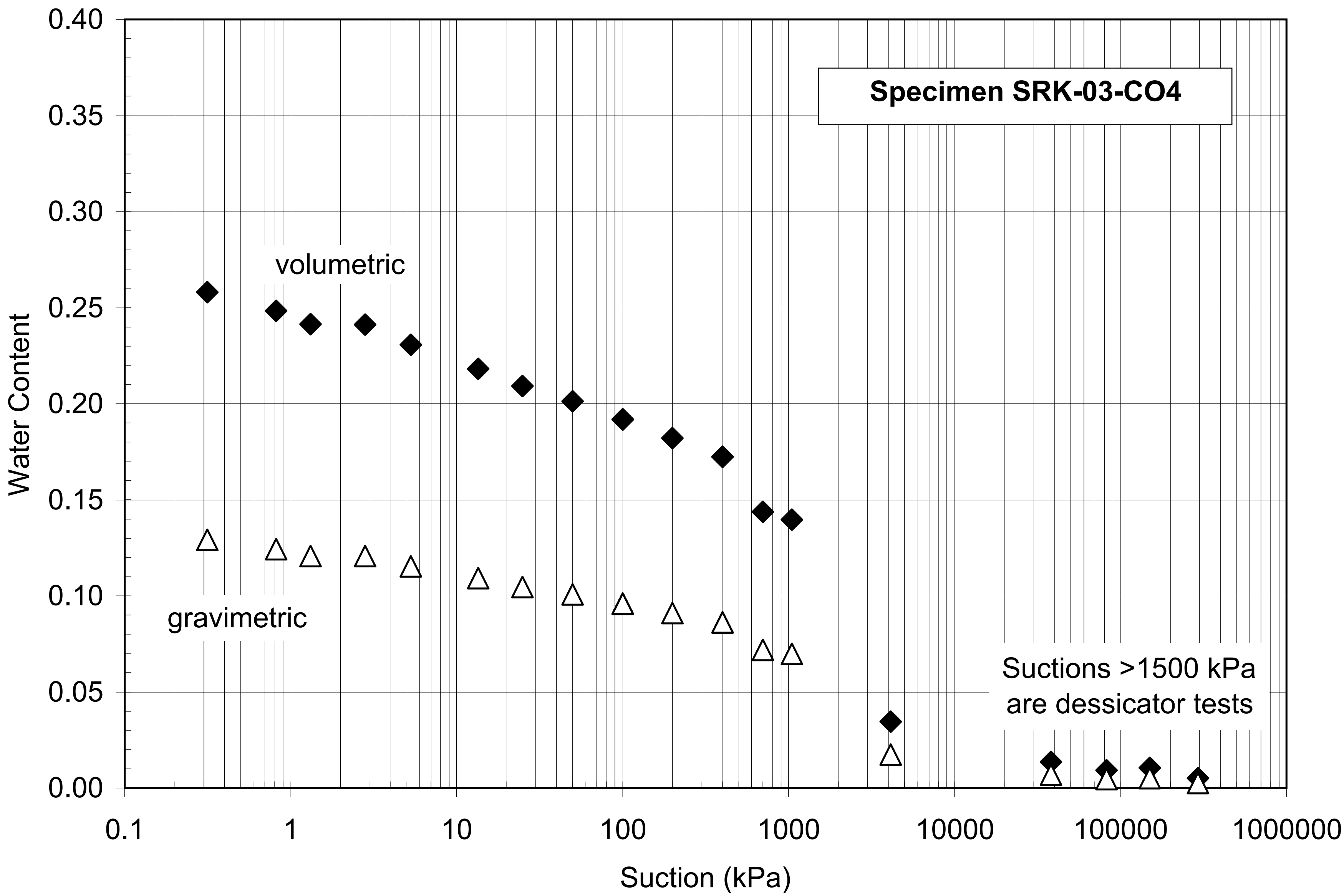
	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)		
1-Bar Stone	0	0	0.31	449.907	139.899	0.000	25.977	0.129	0.258	1.004		
	5	0	0.81	448.923	139.899	0.984	24.993	0.124	0.248	0.966		
	10	0	1.31	448.231	139.899	1.676	24.301	0.121	0.241	0.939		
	25	0	2.81	448.220	139.899	1.687	24.290	0.121	0.241	0.939		
	50	0	5.31	447.161	139.899	2.746	23.231	0.115	0.231	0.898		
	0	13.5	13.5	445.905	139.899	4.002	21.975	0.109	0.218	0.849		
	0	25	25	444.984	139.899	4.923	21.054	0.105	0.209	0.814		
	0	50	50	444.196	139.899	5.711	20.266	0.101	0.201	0.783		
	0	100	100	443.251	139.899	6.656	19.321	0.096	0.192	0.747		
	0	100	100	443.251	139.899	6.656	19.321	0.096	0.192	0.747		
	0	100	100	443.251	139.899	6.656	19.321	0.096	0.192	0.747		
	0	100	100	443.251	139.899	6.656	19.321	0.096	0.192	0.747		
5-Bar Stone	0	100	100	434.891	131.595	6.656	19.321	0.096	0.192	0.747		
	0	200	200	433.902	131.595	7.645	18.332	0.091	0.182	0.709		
	0	400	400	432.922	131.595	8.625	17.352	0.086	0.172	0.671		
15-Bar Stone	0	400	400	301.274	0.000	8.625	17.352	0.086	0.172	0.671		
	0	700	700	298.381	0.000	11.518	14.459	0.072	0.144	0.559		
	0	1050	1050	297.979	0.000	11.920	14.057	0.070	0.140	0.543		

Desiccator tests	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)		Gravimetric water content	Volumetric water content
	4120	4.496	4.435	0.913		0.017	0.03458
	38000	3.987	3.966	0.880		0.007	0.01359
	82600	4.406	4.389	0.747		0.005	0.00932
	150000	4.974	4.953	0.926		0.005	0.01041
	293000	5.624	5.612	0.869		0.003	0.00505

Final water content determination

Weight of ring (g)	82.668
Weight of tare (g)	31.076
Tare + ring + soil wet (g)	329.055
Tare + ring + soil dry (g)	314.998
Weight of dry soil (g)	201.254
Weight of water in soil (g)	14.057
Specific gravity, G_s	2.69

Dimensions of specimen	**Initial**
Diameter of specimen (mm)	63.80
Height of specimen (mm)	31.49
Volume of specimen (cc)	100.68
Dry density of specimen (kg/m^3)	1998.9
Volume of solids (cc)	74.82
Porosity	0.257


Specimen SRK-03-CO4
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water Content
Suction (kPa)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.1
1
10
100
1000
10000
100000
1000000

ENGINEERED SOLUTIONS

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants
Location: Faro Mine, Whitehorse
Date: 10-Aug-03

Sample: SRK-03-CO5

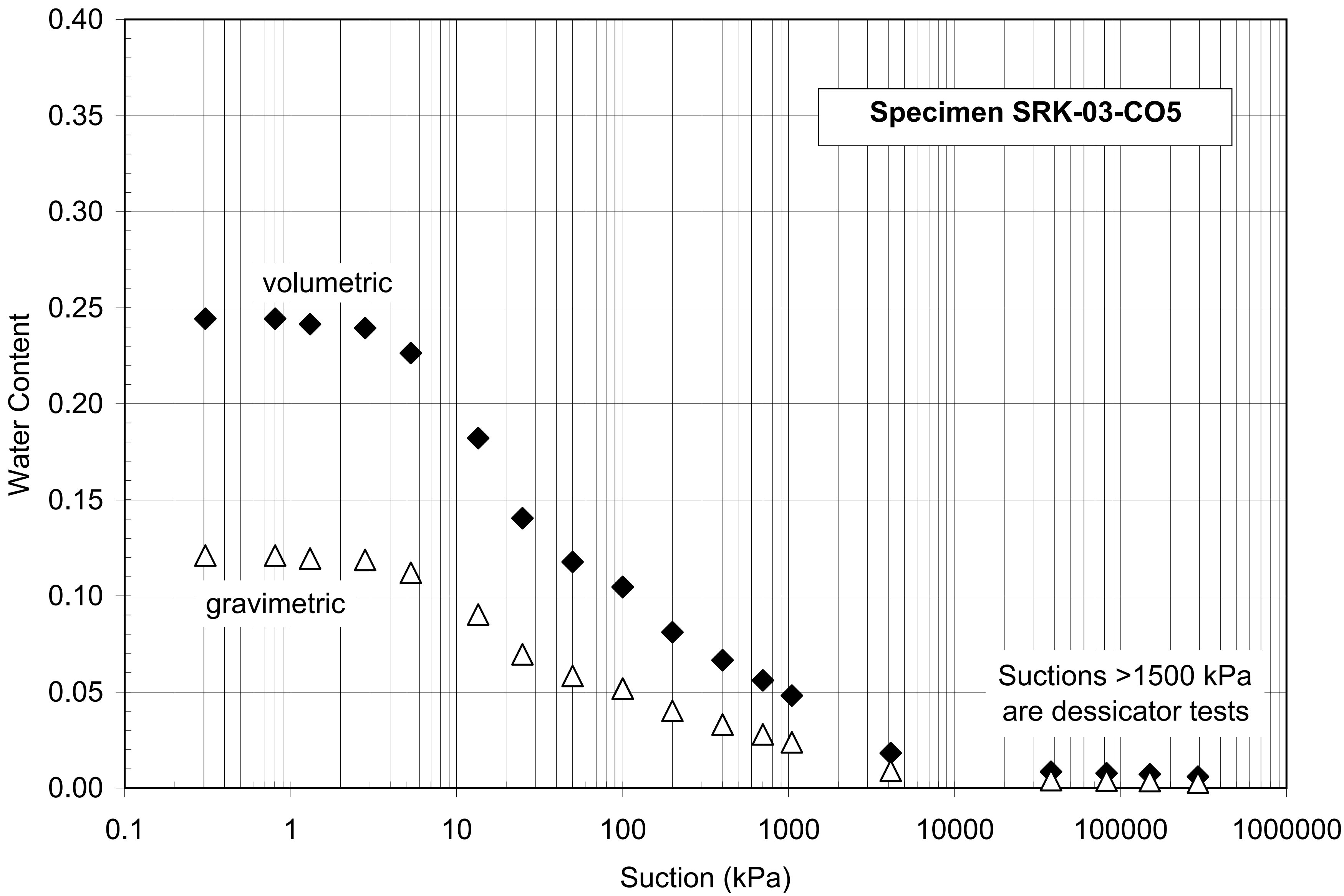
	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)
1-Bar Stone	0	0	0.31	432.112	137.616	0.000	23.884	0.121	0.244	0.992
	5	0	0.81	432.112	137.616	0.000	23.884	0.121	0.244	0.992
	10	0	1.31	431.839	137.616	0.273	23.611	0.119	0.241	0.980
	25	0	2.81	431.656	137.616	0.456	23.428	0.119	0.240	0.973
	50	0	5.31	430.376	137.616	1.736	22.148	0.112	0.226	0.919
	0	13.5	13.5	426.046	137.616	6.066	17.818	0.090	0.182	0.740
	0	25	25	421.950	137.616	10.162	13.722	0.069	0.140	0.570
	0	50	50	419.741	137.616	12.371	11.513	0.058	0.118	0.478
	0	100	100	418.457	137.616	13.655	10.229	0.052	0.105	0.425
	0	100	100	418.457	137.616	13.655	10.229	0.052	0.105	0.425
	0	100	100	418.457	137.616	13.655	10.229	0.052	0.105	0.425
	0	100	100	418.457	137.616	13.655	10.229	0.052	0.105	0.425
5-Bar Stone	0	100	100	412.050	131.218	13.655	10.229	0.052	0.105	0.425
	0	200	200	409.742	131.218	15.963	7.921	0.040	0.081	0.329
	0	400	400	408.333	131.218	17.372	6.512	0.033	0.067	0.270
15-Bar Stone	0	400	400	277.059	0.000	17.372	6.512	0.033	0.067	0.270
	0	700	700	276.034	0.000	18.397	5.487	0.028	0.056	0.228
	0	1050	1050	275.258	0.000	19.173	4.711	0.024	0.048	0.196

Desiccator tests	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)		Gravimetric water content	Volumetric water content
	4120	6.288	6.239	0.742		0.009	0.01804
	38000	3.749	3.737	0.861		0.004	0.00845
	82600	4.282	4.269	0.880		0.004	0.00776
	150000	4.096	4.085	0.927		0.003	0.00705
	293000	5.396	5.383	0.909		0.003	0.00588

Final water content determination

Weight of ring (g)	72.865
Weight of tare (g)	30.905
Tare + ring + soil wet (g)	306.072
Tare + ring + soil dry (g)	301.361
Weight of dry soil (g)	197.591
Weight of water in soil (g)	4.711
Specific gravity, G_s	2.68

Dimensions of specimen	**Initial**
Diameter of specimen (mm)	63.73
Height of specimen (mm)	30.66
Volume of specimen (cc)	97.82
Dry density of specimen (kg/m^3)	2020.0
Volume of solids (cc)	73.73
Porosity	0.246



Specimen SRK-03-CO5
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water Content
Suction (kPa)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1
1
10
100
1000
10000
100000
1000000

MDH ENGINEERED SOLUTIONS

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants

Location: Faro Mine, Whitehorse

Date: 10-Aug-03

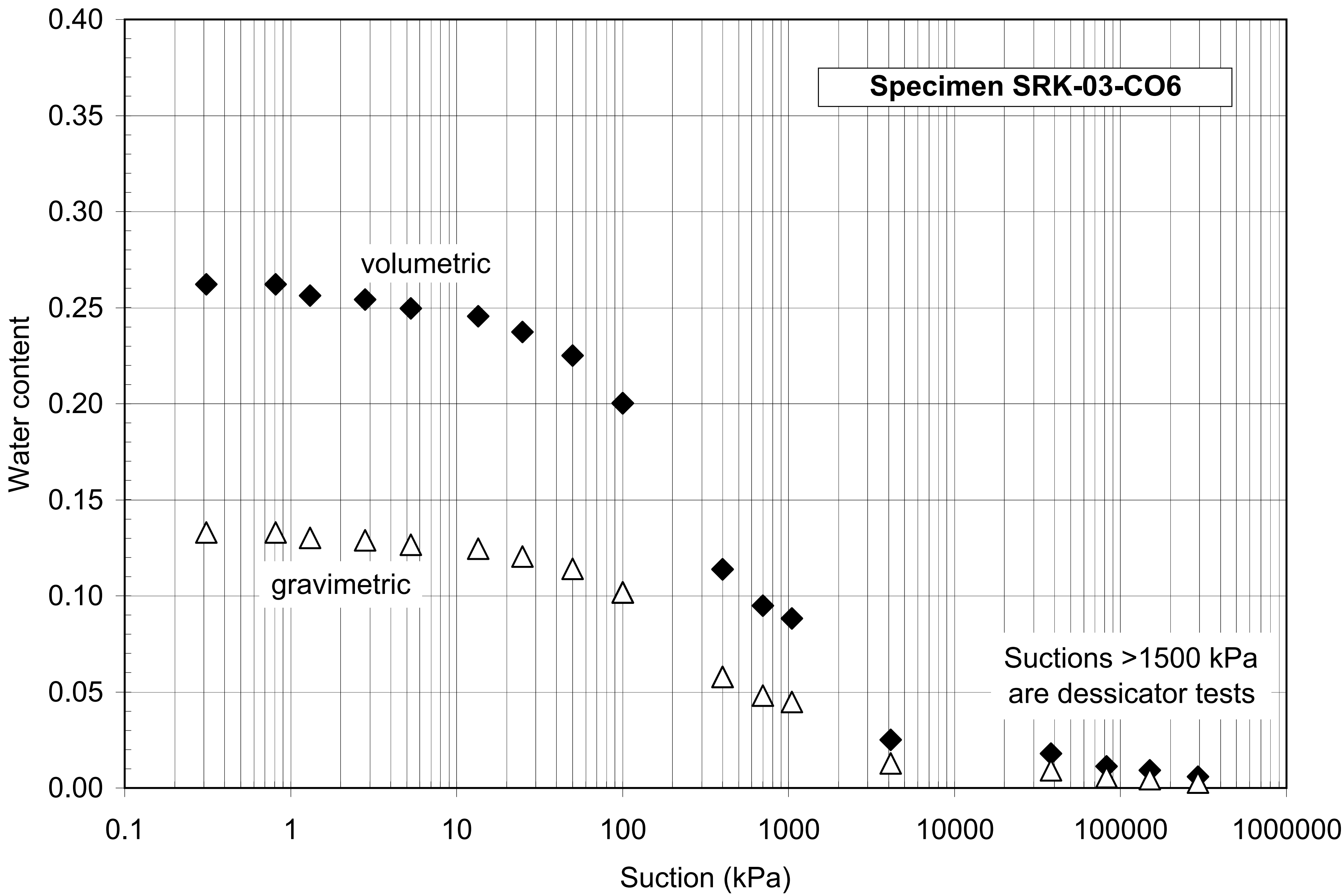
Sample: SRK-03-CO6

	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)
1-Bar Stone	0	0	0.31	438.787	139.022	0.000	25.972	0.133	0.262	0.990
	5	0	0.81	438.787	139.022	0.000	25.972	0.133	0.262	0.990
	10	0	1.31	438.200	139.022	0.587	25.385	0.130	0.256	0.968
	25	0	2.81	437.992	139.022	0.795	25.177	0.129	0.254	0.960
	50	0	5.31	437.542	139.022	1.245	24.727	0.127	0.250	0.943
	0	13.5	13.5	437.146	139.022	1.641	24.331	0.125	0.246	0.928
	0	25	25	436.320	139.022	2.467	23.505	0.120	0.237	0.896
	0	50	50	435.096	139.022	3.691	22.281	0.114	0.225	0.849
	0	100	100	432.659	139.022	6.128	19.844	0.102	0.200	0.756
	0	100	100	432.659	139.022	6.128	19.844	0.102	0.200	0.756
	0	100	100	432.659	139.022	6.128	19.844	0.102	0.200	0.756
	0	100	100	432.659	139.022	6.128	19.844	0.102	0.200	0.756
5-Bar Stone	0	100	100	371.970	78.493	6.128	19.844	0.102	0.200	0.756
	0	400	400	363.401	78.493	14.697	11.275	0.058	0.114	0.430
	0	400	400	363.401	78.493	14.697	11.275	0.058	0.114	0.430
15-Bar Stone	0	400	400	284.796	0.000	14.697	11.275	0.058	0.114	0.430
	0	700	700	282.907	0.000	16.586	9.386	0.048	0.095	0.358
	0	1050	1050	282.254	0.000	17.239	8.733	0.045	0.088	0.333

	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)		Gravimetric water content	Volumetric water content
Desiccator tests	4120	3.120	3.090	0.731		0.013	0.02512
	38000	5.005	4.968	0.900		0.009	0.01797
	82600	3.319	3.305	0.824		0.006	0.01115
	150000	3.541	3.529	0.920		0.005	0.00909
	293000	3.311	3.304	0.909		0.003	0.00577

Final water content determination	
Weight of ring (g)	78.271
Weight of tare (g)	32.052
Tare + ring + soil wet (g)	314.215
Tare + ring + soil dry (g)	305.482
Weight of dry soil (g)	195.159
Weight of water in soil (g)	8.733
Specific gravity, G_s	2.68

Dimensions of specimen	Initial
Diameter of specimen (mm)	63.80
Height of specimen (mm)	30.98
Volume of specimen (cc)	99.05
Dry density of specimen (kg/m^3)	1970.2
Volume of solids (cc)	72.82
Porosity	0.265


Specimen SRK-03-CO6
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water content
Suction (kPa)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1
1
10
100
1000
10000
100000
1000000

MDH
ENGINEERED SOLUTIONS

SOIL-WATER CHARACTERISTIC CURVE

Project: SRK Consultants
Location: Faro Mine, Whitehorse
Date: 10-Aug-03
Sample: SRK-03-CO7

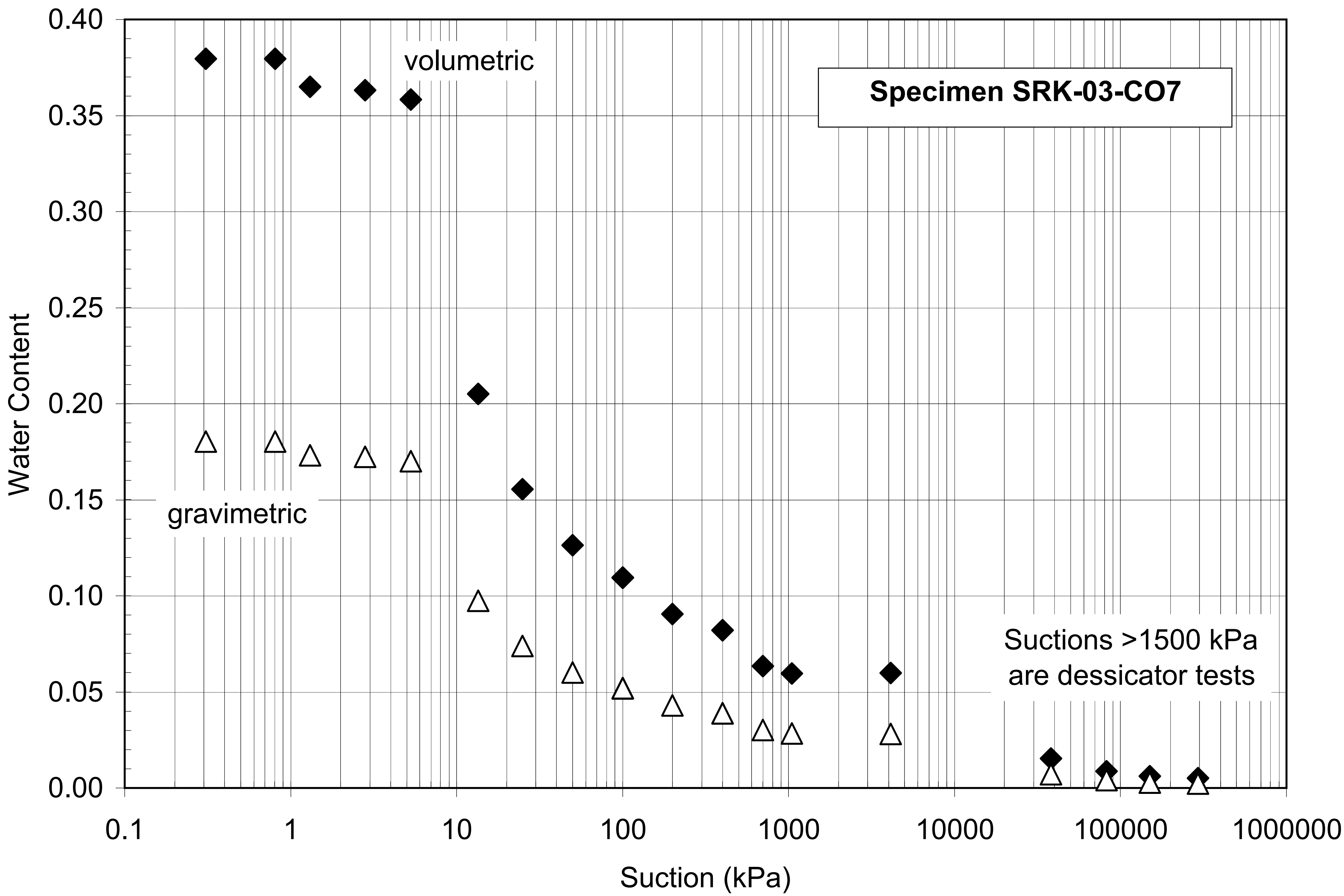
	Elevation of water column below base of sample (cm)	Applied air pressure (kPa)	Suction at surface of sample (kPa)	Weight of system (g)	Weight of saturated stone/lucite plate/etc (g)	Cumulative weight of water loss (g)	Weight of water in soil (g)	Gravimetric water content	Vol. water content (assuming volume constant during test)	Degree of saturation (computed based on Gs)		
1-Bar Stone	0	0	0.31	412.549	89.164	0.000	37.293	0.180	0.380	0.970		
	5	0	0.81	412.549	89.164	0.000	37.293	0.180	0.380	0.970		
	10	0	1.31	411.106	89.164	1.443	35.850	0.173	0.365	0.932		
	25	0	2.81	410.934	89.164	1.615	35.678	0.172	0.363	0.928		
	50	0	5.31	410.475	89.164	2.074	35.219	0.170	0.358	0.916		
	0	13.5	13.5	395.419	89.164	17.130	20.163	0.097	0.205	0.524		
	0	25	25	390.536	89.164	22.013	15.280	0.074	0.156	0.397		
	0	50	50	387.676	89.164	24.873	12.420	0.060	0.126	0.323		
	0	100	100	386.013	89.164	26.536	10.757	0.052	0.109	0.280		
	0	100	100	386.013	89.164	26.536	10.757	0.052	0.109	0.280		
	0	100	100	386.013	89.164	26.536	10.757	0.052	0.109	0.280		
	0	100	100	386.013	89.164	26.536	10.757	0.052	0.109	0.280		
5-Bar Stone	0	100	100	374.315	78.176	26.536	10.757	0.052	0.109	0.280		
	0	200	200	372.455	78.176	28.396	8.897	0.043	0.091	0.231		
	0	400	400	371.624	78.176	29.227	8.066	0.039	0.082	0.210		
15-Bar Stone	0	400	400	293.370	0.000	29.227	8.066	0.039	0.082	0.210		
	0	700	700	291.533	0.000	31.064	6.229	0.030	0.063	0.162		
	0	1050	1050	291.165	0.000	31.432	5.861	0.028	0.060	0.152		

Desiccator tests	Suction (kPa)	Soil wet + tare (g)	Soil dry + tare (g)	Weight of tare (g)		Gravimetric water content	Volumetric water content		
	4120	4.089	4.001	0.866		0.028	0.05982		
	38000	3.132	3.114	0.623		0.007	0.0154		
	82600	4.131	4.118	0.968		0.004	0.0088		
	150000	2.268	2.264	0.889		0.003	0.0062		
	293000	3.924	3.917	0.958		0.002	0.00504		

Final water content determination

Weight of ring (g)	78.343
Weight of tare (g)	122.835
Tare + ring + soil wet (g)	414.004
Tare + ring + soil dry (g)	408.143
Weight of dry soil (g)	206.965
Weight of water in soil (g)	5.861
Specific gravity, G_s	3.46

Dimensions of specimen	**Initial**	
Diameter of specimen (mm)	63.73	
Height of specimen (mm)	30.80	
Volume of specimen (cc)	98.26	
Dry density of specimen (kg/m^3)	2106.3	
Volume of solids (cc)	59.82	
Porosity	0.391	


Specimen SRK-03-CO7
volumetric
gravimetric
Suctions >1500 kPa
are dessicator tests
Water Content
Suction (kPa)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1
1
10
100
1000
10000
100000
1000000

APPENDIX VI

Consolidation Tests Results

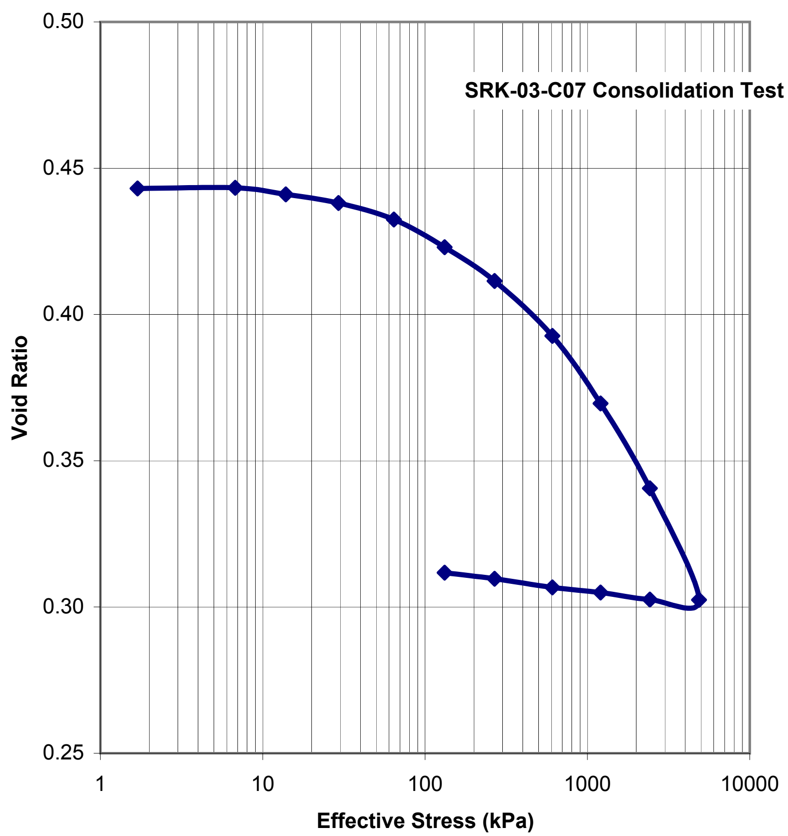
Input:

Diameter of ring:	63.84	mm
Initial height of sample:	18.99	mm
Specific gravity:	3.45	
Initial wet sample mass:	173.22	g
Initial water content:	19.2	%
Initial dial reading:	0.0548	inches
Final dry mass of sample:	145.32	g
Mechanical Advantage:	11.04	

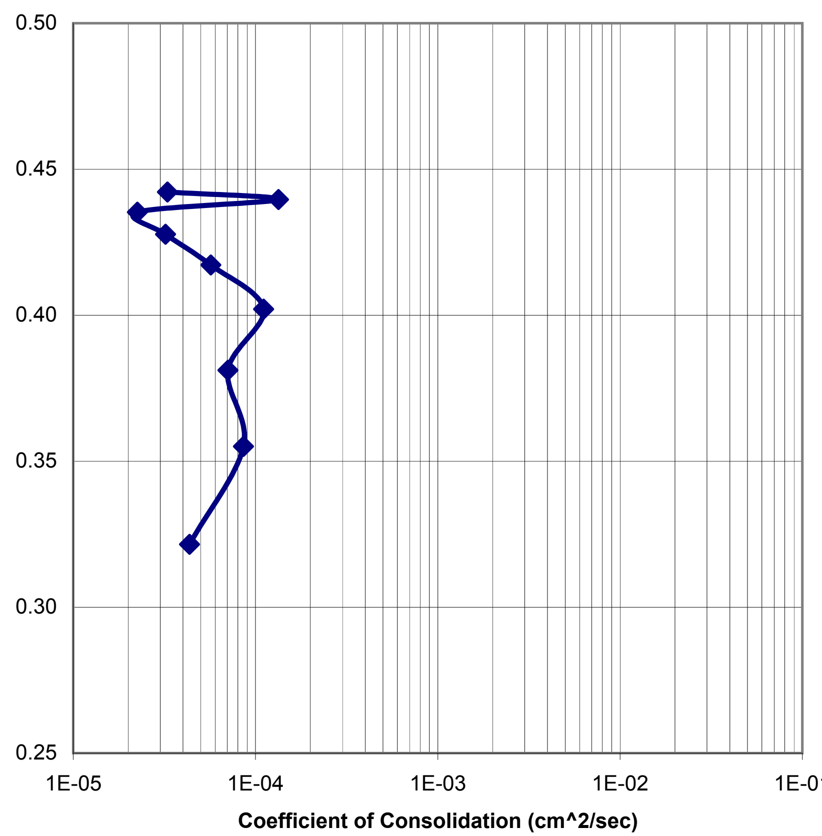
Calculations:

Cross-sectional area:	32.01	cc	3.2E-03 m^3
Volume of solids:	42.12	cc	4.2E-05 m^3
Total volume:	60.79	cc (prior to loading)	
Volume of voids:	18.66	cc (prior to loading)	
Initial void ratio:	0.44	(prior to loading)	
Dry mass of solids:	145.32	g	
Initial wet density:	2850	kg/m^3 (prior to loading)	
Initial dry density:	2391	kg/m^3 (prior to loading)	
Initial dial reading:	1.39	mm	

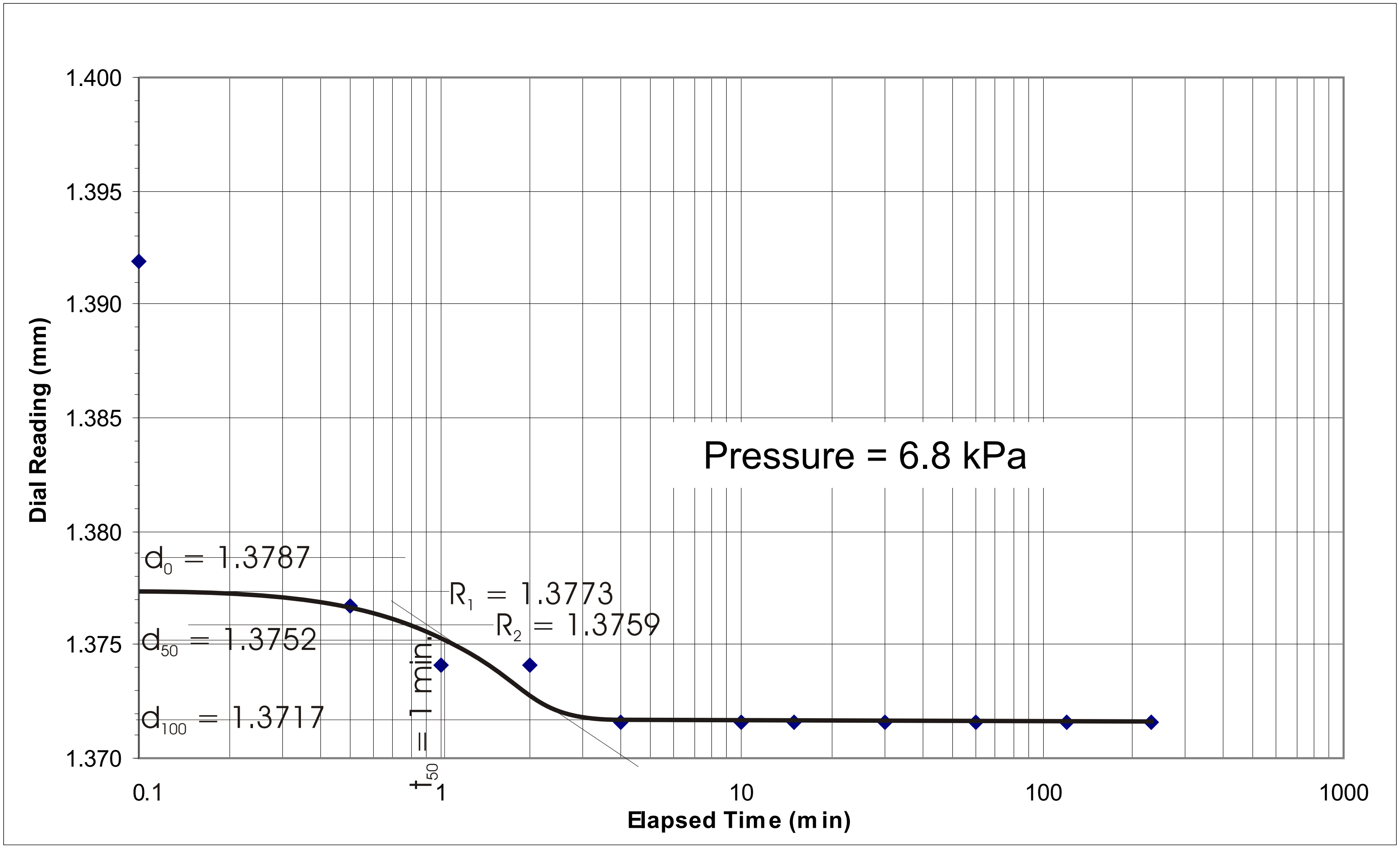
Loading Increment	Pressure (kPa)	At End of Primary Consolidation							Coefficient of Consolidation					
		R_{100} (mm)	Uncorrected Sample Height (mm)	Equipment Compressibility (mm)	Corrected Sample Height (mm)	Volume of Sample (cc)	Volume of Voids (cc)	Void Ratio	Average Void Ratio	R_{50} (mm)	Corrected Sample Height at R_{50} (mm)	H_{D50} (mm)	time50 (sec)	Coefficient of Consolidation c_v (cm^2/s)
swelling	1.7							0.44						
1	6.8	1.37	18.97	0.023	18.99	60.79	18.67	0.44						
2	13.9	1.32	18.92	0.043	18.96	60.70	18.58	0.44	0.44	1.34	18.98	9.49	5400	3.29E-05
3	29.3	1.27	18.87	0.056	18.92	60.58	18.45	0.44	0.44	1.28	18.93	9.47	1320	1.34E-04
4	64.2	1.17	18.76	0.086	18.85	60.34	18.22	0.43	0.44	1.19	18.88	9.44	7800	2.25E-05
5	131.9	1.01	18.61	0.119	18.73	59.94	17.82	0.42	0.43	1.05	18.76	9.38	5400	3.21E-05
6	267.6	0.82	18.42	0.152	18.57	59.45	17.33	0.41	0.42	0.86	18.61	9.31	3000	5.69E-05
7	607.8	0.52	18.11	0.213	18.33	58.66	16.54	0.39	0.40	0.56	18.37	9.19	1500	1.11E-04
8	1204.7	0.15	17.75	0.274	18.02	57.69	15.57	0.37	0.38	0.22	18.09	9.04	2280	7.07E-05
9	2426.5	-0.32	17.28	0.358	17.64	56.47	14.35	0.34	0.36	-0.24	17.72	8.86	1800	8.59E-05
10	4866.6	-0.93	16.66	0.475	17.14	54.86	12.74	0.30	0.32	-0.24	17.83	8.92	3600	4.35E-05
11	2426.5	-0.86	16.73	0.406	17.14	54.86	12.74	0.30	0.30					
12	1204.7	-0.79	16.81	0.366	17.17	54.97	12.84	0.30	0.30					
13	607.8	-0.74	16.86	0.333	17.20	55.04	12.92	0.31	0.31					
14	267.6	-0.67	16.93	0.305	17.23	55.17	13.04	0.31	0.31					
15	131.9	-0.62	16.98	0.279	17.26	55.25	13.13	0.31	0.31					



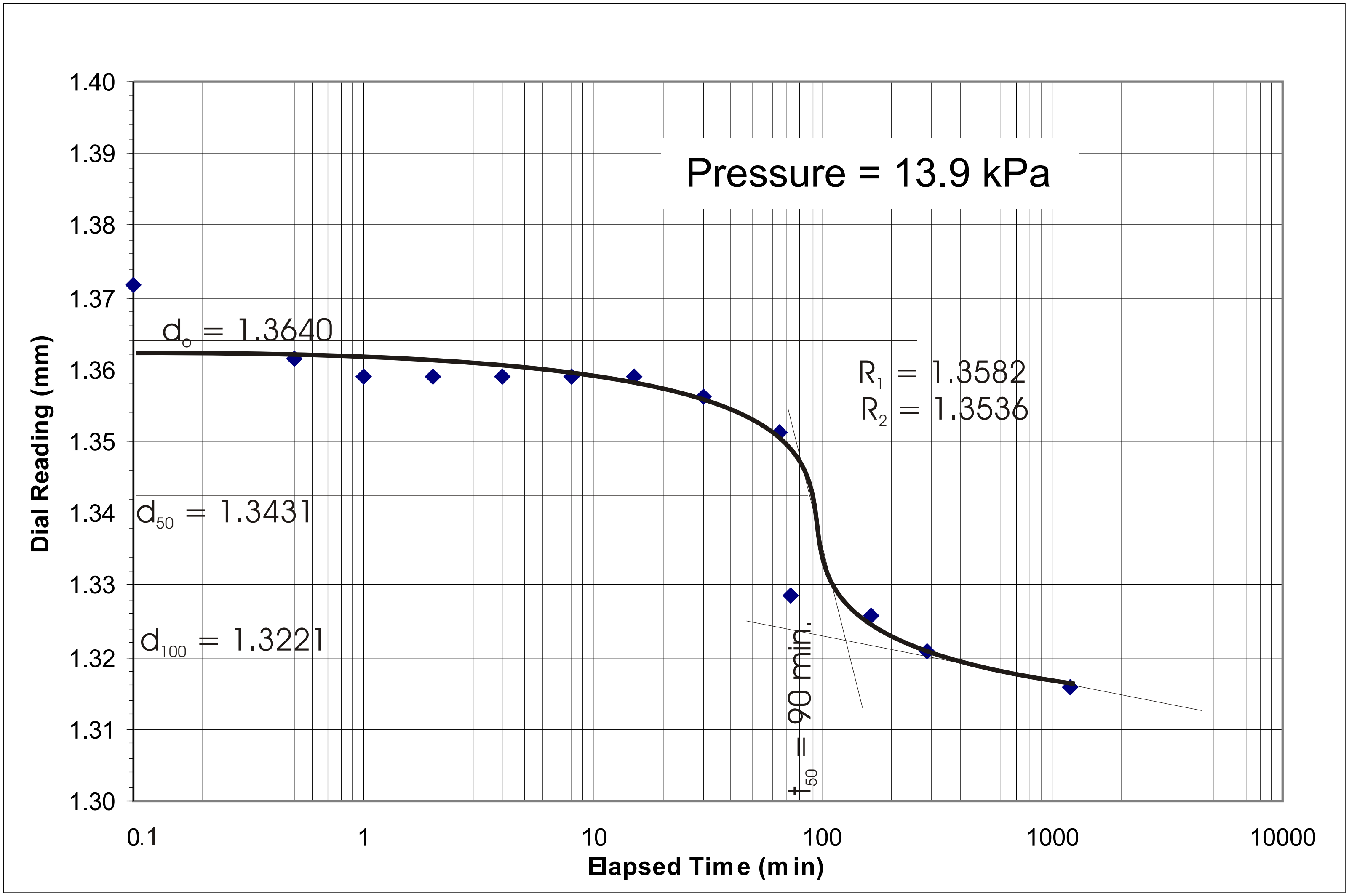
SRK-03-C07 Consolidation Test
Void Ratio
0.50
0.45
0.40
0.35
0.30
0.25
1
10
100
1000
10000
Effective Stress (kPa)



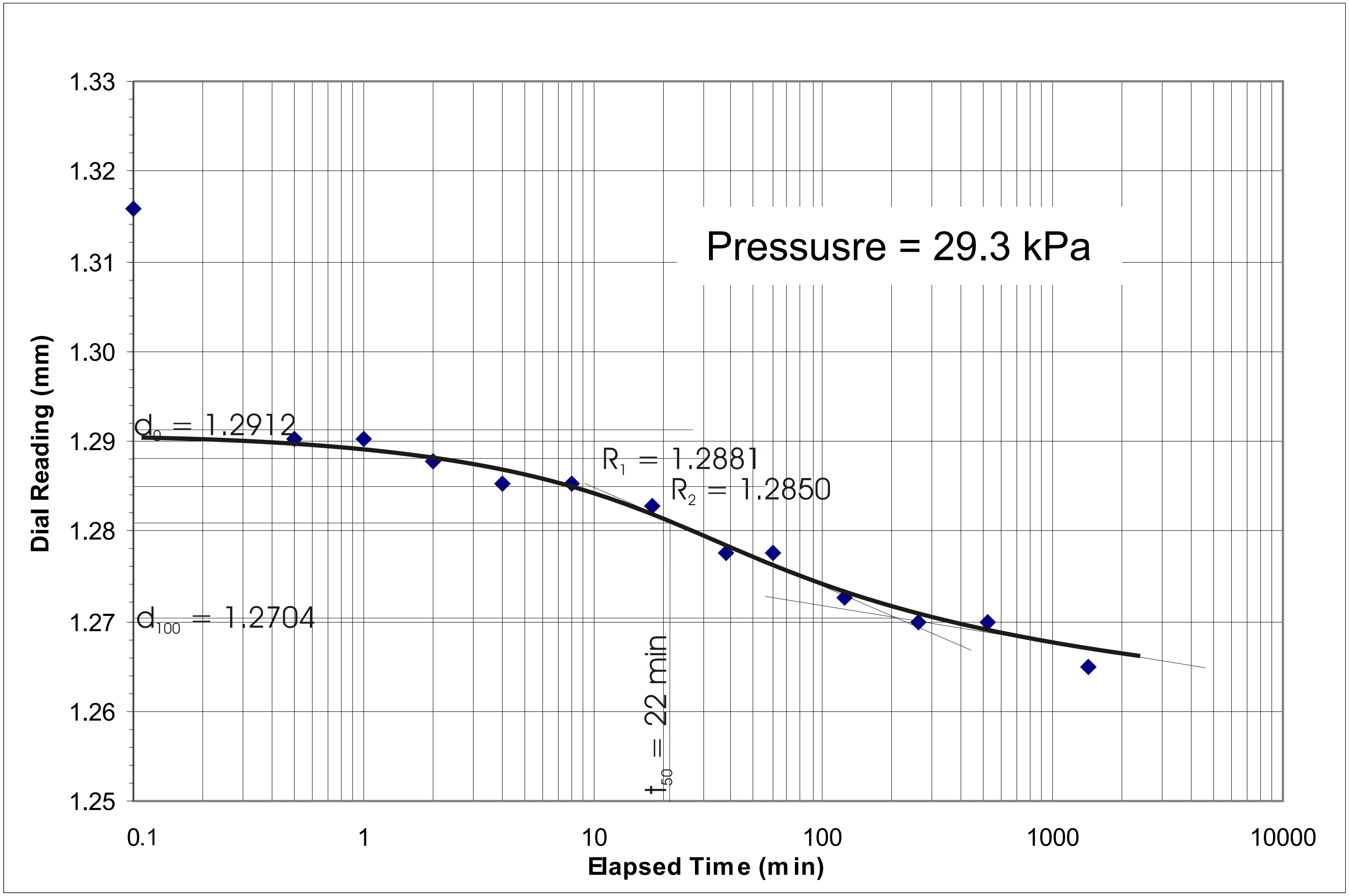
0.50
0.45
0.40
0.35
0.30
0.25
1E-05
1E-04
1E-03
1E-02
1E-01
Coefficient of Consolidation (cm^2/sec)



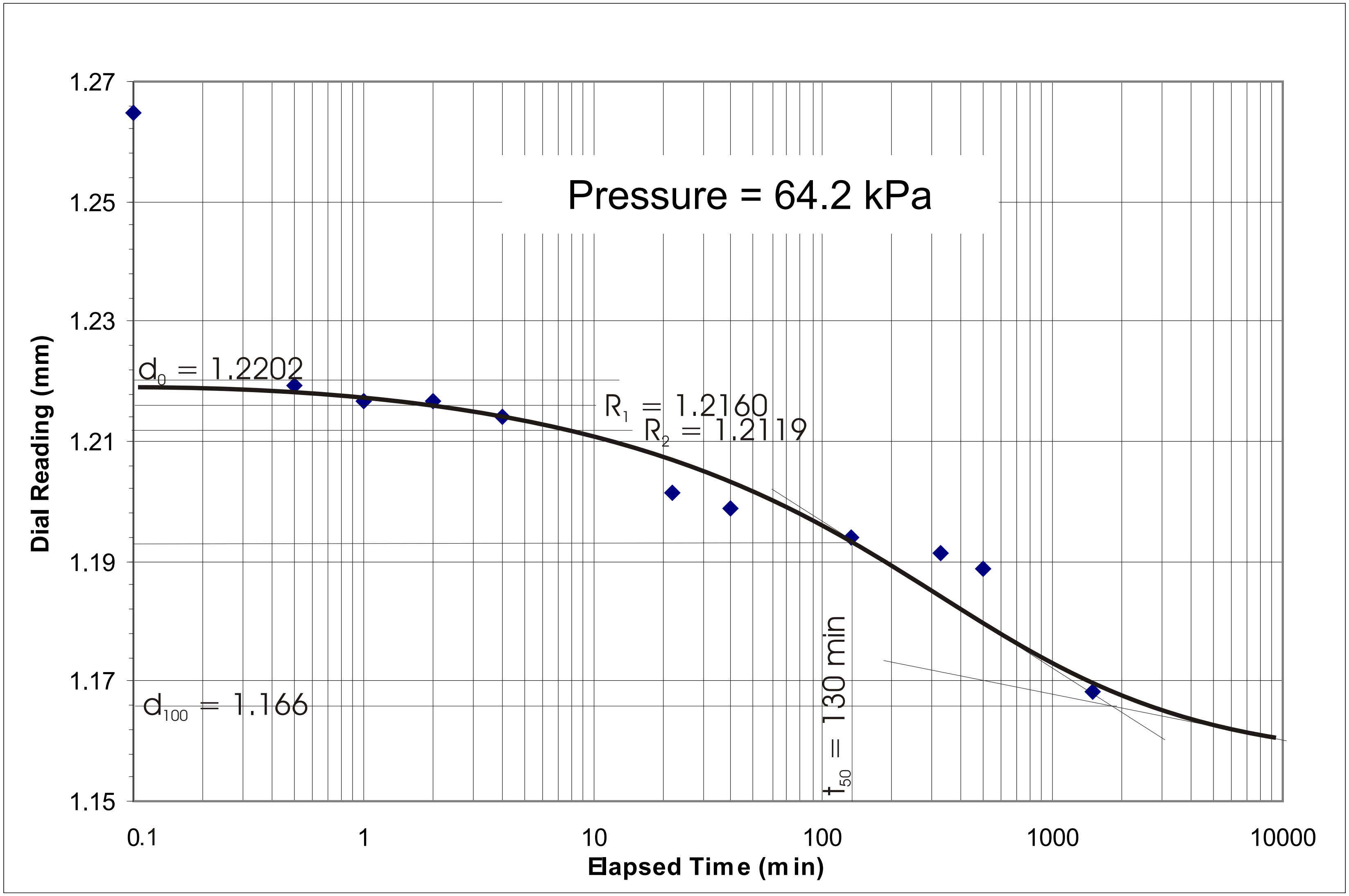
Pressure = 6.8 kPa
Dial Reading (mm)
Elapsed Time (min)
1.400
1.395
1.390
1.385
1.380
1.375
1.370
0.1
1
10
100
1000
d0 = 1.3787
R1 = 1.3773
R2 = 1.3759
d50 = 1.3752
d100 = 1.3717
t50 = 1 min.



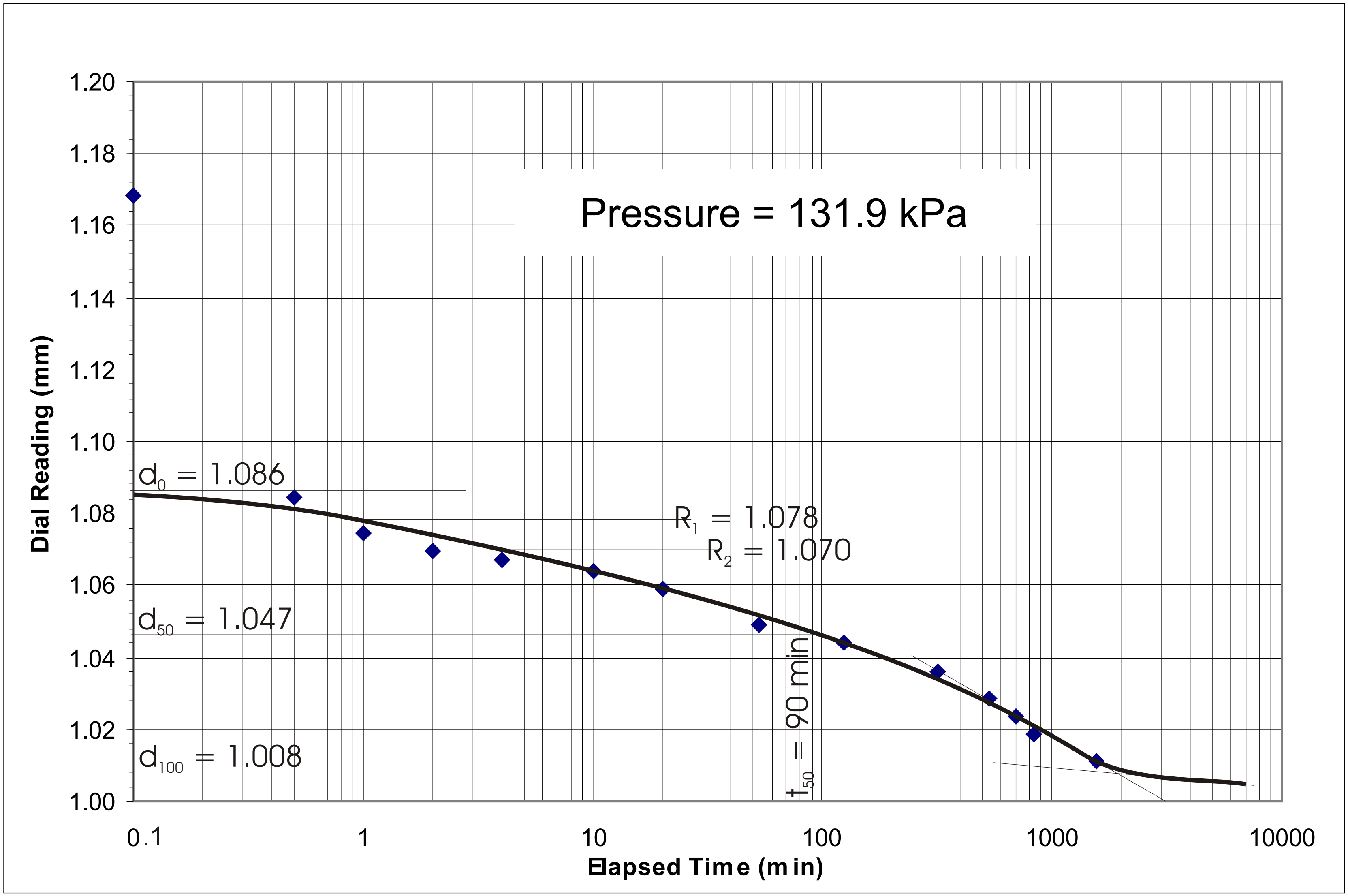
Pressure = 13.9 kPa
Dial Reading (mm)
Elapsed Time (min)
1.40
1.39
1.38
1.37
1.36
1.35
1.34
1.33
1.32
1.31
1.30
0.1
1
10
100
1000
10000
d_o = 1.3640
R_1 = 1.3582
R_2 = 1.3536
d_{50} = 1.3431
d_{100} = 1.3221
t_{50} = 90 min.

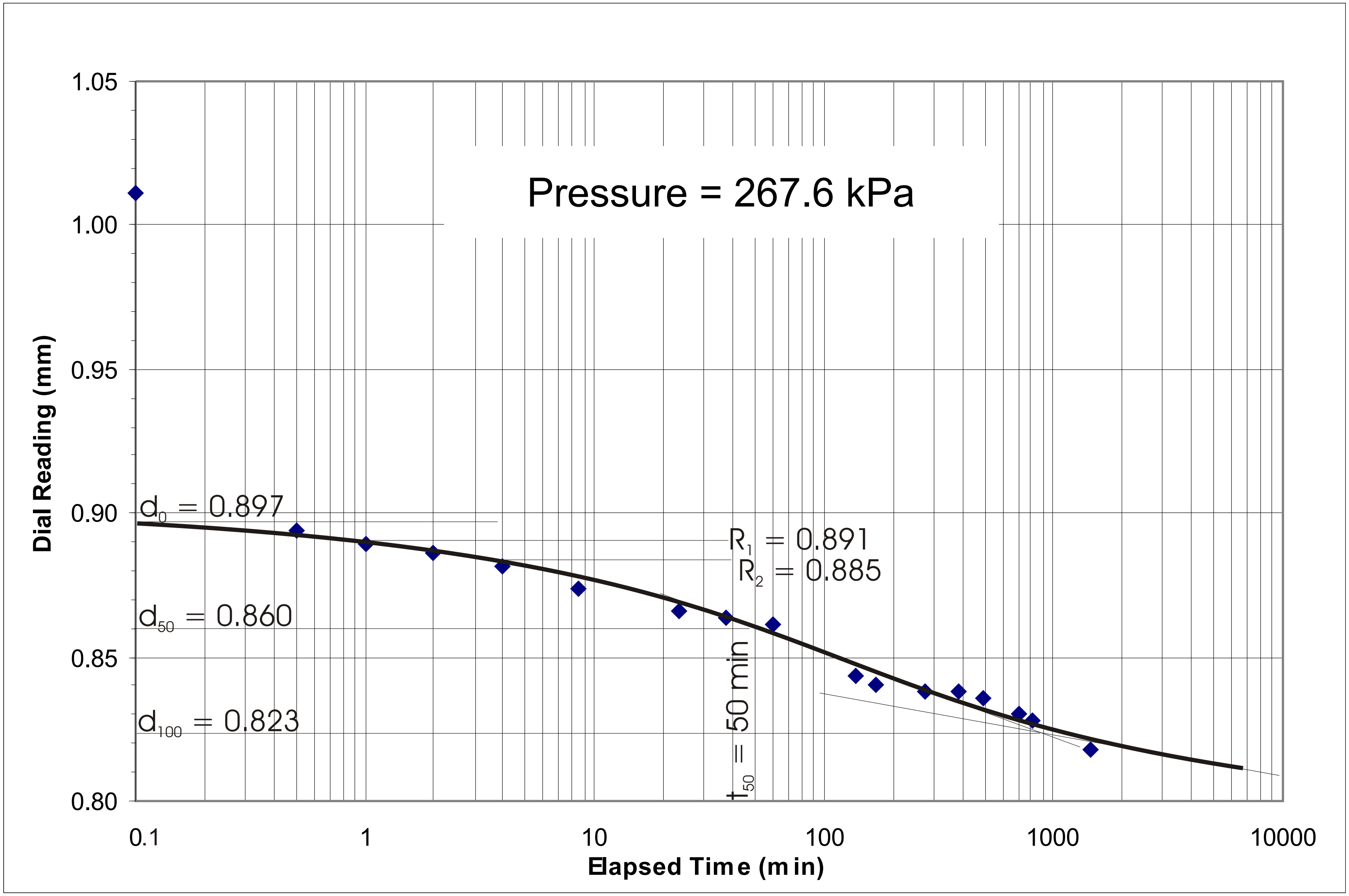


Pressusre = 29.3 kPa
Dial Reading (mm)
Elapsed Time (min)
1.33
1.32
1.31
1.30
1.29
1.28
1.27
1.26
1.25
0.1
1
10
100
1000
10000
d0 = 1.2912
R1 = 1.2881
R2 = 1.2850
d100 = 1.2704
t50 = 22 min

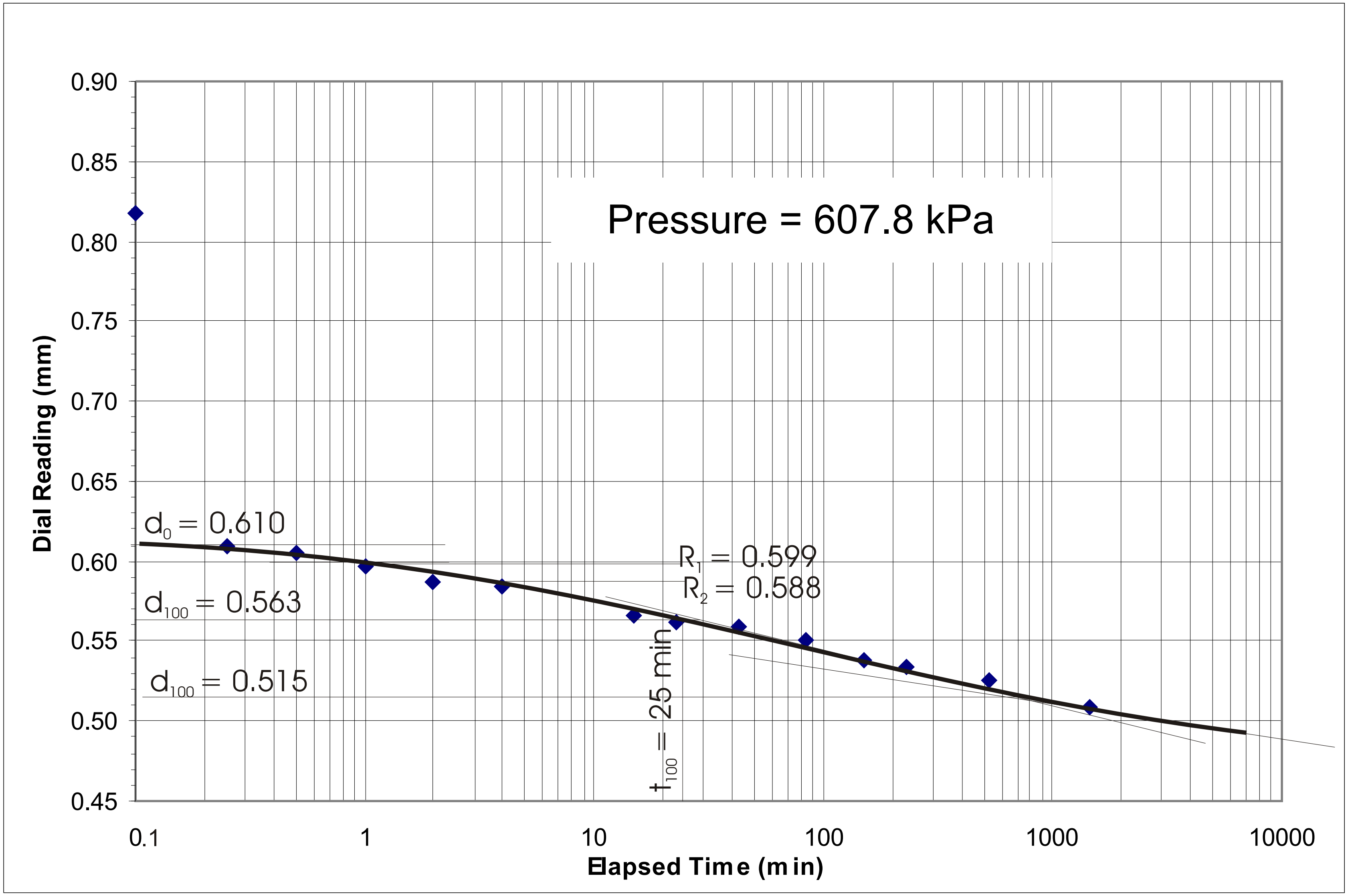


Pressure = 64.2 kPa
Dial Reading (mm)
Elapsed Time (min)
1.27
1.25
1.23
1.21
1.19
1.17
1.15
0.1
1
10
100
1000
10000
d0 = 1.2202
R1 = 1.2160
R2 = 1.2119
d100 = 1.166
t50 = 130 min

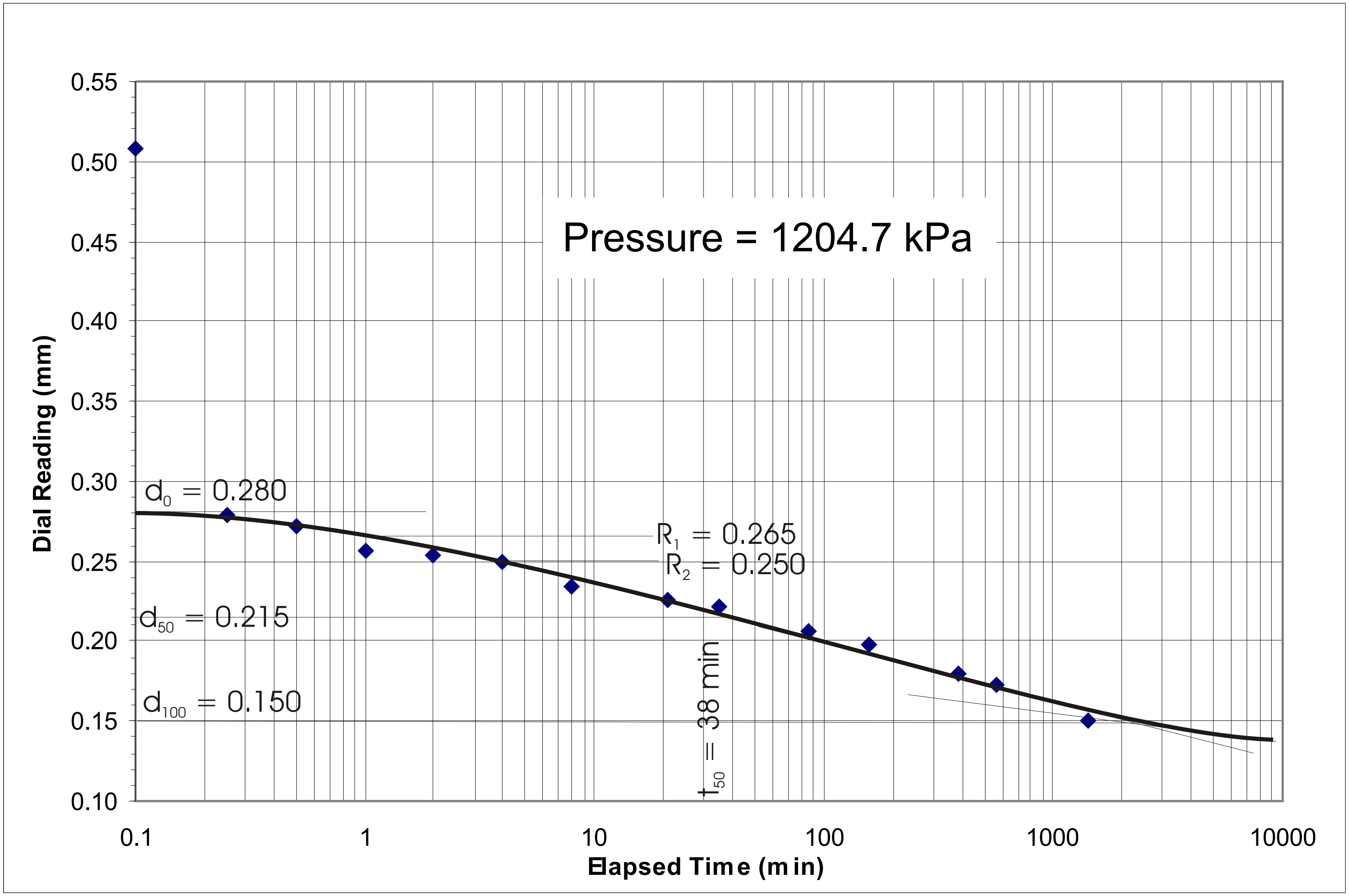

Pressure = 131.9 kPa
Dial Reading (mm)
Elapsed Time (min)
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.1
1
10
100
1000
10000
d0 = 1.086
d50 = 1.047
d100 = 1.008
R1 = 1.078
R2 = 1.070
t50 = 90 min

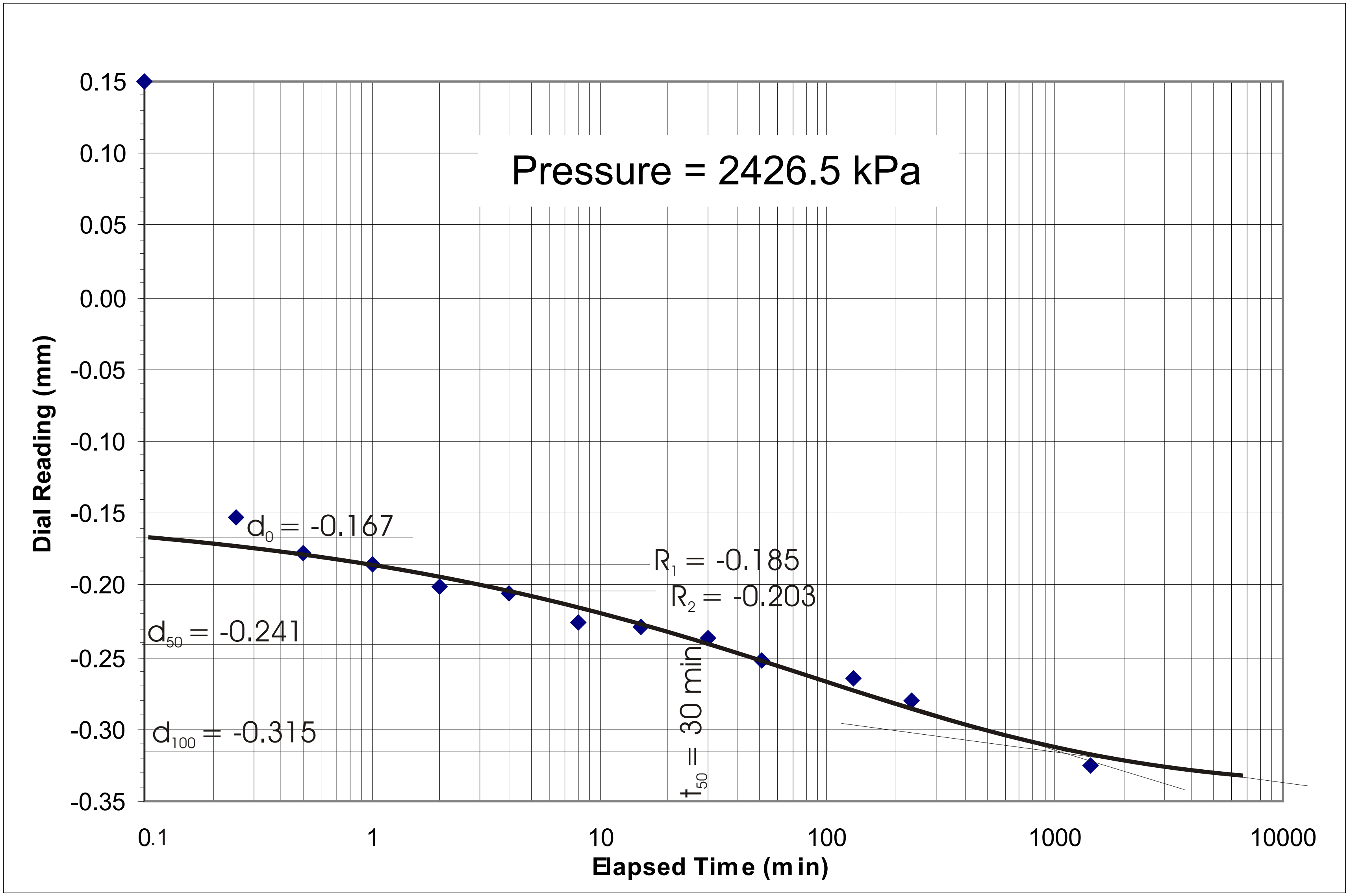


Pressure = 267.6 kPa
Dial Reading (mm)
1.05
1.00
0.95
0.90
0.85
0.80
d_0 = 0.897
R_1 = 0.891
R_2 = 0.885
d_{50} = 0.860
d_{100} = 0.823
t_{50} = 50 min
0.1
1
10
100
1000
10000
Elapsed Time (min)

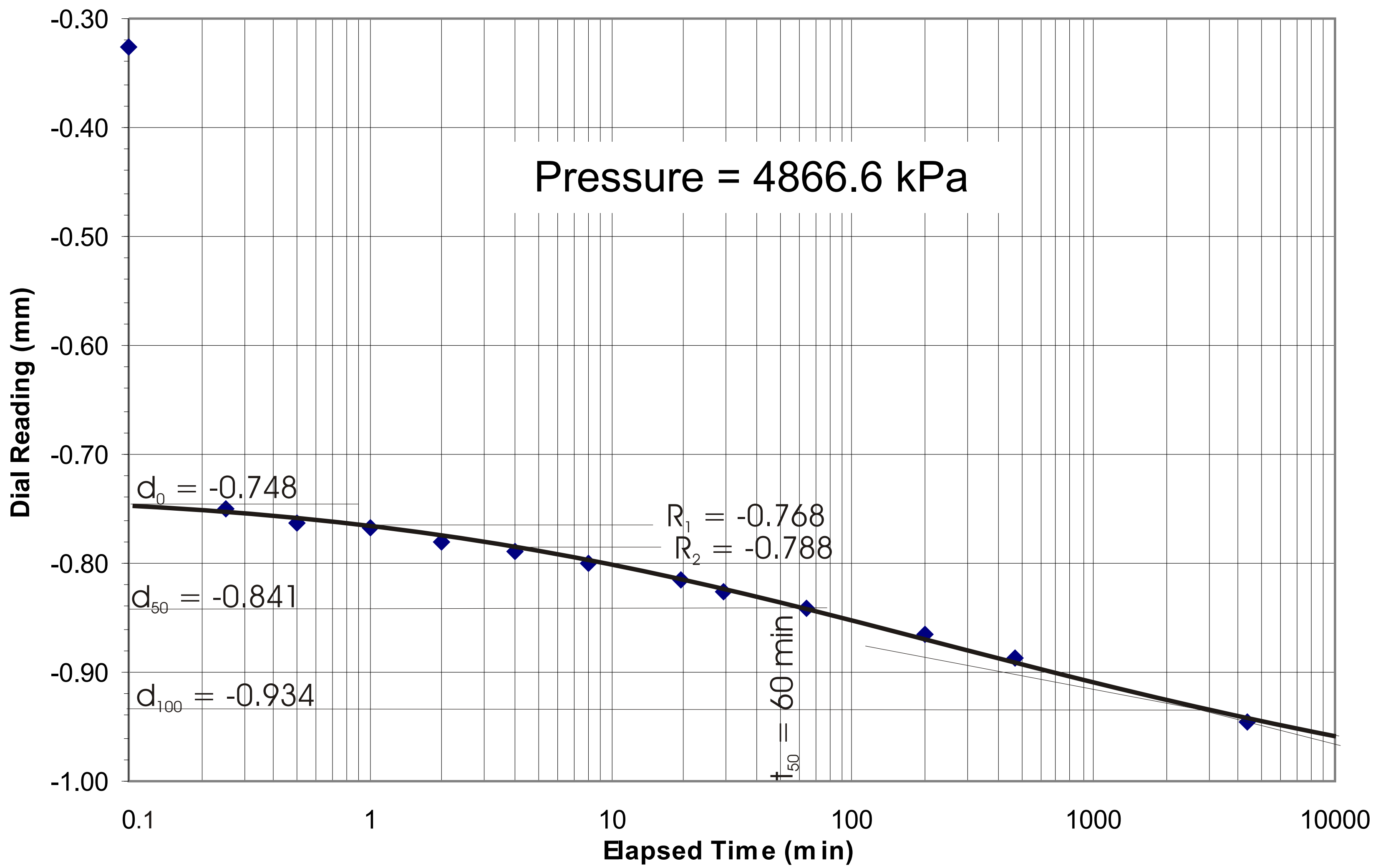


Pressure = 607.8 kPa
Dial Reading (mm)
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
d0 = 0.610
d100 = 0.563
d100 = 0.515
R1 = 0.599
R2 = 0.588
t100 = 25 min
0.1
1
10
100
1000
10000
Elapsed Time (min)

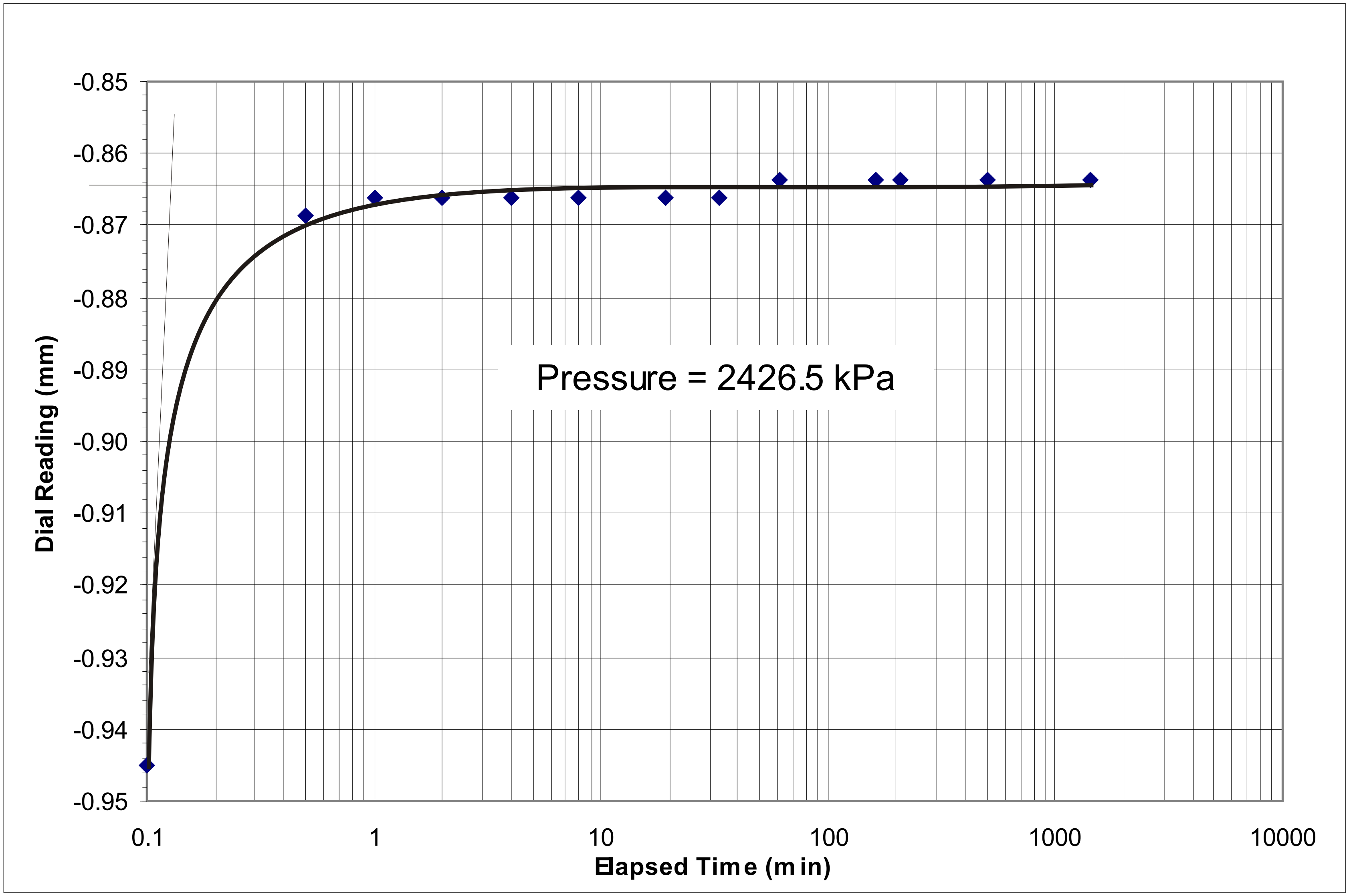

Pressure = 1204.7 kPa
Dial Reading (mm)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
d0 = 0.280
R1 = 0.265
R2 = 0.250
d50 = 0.215
d100 = 0.150
t50 = 38 min
0.1
1
10
100
1000
10000
Elapsed Time (min)

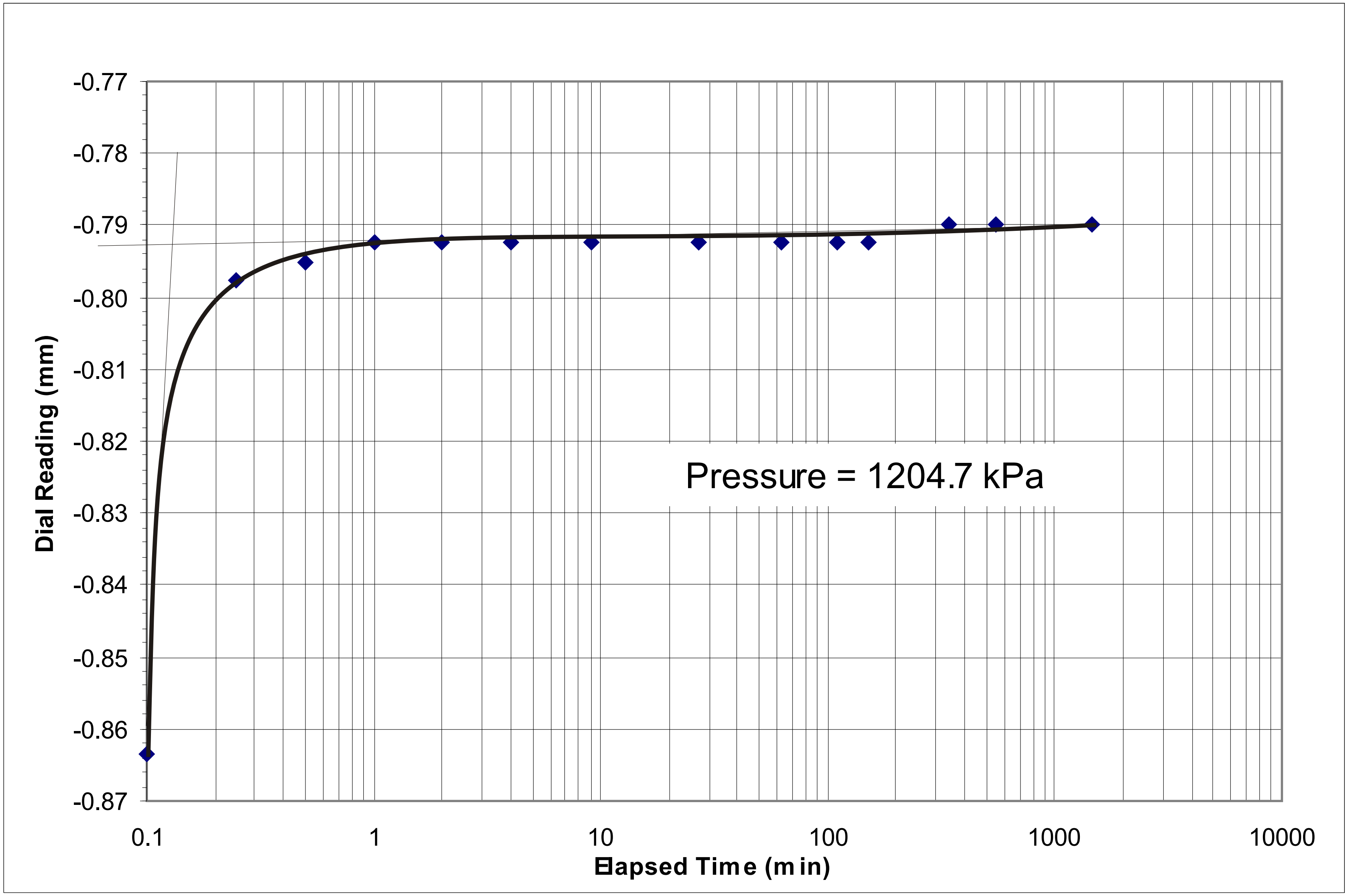


Pressure = 2426.5 kPa
Dial Reading (mm)
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
d0 = -0.167
R1 = -0.185
R2 = -0.203
d50 = -0.241
d100 = -0.315
t50 = 30 min
0.1
1
10
100
1000
10000
Elapsed Time (min)

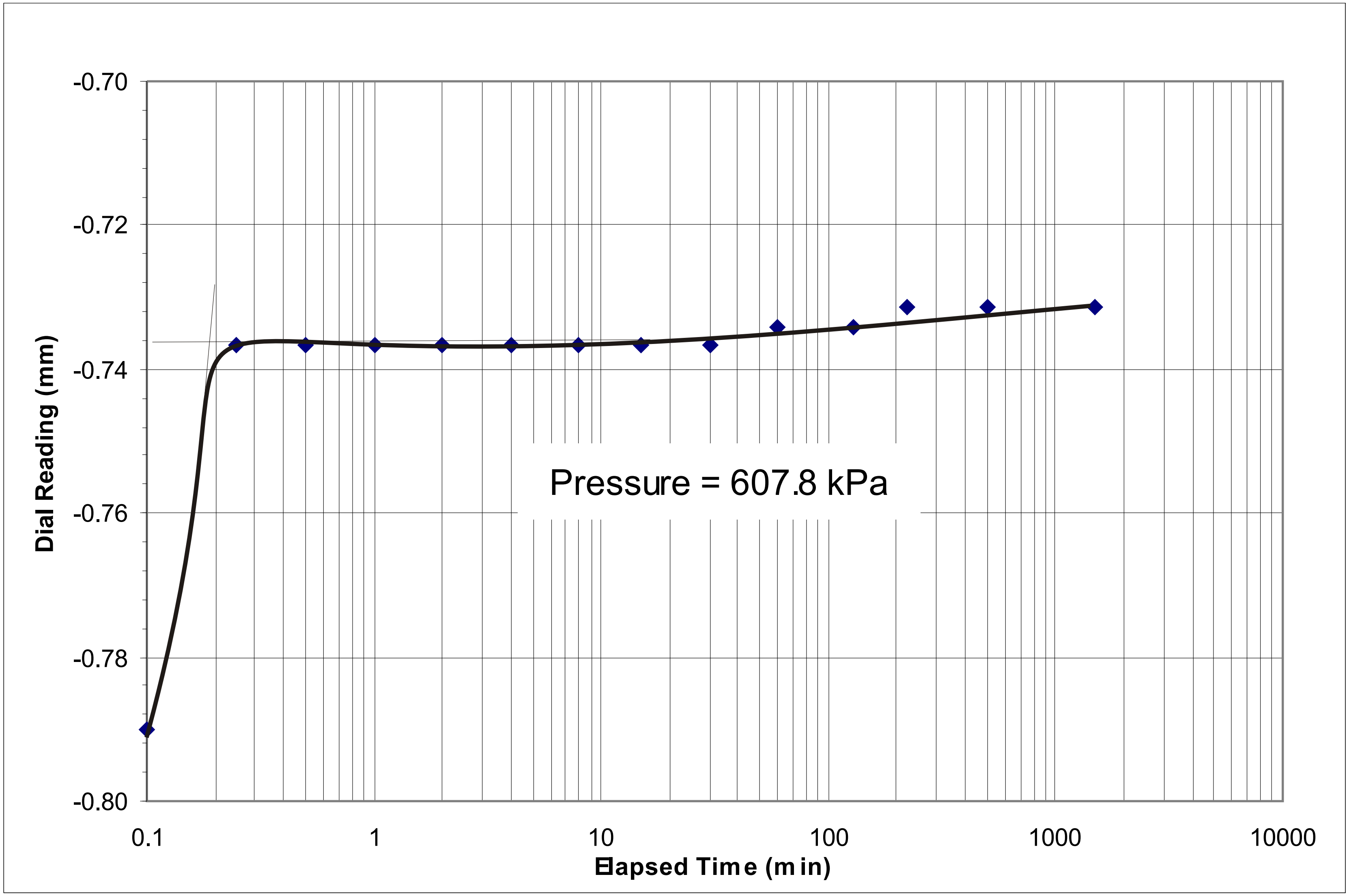


Pressure = 4866.6 kPa
Dial Reading (mm)
Elapsed Time (min)
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
0.1
1
10
100
1000
10000
d0 = -0.748
R1 = -0.768
R2 = -0.788
d50 = -0.841
d100 = -0.934
t50 = 60 min

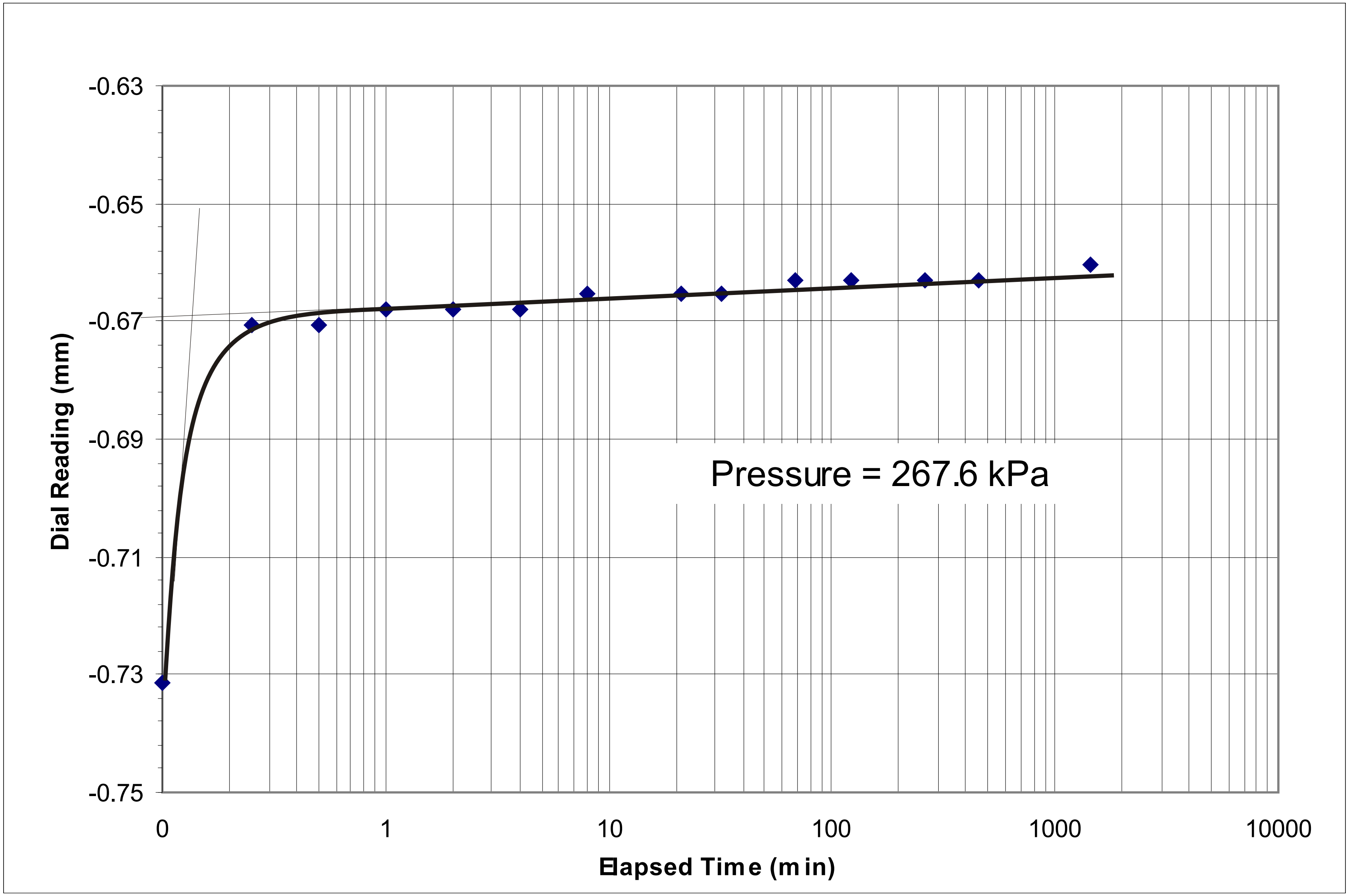

-0.85
-0.86
-0.87
-0.88
-0.89
-0.90
-0.91
-0.92
-0.93
-0.94
-0.95
Dial Reading (mm)
Pressure = 2426.5 kPa
0.1
1
10
100
1000
10000
Elapsed Time (min)



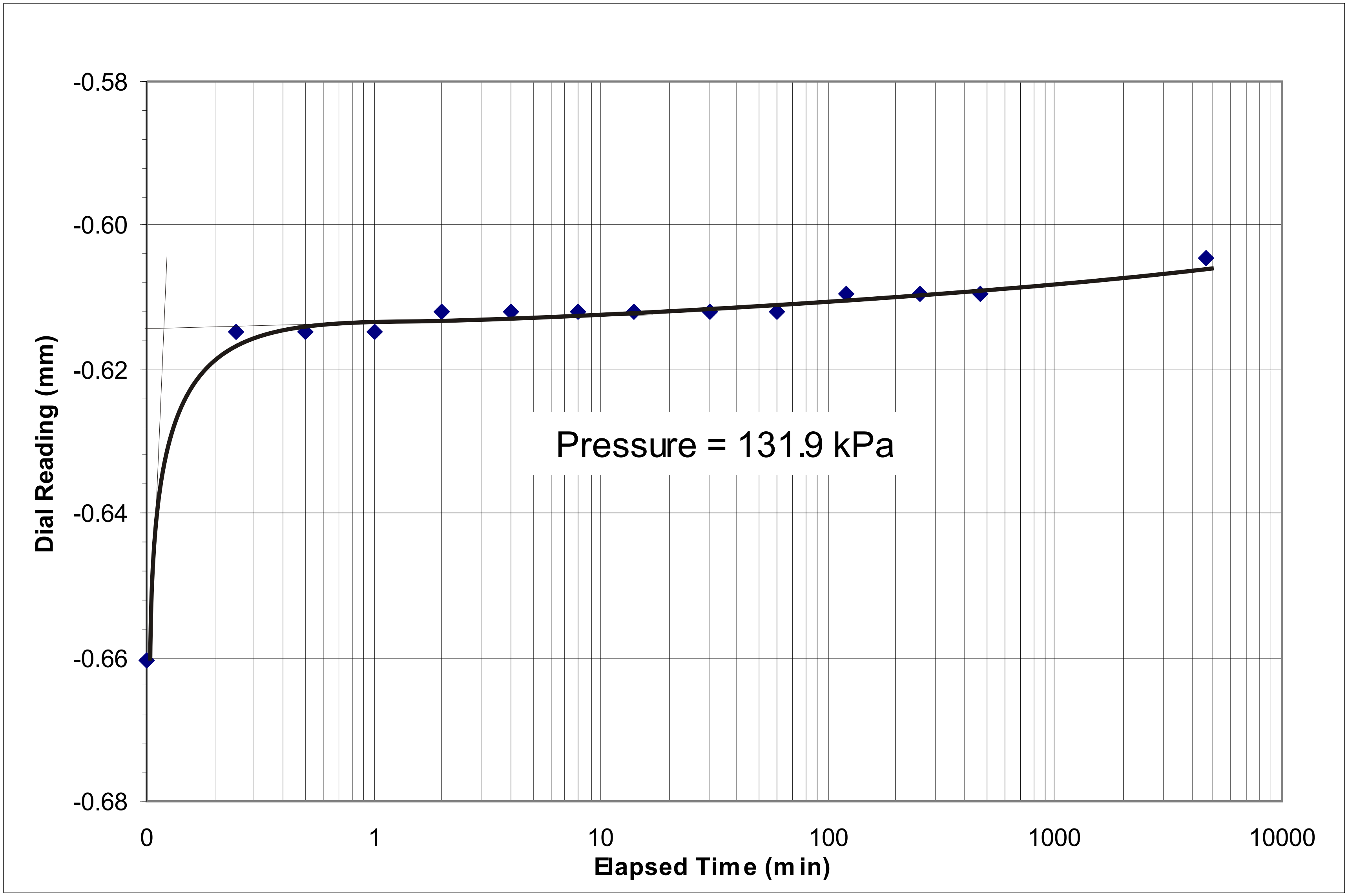
-0.77
-0.78
-0.79
-0.80
-0.81
-0.82
-0.83
-0.84
-0.85
-0.86
-0.87
Dial Reading (mm)
Pressure = 1204.7 kPa
0.1
1
10
100
1000
10000
Elapsed Time (min)



-0.70
-0.72
-0.74
-0.76
-0.78
-0.80
Dial Reading (mm)
0.1
1
10
100
1000
10000
Elapsed Time (min)
Pressure = 607.8 kPa



-0.63
-0.65
-0.67
-0.69
-0.71
-0.73
-0.75
Dial Reading (mm)
0
1
10
100
1000
10000
Elapsed Time (min)
Pressure = 267.6 kPa


-0.58
-0.60
-0.62
-0.64
-0.66
-0.68
Dial Reading (mm)
Pressure = 131.9 kPa
0
1
10
100
1000
10000
Elapsed Time (min)

APPENDIX VII-a

Falling Head Hydraulic Conductivity Tests Results

FALLING-HEAD K-TEST

Sample: **SRK-03-C01**

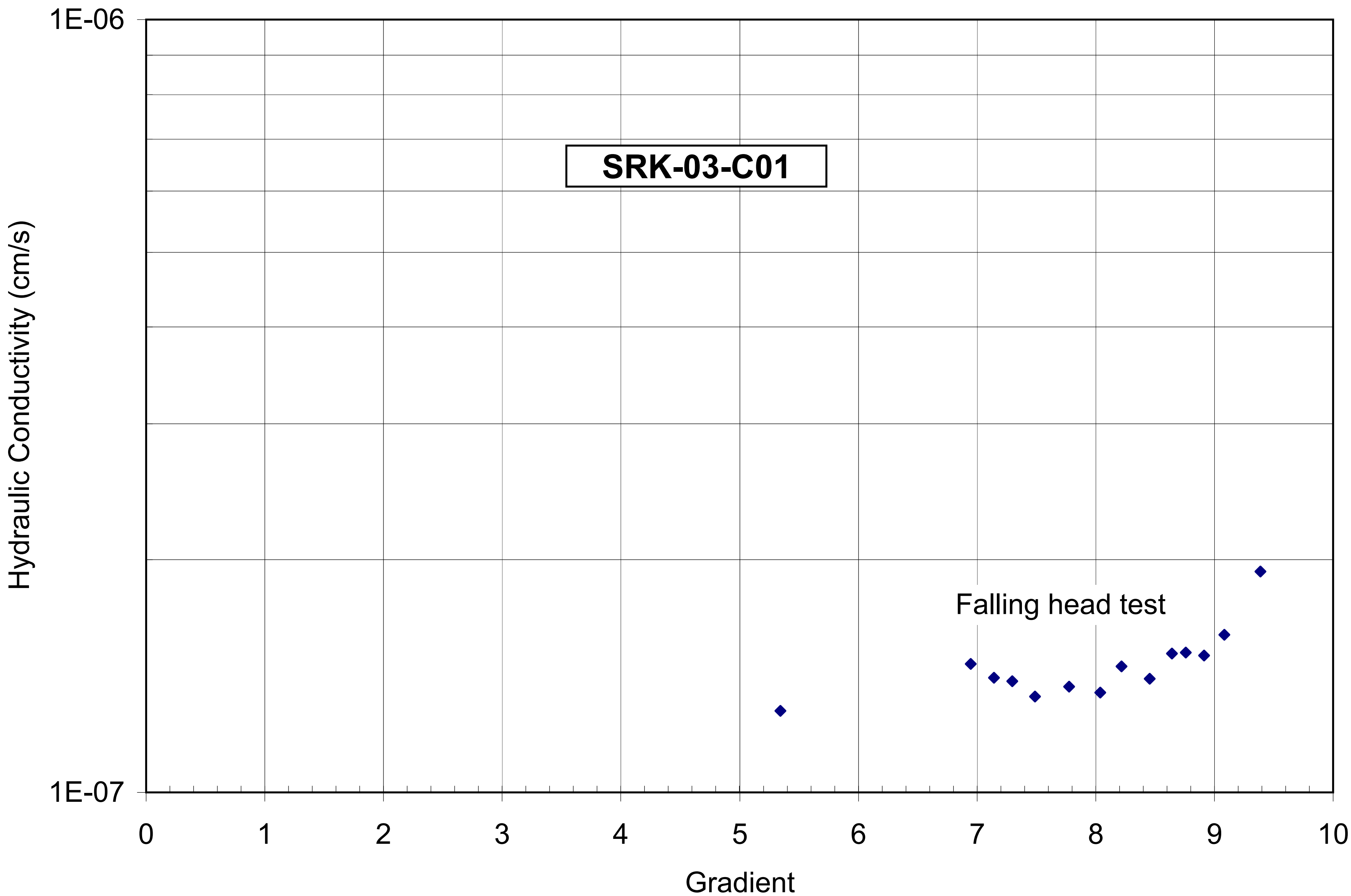
Time T1	Time T2	delta t min	Buret reading at T1	H1 cm	Buret reading at T2	H2 cm	k cm/s	Average gradient
9:26:00	10:16:00	50	98.30	113.300	93.10	108.100	1.93E-07	9.39
10:16:00	10:40:00	24	93.10	108.100	91.10	106.100	1.60E-07	9.08
10:40:00	11:06:00	26	91.10	106.100	89.10	104.100	1.50E-07	8.91
11:06:00	11:27:00	21	89.10	104.100	87.50	102.500	1.52E-07	8.76
11:27:00	11:43:00	16	87.50	102.500	86.30	101.300	1.51E-07	8.64
11:43:00	12:30:00	47	86.30	101.300	83.10	98.100	1.40E-07	8.45
12:30:00	13:05:00	35	83.10	98.100	80.70	95.700	1.45E-07	8.22
13:05:00	13:34:00	29	80.70	95.700	78.90	93.900	1.35E-07	8.04
13:34:00	14:46:00	72	78.90	93.900	74.50	89.500	1.37E-07	7.78
14:46:00	15:28:00	42	74.50	89.500	72.10	87.100	1.33E-07	7.49
15:28:00	16:04:00	36	72.10	87.100	70.00	85.000	1.39E-07	7.30
16:04:00	16:30:00	26	70.00	85.000	68.50	83.500	1.41E-07	7.14
16:30:00	17:23:00	53	68.50	83.500	65.40	80.400	1.47E-07	6.95
17:23:00	8:37:00	914	65.40	80.400	30.60	45.600	1.28E-07	5.34

Test using material <#4 sieve
Maximum dry density = 1980 Mg/m3
Optimum water content = 12.5%

Buret, a = 0.183 cm2

Specimen dimensions
Height, L = 5.4 cm
Diameter, D= 10.1 cm
X-sectional area, A = 80.13 cm2

Post-test information
Water content
Tare mass = 18.47 g
Wet sample + tare = 1004.32 g
Dry sample + tare 869.05 g
Water content = 15.9%
Dry density = 1.966 Mg/m3


SRK-03-C01
Falling head test
Hydraulic Conductivity (cm/s)
1E-06
1E-07
0
1
2
3
4
5
6
7
8
9
10
Gradient

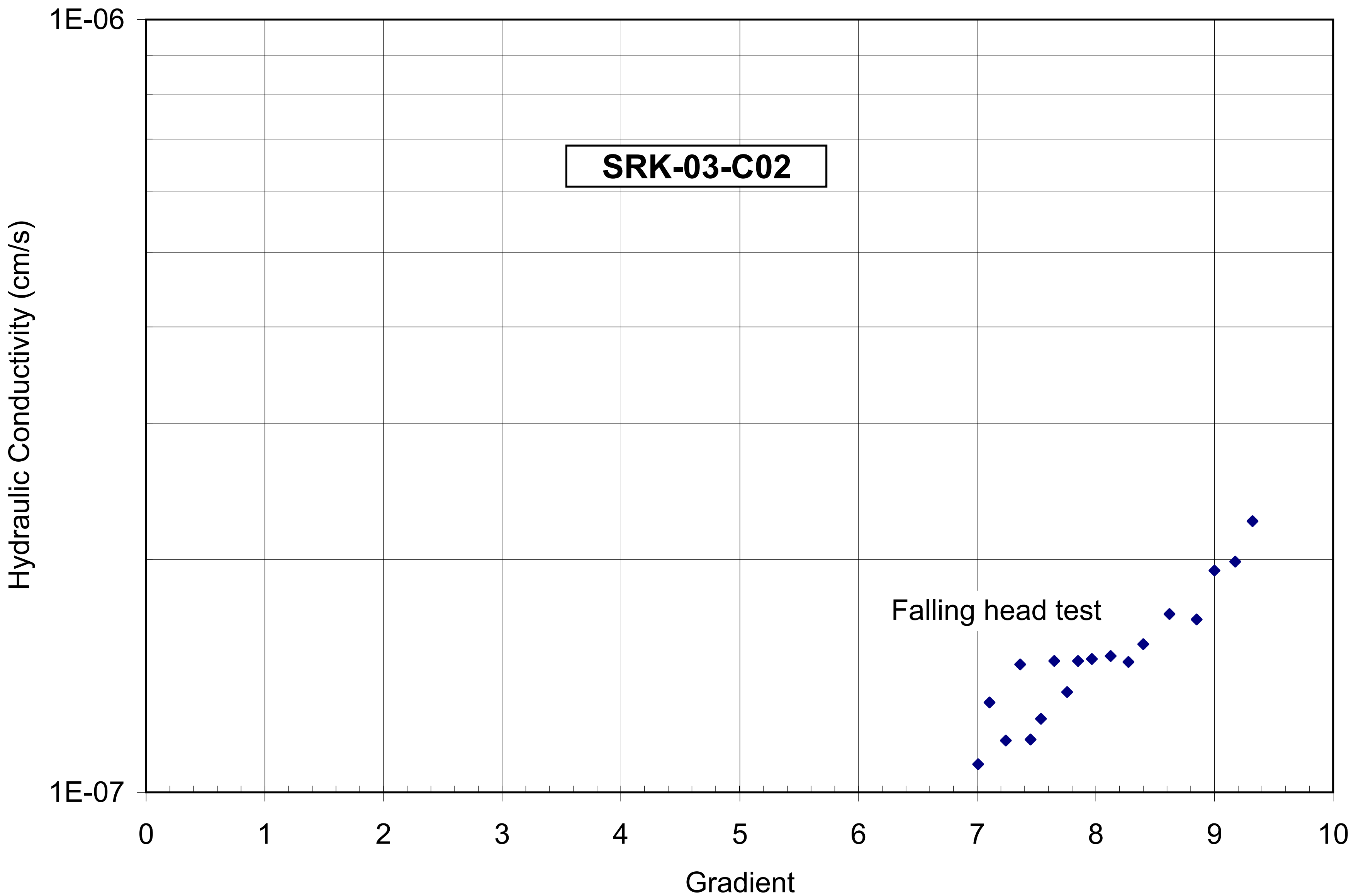
FALLING-HEAD K-TEST

Sample: **SRK-03-C02**

Time T1	Time T2	delta t min	Buret reading at T1	H1 cm	Buret reading at T2	H2 cm	k cm/s	Average gradient
9:17:00	9:27:00	10	95.50	110.500	94.30	109.300	2.24E-07	9.32
9:27:00	9:48:00	21	94.30	109.300	92.10	107.100	1.99E-07	9.17
9:48:00	10:07:00	19	92.10	107.100	90.20	105.200	1.94E-07	9.00
10:07:00	10:27:00	20	90.20	105.200	88.50	103.500	1.67E-07	8.85
10:27:00	11:11:00	44	88.50	103.500	84.80	99.800	1.70E-07	8.62
11:11:00	11:31:00	20	84.80	99.800	83.30	98.300	1.56E-07	8.40
11:31:00	11:51:00	20	83.30	98.300	81.90	96.900	1.47E-07	8.28
11:51:00	12:21:00	30	81.90	96.900	79.80	94.800	1.50E-07	8.13
12:21:00	12:46:00	25	79.80	94.800	78.10	93.100	1.49E-07	7.97
12:46:00	13:01:00	15	78.10	93.100	77.10	92.100	1.48E-07	7.85
13:01:00	13:21:00	20	77.10	92.100	75.90	90.900	1.35E-07	7.76
13:21:00	13:41:00	20	75.90	90.900	74.60	89.600	1.48E-07	7.65
13:41:00	14:07:00	26	74.60	89.600	73.20	88.200	1.24E-07	7.54
14:07:00	14:21:00	14	73.20	88.200	72.50	87.500	1.17E-07	7.45
14:21:00	14:42:00	21	72.50	87.500	71.20	86.200	1.47E-07	7.36
14:42:00	15:15:00	33	71.20	86.200	69.60	84.600	1.17E-07	7.24
15:15:00	15:45:00	30	69.60	84.600	68.00	83.000	1.31E-07	7.11
15:45:00	16:01:00	16	68.00	83.000	67.30	82.300	1.09E-07	7.01

Test using material <#4 sieve
Maximum dry density = 1975 Mg/m3
Optimum water content = 12.0 %

Buret, a =	0.183	cm2
Specimen dimensions		
Height, L =	5.4	cm
Diameter, D=	10.1	cm
X-sectional area, A =	80.13	cm2
Post-test information		
Water content		
Tare mass =	312	g
Wet sample + tare =	1272	g
Dry sample + tare	1148.16	g
Water content =	14.8%	
Dry density =	1.932	Mg/m3



SRK-03-C02
Falling head test
1E-06
1E-07
0
1
2
3
4
5
6
7
8
9
10
Gradient
Hydraulic Conductivity (cm/s)

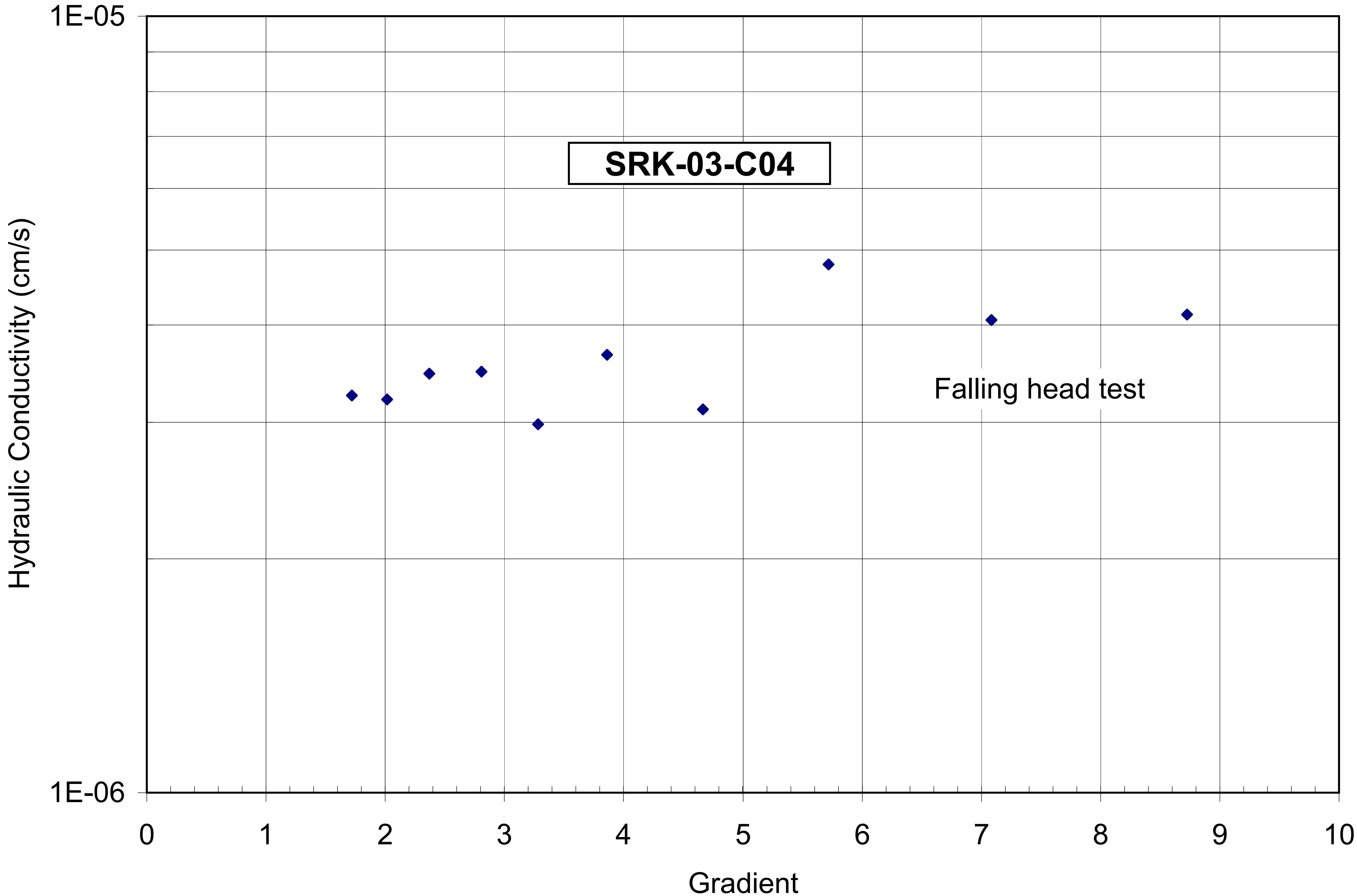
FALLING-HEAD K-TEST

Sample: **SRK-03-C04**

Time T1	Time T2	delta t min	Buret reading at T1	H1 cm	Buret reading at T2	H2 cm	k cm/s	Average gradient
10:58:00	11:08:00	10	98.20	113.200	77.60	92.600	4.13E-06	8.73
11:08:00	11:19:00	11	77.60	92.600	59.50	74.500	4.06E-06	7.08
11:19:00	11:28:00	9	59.50	74.500	45.40	60.400	4.79E-06	5.72
11:28:00	11:41:00	13	45.40	60.400	34.60	49.600	3.11E-06	4.66
11:41:00	11:51:00	10	34.60	49.600	26.50	41.500	3.66E-06	3.86
11:51:00	12:01:00	10	26.50	41.500	20.90	35.900	2.98E-06	3.28
12:01:00	12:11:00	10	20.90	35.900	15.30	30.300	3.49E-06	2.81
12:11:00	12:21:00	10	15.30	30.300	10.60	25.600	3.46E-06	2.37
12:21:00	12:31:00	10	10.60	25.600	6.90	21.900	3.21E-06	2.01
12:31:00	12:41:00	10	6.90	21.900	3.70	18.700	3.25E-06	1.72

Test using material <#4 sieve
Maximum dry density = 2045 Mg/m3
Optimum water content = 9.0 %

Buret, a =	0.183	cm2
Specimen dimensions		
Height, L =	5.4	cm
Diameter, D=	10.1	cm
X-sectional area, A =	80.13	cm2
Post-test information		
Water content		
Tare mass =	308.42	g
Wet sample + tare =	1309.66	g
Dry sample + tare	1184.82	g
Water content =	14.2%	
Dry density =	2.025	Mg/m3



SRK-03-C04
Falling head test
Hydraulic Conductivity (cm/s)
1E-05
1E-06
0
1
2
3
4
5
6
7
8
9
10
Gradient

FALLING-HEAD K-TEST

Sample: **SRK-03-C05**

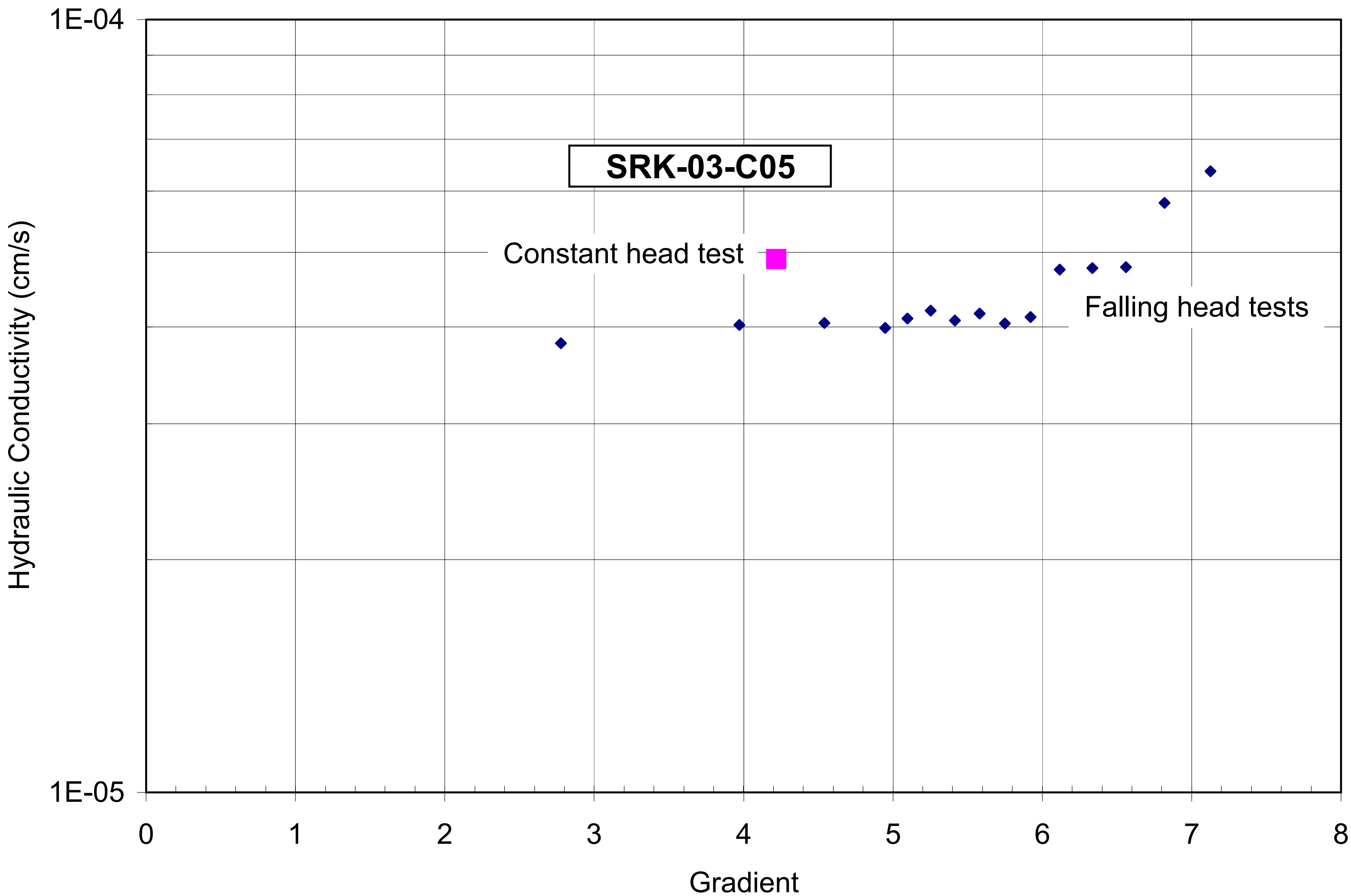
Time T1	Time T2	delta t min	Buret reading at T1	H1 cm	Buret reading at T2	H2 cm	k cm/s	Average gradient
16:46:30	16:47:00	0.5	84.30	86.000	80.40	82.100	6.36E-05	7.13
16:47:00	16:47:30	0.5	80.40	82.100	77.00	78.700	5.80E-05	6.82
16:47:30	16:48:00	0.5	77.00	78.700	74.30	76.000	4.78E-05	6.56
16:48:00	16:48:30	0.5	74.30	76.000	71.70	73.400	4.77E-05	6.33
16:48:30	16:49:00	0.5	71.70	73.400	69.20	70.900	4.75E-05	6.12
16:49:00	16:49:30	0.5	69.20	70.900	67.10	68.800	4.12E-05	5.92
16:49:30	16:50:00	0.5	67.10	68.800	65.10	66.800	4.04E-05	5.75
16:50:00	16:50:30	0.5	65.10	66.800	63.10	64.800	4.17E-05	5.58
16:50:30	16:51:00	0.5	63.10	64.800	61.20	62.900	4.08E-05	5.41
16:51:00	16:51:30	0.5	61.20	62.900	59.30	61.000	4.20E-05	5.25
16:51:30	16:52:00	0.5	59.30	61.000	57.50	59.200	4.10E-05	5.10
16:52:00	16:52:30	0.5	57.50	59.200	55.80	57.500	3.99E-05	4.95
16:52:30	16:55:00	2.5	55.80	57.500	47.90	49.600	4.05E-05	4.54
16:55:00	16:57:00	2	47.90	49.600	42.40	44.100	4.03E-05	3.97
16:57:00	17:10:00	13	42.40	44.100	19.70	21.400	3.81E-05	2.78
					Constant head test		4.90E-05	4.22

Test using material <#4 sieve
Maximum dry density = 2020 Mg/m3
Optimum water content = 10.5 %

Buret, a = 0.183 cm2

Specimen dimensions
Height, L = 18.0 cm
Diameter, D= 10.1 cm
X-sectional area, A = 80.13 cm2

Initial dry density = 2.011 Mg/m3


SRK-03-C05
Constant head test
Falling head tests
Hydraulic Conductivity (cm/s)
1E-04
1E-05
Gradient
0
1
2
3
4
5
6
7
8

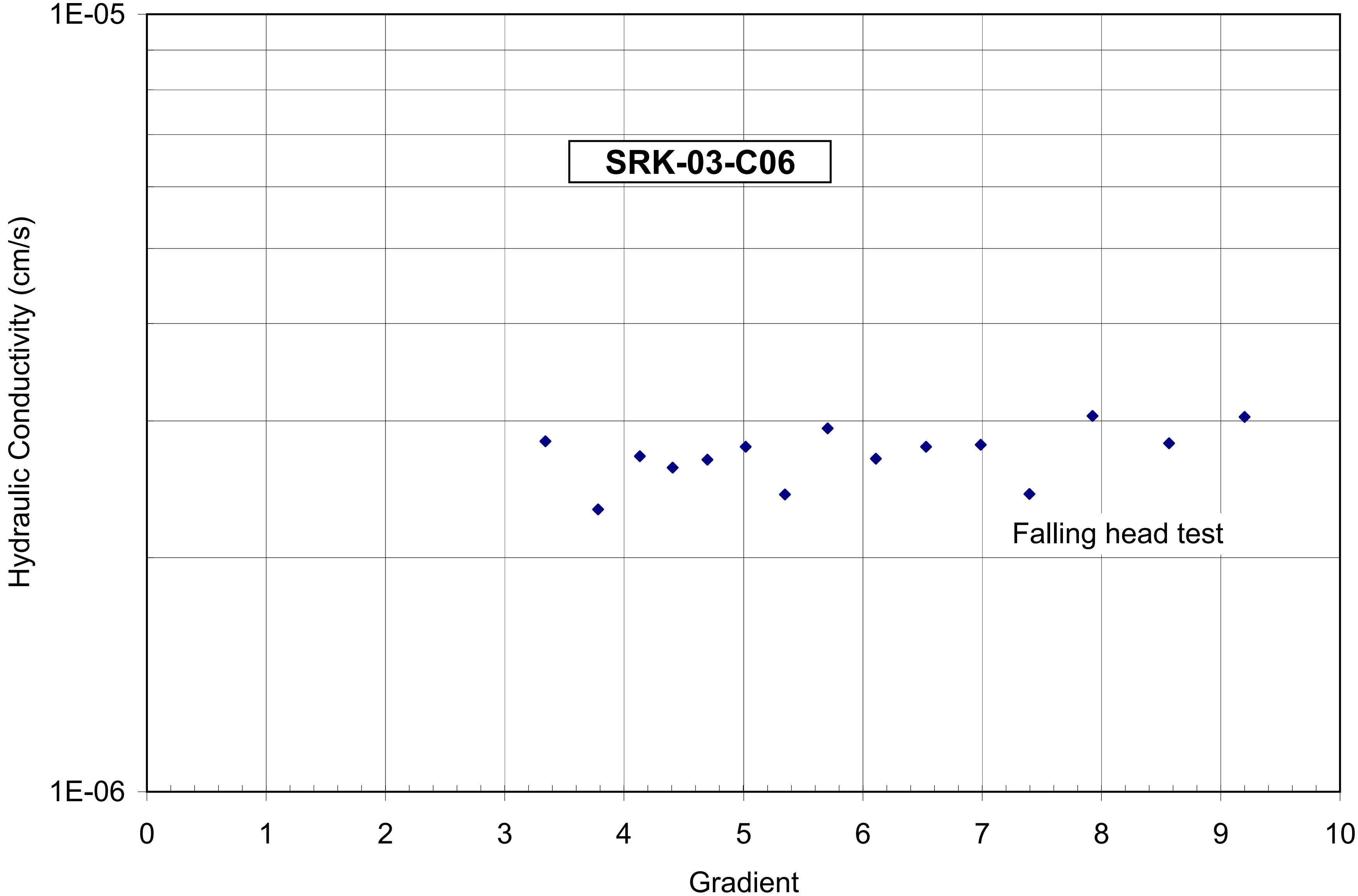
FALLING-HEAD K-TEST

Sample: **SRK-03-C06**

Time T1	Time T2	delta t min	Buret reading at T1	H1 cm	Buret reading at T2	H2 cm	k cm/s	Average gradient
13:37:00	13:42:00	5	97.50	112.500	89.50	104.500	3.03E-06	9.20
13:42:00	13:47:00	5	89.50	104.500	82.60	97.600	2.81E-06	8.57
13:47:00	13:53:00	6	82.60	97.600	74.30	89.300	3.04E-06	7.92
13:53:00	13:57:00	4	74.30	89.300	70.20	85.200	2.42E-06	7.40
13:57:00	14:02:00	5	70.20	85.200	64.60	79.600	2.79E-06	6.99
14:02:00	14:07:00	5	64.60	79.600	59.40	74.400	2.78E-06	6.53
14:07:00	14:12:00	5	59.40	74.400	54.70	69.700	2.68E-06	6.11
14:12:00	14:17:00	5	54.70	69.700	49.90	64.900	2.93E-06	5.71
14:17:00	14:22:00	5	49.90	64.900	46.20	61.200	2.41E-06	5.35
14:22:00	14:27:00	5	46.20	61.200	42.20	57.200	2.78E-06	5.02
14:27:00	14:32:00	5	42.20	57.200	38.60	53.600	2.67E-06	4.70
14:32:00	14:37:00	5	38.60	53.600	35.30	50.300	2.61E-06	4.41
14:37:00	14:42:00	5	35.30	50.300	32.10	47.100	2.70E-06	4.13
14:42:00	14:52:00	10	32.10	47.100	27.10	42.100	2.31E-06	3.78
14:52:00	15:02:00	10	27.10	42.100	21.70	36.700	2.82E-06	3.34
15:02:00	15:12:00	10	21.70	36.700	17.30	32.300	2.62E-06	2.93
15:12:00	15:22:00	10	17.30	32.300	13.40	28.400	2.64E-06	2.57
15:22:00	15:32:00	10	13.40	28.400	10.40	25.400	2.29E-06	2.28
15:32:00	15:47:00	15	10.40	25.400	6.20	21.200	2.48E-06	1.98

Test using material <#4 sieve
Maximum dry density = 2000 Mg/m3
Optimum water content = 10.5 %

Buret, a =	0.183	cm2
Specimen dimensions		
Height, L =	5.4	cm
Diameter, D=	10.1	cm
X-sectional area, A =	80.13	cm2
Post-test information		
Water content		
Tare mass =	13.26	g
Wet sample + tare =	990.2	g
Dry sample + tare	864.57	g
Water content =	14.8%	
Dry density =	1.967	Mg/m3


SRK-03-C06
Falling head test
Hydraulic Conductivity (cm/s)
Gradient
1E-05
1E-06
0
1
2
3
4
5
6
7
8
9
10

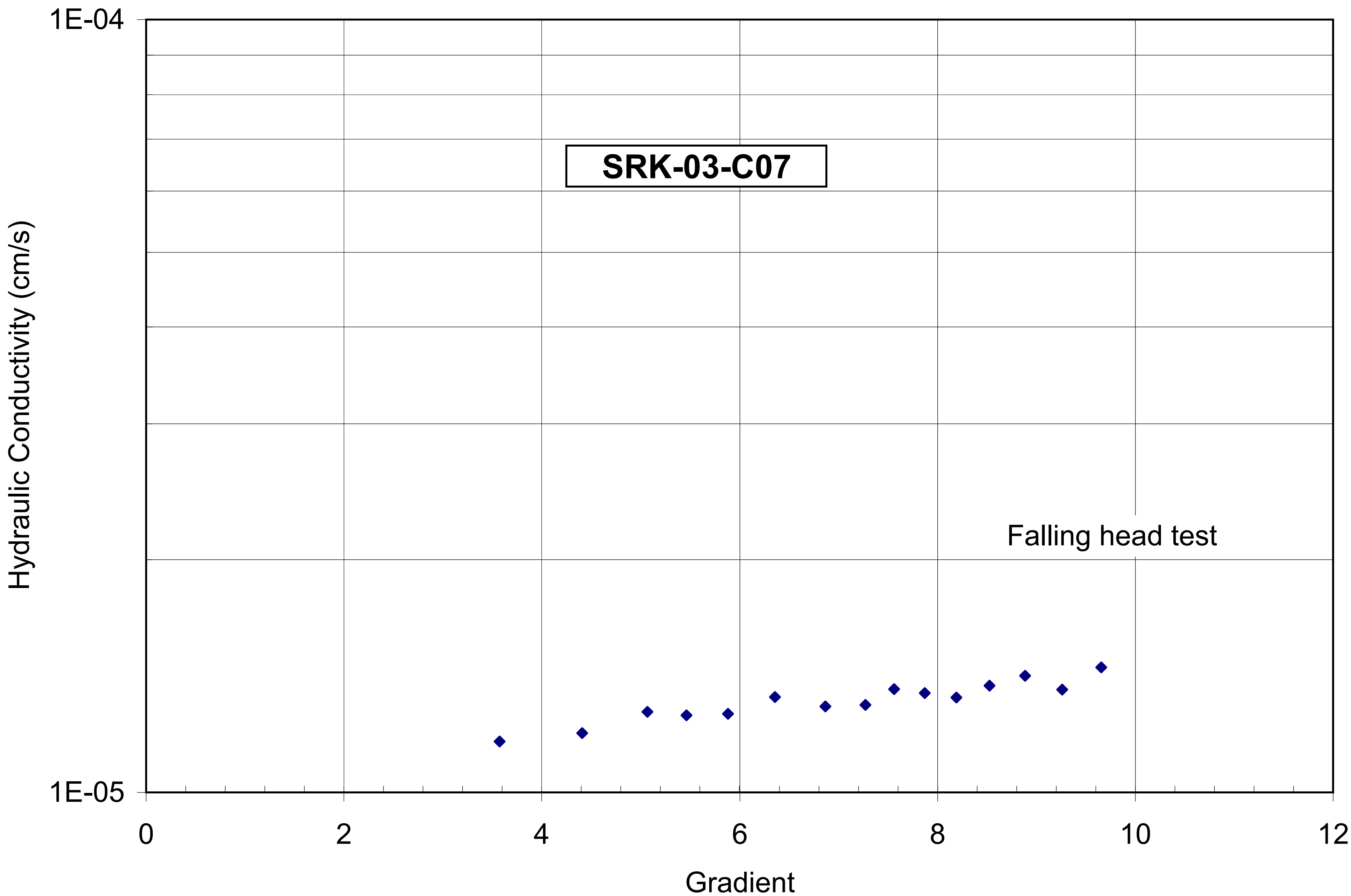
FALLING-HEAD K-TEST

Sample: **SRK-03-C07**

Time T1	Time T2	delta t min	Buret reading at T1	H1 cm	Buret reading at T2	H2 cm	k cm/s	Average gradient
14:27:00	14:27:30	0.5	95.60	116.300	90.70	111.400	1.45E-05	9.65
14:27:30	14:28:00	0.5	90.70	111.400	86.30	107.000	1.36E-05	9.26
14:28:00	14:28:30	0.5	86.30	107.000	81.90	102.600	1.42E-05	8.89
14:28:30	14:29:00	0.5	81.90	102.600	77.80	98.500	1.38E-05	8.53
14:29:00	14:29:30	0.5	77.80	98.500	74.00	94.700	1.33E-05	8.19
14:29:30	14:30:00	0.5	74.00	94.700	70.30	91.000	1.34E-05	7.87
14:30:00	14:30:30	0.5	70.30	91.000	66.70	87.400	1.36E-05	7.56
14:30:30	14:31:00	0.5	66.70	87.400	63.40	84.100	1.30E-05	7.27
14:31:00	14:32:00	1	63.40	84.100	57.20	77.900	1.29E-05	6.87
14:32:00	14:33:00	1	57.20	77.900	51.30	72.000	1.33E-05	6.36
14:33:00	14:34:00	1	51.30	72.000	46.10	66.800	1.26E-05	5.88
14:34:00	14:35:00	1	46.10	66.800	41.30	62.000	1.26E-05	5.46
14:35:00	14:36:00	1	41.30	62.000	36.80	57.500	1.27E-05	5.07
14:36:00	14:39:00	3	36.80	57.500	25.80	46.500	1.19E-05	4.41
14:39:00	14:42:00	3	25.80	46.500	17.10	37.800	1.16E-05	3.57

Test using material <#4 sieve

Buret, a =	0.183	cm2
Specimen dimensions		
Height, L =	5.7	cm
Diameter, D=	11.457	cm
X-sectional area, A =	103.11	cm2
Post-test information		
Water content		
Tare mass =	308.23	g
Wet sample + tare =	2123.2	g
Dry sample + tare	1880.96	g
Water content =	15.4%	
Dry density =	2.676	Mg/m3


SRK-03-C07
Falling head test
1E-04
1E-05
0
2
4
6
8
10
12
Hydraulic Conductivity (cm/s)
Gradient

APPENDIX VII-b

Constant Head Hydraulic Conductivity Tests Results

M.D. Haug & Associates Ltd.

Project: SRK Consultants, Vancouver
Location: Faro Mine, Whitehorse

Date: 11-Aug-03

Sample:SRK-03-C05

Initial condition of test specimen

Diameter of specimen, D, cm =	10.1	Weight of wet soil, g =	3204
Height of specimen, L, cm =	18	Water content of wet soil, % =	10%
Cross-sectional Area, A, cm^2 =	80.12886	Weight of dry soil, g =	2912.7
		Volume of test specimen, cm^3 =	1442.3194
		Dry density of test specimen, kg/m^3 =	2019

Time		Water level		Head, h	Q cm3	t sec	Q/At	i = h/L	k cm/s
Start	End	H_1	H_2	cm					
15:48	16:09	76	0	76.0	21.21	1260	2.10E-04	4.222	4.98E-05

M.D. Haug & Associates Ltd.

Project: SRK Consultants, Vancouver
Location: Faro Mine, Whitehorse

Date: 18-Aug-03

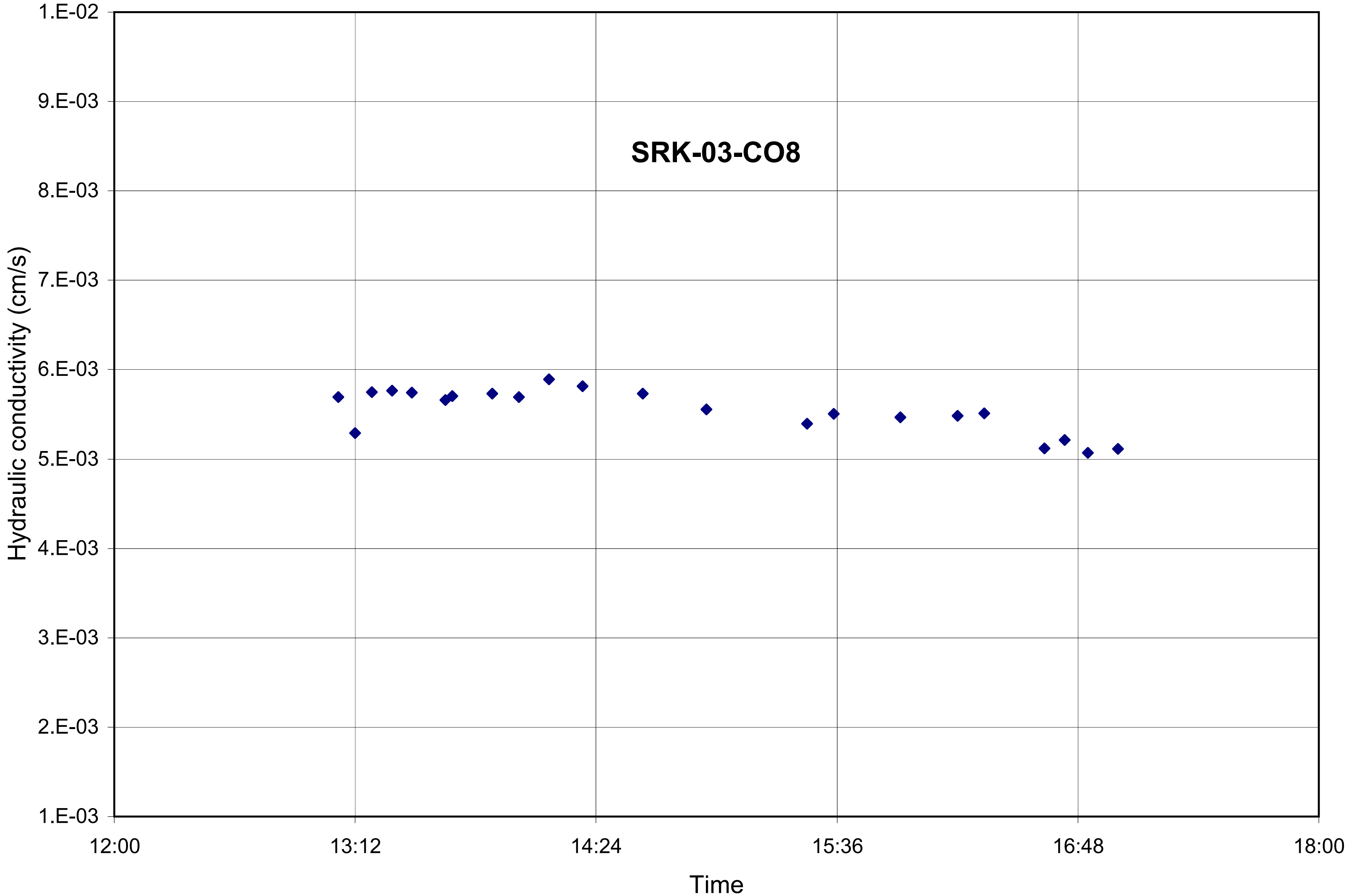
Sample:SRK-03-C08

Diameter of specimen, D, cm = 19.95
Height of specimen, L, cm = 15.84
Cross-sectional Area, A, cm^2 = 312.631

Initial condition of test specimen

Weight of wet soil, g = 9914
Water content of wet soil, % = 8%
Weight of dry soil, g = 9171
Volume of test specimen, cm^3 = 4952
Dry density of test specimen, kg/m^3 = 1852

Time		Water level		Head, h	Q cm3	t sec	Q/At	i = h/L	k cm/s
Start	End	H_1	H_2	cm					
13:07	13:08	26.5	13.4	13.1	88.3	60	4.71E-03	0.827	5.69E-03
13:12	13:13	26.5	13.4	13.1	82.1	60	4.38E-03	0.827	5.29E-03
13:17	13:18	26.5	13.4	13.1	89.2	60	4.76E-03	0.827	5.75E-03
13:23	13:24	26.5	13.4	13.1	89.4	60	4.77E-03	0.827	5.76E-03
13:29	13:30	26.5	13.4	13.1	89.1	60	4.75E-03	0.827	5.74E-03
13:39	13:40	26.5	13.4	13.1	87.8	60	4.68E-03	0.827	5.66E-03
13:41	13:42	26.5	13.4	13.1	88.5	60	4.72E-03	0.827	5.70E-03
13:53	13:54	26.5	13.4	13.1	88.9	60	4.74E-03	0.827	5.73E-03
14:01	14:02	26.5	13.4	13.1	88.3	60	4.71E-03	0.827	5.69E-03
14:10	14:11	26.5	13.4	13.1	91.4	60	4.87E-03	0.827	5.89E-03
14:20	14:21	26.5	13.4	13.1	90.2	60	4.81E-03	0.827	5.81E-03
14:38	14:39	26.5	13.4	13.1	88.9	60	4.74E-03	0.827	5.73E-03
14:57	14:58	26.5	13.4	13.1	86.2	60	4.60E-03	0.827	5.56E-03
15:27	15:28	26.5	13.4	13.1	83.7	60	4.46E-03	0.827	5.40E-03
15:35	15:36	26.5	13.4	13.1	85.4	60	4.55E-03	0.827	5.51E-03
15:55	15:56	26.5	13.4	13.1	84.8	60	4.52E-03	0.827	5.47E-03
16:12	16:13	26.5	13.4	13.1	85.1	60	4.54E-03	0.827	5.49E-03
16:20	16:21	26.5	13.4	13.1	85.5	60	4.56E-03	0.827	5.51E-03
16:38	16:39	26.5	13.4	13.1	79.4	60	4.23E-03	0.827	5.12E-03
16:44	16:45	26.5	13.4	13.1	80.9	60	4.31E-03	0.827	5.21E-03
16:51	16:52	26.5	13.4	13.1	78.6	60	4.19E-03	0.827	5.07E-03
17:00	17:01	26.5	13.4	13.1	79.3	60	4.23E-03	0.827	5.11E-03


SRK-03-CO8
Hydraulic conductivity (cm/s)
1.E-02
9.E-03
8.E-03
7.E-03
6.E-03
5.E-03
4.E-03
3.E-03
2.E-03
1.E-03
12:00
13:12
14:24
15:36
16:48
18:00
Time

M.D. Haug & Associates Ltd.

Project: SRK Consultants, Vancouver
Location: Faro Mine, Whitehorse

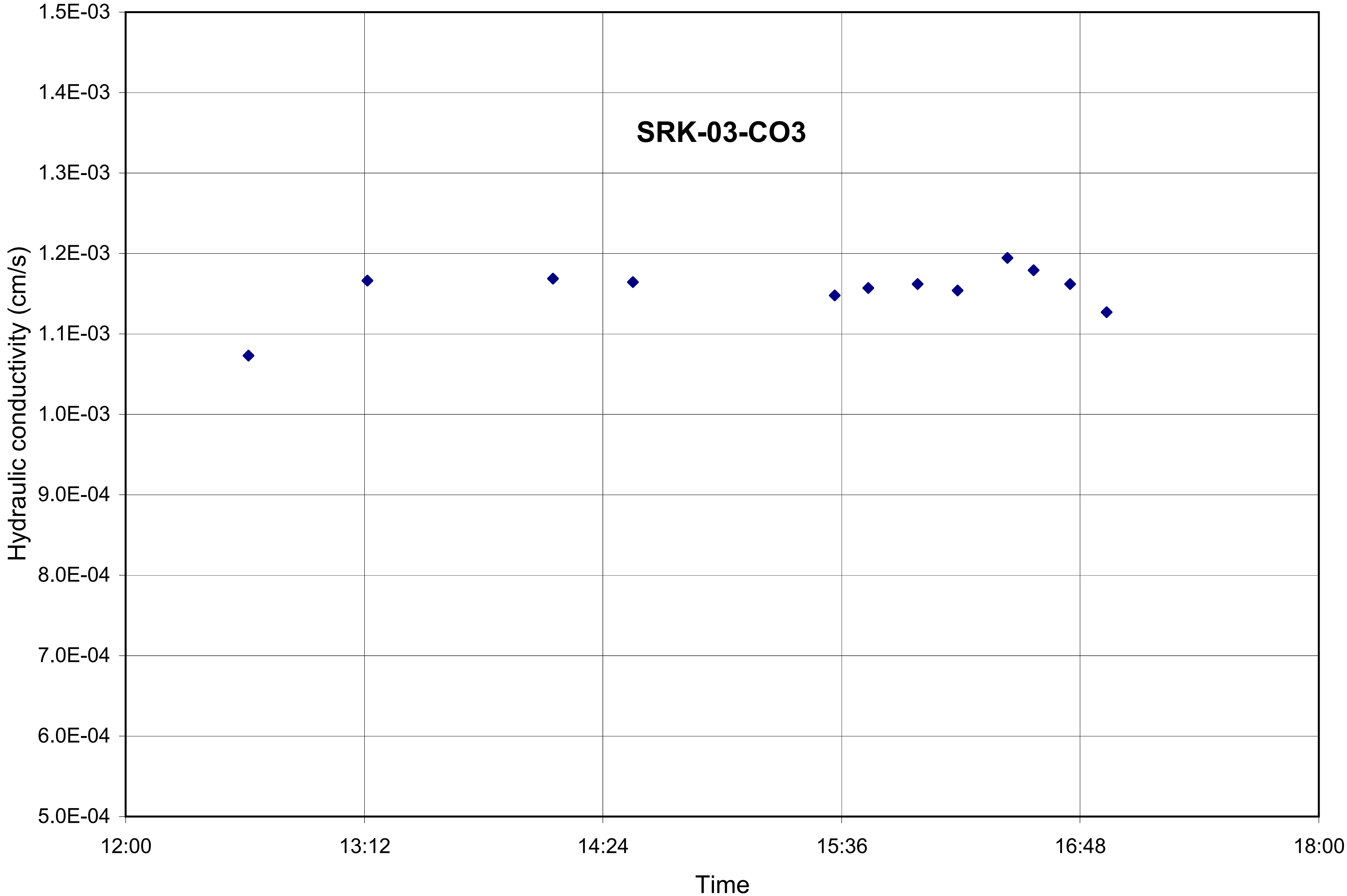
Date: 18-Aug-03

Sample:SRK-03-C03

Initial condition of test specimen

Diameter of specimen, D, cm =	19.95	Weight of wet soil, g =	11353
Height of specimen, L, cm =	16.06	Water content of wet soil, % =	8%
Cross-sectional Area, A, cm^2 =	312.631	Weight of dry soil, g =	10520
		Volume of test specimen, cm^3 =	5021
		Dry density of test specimen, kg/m^3 =	2095

Time		Water level		**Head, h**	**Q cm3**	**t sec**	**Q/At**	**i = h/L**	**k cm/s**
Start	**End**	H_1	H_2	**cm**					
9:36	9:41	26.5	13.4	13.1	88.3	300	9.41E-04	0.816	1.15E-03
12:37	12:42	26.5	13.4	13.1	82.1	300	8.75E-04	0.816	1.07E-03
13:13	13:18	26.5	13.4	13.1	89.2	300	9.51E-04	0.816	1.17E-03
14:09	14:14	26.5	13.4	13.1	89.4	300	9.53E-04	0.816	1.17E-03
14:33	14:38	26.5	13.4	13.1	89.1	300	9.50E-04	0.816	1.16E-03
15:34	15:39	26.5	13.4	13.1	87.8	300	9.36E-04	0.816	1.15E-03
15:44	15:49	26.5	13.4	13.1	88.5	300	9.44E-04	0.816	1.16E-03
15:59	16:04	26.5	13.4	13.1	88.9	300	9.48E-04	0.816	1.16E-03
16:11	16:16	26.5	13.4	13.1	88.3	300	9.41E-04	0.816	1.15E-03
16:26	16:31	26.5	13.4	13.1	91.4	300	9.75E-04	0.816	1.19E-03
16:34	16:39	26.5	13.4	13.1	90.2	300	9.62E-04	0.816	1.18E-03
16:45	16:50	26.5	13.4	13.1	88.9	300	9.48E-04	0.816	1.16E-03
16:56	17:01	26.5	13.4	13.1	86.2	300	9.19E-04	0.816	1.13E-03



SRK-03-CO3
Hydraulic conductivity (cm/s)
1.5E-03
1.4E-03
1.3E-03
1.2E-03
1.1E-03
1.0E-03
9.0E-04
8.0E-04
7.0E-04
6.0E-04
5.0E-04
12:00
13:12
14:24
15:36
16:48
18:00
Time

Appendix B

Field Investigation In-Situ Test Data

Appendix B-1

Single Ring Infiltration Test Data

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Till Cover	**Inner Diameter of Ring:**	57.0	cm
Date:	11-Sep-03	**Inner Area of Ring:**	2551.8	cm^2
Test Pit No.:	VA-CT-TP01	**Lateral Divergence:**	5	cm
Ring No.:	SR-01	**Depth of Wetting Front:**	6.5	cm
Tested By:	Joe Pun	**Water Entry Value:**	-24	cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:35	9:38	3.0	5.0	4.0	1.0	2551.8	20.0
2	9:38	9:42	4.0	5.0	4.0	1.0	2551.8	15.0
3	9:42	15:29	347.0	5.5	5.0	0.5	1275.9	0.1
4								
5								
6								
7								
8								
9								
10								
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12								
13								
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26								
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.2 cm

Average Infiltraiton Rate: 11.7 cm/hr

Infiltration Rate (account for lateral divergence): 8.46 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 4.29E-04 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Till Cover	**Inner Diameter of Ring:**	57.0 cm
Date:	11-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-CT-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-02	**Depth of Wetting Front:**	9 cm
Tested By:	Joe Pun	**Water Entry Value:**	-24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:16	10:02	46.0	5.0	4.0	1.0	2551.8	1.3
2	10:02	12:26	144.0	5.0	4.0	1.0	2551.8	0.4
3	12:26	15:07	161.0	5.0	4.1	0.9	2296.6	0.3
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.7 cm/hr

Infiltration Rate (account for lateral divergence): 0.50 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 3.26E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Till Cover	**Inner Diameter of Ring:**	57.0 cm
Date:	11-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-CT-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-03	**Depth of Wetting Front:**	30 cm
Tested By:	Joe Pun	**Water Entry Value:**	-24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	10:00	10:22	22.0	5.0	4.0	1.0	2551.8	2.7
2	10:22	10:58	36.0	5.0	4.0	1.0	2551.8	1.7
3	10:58	11:35	37.0	5.0	4.0	1.0	2551.8	1.6
4	11:35	12:20	45.0	5.0	4.0	1.0	2551.8	1.3
5	12:20	13:05	45.0	5.0	4.0	1.0	2551.8	1.3
6	13:05	13:50	45.0	5.0	4.0	1.0	2551.8	1.3
7	13:50	14:40	50.0	5.0	4.0	1.0	2551.8	1.2
8	14:40	16:28	108.0	5.0	4.0	1.0	2551.8	0.6
9	16:28	17:18	50.0	5.0	4.2	0.8	2041.4	1.0
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.9 cm/hr

Infiltration Rate (account for lateral divergence): 0.66 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 9.25E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Till Cover	**Inner Diameter of Ring:**	57.0 cm
Date:	11-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-CT-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-04	**Depth of Wetting Front:**	20 cm
Tested By:	Joe Pun	**Water Entry Value:**	-24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	10:13	11:14	61.0	5.0	3.7	1.3	3317.3	1.3
2	11:14	12:25	71.0	5.0	4.0	1.0	2551.8	0.8
3	12:25	14:18	113.0	5.0	4.0	1.0	2551.8	0.5
4	14:18	15:40	82.0	5.0	4.0	1.0	2551.8	0.7
5	15:40	16:59	79.0	5.0	4.0	1.0	2551.8	0.8
6	16:59	17:20	21.0	5.0	4.4	0.6	1531.1	1.7
7								
8								
9								
10								
11								
12								
13								
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16								
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26								
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 1.1 cm/hr

Infiltration Rate (account for lateral divergence): 0.77 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 8.77E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Overburden Dump
Date: 9-Sep-03
Test Pit No.: VA-OD-TP01
Ring No.: SR-01
Tested By: Maritz Rykaart

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 20 cm
Water Entry Value: -24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	14:07	14:11	4.0	5.0	4.0	1.0	2551.8	15.0
2	14:11	14:37	26.0	5.0	3.5	1.5	3827.6	3.5
3	14:38	15:13	35.0	5.0	4.0	1.0	2551.8	1.7
4	15:13	15:45	32.0	5.5	4.0	1.5	3827.6	2.8
5	15:46	16:20	34.0	5.0	4.0	1.0	2551.8	1.8
6	16:20	16:45	25.0	5.0	4.0	1.0	2551.8	2.4
7	16:45	17:01	16.0	5.0	4.5	0.5	1275.9	1.9
8								
9								
10								
11								
12								
13								
14								
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30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 2.0 cm/hr

Infiltration Rate (account for lateral divergence): 1.46 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.65E-04 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Overburden Dump
Date: 9-Sep-03
Test Pit No.: VA-OD-TP01
Ring No.: SR-02
Tested By: Maritz Rykaart

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 20 cm
Water Entry Value: -24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	14:21	14:48	27.0	5.0	4.0	1.0	2551.8	2.2
2	14:49	15:56	67.0	5.0	4.0	1.0	2551.8	0.9
3	15:56	17:07	71.0	5.0	4.1	0.9	2296.6	0.8
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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26								
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 1.3 cm/hr

Infiltration Rate (account for lateral divergence): 0.94 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.06E-04 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Glaciofluvial
Date: 13-Sep-03
Test Pit No.: VA-GF-TP01
Ring No.: SR-01
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 50 cm
Water Entry Value: -8.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:12	9:14	2.0	5.0	4.0	1.0	2551.8	30.0
2	9:14	9:17	3.0	5.0	4.0	1.0	2551.8	20.0
3	9:17	9:20	3.0	5.0	4.0	1.0	2551.8	20.0
4	9:20	9:23	3.0	5.0	4.0	1.0	2551.8	20.0
5	9:23	9:26	3.0	5.0	4.0	1.0	2551.8	20.0
6	9:26	9:30	4.0	5.0	4.0	1.0	2551.8	15.0
7	9:30	9:33	3.0	5.0	4.0	1.0	2551.8	20.0
8	9:33	9:36	3.0	5.0	4.0	1.0	2551.8	20.0
9	9:36	9:39	3.0	5.0	4.0	1.0	2551.8	20.0
10	9:39	9:42	3.0	5.0	4.0	1.0	2551.8	20.0
11	9:42	9:45	3.0	5.0	4.0	1.0	2551.8	20.0
12	9:45	9:49	4.0	5.0	4.0	1.0	2551.8	15.0
13	9:49	9:52	3.0	5.0	4.0	1.0	2551.8	20.0
14	9:52	9:55	3.0	5.0	4.0	1.0	2551.8	20.0
15	9:55	9:58	3.0	5.0	4.0	1.0	2551.8	20.0
16	9:58	10:01	3.0	5.0	4.0	1.0	2551.8	20.0
17	10:01	10:04	3.0	5.0	4.0	1.0	2551.8	20.0
18	10:04	10:07	3.0	5.0	4.0	1.0	2551.8	20.0
19	10:07	10:10	3.0	5.0	4.0	1.0	2551.8	20.0
20	10:10	10:14	4.0	5.0	4.0	1.0	2551.8	15.0
21	10:14	10:17	3.0	5.0	4.0	1.0	2551.8	20.0
22	10:17	10:20	3.0	5.0	4.0	1.0	2551.8	20.0
23	10:20	10:23	3.0	5.0	4.0	1.0	2551.8	20.0
24	10:23	10:27	4.0	5.0	4.0	1.0	2551.8	15.0
25	10:27	10:30	3.0	5.0	4.0	1.0	2551.8	20.0
26								
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 18.3 cm/hr

Infiltration Rate (account for lateral divergence): 13.27 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 2.90E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Glaciofluvial
Date: 13-Sep-03
Test Pit No.: VA-GF-TP01
Ring No.: SR-02
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 10 cm
Water Entry Value: -8.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	12:32	17:10	278.0	5.0	4.2	0.8	2041.4	0.2
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.2 cm/hr

Infiltration Rate (account for lateral divergence): 0.12 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.48E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Glaciofluvial
Date: 13-Sep-03
Test Pit No.: VA-GF-TP01
Ring No.: SR-03
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 20 cm
Water Entry Value: -8.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	13:08	13:30	22.0	5.0	4.0	1.0	2551.8	2.7
2	13:30	14:13	43.0	5.0	4.0	1.0	2551.8	1.4
3	14:13	15:12	59.0	5.0	4.0	1.0	2551.8	1.0
4	15:12	16:19	67.0	5.0	4.0	1.0	2551.8	0.9
5	16:19	17:12	53.0	5.0	4.4	0.6	1531.1	0.7
6								
7								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.9 cm/hr

Infiltration Rate (account for lateral divergence): 0.63 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.04E-04 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Glaciofluvial
Date: 13-Sep-03
Test Pit No.: VA-GF-TP01
Ring No.: SR-04
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 50 cm
Water Entry Value: -8.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	15:39	15:40	1.0	5.0	4.0	1.0	2551.8	60.0
2	15:40	15:42	2.0	5.0	4.0	1.0	2551.8	30.0
3	15:42	15:44	2.0	5.0	4.0	1.0	2551.8	30.0
4	15:44	15:46	2.0	5.0	4.0	1.0	2551.8	30.0
5	15:46	15:48	2.0	5.0	4.0	1.0	2551.8	30.0
6	15:48	15:50	2.0	5.0	4.0	1.0	2551.8	30.0
7	15:50	15:52	2.0	5.0	4.0	1.0	2551.8	30.0
8	15:52	15:54	2.0	5.0	4.0	1.0	2551.8	30.0
9	15:54	15:56	2.0	5.0	4.0	1.0	2551.8	30.0
10	15:56	15:58	2.0	5.0	4.0	1.0	2551.8	30.0
11	15:58	16:00	2.0	5.0	4.0	1.0	2551.8	30.0
12	16:00	16:02	2.0	5.0	4.0	1.0	2551.8	30.0
13	16:02	16:04	2.0	5.0	4.0	1.0	2551.8	30.0
14	16:04	16:06	2.0	5.0	4.0	1.0	2551.8	30.0
15	16:06	16:08	2.0	5.0	4.0	1.0	2551.8	30.0
16	16:08	16:10	2.0	5.0	4.0	1.0	2551.8	30.0
17	16:10	16:12	2.0	5.0	4.0	1.0	2551.8	30.0
18	16:12	16:14	2.0	5.0	4.0	1.0	2551.8	30.0
19	16:14	16:16	2.0	5.0	4.0	1.0	2551.8	30.0
20	16:16	16:18	2.0	5.0	4.0	1.0	2551.8	30.0
21	16:18	16:20	2.0	5.0	4.0	1.0	2551.8	30.0
22	16:20	16:22	2.0	5.0	4.0	1.0	2551.8	30.0
23	16:22	16:24	2.0	5.0	4.0	1.0	2551.8	30.0
24	16:24	16:26	2.0	5.0	4.0	1.0	2551.8	30.0
25	16:26	16:28	2.0	5.0	4.0	1.0	2551.8	30.0
26	16:28	16:30	2.0	5.0	4.0	1.0	2551.8	30.0
27	16:30	16:32	2.0	5.0	4.0	1.0	2551.8	30.0
28	16:32	16:35	3.0	5.0	4.0	1.0	2551.8	20.0
29	16:35	16:37	2.0	5.0	4.0	1.0	2551.8	30.0
30	16:37	16:39	2.0	5.0	4.0	1.0	2551.8	30.0
31	16:39	16:41	2.0	5.0	4.0	1.0	2551.8	30.0
32	16:41	16:44	3.0	5.0	4.0	1.0	2551.8	20.0
33	16:44	16:46	2.5	5.0	4.0	1.0	2551.8	24.0
34	16:46:30	16:49	2.5	5.0	4.0	1.0	2551.8	24.0
35	16:49	16:51	2.5	5.0	4.0	1.0	2551.8	24.0
36	16:51:30	16:54	2.5	5.0	4.0	1.0	2551.8	24.0
37	16:54	16:56	2.0	5.0	4.0	1.0	2551.8	30.0
38	16:56	16:58	2.0	5.0	4.0	1.0	2551.8	30.0
39	16:58	17:00	2.0	5.0	4.0	1.0	2551.8	30.0
40								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 30.0 cm/hr

Infiltration Rate (account for lateral divergence): 21.71 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 4.75E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Embankment Till	**Inner Diameter of Ring:**	57.0	cm
Date:	10-Sep-03	**Inner Area of Ring:**	2551.8	cm^2
Test Pit No.:	VA-ET-TP01	**Lateral Divergence:**	5	cm
Ring No.:	SR-01	**Depth of Wetting Front:**	70	cm
Tested By:	Joe Pun	**Water Entry Value:**	-24	cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:12	9:14	2.0	5.0	4.0	1.0	2551.8	30.0
2	9:14	9:19	5.0	5.0	4.0	1.0	2551.8	12.0
3	9:19	9:30	11.0	5.0	4.0	1.0	2551.8	5.5
4	9:30	9:50	20.0	5.5	4.0	1.5	3827.6	4.5
5	9:50	10:12	22.0	5.0	4.0	1.0	2551.8	2.7
6	10:12	10:31	19.0	5.0	4.0	1.0	2551.8	3.2
7	10:31	10:48	17.0	5.0	4.0	1.0	2551.8	3.5
8	10:48	10:59	11.0	5.0	4.0	1.0	2551.8	5.5
9	10:59	11:13	14.0	5.0	4.0	1.0	2551.8	4.3
10	11:13	11:35	22.0	5.0	4.0	1.0	2551.8	2.7
11	11:35	12:02	27.0	5.0	4.0	1.0	2551.8	2.2
12	12:02	12:32	30.0	5.0	4.0	1.0	2551.8	2.0
13	12:32	13:02	30.0	5.0	4.0	1.0	2551.8	2.0
14	13:02	13:32	30.0	5.0	4.0	1.0	2551.8	2.0
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 2.0 cm/hr

Infiltration Rate (account for lateral divergence): 1.45 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 2.84E-04 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Embankment Till
Date: 10-Sep-03
Test Pit No.: VA-ET-TP01
Ring No.: SR-02
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 20 cm
Water Entry Value: -24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:25	10:23	58.0	5.0	4.0	1.0	2551.8	1.0
2	10:23	11:35	72.0	5.0	4.2	0.8	2041.4	0.7
3	11:35	14:02	147.0	5.1	4.3	0.8	2041.4	0.3
4	14:02	15:20	78.0	5.5	4.5	1.0	2551.8	0.8
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Average Depth of Water in the Ring: 5.2 cm

Average Infiltraiton Rate: 0.6 cm/hr

Infiltration Rate (account for lateral divergence): 0.43 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 4.80E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Embankment Till
Date: 10-Sep-03
Test Pit No.: VA-ET-TP01
Ring No.: SR-03
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 16 cm
Water Entry Value: -24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	13:34	14:28	54.0	5.0	4.0	1.0	2551.8	1.1
2	14:28	17:16	168.0	5.0	4.2	0.8	2041.4	0.3
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5								
6								
7								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.7 cm/hr

Infiltration Rate (account for lateral divergence): 0.51 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 4.99E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Embankment Till	**Inner Diameter of Ring:**	57.0 cm
Date:	10-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-ET-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-04	**Depth of Wetting Front:**	30 cm
Tested By:	Joe Pun	**Water Entry Value:**	-24 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	12:55	13:28	33.0	5.0	4.0	1.0	2551.8	1.8
2	13:28	14:18	50.0	5.0	4.0	1.0	2551.8	1.2
3	14:18	16:00	102.0	5.0	4.0	1.0	2551.8	0.6
4	16:00	17:01	61.0	5.0	4.4	0.6	1531.1	0.6
5								
6								
7								
8								
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30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.8 cm/hr

Infiltration Rate (account for lateral divergence): 0.57 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 8.10E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Faro Slime Tailings	**Inner Diameter of Ring:**	57.0 cm
Date:	14-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	FA-TS-TP01	**Lateral Divergence:**	3 cm
Ring No.:	SR-01	**Depth of Wetting Front:**	1.5 cm
Tested By:	Joe Pun	**Water Entry Value:**	-60 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	10:54	17:06	372.0	5.0	4.9	0.1	255.2	0.02
2								
3								
4								
5								
6								
7								
8								
9								
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11								
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27								
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30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.02 cm/hr

Infiltration Rate (account for lateral divergence): 0.01 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 8.27E-08 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Faro Slime Tailings	**Inner Diameter of Ring:**	57.0 cm
Date:	14-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	FA-TS-TP01	**Lateral Divergence:**	3 cm
Ring No.:	SR-02	**Depth of Wetting Front:**	5 cm
Tested By:	Joe Pun	**Water Entry Value:**	-60 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	11:09	14:14	185.0	5.0	4.0	1.0	2551.8	0.3
2	14:14	17:18	184.0	5.0	4.5	0.5	1275.9	0.2
3								
4								
5								
6								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.2 cm/hr

Infiltration Rate (account for lateral divergence): 0.20 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 3.96E-06 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Faro Slime Tailings
Date: 14-Sep-03
Test Pit No.: FA-TS-TP01
Ring No.: SR-03
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 3 cm
Depth of Wetting Front: 16 cm
Water Entry Value: -60 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	11:24	11:43	19.0	5.0	4.0	1.0	2551.8	3.2
2	11:43	12:35	52.0	5.0	4.0	1.0	2551.8	1.2
3	12:35	13:44	69.0	5.0	4.0	1.0	2551.8	0.9
4	13:44	15:23	99.0	5.0	4.0	1.0	2551.8	0.6
5	15:23	17:19	116.0	5.0	4.0	1.0	2551.8	0.5
6								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.7 cm/hr

Infiltration Rate (account for lateral divergence): 0.54 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 2.98E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Faro Slime Tailings
Date: 14-Sep-03
Test Pit No.: FA-TS-TP01
Ring No.: SR-04
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 3 cm
Depth of Wetting Front: 1.5 cm
Water Entry Value: -60 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	11:49	17:39	350.0	5.0	4.9	0.1	255.2	0.02
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.02 cm/hr

Infiltration Rate (account for lateral divergence): 0.01 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 8.79E-08 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Faro Slime Tailings	**Inner Diameter of Ring:**	57.0 cm
Date:	14-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	FA-TS-TP01	**Lateral Divergence:**	3 cm
Ring No.:	SR-05	**Depth of Wetting Front:**	4.5 cm
Tested By:	Joe Pun	**Water Entry Value:**	-60 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	12:09	17:42	333.0	5.0	4.3	0.7	1786.2	0.13
2								
3								
4								
5								
6								
7								
8								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 0.13 cm/hr

Infiltration Rate (account for lateral divergence): 0.10 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 1.86E-06 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Faro Beach Tailings
Date: 17-Sep-03
Test Pit No.: FA-TB-TP01
Ring No.: SR-01
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 70 cm
Water Entry Value: -42 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:36	9:40	4.0	5.0	4.0	1.0	2551.8	15.0
2	9:40	9:45	5.0	5.0	4.0	1.0	2551.8	12.0
3	9:45	9:50	5.0	5.0	4.0	1.0	2551.8	12.0
4	9:50	9:55	5.0	5.0	4.0	1.0	2551.8	12.0
5	9:55	10:00	5.0	5.0	4.0	1.0	2551.8	12.0
6	10:00	10:05	5.0	5.0	4.0	1.0	2551.8	12.0
7	10:05	10:10	5.0	5.0	4.0	1.0	2551.8	12.0
8	10:10	10:15	5.0	5.0	4.0	1.0	2551.8	12.0
9	10:15	10:20	5.0	5.0	4.0	1.0	2551.8	12.0
10	10:20	10:25	5.0	5.0	4.0	1.0	2551.8	12.0
11	10:25	10:30	5.0	5.0	4.0	1.0	2551.8	12.0
12	10:30	10:35	5.0	5.0	4.0	1.0	2551.8	12.0
13	10:35	10:40	5.0	5.0	4.0	1.0	2551.8	12.0
14	10:40	10:45	5.0	5.0	4.0	1.0	2551.8	12.0
15	10:45	10:50	5.0	5.0	4.0	1.0	2551.8	12.0
16	10:50	10:55	5.0	5.0	4.0	1.0	2551.8	12.0
17	10:55	11:00	5.0	5.0	4.0	1.0	2551.8	12.0
18	11:00	11:04	4.0	5.0	4.0	1.0	2551.8	15.0
19	11:04	11:09	5.0	5.0	4.0	1.0	2551.8	12.0
20	11:09	11:13	4.0	5.0	4.0	1.0	2551.8	15.0
21	11:13	11:19	6.0	5.0	3.5	1.5	3827.6	15.0
22	11:19	11:24	5.0	5.0	4.0	1.0	2551.8	12.0
23	11:24	11:28	4.0	5.0	4.0	1.0	2551.8	15.0
24	11:28	11:33	5.0	5.0	4.0	1.0	2551.8	12.0
25	11:33	11:37	4.0	5.0	4.0	1.0	2551.8	15.0
26	11:37	11:41	4.0	5.0	4.0	1.0	2551.8	15.0
27								
28								
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 14.0 cm/hr

Infiltration Rate (account for lateral divergence): 10.13 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.68E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Faro Beach Tailings
Date: 17-Sep-03
Test Pit No.: FA-TB-TP01
Ring No.: SR-02
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 55 cm
Water Entry Value: -42 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	10:17	10:21	4.0	5.0	4.0	1.0	2551.8	15.0
2	10:21	10:28	7.0	5.0	4.0	1.0	2551.8	8.6
3	10:28	10:34	6.0	5.0	4.0	1.0	2551.8	10.0
4	10:34	10:40	6.0	5.0	4.0	1.0	2551.8	10.0
5	10:40	10:47	7.0	5.0	4.0	1.0	2551.8	8.6
6	10:47	10:54	7.0	5.0	4.0	1.0	2551.8	8.6
7	10:54	11:00	6.0	5.0	4.0	1.0	2551.8	10.0
8	11:00	11:05	5.0	5.0	4.0	1.0	2551.8	12.0
9	11:05	11:10	5.0	5.0	4.0	1.0	2551.8	12.0
10	11:10	11:14	4.0	5.0	4.0	1.0	2551.8	15.0
11	11:14	11:19	5.0	5.0	4.0	1.0	2551.8	12.0
12	11:19	11:23	4.0	5.0	4.0	1.0	2551.8	15.0
13	11:23	11:27	4.0	5.0	4.0	1.0	2551.8	15.0
14	11:27	11:32	5.0	5.0	4.0	1.0	2551.8	12.0
15	11:32	11:36	4.0	5.0	4.0	1.0	2551.8	15.0
16	11:36	11:40	4.0	5.0	4.0	1.0	2551.8	15.0
17	11:40	11:44	4.0	5.0	4.0	1.0	2551.8	15.0
18								
19								
20								
21								
22								
23								
24								
25								
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27								
28								
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30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 15.0 cm/hr

Infiltration Rate (account for lateral divergence): 10.86 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.63E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Faro Beach Tailings
Date: 17-Sep-03
Test Pit No.: FA-TB-TP01
Ring No.: SR-03
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 70 cm
Water Entry Value: -42 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	14:05	14:07	2.0	5.0	4.0	1.0	2551.8	30.0
2	14:07	14:10	3.0	5.0	4.0	1.0	2551.8	20.0
3	14:10	14:14	4.0	5.0	4.0	1.0	2551.8	15.0
4	14:14	14:18	4.0	5.0	4.0	1.0	2551.8	15.0
5	14:18	14:22	4.0	5.0	4.0	1.0	2551.8	15.0
6	14:22	14:27	5.0	5.0	4.0	1.0	2551.8	12.0
7	14:27	14:31	4.0	5.0	4.0	1.0	2551.8	15.0
8	14:31	14:35	4.0	5.0	4.0	1.0	2551.8	15.0
9	14:35	14:40	5.0	5.0	4.0	1.0	2551.8	12.0
10	14:40	14:44	4.0	5.0	4.0	1.0	2551.8	15.0
11	14:44	14:48	4.0	5.0	4.0	1.0	2551.8	15.0
12	14:48	14:52	4.0	5.0	4.0	1.0	2551.8	15.0
13	14:52	14:57	5.0	5.0	4.0	1.0	2551.8	12.0
14	14:57	15:01	4.0	5.0	4.0	1.0	2551.8	15.0
15	15:01	15:05	4.0	5.0	4.0	1.0	2551.8	15.0
16	15:05	15:09	4.0	5.0	4.0	1.0	2551.8	15.0
17	15:09	15:13	4.0	5.0	4.0	1.0	2551.8	15.0
18	15:13	15:17	4.0	5.0	4.0	1.0	2551.8	15.0
19	15:17	15:22	5.0	5.0	4.0	1.0	2551.8	12.0
20	15:22	15:26	4.0	5.0	4.0	1.0	2551.8	15.0
21	15:26	15:31	5.0	5.0	4.0	1.0	2551.8	12.0
22	15:31	15:35	4.0	5.0	4.0	1.0	2551.8	15.0
23	15:35	15:39	4.0	5.0	4.0	1.0	2551.8	15.0
24								
25								
26								
27								
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30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 14.0 cm/hr

Infiltration Rate (account for lateral divergence): 10.13 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.68E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Faro Beach Tailings
Date: 17-Sep-03
Test Pit No.: FA-TB-TP01
Ring No.: SR-04
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 70 cm
Water Entry Value: -42 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	14:32	14:35	3.0	5.0	4.0	1.0	2551.8	20.0
2	14:35	14:38	3.0	5.0	4.0	1.0	2551.8	20.0
3	14:38	14:41	3.0	5.0	4.0	1.0	2551.8	20.0
4	14:41	14:44	3.0	5.0	4.0	1.0	2551.8	20.0
5	14:44	14:48	4.0	5.0	4.0	1.0	2551.8	15.0
6	14:48	14:51	3.0	5.0	4.0	1.0	2551.8	20.0
7	14:51	14:54	3.0	5.0	4.0	1.0	2551.8	20.0
8	14:54	14:57	3.0	5.0	4.0	1.0	2551.8	20.0
9	14:57	15:01	4.0	5.0	4.0	1.0	2551.8	15.0
10	15:01	15:04	3.0	5.0	4.0	1.0	2551.8	20.0
11	15:04	15:08	4.0	5.0	4.0	1.0	2551.8	15.0
12	15:08	15:11	3.0	5.0	4.0	1.0	2551.8	20.0
13	15:11	15:14	3.0	5.0	4.0	1.0	2551.8	20.0
14	15:14	15:17	3.0	5.0	4.0	1.0	2551.8	20.0
15	15:17	15:21	4.0	5.0	4.0	1.0	2551.8	15.0
16	15:21	15:24	3.0	5.0	4.0	1.0	2551.8	20.0
17	15:24	15:27	3.0	5.0	4.0	1.0	2551.8	20.0
18	15:27	15:30	3.0	5.0	4.0	1.0	2551.8	20.0
19	15:30	15:33	3.0	5.0	4.0	1.0	2551.8	20.0
20	15:33	15:36	3.0	5.0	4.0	1.0	2551.8	20.0
21	15:36	15:39	3.0	5.0	4.0	1.0	2551.8	20.0
22	15:39	15:43	4.0	5.0	4.0	1.0	2551.8	15.0
23	15:43	15:47	4.0	5.0	4.0	1.0	2551.8	15.0
24	15:47	15:52	5.0	5.0	4.0	1.0	2551.8	12.0
25	15:52	15:55	3.0	5.0	4.0	1.0	2551.8	20.0
26	15:55	15:59	4.0	5.0	4.0	1.0	2551.8	15.0
27	15:59	16:02	3.0	5.0	4.0	1.0	2551.8	20.0
28	16:02	16:06	4.0	5.0	4.0	1.0	2551.8	15.0
29	16:06	16:10	4.0	5.0	4.0	1.0	2551.8	15.0
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 16.7 cm/hr

Infiltration Rate (account for lateral divergence): 12.06 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 2.00E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Wasterock Dump	**Inner Diameter of Ring:**	57.0 cm
Date:	12-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-WR-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-01	**Depth of Wetting Front:**	55 cm
Tested By:	Joe Pun	**Water Entry Value:**	-1.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:18	9:19	1.0	5.0	4.0	1.0	2551.8	60.0
2	9:19	9:20	1.0	5.0	4.0	1.0	2551.8	60.0
3	9:20	9:22	2.0	5.0	4.0	1.0	2551.8	30.0
4	9:22	9:24	2.0	5.0	4.0	1.0	2551.8	30.0
5	9:24	9:27	3.0	5.0	4.0	1.0	2551.8	20.0
6	9:27	9:30	3.0	5.0	4.0	1.0	2551.8	20.0
7	9:30	9:33	3.0	5.0	4.0	1.0	2551.8	20.0
8	9:33	9:36	3.0	5.0	4.0	1.0	2551.8	20.0
9	9:36	9:39	3.0	5.0	4.0	1.0	2551.8	20.0
10	9:39	9:42	3.0	5.0	4.0	1.0	2551.8	20.0
11	9:42	9:45	3.0	5.0	4.0	1.0	2551.8	20.0
12	9:45	9:50	5.0	5.0	4.0	1.0	2551.8	12.0
13	9:50	9:54	4.0	5.0	4.0	1.0	2551.8	15.0
14	9:54	9:57	3.0	5.0	4.0	1.0	2551.8	20.0
15	9:57	10:01	4.0	5.0	4.0	1.0	2551.8	15.0
16	10:01	10:05	4.0	5.0	4.0	1.0	2551.8	15.0
17	10:05	10:09	4.0	5.0	4.0	1.0	2551.8	15.0
18	10:09	10:13	4.0	5.0	4.0	1.0	2551.8	15.0
19	10:13	10:16	3.0	5.0	4.0	1.0	2551.8	20.0
20	10:16	10:20	4.0	5.0	4.0	1.0	2551.8	15.0
21	10:20	10:24	4.0	5.0	4.0	1.0	2551.8	15.0
22	10:24	10:28	4.0	5.0	4.0	1.0	2551.8	15.0
23	10:28	10:32	4.0	5.0	4.0	1.0	2551.8	15.0
24	10:32	10:36	4.0	5.0	4.0	1.0	2551.8	15.0
25	10:36	10:40	4.0	5.0	4.0	1.0	2551.8	15.0
26	10:40	10:44	4.0	5.0	4.0	1.0	2551.8	15.0
27	10:44	10:48	4.0	5.0	4.0	1.0	2551.8	15.0
28	10:48	10:51	3.0	5.0	4.0	1.0	2551.8	20.0
29								
30								

Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 16.7 cm/hr

Infiltration Rate (account for lateral divergence): 12.06 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 3.00E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Wasterock Dump	**Inner Diameter of Ring:**	57.0 cm
Date:	12-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-WR-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-02	**Depth of Wetting Front:**	8 cm
Tested By:	Joe Pun	**Water Entry Value:**	-1.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:09	10:30	81.0	5.0	4.0	1.0	2551.8	0.7
2	10:30	12:20	110.0	5.0	4.0	1.0	2551.8	0.5
3	12:20	14:18	118.0	5.0	4.0	1.0	2551.8	0.5
4	14:18	17:05	167.0	5.2	4.1	1.1	2806.9	0.4
5								
6								
7								
8								
9								
10								
11								
12								
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27								
28								
29								
30								

Average Depth of Water in the Ring: 5.1 cm

Average Infiltraiton Rate: 0.5 cm/hr

Infiltration Rate (account for lateral divergence): 0.35 cm/hr

Effective Saturated Hydraulic Conductivity K_{fs}: 5.33E-05 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location:	Vangorda Wasterock Dump	**Inner Diameter of Ring:**	57.0 cm
Date:	12-Sep-03	**Inner Area of Ring:**	2551.8 cm^2
Test Pit No.:	VA-WR-TP01	**Lateral Divergence:**	5 cm
Ring No.:	SR-03	**Depth of Wetting Front:**	13 cm
Tested By:	Joe Pun	**Water Entry Value:**	-1.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	9:57	10:07	10.0	5.0	4.0	1.0	2551.8	6.0
2	10:07	10:29	22.0	5.0	3.7	1.3	3317.3	3.5
3	10:29	10:52	23.0	5.0	4.0	1.0	2551.8	2.6
4	10:52	11:13	21.0	5.0	4.0	1.0	2551.8	2.9
5	11:13	11:41	28.0	5.0	4.0	1.0	2551.8	2.1
6	11:41	12:05	24.0	5.0	4.0	1.0	2551.8	2.5
7	12:05	12:27	22.0	5.0	4.0	1.0	2551.8	2.7
8	12:27	12:51	24.0	5.0	4.0	1.0	2551.8	2.5
9	12:51	13:17	26.0	5.0	4.0	1.0	2551.8	2.3
10	13:17	13:42	25.0	5.0	4.0	1.0	2551.8	2.4
11	13:42	14:09	27.0	5.0	4.8	0.2	510.4	0.4
12								
13								
14								
15								
16								
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28								
29								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 2.4 cm/hr

Infiltration Rate (account for lateral divergence): 1.74 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 3.22E-04 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Wasterock Dump
Date: 12-Sep-03
Test Pit No.: VA-WR-TP01
Ring No.: SR-04
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 20 cm
Water Entry Value: -1.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	10:02	10:04	2.0	5.0	4.0	1.0	2551.8	30.0
2				Paused (drained out)				
3				Continued				
4	11:33	11:40	7.0	5.0	4.0	1.0	2551.8	8.6
5	11:40	11:49	9.0	5.0	4.0	1.0	2551.8	6.7
6	11:49	11:58	9.0	5.0	3.7	1.3	3317.3	8.7
7	11:58	12:08	10.0	5.2	4.0	1.2	3062.1	7.2
8	12:08	12:16	8.0	5.0	4.0	1.0	2551.8	7.5
9	12:16	12:22	6.0	5.0	4.0	1.0	2551.8	10.0
10	12:22	12:28	6.0	5.0	4.0	1.0	2551.8	10.0
11	12:28	12:35	7.0	5.0	4.0	1.0	2551.8	8.6
12	12:35	12:42	7.0	5.0	4.0	1.0	2551.8	8.6
13	12:42	12:49	7.0	5.0	4.0	1.0	2551.8	8.6
14	12:49	12:56	7.0	5.0	4.0	1.0	2551.8	8.6
15	12:56	13:03	7.0	5.0	4.0	1.0	2551.8	8.6
16	13:03	13:10	7.0	5.0	4.0	1.0	2551.8	8.6
17	13:10	13:16	6.0	5.0	4.0	1.0	2551.8	10.0
18	13:16	13:24	8.0	5.0	4.0	1.0	2551.8	7.5
19	13:24	13:31	7.0	5.0	4.0	1.0	2551.8	8.6
20	13:31	13:38	7.0	5.0	4.0	1.0	2551.8	8.6
21	13:38	13:44	6.0	5.0	4.0	1.0	2551.8	10.0
22								
23								
24								
25								
26								
27								
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Average Depth of Water in the Ring: 5.0 cm
Average Infiltraiton Rate: 9.0 cm/hr

Infiltration Rate (account for lateral divergence): 6.55 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 1.37E-03 cm/sec

Single Ring Infiltrometer Calculation Sheet

Location: Vangorda Wasterock Dump
Date: 12-Sep-03
Test Pit No.: VA-WR-TP05
Ring No.: SR-03
Tested By: Joe Pun

Inner Diameter of Ring: 57.0 cm
Inner Area of Ring: 2551.8 cm^2
Lateral Divergence: 5 cm
Depth of Wetting Front: 40 cm
Water Entry Value: -1.5 cm

No.	Start Time (hh:mm)	End Time (hh:mm)	Time Elapsed (min)	Initial Water Level (cm)	Ending Water Level (cm)	Change in Water Level (cm)	Incremental Ring Volume (cm^3)	Infiltration Rate (cm/hr)
1	14:51	14:57	6.0	5.0	4.0	1.0	2551.8	10.0
2	14:57	15:05	8.0	5.0	4.0	1.0	2551.8	7.5
3	15:05	15:14	9.0	5.0	4.0	1.0	2551.8	6.7
4	15:14	15:24	10.0	5.0	4.0	1.0	2551.8	6.0
5	15:24	15:35	11.0	5.0	4.0	1.0	2551.8	5.5
6	15:35	15:46	11.0	5.0	4.0	1.0	2551.8	5.5
7	15:46	15:57	11.0	5.0	4.0	1.0	2551.8	5.5
8	15:57	16:09	12.0	5.0	4.0	1.0	2551.8	5.0
9	16:09	16:22	13.0	5.0	4.0	1.0	2551.8	4.6
10	16:22	16:33	11.0	5.0	4.0	1.0	2551.8	5.5
11	16:33	16:44	11.0	5.0	4.0	1.0	2551.8	5.5
12								
13								
14								
15								
16								
17								
18								
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27								
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Average Depth of Water in the Ring: 5.0 cm

Average Infiltraiton Rate: 5.2 cm/hr

Infiltration Rate (account for lateral divergence): 3.75 cm/hr
Effective Saturated Hydraulic Conductivity K_{fs}: 8.95E-04 cm/sec

Appendix B-2

Guelph Permeameter Infiltration Test Data

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 9, 2003
Investigator:	Maritz Rykaart
Location:	Vangorda Overburden Dump
Site:	VA-OD-TP01-GP01
Dominant Soil Type:	Clay/Gravel & Boulders
Depth of Well Hole:	20 cm

Volumetric Moisture Content

Initial Moisture Content, θ_i:	0.110
Final Moisture Content, θ_{fs}:	0.139
Moisture Content Difference, $\Delta\theta$:	0.029

Resavoir X Constant:	35.22 cm^2
Resavoir Y Constant:	2.15 cm^2
Both Resavoirs Used:	Yes
Only Inner Resavoir Used:	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	15:53	0.00	0.0	0.0	0.000
2	15:53:30	0.50	1.6	1.6	0.053
3	15:55	1.50	2.0	0.4	0.004
4	16:02	7.00	3.2	1.2	0.003
5	16:05	3.00	3.9	0.7	0.004
6	16:10	5.00	4.8	0.9	0.003
7	16:15	5.00	6.5	1.7	0.006
8	16:20	5.00	8.1	1.6	0.005
9	16:25	5.00	10.0	1.9	0.006
10	16:30	5.00	11.4	1.4	0.005
11	16:35	5.00	12.8	1.4	0.005
12	16:40	5.00	14.2	1.4	0.005
13					
14					
15					
16					
17					
18					
19					
20					

$R1_{avg}$: **0.005 cm/sec**

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	16:41	0.00	14.5	0.0	0.000
2	16:42	1.00	14.7	0.2	0.003
3	16:45	3.00	15.7	1.0	0.006
4	16:50	5.00	17.1	1.4	0.005
5	16:55	5.00	18.5	1.4	0.005
6	17:00	5.00	19.8	1.3	0.004
7	17:05	5.00	21.1	1.3	0.004
8	17:10	5.00	22.4	1.3	0.004
9	17:15	5.00	23.7	1.3	0.004
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

$R2_{avg}$: **0.004 cm/sec**

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	-2.62E-04	cm/sec
Matric Flux Potential, ϕ_m:	5.78E-03	cm^2/sec
Sorptivity, S:	0.0183	$cm/sec^{-1/2}$
Alpha Parameter, α:	-0.0453	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	-1.60E-05	cm/sec
Matric Flux Potential, ϕ_m:	3.53E-04	cm^2/sec
Sorptivity, S:	0.0045	$cm/sec^{-1/2}$
Alpha Parameter, α:	-0.0453	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Sample (g)		
Tare + Dry Sample (g)		
Weight Water (g)	0	0
Weight Dry Sample (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	11.0%	13.9%

Special Note: A negative result indicates soil heterogeneities - further testing required

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 10, 2003
Investigator:	Maritz Rykaart/Joe Pun
Location:	Vangorda Embankment Till
Site:	VA-ET-TP01-GP01
Dominant Soil Type:	Sand/Silt
Depth of Well Hole:	20 cm

Volumetric Moisture Content

Initial Moisture Content, θ_i:	0.115
Final Moisture Content, θ_{fs}:	0.185
Moisture Content Difference, $\Delta\theta$:	0.070

Resavoir X Constant:	35.22	cm^2
Resavoir Y Constant:	2.15	cm^2

Both Resavoirs Used:	Yes
Only Inner Resavoir Used:	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	10:00	0.00	0.0	0.0	0.000
2	10:01	1.00	2.4	2.4	0.040
3	10:05	4.00	3.1	0.7	0.003
4	10:15	10.00	4.2	1.1	0.002
5	10:25	10.00	5.4	1.2	0.002
6	10:35	10.00	6.3	0.9	0.001
7	10:45	10.00	7.2	0.9	0.002
8	10:55	10.00	8.1	0.9	0.002
9	11:05	10.00	9.0	0.9	0.001
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

$R1_{avg}$: 0.002 cm/sec

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	11:17	0.00	13.5	0.0	0.000
2	11:18	1.00	13.7	0.2	0.003
3	11:20	2.00	14.0	0.3	0.003
4	11:25	5.00	15.0	1.0	0.003
5	11:30	5.00	15.8	0.8	0.003
6	11:40	10.00	17.5	1.7	0.003
7	11:50	10.00	19.1	1.6	0.003
8	12:00	10.00	21.0	1.9	0.003
9	12:10	10.00	23.0	2.0	0.003
10	12:20	10.00	24.6	1.6	0.003
11	12:30	10.00	26.8	2.2	0.004
12	12:40	10.00	28.0	1.2	0.002
13	12:50	10.00	31.4	3.4	0.006
14	13:00	10.00	35.7	4.3	0.007
15	13:10	10.00	36.2	0.5	0.001
16	13:20	10.00	39.2	3.0	0.005
17	13:30	10.00	42.2	3.0	0.005
18	13:40	10.00	45.5	3.3	0.006
19	13:50	10.00	48.8	3.3	0.005
20					

$R2_{avg}$: 0.005 cm/sec

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	4.85E-04	cm/sec
Matric Flux Potential, ϕ_m:	-1.43E-03	cm^2/sec
Sorptivity, S:	#NUM!	$cm/sec^{-1/2}$
Alpha Parameter, α:	-0.3391	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	2.96E-05	cm/sec
Matric Flux Potential, ϕ_m:	-8.73E-05	cm^2/sec
Sorptivity, S:	#NUM!	$cm/sec^{-1/2}$
Alpha Parameter, α:	-0.3391	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Sample (g)		
Tare + Dry Sample (g)		
Weight Water (g)	0	0
Weight Dry Sample (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	11.5%	18.5%

Special Note: A negative result indicates soil heterogeneities - further testing required

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 10, 2003
Investigator:	Joe Pun
Location:	Vangorda Embankment Till
Site:	VA-ET-TP01-GP02
Dominant Soil Type:	Sand/Silt
Depth of Well Hole:	20 cm

Volumetric Moisture Content

Initial Moisture Content, θ_i:	0.114
Final Moisture Content, θ_{fs}:	0.185
Moisture Content Difference, $\Delta\theta$:	0.071

Resavoir X Constant:	35.22	cm^2
Resavoir Y Constant:	2.15	cm^2

Both Resavoirs Used:	Yes
Only Inner Resavoir Used:	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	14:43	0.00	0.0	0.0	0.000
2	14:44	1.00	1.8	1.8	0.030
3	14:45	1.00	4.0	2.2	0.037
4	14:46	1.00	6.3	2.3	0.038
5	14:47	1.00	8.4	2.1	0.035
6	14:48	1.00	10.4	2.0	0.033
7	14:49	1.00	12.4	2.0	0.033
8	14:50	1.00	14.0	1.6	0.027
9	14:51	1.00	16.1	2.1	0.035
10	14:52	1.00	18.0	1.9	0.032
11	14:53	1.00	19.8	1.8	0.030
12	14:54	1.00	21.8	2.0	0.033
13	14:55	1.00	23.6	1.8	0.030
14	14:56	1.00	25.5	1.9	0.032
15	14:57	1.00	27.3	1.8	0.030
16	14:58	1.00	29.1	1.8	0.030
17	14:59	1.00	30.8	1.7	0.028
18	15:00	1.00	32.4	1.6	0.027
19	15:01	1.00	34.0	1.6	0.027
20	15:02	1.00	35.6	1.6	0.027

$R1_{avg}$: 0.027 cm/sec

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	15:13	0.00	0.0	0.0	0.000
2	15:41	28.00	2.4	2.4	0.001
3	15:51	10.00	4.4	2.0	0.003
4	15:56	5.00	5.9	1.5	0.005
5	16:02	6.00	7.2	1.3	0.004
6	16:07	5.00	9.4	2.2	0.007
7	16:12	5.00	11.6	2.2	0.007
8	16:17	5.00	13.9	2.3	0.008
9	16:22	5.00	15.7	1.8	0.006
10	16:29	7.00	18.1	2.4	0.006
11	16:34	5.00	20.3	2.2	0.007
12	16:39	5.00	22.5	2.2	0.007
13	16:44	5.00	24.0	1.5	0.005
14	16:49	5.00	25.6	1.6	0.005
15	16:54	5.00	27.2	1.6	0.005
16	16:59	5.00	28.7	1.5	0.005
17	17:04	5.00	30.2	1.5	0.005
18	17:09	5.00	31.7	1.5	0.005
19					
20					

$R2_{avg}$: 0.005 cm/sec

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	-4.35E-03	cm/sec
Matric Flux Potential, ϕ_m:	4.95E-02	cm^2/sec
Sorptivity, S:	0.0839	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	-0.0878	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	-2.66E-04	cm/sec
Matric Flux Potential, ϕ_m:	3.02E-03	cm^2/sec
Sorptivity, S:	0.0207	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	-0.0878	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Spmple (g)		
Tare + Dry Spmple (g)		
Weight Water (g)	0	0
Weight Dry Spmple (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	11.4%	18.5%

Special Note: A negative result indicates soil heterogeneities - further testing required

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 18, 2003
Investigator:	Joe Pun
Location:	Faro Beach Tailings
Site:	FA-TB-TP01-GP01
Dominant Soil Type:	Beach Tailings
Depth of Well Hole:	20 cm

Volumetric Moisture Content

Initial Moisture Content, θ_i:	0.067
Final Moisture Content, θ_{fs}:	0.235
Moisture Content Difference, $\Delta\theta$:	**0.168**

Resavoir X Constant:	35.22	cm^2
Resavoir Y Constant:	2.15	cm^2

Both Resavoirs Used:	Yes
Only Inner Resavoir Used:	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	16:11	0.00	0.0	0.0	0.000
2	16:12	1.00	4.7	4.7	0.078
3	16:13	1.00	6.5	1.8	0.030
4	16:14	1.00	8.9	2.4	0.040
5	16:15	1.00	10.0	1.1	0.018
6	16:16	1.00	11.6	1.6	0.027
7	16:17	1.00	13.4	1.8	0.030
8	16:18	1.00	15.1	1.7	0.028
9	16:19	1.00	16.8	1.7	0.028
10	16:20	1.00	18.4	1.6	0.027
11	16:21	1.00	20.1	1.7	0.028
12					
13					
14					
15					
16					
17					
18					
19					
20					

$R1_{avg}$: 0.028 cm/sec

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	16:22	0.00	26.9	0.0	0.000
2	16:23	1.00	31.1	4.2	0.070
3	16:24	1.00	35.0	3.9	0.065
4	16:25	1.00	38.7	3.7	0.062
5	16:26	1.00	42.4	3.7	0.062
6	16:27	1.00	46.2	3.8	0.063
7	16:28	1.00	49.7	3.5	0.058
8	16:29	1.00	53.3	3.6	0.060
9	16:30	1.00	57.2	3.9	0.065
10	16:31	1.00	61.5	4.3	0.072
11	16:32	1.00	65.3	3.8	0.063
12	16:33	1.00	69.1	3.8	0.063
13	16:34	1.00	72.9	3.8	0.063
14					
15					
16					
17					
18					
19					
20					

$R2_{avg}$: 0.063 cm/sec

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	3.86E-03	cm/sec
Matric Flux Potential, ϕ_m:	3.10E-03	cm^2/sec
Sorptivity, S:	0.0323	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	1.2478	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	2.36E-04	cm/sec
Matric Flux Potential, ϕ_m:	1.89E-04	cm^2/sec
Sorptivity, S:	0.0080	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	1.2478	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Spmple (g)		
Tare + Dry Spmple (g)		
Weight Water (g)	0	0
Weight Dry Spmple (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	6.7%	23.5%

Special Note: A negative result indicates soil heterogeneities - further testing required

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 19, 2003
Investigator:	Joe Pun
Location:	Faro Beach Tailings
Site:	FA-TB-TP01-GP01
Dominant Soil Type:	Beach Tailings
Depth of Well Hole:	50 cm

Volumetric Moisture Content

Initial Moisture Content, θ_i:	0.067
Final Moisture Content, θ_{fs}:	0.235
Moisture Content Difference, $\Delta\theta$:	0.168

Resavoir X Constant:	35.22	cm^2
Resavoir Y Constant:	2.15	cm^2

Both Resavoirs Used:	Yes
Only Inner Resavoir Used:	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	10:39	0.00	0	0.0	0.000
2	10:40	1.00	4.9	4.9	0.082
3	10:41	1.00	8.2	3.3	0.055
4	10:42	1.00	11.2	3.0	0.050
5	10:43	1.00	14.0	2.8	0.047
6	10:44	1.00	16.9	2.9	0.048
7	10:45	1.00	19.6	2.7	0.045
8	10:46	1.00	22.2	2.6	0.043
9	10:47	1.00	25.0	2.8	0.047
10	10:48	1.00	27.8	2.8	0.047
11	10:49	1.00	30.6	2.8	0.047
12	10:50	1.00	33.5	2.9	0.048
13					
14					
15					
16					
17					
18					
19					
20					

$R1_{avg}$: 0.047 cm/sec

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	10:51	0.00	36.2	0.0	0.000
2	10:52	1.00	45.1	8.9	0.148
3	10:53	1.00	50.0	4.9	0.082
4	10:54	1.00	54.5	4.5	0.075
5	10:55	1.00	59.3	4.8	0.080
6	10:56	1.00	63.7	4.4	0.073
7	10:57	1.00	68.2	4.5	0.075
8	10:58	1.00	72.7	4.5	0.075
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

$R2_{avg}$: 0.074 cm/sec

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	1.77E-03	cm/sec
Matric Flux Potential, ϕ_m:	3.30E-02	cm^2/sec
Sorptivity, S:	0.1053	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	0.0536	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	1.08E-04	cm/sec
Matric Flux Potential, ϕ_m:	2.01E-03	cm^2/sec
Sorptivity, S:	0.0260	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	0.0536	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Spmple (g)		
Tare + Dry Spmple (g)		
Weight Water (g)	0	0
Weight Dry Spmple (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	6.7%	23.5%

Special Note: A negative result indicates soil heterogeneities - further testing required

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 19, 2003
Investigator:	Joe Pun
Location:	Faro Beach Tailings
Site:	FA-TB-TP01-GP02
Dominant Soil Type:	Beach Tailings
Depth of Well Hole:	20 cm

Volumetric Moisture Content

Initial Moisture Content, θ_i:	0.067
Final Moisture Content, θ_{fs}:	0.235
Moisture Content Difference, $\Delta\theta$:	0.168

Resavoir X Constant:	35.22	cm^2
Resavoir Y Constant:	2.15	cm^2

Both Resavoirs Used:	Yes
Only Inner Resavoir Used:	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	11:44	0.00	0	0.0	0.000
2	11:45	1.00	4.4	4.4	0.073
3	11:46	1.00	6.5	2.1	0.035
4	11:47	1.00	8.3	1.8	0.030
5	11:48	1.00	10.2	1.9	0.032
6	11:49	1.00	12.0	1.8	0.030
7	11:50	1.00	13.7	1.7	0.028
8	11:51	1.00	15.5	1.8	0.030
9	11:52	1.00	17.3	1.8	0.030
10	11:53	1.00	19.1	1.8	0.030
11					
12					
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17					
18					
19					
20					

$R1_{avg}$: 0.030 cm/sec

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	11:54	0.00	20.9	0.0	0.000
2	11:55	1.00	29.3	8.4	0.140
3	11:56	1.00	34.3	5.0	0.083
4	11:57	1.00	38.8	4.5	0.075
5	11:58	1.00	43.4	4.6	0.077
6	11:59	1.00	48.0	4.6	0.077
7	12:00	1.00	52.0	4.0	0.067
8	12:01	1.00	56.5	4.5	0.075
9	12:02	1.00	61.1	4.6	0.077
10	12:03	1.00	65.3	4.2	0.070
11	12:04	1.00	69.5	4.2	0.070
12	12:05	1.00	73.7	4.2	0.070
13					
14					
15					
16					
17					
18					
19					
20					

$R2_{avg}$: 0.070 cm/sec

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	4.40E-03	cm/sec
Matric Flux Potential, ϕ_m:	2.01E-03	cm^2/sec
Sorptivity, S:	0.0260	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	2.1930	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	2.69E-04	cm/sec
Matric Flux Potential, ϕ_m:	1.23E-04	cm^2/sec
Sorptivity, S:	0.0064	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	2.1930	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Spmple (g)		
Tare + Dry Spmple (g)		
Weight Water (g)	0	0
Weight Dry Spmple (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	6.7%	23.5%

Special Note: A negative result indicates soil heterogeneities - further testing required

GUELPH INFILTROMETER CALCULATION SHEET

Date:	September 19, 2003		**Volumetric Moisture Content**	
Investigator:	Joe Pun		**Initial Moisture Content, θ_i:**	0.067
Location:	Faro Beach Tailings		**Final Moisture Content, θ_{fs}:**	0.235
Site:	FA-TB-TP01-GP02		**Moisture Content Difference, $\Delta\theta$:**	**0.168**
Dominant Soil Type:	Beach Tailings			
Depth of Well Hole:	50 cm			

Resavoir X Constant:	35.22	cm^2	**Both Resavoirs Used:**	Yes
Resavoir Y Constant:	2.15	cm^2	**Only Inner Resavoir Used:**	

Reading Set #1 - H1 = 5 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	12:26	0.00	0	0.0	0.000
2	12:27	1.00	5.0	5.0	0.083
3	12:28	1.00	8.1	3.1	0.052
4	12:29	1.00	10.8	2.7	0.045
5	12:30	1.00	13.5	2.7	0.045
6	12:31	1.00	16.2	2.7	0.045
7	12:32	1.00	19.0	2.8	0.047
8	12:33	1.00	21.7	2.7	0.045
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

$R1_{avg}$: 0.046 cm/sec

Reading Set #1 - H1 = 10 cm:

No.	Time [hh:mm]	Time Int. [min]	Water Level [cm]	Level Change [cm]	Rate of Change, R1 [cm/sec]
1	12:37	0.00	0	0.0	0.000
2	12:38	1.00	7.0	7.0	0.117
3	12:39	1.00	12.8	5.8	0.097
4	12:40	1.00	15.7	2.9	0.048
5	12:41	1.00	20.0	4.3	0.072
6	12:42	1.00	24.2	4.2	0.070
7	12:43	1.00	28.2	4.0	0.067
8	12:44	1.00	32.7	4.5	0.075
9	12:45	1.00	36.8	4.1	0.068
10	12:46	1.00	41.2	4.4	0.073
11	12:47	1.00	45.6	4.4	0.073
12	12:48	1.00	50.0	4.4	0.073
13	12:49	1.00	54.4	4.4	0.073
14					
15					
16					
17					
18					
19					
20					

$R2_{avg}$: 0.073 cm/sec

When Using Both Resavoirs

Field Saturated Hyd. Cond., K_{fs}:	1.93E-03	cm/sec
Matric Flux Potential, ϕ_m:	3.06E-02	cm^2/sec
Sorptivity, S:	0.1013	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	0.0630	1/cm

When Using Only Inner Resavoir

Field Saturated Hyd. Cond., K_{fs}:	1.18E-04	cm/sec
Matric Flux Potential, ϕ_m:	1.87E-03	cm^2/sec
Sorptivity, S:	0.0250	$cm/sec^{-1/2}$
Alpha Parpmeter, a:	0.0630	1/cm

Field Measured Moisture Contents

	Before	After
Tare (g)		
Tare + Wet Spmple (g)		
Tare + Dry Spmple (g)		
Weight Water (g)	0	0
Weight Dry Spmple (g)	0	0
Gravimetric Moisture Content	-	-
Water Density (g/cm^3)	1.000	
Tailings Dry Density (g/cm^3)	1.400	
Water Volume (cm^3)	0.00	0.00
Total Volume (cm^3)	0.00	0.00
Volumetric Moisture Content	6.7%	23.5%

Special Note: A negative result indicates soil heterogeneities - further testing required

Appendix B-3

Sand Cone In-Situ Density Test Data

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Embankment Till

Soil Description :	Well-grained silt, clay	Test Pit # :	VA-ET-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-01
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1650.1
Mass of Wet Sample Removed From Hole (g)	1609.7
Water Content (%)	10.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3261.4
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3134.4
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	905.0
Mass of Dry Soil Removed From Test Hole (g)	1455.4
In-Situ Wet Density (g/cm^3)	1.8
In-Situ Dry Density (g/cm^3)	1.6

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Embankment Till

Soil Description :	Well-grained silt, clay	Test Pit # :	VA-ET-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-02
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1427.4
Mass of Wet Sample Removed From Hole (g)	1387.0
Water Content (%)	10.1
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3323.6
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3072.2
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	861.4
Mass of Dry Soil Removed From Test Hole (g)	1259.8
In-Situ Wet Density (g/cm^3)	1.6
In-Situ Dry Density (g/cm^3)	1.5

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Embankment Till

Soil Description :	Well-grained silt, clay	Test Pit # :	VA-ET-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-03
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1981.6
Mass of Wet Sample Removed From Hole (g)	1941.2
Water Content (%)	10.5
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	2650.4
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3745.4
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1333.9
Mass of Dry Soil Removed From Test Hole (g)	1756.7
In-Situ Wet Density (g/cm^3)	1.5
In-Situ Dry Density (g/cm^3)	1.3

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Till Cover

Soil Description :	Sand, silt, cobbles	Test Pit # :	VA-CT-TP01
Sand Type:	Ottawa Sand	Test Date:	11-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-01
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Maritz Rykaart

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2149.2
Mass of Wet Sample Removed From Hole (g)	2108.8
Water Content (%)	7.9
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3089.2
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3306.6
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1025.9
Mass of Dry Soil Removed From Test Hole (g)	1954.4
In-Situ Wet Density (g/cm^3)	2.1
In-Situ Dry Density (g/cm^3)	1.9

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Till Cover

Soil Description :	Sand, silt, cobbles	Test Pit # :	VA-CT-TP01
Sand Type:	Ottawa Sand	Test Date:	11-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-02
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Maritz Rykaart

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1841.5
Mass of Wet Sample Removed From Hole (g)	1801.1
Water Content (%)	8.0
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3390.5
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3005.3
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	814.4
Mass of Dry Soil Removed From Test Hole (g)	1667.7
In-Situ Wet Density (g/cm^3)	2.2
In-Situ Dry Density (g/cm^3)	2.0

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Till Cover

Soil Description :	Sand, silt, cobbles	Test Pit # :	VA-CT-TP01
Sand Type:	Ottawa Sand	Test Date:	15-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-03
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1743.9
Mass of Wet Sample Removed From Hole (g)	1703.5
Water Content (%)	11.3
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3307.2
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3088.6
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	872.9
Mass of Dry Soil Removed From Test Hole (g)	1530.5
In-Situ Wet Density (g/cm^3)	2.0
In-Situ Dry Density (g/cm^3)	1.8

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Till Cover

Soil Description :	Sand, silt, cobbles	Test Pit # :	VA-CT-TP01
Sand Type:	Ottawa Sand	Test Date:	15-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-04
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1540.1
Mass of Wet Sample Removed From Hole (g)	1499.7
Water Content (%)	10.1
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3358.9
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3036.9
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	836.6
Mass of Dry Soil Removed From Test Hole (g)	1362.1
In-Situ Wet Density (g/cm^3)	1.8
In-Situ Dry Density (g/cm^3)	1.6

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Overburden Dump

Soil Description :	Clay, sand, cobbles	Test Pit # :	VA-OD-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-01
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1517.1
Mass of Wet Sample Removed From Hole (g)	1476.7
Water Content (%)	11.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3474.7
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	2921.1
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	755.3
Mass of Dry Soil Removed From Test Hole (g)	1323.2
In-Situ Wet Density (g/cm^3)	2.0
In-Situ Dry Density (g/cm^3)	1.8

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Overburden Dump

Soil Description :	Clay, sand, cobbles	Test Pit # :	VA-OD-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-02
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1634.4
Mass of Wet Sample Removed From Hole (g)	1594.0
Water Content (%)	12.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3463.0
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	2932.8
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	763.5
Mass of Dry Soil Removed From Test Hole (g)	1415.6
In-Situ Wet Density (g/cm^3)	2.1
In-Situ Dry Density (g/cm^3)	1.9

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Overburden Dump

Soil Description :	Clay, sand, cobbles	Test Pit # :	VA-OD-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-03
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1821.2
Mass of Wet Sample Removed From Hole (g)	1780.8
Water Content (%)	8.7
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3180.5
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3215.3
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	961.8
Mass of Dry Soil Removed From Test Hole (g)	1638.3
In-Situ Wet Density (g/cm^3)	1.9
In-Situ Dry Density (g/cm^3)	1.7

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Glaciofluvial Deposit

Soil Description :	Sand & Silt	Test Pit # :	VA-GF-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-01
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1816.0
Mass of Wet Sample Removed From Hole (g)	1775.6
Water Content (%)	4.1
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3264.7
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3131.1
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	902.7
Mass of Dry Soil Removed From Test Hole (g)	1705.7
In-Situ Wet Density (g/cm^3)	2.0
In-Situ Dry Density (g/cm^3)	1.9

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Glaciofluvial Deposit			
Soil Description :	Sand & Silt	Test Pit # :	VA-GF-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-02
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2071.4
Mass of Wet Sample Removed From Hole (g)	2031.0
Water Content (%)	4.2
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3203.2
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3192.6
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	945.9
Mass of Dry Soil Removed From Test Hole (g)	1949.1
In-Situ Wet Density (g/cm^3)	2.1
In-Situ Dry Density (g/cm^3)	2.1

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Vangorda Glaciofluvial Deposit

Soil Description :	Sand & Silt	Test Pit # :	VA-GF-TP01
Sand Type:	Ottawa Sand	Test Date:	16-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-03
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1925.5
Mass of Wet Sample Removed From Hole (g)	1885.1
Water Content (%)	4.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3319.7
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3076.1
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	864.1
Mass of Dry Soil Removed From Test Hole (g)	1802.2
In-Situ Wet Density (g/cm^3)	2.2
In-Situ Dry Density (g/cm^3)	2.1

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Faro Slime Tailings

Soil Description : Slime Tailings	Test Pit # : FA-TS-TP01
Sand Type: Ottawa Sand	Test Date: 14-Sep-03
Specific Gravity of Sand: 2.65	Test No: SC-01
Sand Bulk Density (g/cm^3): 1.42	Tested By: Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2428.0
Mass of Wet Sample Removed From Hole (g)	2387.6
Water Content (%)	20.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	2848.4
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3547.4
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1194.9
Mass of Dry Soil Removed From Test Hole (g)	1979.8
In-Situ Wet Density (g/cm^3)	2.0
In-Situ Dry Density (g/cm^3)	1.7

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Faro Slime Tailings

Soil Description :	Slime Tailings	Test Pit # :	FA-TS-TP01
Sand Type:	Ottawa Sand	Test Date:	14-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-02
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2364.1
Mass of Wet Sample Removed From Hole (g)	2323.7
Water Content (%)	22.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3034.8
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3361.0
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1064.1
Mass of Dry Soil Removed From Test Hole (g)	1895.4
In-Situ Wet Density (g/cm^3)	2.2
In-Situ Dry Density (g/cm^3)	1.8

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Faro Slime Tailings

Soil Description :	Slime Tailings	Test Pit # :	FA-TS-TP01
Sand Type:	Ottawa Sand	Test Date:	14-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-03
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2270.5
Mass of Wet Sample Removed From Hole (g)	2230.1
Water Content (%)	23.2
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	3202.7
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3193.1
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	946.2
Mass of Dry Soil Removed From Test Hole (g)	1810.1
In-Situ Wet Density (g/cm^3)	2.4
In-Situ Dry Density (g/cm^3)	1.9

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Faro Beach Tailings

Soil Description :	Beach Tailings	Test Pit # :	FA-TB-TP01
Sand Type:	Ottawa Sand	Test Date:	17-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-01
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	1983.9
Mass of Wet Sample Removed From Hole (g)	1943.5
Water Content (%)	11.0
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	2806.0
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3589.8
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1224.7
Mass of Dry Soil Removed From Test Hole (g)	1750.9
In-Situ Wet Density (g/cm^3)	1.6
In-Situ Dry Density (g/cm^3)	1.4

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Faro Beach Tailings

Soil Description :	Beach Tailings	Test Pit # :	FA-TB-TP01
Sand Type:	Ottawa Sand	Test Date:	17-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-02
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2087.9
Mass of Wet Sample Removed From Hole (g)	2047.5
Water Content (%)	11.7
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	2600.4
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	3795.4
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1369.0
Mass of Dry Soil Removed From Test Hole (g)	1833.0
In-Situ Wet Density (g/cm^3)	1.5
In-Situ Dry Density (g/cm^3)	1.3

IN-SITU DENSITY (Sand-Cone Method)

Site Location: Faro Beach Tailings

Soil Description :	Beach Tailings	Test Pit # :	FA-TB-TP01
Sand Type:	Ottawa Sand	Test Date:	17-Sep-03
Specific Gravity of Sand:	2.65	Test No:	SC-03
Sand Bulk Density (g/cm^3):	1.42	Tested By:	Joe Pun

Maximum Particle Size	Minimum Test Hole Volume
1/2" (12.7 mm)	1415 cm^3 (0.05 ft^3)
1" (25.4 mm)	2125 cm^3 (0.075 ft^3)
1.5" (38 mm)	2830 cm^3 (0.1 ft^3)

Approximate Hole Size	6" Φ, 9cm depth
Mass of Empty Moisture Tight Container (g)	40.4
Mass of Moisture Tight Container with Wet Sample (g)	2895.5
Mass of Wet Sample Removed From Hole (g)	2855.1
Water Content (%)	6.6
Mass of Apparatus Filled With Sand Prior to Test (g)	6550.0
Mass of Empty Apparatus (g)	194.6
Mass of Remaining Sand in Sample Container (g)	1884.3
Mass of Sand Used to Fill Test Hole, Funnel & Base Plate (g)	4511.5
Mass of Sand Used to Fill Funnel & Base Plate (g)	1845.0
Calculated Volume of Test Hole (cm^3)	1871.6
Mass of Dry Soil Removed From Test Hole (g)	2678.3
In-Situ Wet Density (g/cm^3)	1.5
In-Situ Dry Density (g/cm^3)	1.4

Appendix B-4

EBA Engineering Laboratory Report

EBA Engineering Consultants Ltd.

Creating and Delivering Better Solutions

October 14, 2003

SRK Consulting
Suite 800, 1066 West Hastings
Vancouver, B.C.
V6E 3X2

EBA File: 1200034.026

Attention: Mr. Joe Pun
Project Engineer

Subject: Summary Letter – Moisture Content Testing
Faro, Yukon

As requested, this letter summarizes the moisture content testing program completed on the samples which were collected by SRK forces in Faro, Yukon and delivered to EBA's Whitehorse laboratory for natural moisture content testing. Testing was completed on "whole samples" (delivered in bags and jars) in accordance to test method designation ASTM D2216. Results are presented below:

Test Pit Location	Sample No.	Moisture Content
VA-OD-TP1	SR01-B0	11.9
	SR01-B15	12.0
	SR01-B30	8.9
	SR01-B45	10.7
	SR01-B60	10.9
	SR01-Af0	16.6
	SR01-Af15	19.7
	SR01-Af30	15.7
	SR01-Af45	16.9
	SR01-Af60	12.9
	SR02-B0	11.0
	SR02-B15	12.5
	SR02-B30	12.8
	SR02-B45	13.6
	SR02-B60	12.0
	SR02-Af0	13.9
	SR02-Af15	11.3
	SR02-Af30	12.8
	SR02-Af45	13.7
	SR02-Af60	12.2
	SC-01	11.6
	SC-02	12.6
	SC-03	8.7

Test Pit Location	Sample No.	Moisture Content
VA-ET-TP1	SR01-B0	11.4
	SR01-B15	11.2
	SR01-B30	12.9
	SR01-B45	11.9
	SR01-B60	12.3
	SR01-Af0	18.5
	SR01-Af15	18.5
	SR01-Af30	18.9
	SR02-B0	11.5
	SR02-B15	11.9
	SR02-B30	10.2
	SR02-B45	9.4
	SR02-B60	9.6
	SC-01	10.6
	SC-02	10.1
	SC-03	10.5
VA-CT-TP1	SR02-B0	5.4
	SR02-B15	5.7
	SR02-Af0	17.9
	SC-01	7.9
	SC-02	8.0
	SC-03	11.3
	SC-04	10.1
VA-WR-TP1	SR03-B0	3.8
	SR03-B15	3.8
	SR01-Af0	13.6
	SR03-Af0	14.2
	SR04-Af0	13.2

Test Pit Location	Sample No.	Moisture Content
VA-GF-TP1	SR01-B0	2.7
	SR01-B15	2.8
	SR01-B30	2.9
	SR01-B45	3.1
	SR01-B60	3.4
	SR01-Af0	11.6
	SC-01	4.1
	SC-02	4.2
	SC-03	4.6
FA-TS-TP1	SR01-B0	24.2
	SR01-B15	32.4
	SR01-B30	29.7
	SR01-B45	25.3
	SR01-B60	22.9
	SR01-Af0	22.3
	SC-01	20.6
	SC-02	22.6
	SC-03	23.2
FA-TB-TP1	SR03-B0	6.7
	SR03-B15	6.2
	SR03-B30	6.1
	SR03-B45	6.8
	SR03-B60	6.1
	SR03-Af0	23.5
	SC-01	11.0
	SC-02	11.7
	SC-03	6.6

Calcite Business Centre, Unit 6, 151 Industrial Road, Whitehorse, Yukon Y1A 2V3
Tel: (867) 668-3068 - Fax: (867) 668-4349 Internet: whitehorse@eba.ca - Web Site: www.eba.ca

We trust this summary meets your present requirements; however, if you have any questions or concerns please contact the undersigned.

Yours truly,
EBA Engineering Consultants Ltd.

Myles C. Plaunt, C.E.T.
Senior Technologist
(Direct Line: (867) 668-2071, ext. 27)
(email: mplaunt@eba.ca)

Appendix B-5

Conductivity & pH Test Data

Faro Field SampleS Log

Test Pit	Date Collected	Sample No.	Location		pH	Conductivity (Initial)	Corrections	Conductivity (Final)
		L: left side of test pit R: right side of test pit	Inclined Depth from Ground Surface (m)	Vertical Depth from Ground Surface (m)				
Vangorda Overburden Dump	9-Sep-03	L1-0	0	0.00	7.60	280 µS	-	280 µS
		L1-1	1	0.71	7.00	546 µS	-	546 µS
		L1-2	2	1.41	6.88	787 µS	-	787 µS
		L1-3	3	2.12	6.82	626 µS	-	626 µS
		R1-0	0	0.00	7.20	162.2 µS	-	162.2 µS
		R1-1	1	0.71	6.85	611 µS	-	611 µS
		R1-2	2	1.41	6.78	816 µS	-	816 µS
		R1-3	3	2.12	6.77	638 µS	-	638 µS
Vangorda Embankment Till	10-Sep-03	L1-0	0	0.00	6.98	1188 µS	-	1188 µS
		L1-1	1	0.71	6.90	976 µS	-	976 µS
		L1-2	2	1.41	5.79	1223 µS	-	1223 µS
		L1-3	3	2.12	5.76	1220 µS	-	1220 µS
		R1-0	0	0.00	5.75	1149 µS	-	1149 µS
		R1-1	1	0.71	5.71	947 µS	-	947 µS
		R1-2	2	1.41	5.71	1038 µS	-	1038 µS
		R1-3	3	2.12	5.62	1210 µS	-	1210 µS
Vangorda Till Cover	11-Sep-03	L1-0	0	0.00	7.67	636 µS	-	636 µS
		L1-1	1	0.71	7.64	456 µS	-	456 µS
		L1-2	2	1.41	7.46	803 µS	-	803 µS
		L1-3	3	2.12	7.44	298 µS	-	298 µS
		R1-0	0	0.00	7.56	560 µS	-	560 µS
		R1-1	1	0.71	7.58	381 µS	-	381 µS
		R1-2	2	1.41	7.74	447 µS	-	447 µS
		R1-3	3	2.12	7.52	742 µS	-	742 µS
Vangorda Waste Rock	12-Sep-03	L1-0	0	0.00	5.12	6.35 mS	-40 µS	6.31 mS
		L1-1	1	0.71	5.74	3.5 mS	-40 µS	3.46 mS
		L1-2	2	1.41	5.68	5.56 mS	-40 µS	5.52 mS
		L1-3	3	2.12	5.48	4.41 mS	-40 µS	4.37 mS
		R1-0	0	0.00	5.90	4.33 mS	-40 µS	4.29 mS
		R1-1	1	0.71	5.75	2.48 mS	-40 µS	2.44 mS
		R1-2	2	1.41	5.66	5.23 mS	-40 µS	5.19 mS
		R1-3	3	2.12	5.90	3.7 mS	-40 µS	3.66 mS

Test Pit	Date Collected	Sample No. *L: left side of test pit R: right side of test pit*	Location: Inclined Depth from Ground Surface (m)	Location: Vertical Depth from Ground Surface (m)	pH	Conductivity (Initial)	Corrections	Conductivity (Final)
Vangorda Glaciofluvial Deposits	13-Sep-03	Sample 1	N/A	N/A	7.32	50 µS	-	50 µS
		Sample 2	N/A	N/A	7.47	49 µS	-	49 µS
		Sample 3	N/A	N/A	7.63	64 µS	-	64 µS
		Sample 4	N/A	N/A	6.45	54 µS	-	54 µS
Faro Tailings	11-Sep-03	T1-0	N/A	0	2.06	8.65 mS	-27 µS	8.62 mS
		T1-50	N/A	50	2.28	7.99 mS	-27 µS	7.96 mS
		T1-100	N/A	100	2.26	10.41 mS	-27 µS	10.38 mS
		T1-150	N/A	150	2.82	7.21 mS	-27 µS	7.18 mS
		T1-200	N/A	200	4.41	3.13 mS	-27 µS	3.10 mS
		T1-250	N/A	250	5.05	4.9 mS	-27 µS	4.87 mS
		T1-300	N/A	300	4.20	8.27 mS	-27 µS	8.24 mS
		T1-350	N/A	350	4.69	19.75 mS	-27 µS	19.72 mS
		T1-400	N/A	400	4.48	9.39 mS	-27 µS	9.36 mS
		T1-450	N/A	450	4.09	4.59 mS	-27 µS	4.56 mS
		T1-500	N/A	500	4.26	5.99 mS	-27 µS	5.96 mS
		T2-0	N/A	0	1.65	15.57 mS	-22 µS	15.55 mS
		T2-50	N/A	50	2.26	11.55 mS	-22 µS	11.53 mS
		T2-100	N/A	100	3.81	6.9 mS	-22 µS	6.88 mS
		T2-150	N/A	150	4.31	10.35 mS	-22 µS	10.33 mS
		T2-200	N/A	200	4.16	6.24 mS	-22 µS	6.22 mS
		T2-250	N/A	250	4.14	10.32 mS	-22 µS	10.30 mS
		T2-300	N/A	300	4.48	19.18 mS	-22 µS	19.16 mS
		T2-350	N/A	350	3.24	14.04 mS	-22 µS	14.02 mS
		T2-400	N/A	400	3.36	14.11 mS	-22 µS	14.09 mS
		T3-0	N/A	0	1.87	8.67 mS	-34 µS	8.64 mS
		T3-50	N/A	50	2.46	34.1 mS	-34 µS	34.07 mS
		T3-100	N/A	100	2.93	5.09 mS	-34 µS	5.06 mS
		T3-150	N/A	150	4.25	2.99 mS	-34 µS	2.96 mS
		T3-200	N/A	200	3.97	7.78 mS	-34 µS	7.75 mS
		T3-250	N/A	250	3.77	5.48 mS	-34 µS	5.45 mS
		T3-300	N/A	300	4.07	10.37 mS	-34 µS	10.34 mS
		T3-350	N/A	350	4.71	13.74 mS	-34 µS	13.71 mS
		T3-400	N/A	400	4.42	9.96 mS	-34 µS	9.93 mS
		T3-450	N/A	450	5.16	13.45 mS	-34 µS	13.42 mS
		T3-500	N/A	500	5.11	15.8 mS	-34 µS	15.77 mS
		T4-0	N/A	0	1.57	19.13 mS	-31 µS	19.10 mS
		T4-50	N/A	50	2.61	20.5 mS	-31 µS	20.47 mS
		T4-100	N/A	100	4.08	10.92 mS	-31 µS	10.89 mS
		T4-150	N/A	150	4.69	10.13 mS	-31 µS	10.10 mS
		T4-200	N/A	200	4.84	5.51 mS	-31 µS	5.48 mS
		T4-250	N/A	250	4.67	2.53 mS	-31 µS	2.50 mS
		T4-300	N/A	300	4.63	4.95 mS	-31 µS	4.92 mS
		T4-350	N/A	350	4.03	6.09 mS	-31 µS	6.06 mS
		T4-400	N/A	400	4.93	10.41 mS	-31 µS	10.38 mS
		T4-450	N/A	450	5.12	9.85 mS	-31 µS	9.82 mS

Appendix B-6
Thermistor Data

THERMISTOR DATA			
TS-01	**Read By**		**Joe Pun**
	Date		**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**
Bead 1	1.5	0.05	5.2
Bead 2	2.0	0.36	7.0
Bead 3	2.5	0.86	7.8
Bead 4	3.0	1.36	6.7
Bead 5	4.0	2.36	3.6
Bead 6	5.0	3.36	0.4

String Serial No. = 23262-1

Total string length = 5.0 m

THERMISTOR DATA			
TS-02	**Read By**		**Joe Pun**
	Date		**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**
Bead 1	1.5	0.05	6.1
Bead 2	2.0	0.10	3.0
Bead 3	2.5	0.15	0.0
Bead 4	3.0	0.20	-0.1
Bead 5	4.0	0.50	-0.1
Bead 6	5.0	1.50	-0.1

String Serial No. = 23262-2

Total string length = 5.0 m

THERMISTOR DATA			
TS-03	**Read By**		**Joe Pun**
	Date		**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**
Bead 1	1.5	0.05	5.7
Bead 2	2.0	0.23	7.2
Bead 3	2.5	0.73	7.1
Bead 4	3.0	1.23	5.4
Bead 5	4.0	2.23	1.8
Bead 6	5.0	3.23	0.4

String Serial No. = 23262-3

Total string length = 5.0 m

THERMISTOR DATA				
TS-04	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	6.6	6.2
Bead 2	2.0	0.40	7.2	7.0
Bead 3	2.5	0.90	7.8	6.6
Bead 4	3.0	1.40	7.9	5.2
Bead 5	4.0	2.40	7.6	2.4
Bead 6	5.0	3.40	4.5	-0.6

String Serial No. = 23262-4

Total string length = 5.0 m

THERMISTOR DATA			
TS-05	**Read By**		**Joe Pun**
	Date		**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**
Bead 1	1.5	0.05	6.6
Bead 2	2.0	0.10	7.6
Bead 3	2.5	0.53	6.5
Bead 4	3.0	1.03	3.8
Bead 5	4.0	2.03	0.0
Bead 6	5.0	3.03	0.0
String Serial No. = 23262-5			
Total string length = 5.0 m			

THERMISTOR DATA				
TS-06	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	6.8	6.4
Bead 2	2.0	0.50	7.1	7.3
Bead 3	2.5	1.00	8.2	7.4
Bead 4	3.0	1.50	8.2	6.3
Bead 5	4.0	2.50	8.3	3.8
Bead 6	5.0	3.50	5.0	-0.2

String Serial No. = 23262-6

Total string length = 5.0 m

THERMISTOR DATA				
TS-07	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	5.3	5.3
Bead 2	2.0	0.45	6.6	6.5
Bead 3	2.5	0.95	8.2	7.5
Bead 4	3.0	1.45	8.6	7.1
Bead 5	4.0	2.45	8.7	4.5
Bead 6	5.0	3.45	5.9	2.4
String Serial No. = 23262-7 Total string length = 5.0 m				

THERMISTOR DATA				
TS-08	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	6.7	6.6
Bead 2	2.0	0.55	7.2	6.9
Bead 3	2.5	1.05	7.4	6.5
Bead 4	3.0	1.55	7.1	5.3
Bead 5	4.0	2.55	7.8	2.8
Bead 6	5.0	3.55	5.3	-1.4
String Serial No. = 23262-8 Total string length = 5.0 m				

THERMISTOR DATA				
TS-09	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.10	8.8	6.6
Bead 2	2.0	0.60	8.9	7.0
Bead 3	2.5	1.10	8.3	6.9
Bead 4	3.0	1.60	6.8	5.9
Bead 5	4.0	2.60	8.2	3.6
Bead 6	5.0	3.60	9.2	-0.1

String Serial No. = 23262-9

Total string length = 5.0 m

THERMISTOR DATA				
TS-10	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	9.1	6.8
Bead 2	2.0	0.20	6.7	6.9
Bead 3	2.5	0.30	8.0	4.5
Bead 4	3.0	0.80	7.0	1.5
Bead 5	4.0	1.80	5.7	0.4
Bead 6	5.0	2.80	4.9	-1.0

String Serial No. = 23262-10

Total string length = 5.0 m

THERMISTOR DATA				
TS-11	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	7.6	6.0
Bead 2	2.0	0.55	16.6	6.5
Bead 3	2.5	1.05	9.8	6.4
Bead 4	3.0	1.55	10.1	5.6
Bead 5	4.0	2.55	10.1	3.3
Bead 6	5.0	3.55	6.9	-0.7

String Serial No. = 23262-11

Total string length = 5.0 m

THERMISTOR DATA				
TS-12	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.50	5.8	5.9
Bead 2	2.0	1.00	7.7	7.6
Bead 3	2.5	1.50	8.9	8.9
Bead 4	3.0	2.00	9.8	9.2
Bead 5	4.0	3.00	10.1	8.8
Bead 6	5.0	4.00	10.4	6.6

String Serial No. = 23262-12

Total string length = 5.0 m

THERMISTOR DATA				
TS-13	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	5.4	5.5
Bead 2	2.0	0.15	7.0	6.9
Bead 3	2.5	0.25	8.6	8.2
Bead 4	3.0	0.75	9.9	7.7
Bead 5	4.0	1.75	8.9	2.7
Bead 6	5.0	2.75	7.9	2.2
Bead 7	6.0	3.75	6.9	3.6
String Serial No. = 23262-13 Total string length = 6.0 m				

THERMISTOR DATA				
TS-14	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.50	5.6	5.4
Bead 2	2.0	1.00	6.7	6.7
Bead 3	2.5	1.50	8.7	8.4
Bead 4	3.0	2.00	10.2	9.7
Bead 5	4.0	3.00	11.4	10.1
Bead 6	5.0	4.00	11.2	9.5
Bead 7	6.0	5.00	13.1	6.3
String Serial No. = 23262-14 Total string length = 6.0 m				

THERMISTOR DATA				
TS-15	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	8.9	6.4
Bead 2	2.0	0.15	8.0	7.8
Bead 3	2.5	0.25	9.3	8.8
Bead 4	3.0	0.55	10.2	6.6
Bead 5	4.0	1.55	9.1	2.6
Bead 6	5.0	2.55	7.9	1.7
Bead 7	6.0	3.55	6.7	2.3

String Serial No. = 23262-15

Total string length = 6.0 m

THERMISTOR DATA				
TS-16	**Read By**		**Maritz Rykaart**	**Joe Pun**
	Date		**09/13/2003**	**09/18/2003**
Bead No.	**Bead Location from Top (m)**	**Bead Depth (m)**	**Temperature (Celsius)**	
Bead 1	1.5	0.05	4.7	4.8
Bead 2	2.0	0.25	6.2	6.1
Bead 3	2.5	0.75	8.3	8.0
Bead 4	3.0	1.25	9.8	8.7
Bead 5	4.0	2.25	9.9	7.8
Bead 6	5.0	3.25	8.2	1.8
Bead 7	6.0	4.25	6.0	2.6

String Serial No. = 23262-16
Total string length = 6.0 m

RST INSTRUMENTS LTD.

200 - 2050 Hartley Avenue, Coquitlam, British Columbia, Canada V3K 6W5

2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-1	5m	Pt. 1	5739	4.9	2879	19.5
		Pt. 2	5749	4.9	2885	19.5
		Pt. 3	5741	4.9	2887	19.5
		Pt. 4	5741	4.9	2876	19.5
		Pt. 5	5755	4.9	2891	19.4
		Pt. 6	5737	5.0	2876	19.5

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-2	5m	Pt. 1	5748	4.9	2879	19.5
		Pt. 2	5727	5.0	2863	19.6
		Pt. 3	5709	5.0	2856	19.7
		Pt. 4	5758	4.9	2881	19.5
		Pt. 5	5743	4.9	2874	19.5
		Pt. 6	5740	4.9	2866	19.6

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= **0.0014733**
C_1= **0.0002372**
C_3= **0.0000001074**
lnR= Natural Log of Resistance
T_c= **Temperature in °C**

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
Date: 4-Sep-03
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Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-3	5m	Pt. 1	5781	4.8	2895	19.4
		Pt. 2	5761	4.9	2887	19.5
		Pt. 3	5759	4.9	2881	19.5
		Pt. 4	5767	4.8	2889	19.4
		Pt. 5	5764	4.9	2879	19.5
		Pt. 6	5753	4.9	2885	19.5

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= **0.0014733**
C_1= **0.0002372**
C_3= **0.0000001074**
lnR= Natural Log of Resistance
T_c= **Temperature in °C**

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-4	5m	Pt. 1	5759	4.9	2888	19.4
		Pt. 2	5773	4.8	2884	19.5
		Pt. 3	5755	4.9	2873	19.6
		Pt. 4	5795	4.7	2898	19.4
		Pt. 5	5759	4.9	2874	19.5
		Pt. 6	5787	4.8	2894	19.4

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
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Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-5	5m	Pt. 1	5709	5.0	2860	19.7
		Pt. 2	5731	5.0	2876	19.5
		Pt. 3	5742	4.9	2881	19.5
		Pt. 4	5706	5.1	2860	19.7
		Pt. 5	5742	4.9	2880	19.5
		Pt. 6	5705	5.1	2869	19.6

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= **0.0014733**
C_1= **0.0002372**
C_3= **0.0000001074**
lnR= Natural Log of Resistance
T_c= **Temperature in °C**

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2252 ohm
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Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-6	5m	Pt. 1	5701	5.1	2858	19.7
		Pt. 2	5742	4.9	2877	19.5
		Pt. 3	5738	4.9	2868	19.6
		Pt. 4	5739	4.9	2876	19.5
		Pt. 5	5717	5.0	2860	19.7
		Pt. 6	5732	5.0	2875	19.5

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-7	5m	Pt. 1	5736	5.0	2867	19.6
		Pt. 2	5751	4.9	2874	19.5
		Pt. 3	5742	4.9	2871	19.6
		Pt. 4	5744	4.9	2885	19.5
		Pt. 5	5746	4.9	2874	19.5
		Pt. 6	5753	4.9	2890	19.4

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= **0.0014733**
C_1= **0.0002372**
C_3= **0.0000001074**
lnR= Natural Log of Resistance
T_c= **Temperature in °C**

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THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-8	5m	Pt. 1	5688	5.1	2849	19.7
		Pt. 2	5730	5.0	2864	19.6
		Pt. 3	5754	4.9	2878	19.5
		Pt. 4	5732	5.0	2876	19.5
		Pt. 5	5759	4.9	2885	19.5
		Pt. 6	5726	5.0	2868	19.6

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-9	5m	Pt. 1	5752	4.9	2880	19.5
		Pt. 2	5748	4.9	2878	19.5
		Pt. 3	5757	4.9	2888	19.4
		Pt. 4	5751	4.9	2873	19.6
		Pt. 5	5780	4.8	2897	19.4
		Pt. 6	5743	4.9	2869	19.6

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
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Customer: SRK
Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-10	5m	Pt. 1	5744	4.9	2888	19.4
		Pt. 2	5758	4.9	2884	19.5
		Pt. 3	5753	4.9	2875	19.5
		Pt. 4	5759	4.9	2882	19.5
		Pt. 5	5726	5.0	2861	19.6
		Pt. 6	5741	4.9	2878	19.5

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
THERMISTOR STRING CALIBRATION

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Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature Measured Resistance ohms	Low Temperature Calculated Temperature °C	High Temperature Measured Resistance ohms	High Temperature Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-11	5m	Pt. 1	5767	4.8	2890	19.4
		Pt. 2	5750	4.9	2877	19.5
		Pt. 3	5732	5.0	2874	19.5
		Pt. 4	5737	5.0	2868	19.6
		Pt. 5	5724	5.0	2882	19.5
		Pt. 6	5731	5.0	2870	19.6

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
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THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-12	5m	Pt. 1	5681	5.1	2854	19.7
		Pt. 2	5726	5.0	2869	19.6
		Pt. 3	5731	5.0	2868	19.6
		Pt. 4	5761	4.9	2888	19.4
		Pt. 5	5739	4.9	2873	19.6
		Pt. 6	5761	4.9	2880	19.5

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature Measured Resistance ohms	Low Temperature Calculated Temperature °C	High Temperature Measured Resistance ohms	High Temperature Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-13	6m	Pt. 1	5750	4.9	2888	19.4
		Pt. 2	5765	4.9	2890	19.4
		Pt. 3	5779	4.8	2890	19.4
		Pt. 4	5759	4.9	2878	19.5
		Pt. 5	5749	4.9	2885	19.5
		Pt. 6	5756	4.9	2878	19.5
		Pt. 7	5780	4.8	2891	19.4

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
THERMISTOR STRING CALIBRATION

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Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature Measured Resistance ohms	Low Temperature Calculated Temperature °C	High Temperature Measured Resistance ohms	High Temperature Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-14	6m	Pt. 1	5746	4.9	2893	19.4
		Pt. 2	5755	4.9	2888	19.4
		Pt. 3	5777	4.8	2893	19.4
		Pt. 4	5741	4.9	2878	19.5
		Pt. 5	5748	4.9	2886	19.5
		Pt. 6	5729	5.0	2873	19.6
		Pt. 7	5768	4.8	2897	19.4

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
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Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature		High Temperature	
			Measured Resistance ohms	Calculated Temperature °C	Measured Resistance ohms	Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-15	6m	Pt. 1	5701	5.1	2857	19.7
		Pt. 2	5710	5.0	2857	19.7
		Pt. 3	5745	4.9	2873	19.6
		Pt. 4	5751	4.9	2880	19.5
		Pt. 5	5718	5.0	2858	19.7
		Pt. 6	5742	4.9	2874	19.5
		Pt. 7	5751	4.9	2878	19.5

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= **0.0014733**
C_1= **0.0002372**
C_3= **0.0000001074**
lnR= Natural Log of Resistance
T_c= **Temperature in °C**

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2252 ohm
THERMISTOR STRING CALIBRATION

Customer: SRK
Date: 4-Sep-03
Calibration Reference HP 34401A Digital Multimeter S/N US36053118
Last referenced to National Standards 11-April-03
Reference Thermistor Number RST0036
Referenced Annually to National Standards

THERMISTOR #	Cable Length	Position	Low Temperature Measured Resistance ohms	Low Temperature Calculated Temperature °C	High Temperature Measured Resistance ohms	High Temperature Calculated Temperature °C
Reference			5738	4.9	2879	19.5
23262-16	6m	Pt. 1	5772	4.8	2887	19.5
		Pt. 2	5773	4.8	2882	19.5
		Pt. 3	5748	4.9	2870	19.6
		Pt. 4	5761	4.9	2879	19.5
		Pt. 5	5751	4.9	2874	19.5
		Pt. 6	5769	4.8	2891	19.4
		Pt. 7	5748	4.9	2873	19.6

Temperature calculated using:

Steinhart-Hart Linearization

$$T_C = \frac{1}{C_0 + C_1(\ln R) + C_3(\ln R)^3} - 273.15$$

2252 Ohm @ 25C NTC Thermistor

C_0= 0.0014733
C_1= 0.0002372
C_3= 0.0000001074
lnR= Natural Log of Resistance
T_c= Temperature in °C

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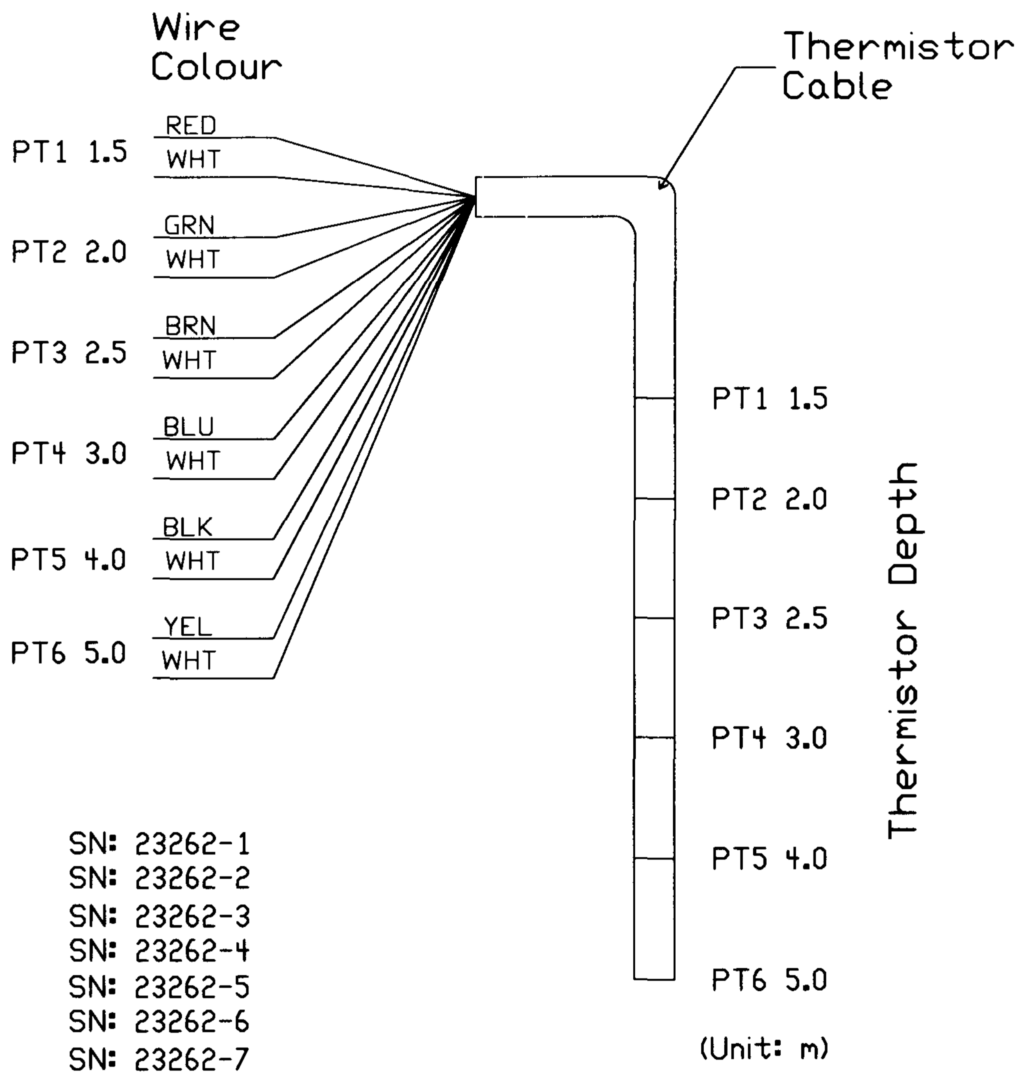
Resistance versus Temperature Relationship 2252 NTC Thermistors

R ohms	T deg C	R ohms	T deg C	R ohms	T deg C	R ohms	T deg C
76000	-40.04	21500	-19.71	7300	0.15	2800	20.11
75000	-39.84	21000	-19.30	7200	0.42	2750	20.51
74000	-39.64	20500	-18.89	7100	0.69	2700	20.92
73000	-39.43	20000	-18.46	7000	0.97	2650	21.33
72000	-39.23	19500	-18.02	6900	1.26	2600	21.76
71000	-39.01	19000	-17.56	6800	1.54	2550	22.19
70000	-38.80	18500	-17.10	6700	1.84	2500	22.64
69000	-38.58	18000	-16.61	6600	2.14	2450	23.09
68000	-38.36	17500	-16.12	6500	2.44	2400	23.56
67000	-38.13	17000	-15.61	6400	2.75	2350	24.04
66000	-37.90	16500	-15.08	6300	3.06	2300	24.52
65000	-37.67	16000	-14.53	6200	3.38	2250	25.02
64000	-37.43	15800	-14.30	6100	3.71	2200	25.54
63000	-37.19	15600	-14.07	6000	4.04	2150	26.06
62000	-36.95	15400	-13.84	5900	4.38	2100	26.60
61000	-36.70	15200	-13.61	5800	4.72	2050	27.16
60000	-36.44	15000	-13.37	5700	5.07	2000	27.73
59000	-36.18	14800	-13.13	5600	5.43	1950	28.32
58000	-35.92	14600	-12.88	5500	5.79	1900	28.92
57000	-35.65	14400	-12.64	5400	6.17	1880	29.17
56000	-35.37	13900	-12.00	5300	6.55	1860	29.42
55000	-35.09	13400	-11.33	5200	6.94	1840	29.67
54000	-34.81	12900	-10.64	5100	7.33	1820	29.93
53000	-34.52	12400	-9.91	5000	7.74	1800	30.19
52000	-34.22	12200	-9.61	4900	8.16	1780	30.45
51000	-33.92	12000	-9.31	4800	8.58	1760	30.72
50000	-33.60	11800	-9.00	4700	9.02	1740	30.99
49000	-33.29	11600	-8.68	4600	9.46	1720	31.26
48000	-32.96	11400	-8.36	4500	9.92	1700	31.54
47000	-32.63	11200	-8.03	4400	10.39	1680	31.82
46000	-32.29	11000	-7.69	4300	10.87	1660	32.10
45000	-31.94	10800	-7.35	4200	11.36	1640	32.39
44000	-31.58	10600	-7.00	4100	11.87	1620	32.69
43000	-31.22	10400	-6.64	4000	12.39	1600	32.98
42000	-30.84	10200	-6.28	3900	12.93	1580	33.28
41000	-30.45	10000	-5.90	3850	13.20	1560	33.59
40000	-30.06	9800	-5.52	3800	13.48	1540	33.90
39000	-29.65	9600	-5.13	3750	13.76	1520	34.21
38000	-29.23	9400	-4.73	3700	14.05	1500	34.53
37000	-28.80	9200	-4.32	3650	14.34	1480	34.85
36000	-28.35	9000	-3.90	3600	14.63	1460	35.18
35000	-27.89	8800	-3.47	3550	14.93	1440	35.52
34000	-27.42	8700	-3.25	3500	15.24	1420	35.86
33000	-26.93	8600	-3.03	3450	15.55	1400	36.20
32000	-26.42	8500	-2.81	3400	15.86	1380	36.55
31000	-25.89	8400	-2.58	3350	16.18	1360	36.91
30000	-25.35	8300	-2.35	3300	16.51	1340	37.27
29000	-24.79	8200	-2.12	3250	16.84	1320	37.64
28000	-24.20	8100	-1.88	3200	17.18	1300	38.02
27000	-23.59	8000	-1.64	3150	17.52	1280	38.40
26000	-22.95	7900	-1.39	3100	17.87	1260	38.79
25000	-22.29	7800	-1.15	3050	18.23	1240	39.18
24000	-21.60	7700	-0.90	3000	18.59	1220	39.58
23000	-20.87	7600	-0.64	2950	18.96	1200	40.00
22500	-20.49	7500	-0.38	2900	19.33	1180	40.41
22000	-20.11	7400	-0.12	2850	19.72	1160	40.84



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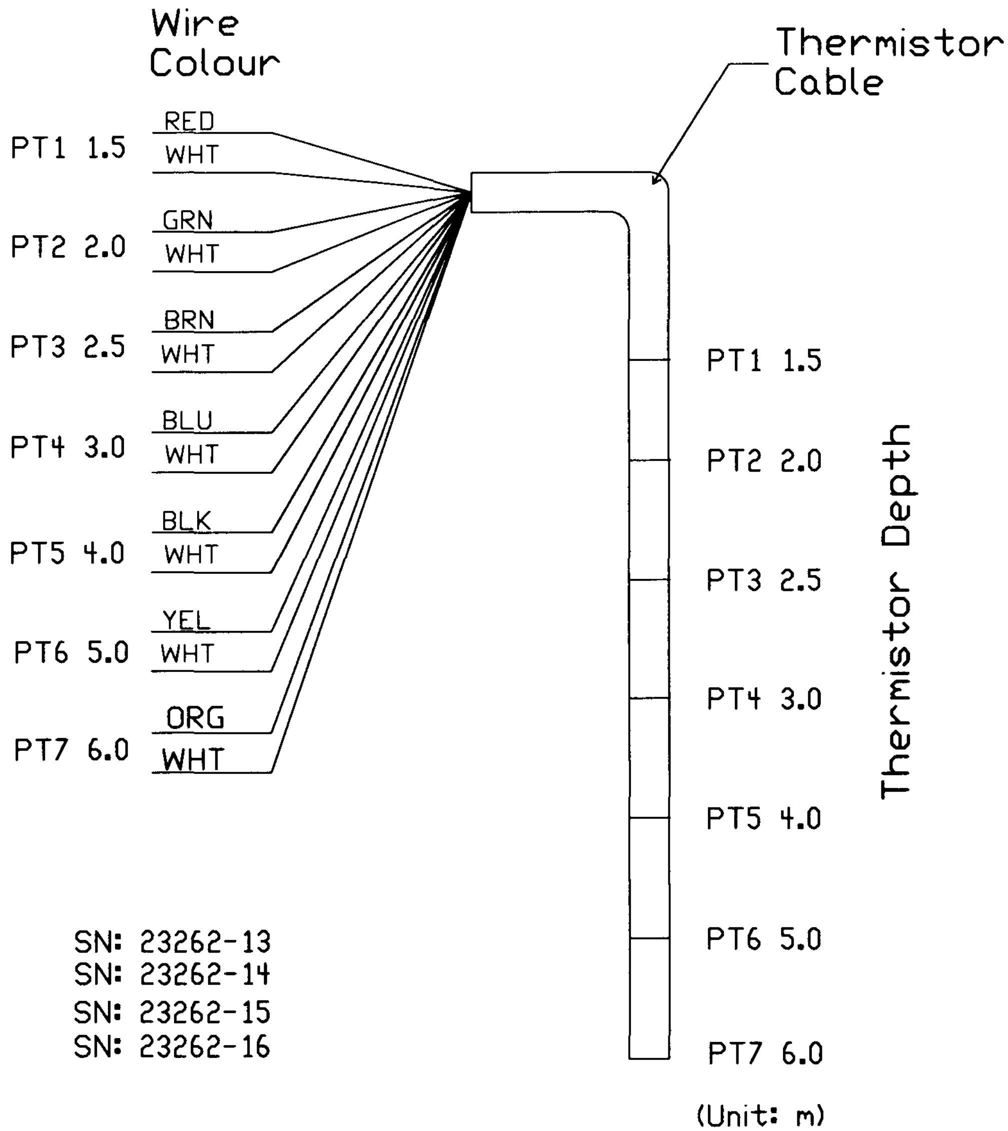
Co:	RST INSTRUMENTS LTD		
Title:	THERMISTOR CABLE		
J/N:	Q01425	Revision:	A
Author:		Size:	A
Date:	2003/09/05	Sheet	1 of 1



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