Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

RECOMMENDATIONS FOR PERFORMANCE INSTRUMENTATION OF THE CYPRUS ANVIL DOWN VALLEY PROJECT NEAR FARO YUKON TERRITORY

Distribution: 6 copies - Cyprus Anvil Mining Corp., Faro, Yukon Territory (Attention: Mr. N.G. Cornish)
4 copies - Golder Associates, Calgary, Alberta

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Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

October 5, 1981
File No: 812-2041

Cyprus Anvil Mining Corporation
P.O. Box 1,000
Faro, Yukon Territory
YOB 1KO

Attention: Mr. H.G. Cornish, P.Eng.
Superintendent Evironmental Control

Dear Mr. Cornish:

Re: Down Valley Project Performance Instrumentation

This letter is bound into each of six copies of our report presenting the philosophy, layout, observation, recommendations, and cost of the proposed instrumentation program for the Down Valley Project. Both dams and the canal are being instrumented.

We expect to mobilize the drilling equipment from Whitehorse on October 13, 1981. The work should be complete within about 56 working days with one rig or about 23 with two rigs. The latter alternative is favoured because of the weather advantages and greater working efficiency it provides.

Respectfully Submitted,
GOLDER ASSOCIATES

H.G. Gilchrist, P.Eng.

H.G. GILCHRIST
YUKON TERRITORIES

Berg Keshian, Jr., P.Eng.

Enclosure

HGG/BK/jh

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1.0 INTRODUCTION

The Cyprus Anvil Down Valley project consists of several items of construction. The resulting containment will provide storage capacity of mill tailings in the bottom of the Rose Creek Valley within a distance of about 4 km of the milling complex. The overall arrangement of the construction is shown on Figure 1 and consists of a valley wall diversion canal to carry the Rose Creek flow adjacent to the future tailings deposit, and two dams situated towards the downstream end of the diversion canal. The upper of these two dams is intended to retain the tailings, whereas the downstream dam is intended to provide a period of decant flow storage to permit of chemical stabilization of water quality.

Details of the project design are contained in previous reports to Cyprus Anvil Mining Corporation (Report 792-2025 dated June, 1980) and, in general terms, the project represents an enlargement of an already proven technique of Rose Creek Diversion and valley bottom utilization for tailings containment. The earlier project has been in use since it was commissioned 1975 and increases of capacity have been achieved by raising of the containing dykes. The new construction, commenced in October, 1980 has been made necessary by Cyprus Anvil's commitment to the milling of newly acquired orebodies.

1.1 Site Geotechnical Conditions

The construction site is within a schistose bedrock valley that has been glacially scoured. Its bottom is filled with a selection of till, alluvial, and colluvial materials, and its walls are discontinuously mantled with glacial till usually capped with colluvium and organic accumulations. The Rose Creek stream bed is at an elevation some 10 to 15 m below extensive terrace deposits of alluvium which dominate the topography of the valley bottom.

In sequence of depth the canal route stratigraphy consists typically of up to about 1.2 m thicknesses of black and brown organic silts and colluvium, some of which is permafrost. Glacial till of variable characteristics is found beneath these surficial strata and it exhibits an erosion surface often showing some concentration of boulders and water-sorted material. There is also evidence of some water modification of the till in that its upper zone on occasion contains organic and gravelly lenses as well as white volcanic ash.

The glacial till has been determined to be discontinuously frozen, and where frozen, to be at a temperature only nominally below 0°C. The distribution between frozen and unfrozen areas seems to be related partially to the natural drainage patterns along the valley wall. The bedrock which exists below the glacial till usually has a structure which dips into the hillside and it is generally a schistose rock of deficient quality concerning engineering application of quarried materials. The rock exists often as permafrost, and consequently its rippability is substantially more difficult than would be indicated directly by rock type and state of weathering.

Groundwater conditions along the route are variable, but generally consist of a summer period water table perched within the seasonally thawed surficial organic and colluvial material above the permafrost, a probably continuous water table substantially below the permafrost, and a more continuous groundwater regime in areas where permafrost is absent.

At the location of the Cross Valley Dam, the Rose Creek Valley has been infilled mainly by granular alluvium to a maximum depth of about 50 m. The Cross Valley Dam site is somewhat unique in that only a small gravel ridge exists to the elevation of the upper level terrace which is characteristic of the Rose Creek Valley.

The alluvial fill materials at or near creek level generally are loose fine sands mixed with organics. In some areas in the vicinity of the upstream toe of the proposed dam, organic silts and muskeg occur to depths of 4.5 m and some of these high water content materials are frozen.

Investigation has shown that some permafrost occurs in the vicinity of the upstream toe of the Cross Valley Dam foundation. Drilling results suggest that the permafrost thins from the dam baseline towards the Cross Valley arm of Rose Creek.

The alluvium which forms the unconsolidated foundation of the Cross Valley Dam is highly variable, and fine grained materials are present, particularly in the vicinity of the current Rose Creek channel. On the north side of the valley bottom, occurrences of schist rich "till" are present within the alluvium and its presence is compatible with the till-like deposits which are wedged within the upper level terrace gravels upstream and downstream of the proposed Cross Valley Dam.

The abutments of the Cross Valley dam are transitional between the valley bottom alluvium and the valley wall tills, the latter often occurring as ice stratified permafrost near surface.

The Intermediate Dam is located about 400 m upstream of the Cross Valley Dam and this site differs from the Cross Valley Dam site in that much of the dam traverses the upper level terrace gravels. Further, no extensive occurrences of permafrost occur in the valley bottom area. As for the Cross Valley Dam, the Intermediate Dam foundation is fine grained in the proximity of the current Rose Creek channel.

The north abutment of the Intermediate Dam consists of relatively coarse sand and gravel till and some alluvium, and bedrock occurs at a relatively shallow depth. In contrast, the south abutment area consists generally of frozen till.

The above generalization of canal route and dam site conditions reflects the results of the pre-design site investigations, as well as what has been revealed by the construction activity. In summary, the construction has made it apparent that there is somewhat more variability in conditions than was expected.

1.2 Construction

The construction of the Down Valley project began in October, 1980 when stripping of the canal route commenced. The stripping and dozer/scraper cutting followed in discontinuous sequence along the canal route and the excavated section was formed ready to receive the thermal lining gravel necessary to control seepage exit gradients on permafrost thaw. Stripping was also completed in the dyke foundation area and the dyke construction consisted of compacted gravel alluvium faced with glacial till for seepage reduction through the dyke. The excavation materials were wasted downhill of the dyke section in a sporadic and uncompacted configuration. Both the dyke and waste material therefore are founded on permafrost and thus degradation of permafrost is a factor for both the dyke and the backslope excavation performance monitoring. In addition, the presence of bedrock sections and the need to key the glacial till seepage liner into the rock makes important the consideration of piezometric profile in and beneath the dyke section at various locations along the canal.

1.3 Design Considerations

The design of the project is detailed in the previously cited reports (No. 792-2025) issued in June, 1980, the design being based on a considerable amount of field investigation carried out during both 1979 and early 1980. The investigation confirmed the anticipated presence of substantial amounts of permafrost along the canal route and the presence of some frozen ground in the valley bottom. The permafrost along the canal route was considered to be of paramount importance not only with respect to design considerations and construction, but also concerning post-commissioning operational performance of the canal.

The existence of permafrost along a substantial part of the canal made necessary a very detailed examination of the consequences of permafrost degradation after construction, and the means by which the permafrost meltwater losses could be accommodated without damage to the construction. Further, the proposed design had to consider the likelihood of creep of permafrost in terms of its impact on the elevation and integrity of both the canal dyke and the excavated backslope of the canal. The analytical conclusions which were reached are contained in the design reports and, in summary, creep was determined not to be a problem because the permafrost is not ice rich, nor was there conclusive evidence of continuous ice lensing in the slope. However, in view of the temperature regime and construction-observed local ice content of the permafrost, it is considered important that the constructed works be properly instrumented to monitor performance, and to provide the necessary forewarning of need for maintenance procedures to mitigate against future canal operational problems.

2.0 INSTRUMENTATION PROGRAM

2.1 Canal Instrumentation Objectives and Requirements

The philosphy that has been used in selecting appropriate locations for instrumentation is that there be balanced coverage of the canal with reference to the geotechnical variability along the first 3,000 m (approximately) of its length. It is believed important to instrument locations which, from both investigation and construction knowledge, are expected to perform well, to instrument sections for which there is a concern about performance such that a forewarning of maintenance is provided, and to utilize the instrumentation data, together with the records of maintenance, to demonstrate the dependability and integrity of the canal. There appears to be no need to instrument downstream of the Cornish Creek situated just downstream of the Cross Valley Dam because the topography is relatively flat and the hydraulic section is well below natural ground level.

More specifically, the objective of the instrumentation program is to obtain a body of data on the performance of the Rose Creek diversion canal with reference to:

(a) Adjustment in thermal regime and melting of the permafrost,
(b) Potential downslope creep of the excavated canal wall and dyke section,
(c) Settlement of the dyke and distribution of settlement within the dyke foundation related to permafrost thaw,
(d) Piezometric levels in the backslope and dyke foundation areas, and
(e) Performance of the waste dump.

The instrumentation readings are important in the short term to assess the geotechnical performance of the canal with reference to providing forewarning of need for mitigative maintenance; they are important in the long-term in providing clear evidence of the unqualified geotechnical permanence of the constructed works. As a consequence it is necessary to insist on quality installations and quality hardware, and to establish and adhere to an organized observational and interpretation program. The various aspects of the required installations are discussed in the subsections below.

2.1.1 Movement and Deflection Instrumentation

Lateral and vertical movement of the zone upslope of the canal cutslope and of the constructed dyke and waste piles can be observed by employing borehole inclinometer casings supplied by Westbay Instruments of Vancouver and by complementing these installations with surface survey monuments from which surface horizontal and vertical movements can be determined with reference to fixed datum points. The inclinometer casings will be profiled on a regular basis with a deviation sensing device manufactured by the Slope Indicator Company and the results compared with the original casing profile. The position of the casing in space will be determined by a vertical and horizontal survey of the casing top using levelling and electronic distance measuring techniques to reference these installations to permanent benchmarks situated on bedrock within the general project area.

As a compliment to the proposed installation of about 16 inclinometer casings with companion horizontal and vertical movement survey points, an additional 10 horizontal and 30 vertical movement points will be established and their movement observed. These installations will be distributed primarily to assess the dyke and backslope performance, but several will be installed to monitor deformation of the waste piles downslope from the canal dyke.

In addition to data expected from the above-described apparatus, it is considered important that the vertical distribution of settlement within the dyke and foundation strata are determined in view of the permafrost degradation which will be occurring. Accordingly, it is recommended that a series of incremental settlement monitor installations be made from which settlement vs. depth profiles can be determined from sensors spaced vertically at approximately one meter intervals. It is proposed that two of these installations be made on the top of the left bank backslope, that six be situated in the top of the dyke, and that two be positioned in the top of the spoil downslope of the constructed dyke. The purpose of these installations is to establish the distribution of settlement with depth, the primary interest being settlement associated with thaw of ice lenses within the permafrost glacial till and colluvium which remained after site stripping. Companion installations at the site of each incremental settlement monitor would consist of a thermister and a survey settlement point. The borehole hardware and sensing apparatus are manufactured by the Slope Indicator Company.

2.1.2 Thermal Regime Instrumentation

The Rose Creek Diversion Canal is situated in an area of warm discontinuous permafrost. The natural cover on the valley wall slopes is highly organic and, because construction has removed this natural insulation, the permafrost regime is expected to degrade. The degradation will occur both behind the cut slope on the left bank of the canal, as well as beneath the constructed dyke of the right bank, and beneath the waste piles downslope from the dyke. Although theoretical studies indicate that the degradation of permafrost within the left bank cut slope of the canal should only be marginal, it is considered important to obtain definitive field data and the use of thermistor strings is proposed.

The degradation of permafrost beneath the constructed dyke and downslope waste pile of the right bank is considerably more complicated to predict because it is impacted by the newly imposed groundwater regime related to normal seepage losses from the canal. Therefore it is considered important to thermally instrument this side of the canal in order that a bank of data can be developed concerning decay of the permafrost, the influence of winter period re-freezing, and the possible relationship between melting, ice loss, and adjustment in the elevations along the top of the dyke.

The instrumentation which is proposed consists of a total of 28 thermistor strings of about 10 metre length, each having sensors spaced at approximately one meter intervals. Ten of the installations will be situated above the top of the backslope, fifteen on the top of the dyke, and three within the spoil pile downslope of the dyke. Minimum companion instrumentation will consist of a settlement hub to determine the total settlement at each of these locations.

2.1.3 Piezometric Instrumentation

The proposed piezometric observation of the performance of the backslope and the canal dyke and foundation will be based on pneumatic piezometer installations. It is envisaged that about 30 pneumatic tips will be installed at a total of about 21 locations. Because the most important aspect of the groundwater regime is that which is expected to develop between the canal and the valley bottom, 15 of these installations will be from the dyke top, and most will be double-tipped. The remaining six installations will be from the area immediately above the top of the left bank backslope. The purpose of the former installations is to determine if a phreatic surface develops within the constructed dyke section, and also to determine the piezometric pressures at greater depth, these providing insight into the seepage loss regime associated with flow in the canal.

While it is probable that piezometers will be installed as companion instrumentation to some of the other instruments discussed above, it is not mandatory that either horizontal or vertical survey movement hubs be located at each of the piezometer installations. However, each will be surveyed to determine its location after the installation is complete.

Table I summarizes the numbers and relative locations of the proposed instrumentation, all of which are to be installed over the upstream 3,000 meters of canal length.

2.1.4 Survey Reference System

The settlement and horizontal movement surveys are only of value if they are referenced to stable and dependable benchmarks. In view of this requirement, and because Underhill Engineering of Whitehorse (the project surveyors) advise that it is operationally convenient, the following is intended:

(a) Elevation bench marks will be established by drilling and plugging of sound rock at convenient locations along the canal (up to ten may be established), and

(b) Horizontal control reference points will be established by drilling and plugging of sound rock at convenient sighting locations along the north wall of the valley somewhat above the elevation of the canal (up to six may be established).

While both the (a) and (b) installations can be used for both horizontal and vertical reference, only the (b) installations will be equipped with permanent reflective mirrors suitable for use with electronic distance measuring equipment. This arrangement permits completion of all the required surveys by using the canal dyke as the principal instrument location area for the work. However, the nature of both the horizontal and vertical survey hubs and the reference points will permit complete interchangeability of survey instrument and target apparatus. This is deemed important in view of the variable weather conditions which will be encountered because of the different seasons during which the surveys will be conducted.

2.2 Readings and Interpretation

The intention of the instrumentation program is:

(a) to observe immediate geotechnical performance of the canal construction, particularly those where there is evidence of localized settlement adjustment, and where there has been a history of seepage to date,

(b) to demonstrate the absence or the amount of downslope permafrost-related creep of the backslope and the dyke section of the construction,

(c) to demonstrate the presence of a stabilized permafrost regime behind the left cut slope and to observe the change in thermal regime beneath the right dyke section, and

(d) to observe the piezometric regime which develops at several typical backslope and dyke construction sections.

These objectives can only be satisfied if a comprehensive program of observations is planned and carried out. Therefore, an initial a set of baseline or reference line measurements will be taken of the deflection casings, vertical and horizontal movement points, incremental settlement casings, and reading of the thermistors and piezometers will begin. It is anticipated that the thermistors will be read annually in early March, mid-August, and November, that the slope indicator deflection casings will be read in August and March, that the incremental settlement monitors will be read simultaneously with the thermistors, and that the piezometers will be read annually in March, late May or early June, and August.

Table II summarizes the program of readings recommeded above.

Thermistor readings will be plotted on calendar graphs, slope deflection casing readings plotted as advancing profiles, the horizontal and vertical survey hubs and incremental settlement monitors as time settlement profiles or vector plots. All the data will be presented in a manner that clearly exhibits trend performance. Subsequent readings will be added to the existing bank of data and related drawings for easy interpretation concerning performance of the sections that have been instrumented. Should the trend results of the instrumentation indicate the possibility of maintenance or remedial measures with reference to the anticipated geotechnical performance outlined in the previously cited design reports, appropriate measures can be taken and specific requirements determined through use of additional instrumentation, if necessary.

It is considered advisable that Golder Associates obtain one annual set of readings, that all engineering survey readings be obtained by Underhill Engineering Limited, and that Cyprus Anvil obtain the remainder of the readings. Golder Associates will retain the responsibility of reducing all but the engineering survey readings, and making the performance interpretations. This approach is considered to be the best from all points of view, and the continuity is most assured because both Golder Associates and Cyprus Anvil will be involved.

2.3 Embankment and Dam Instrumentation, Objectives and Requirements

The objectives of instrumenting the embankment dam sites are:

(a) to verify that the performance of the structures is within limits acceptable to the design,

(b) to observe abutment area performance with respect to both piezometric pressure distribution and thermal regime adjustement,

(c) to observe foundation settlement with time,

(d) to determine that through ongoing observation of instrumentation, the structure is continuing to perform acceptably, and

(e) to obtain forewarning of the need for mitigative measures should deteriorating performance of the structure be indicated.

Both the Cross Valley and the Intermediate Dams are of zoned earthworks construction and each contains a shallow depth core trench. The Cross Valley Dam has a central core, whereas the Intermediate Dam has a core that is either right on or near the upstream face. The Cross Valley dam also contains a core material blanket beneath the upstream shell, and it connects to a further blanket which extends beyond the toe. Whereas the amount of seepage that will pass the Cross Valley Dam represents an important design consideration, the amount of seepage expected to pass the Intermediate Dam is anticipated to be relatively smaller because of the future presence of the tailings upstream, and the relatively much smaller differential head across the structure.

2.3.1 Cross Valley Dam

Instrumentation which has been installed during construction consists of both pneumatic piezometers and settlement plates which double as standpipe piezometers due to their slotted lower section. The pneumatic piezometers were placed in the bottom of the foundation preparation excavation, whereas the settlement plates were situated either there or nominally up in the fill. By necessity, the settlement plates are located almost on the axis of the dam, whereas the pneumatic piezometers were situated to provide an upstream to downstream foundation piezometric pressure profile. Thus the pneumatic leads were extended to the downstream toe of the dam. One pneumatic piezometer was also installed in the left (south) abutment of the Cross Valley Dam in the zone that was subsequently covered with downstream shell materials.

Recognizing the presence of instrumentation as explained above, it is considered that remaining requirements consist of two thermistors in each of the Cross Valley Dam abutments, an additional piezometer in the south abutment, two in the north abutment, and the installation of nine riser pipe piezometers in the foundation zone below the dam. Six of the piezometers will be installed from three holes drilled from the crest and three will be installed from a road location immediately downstream of the downstream toe. The crest piezometers will be installed to two levels from the same hole, and they can be utilized for obtaining water samples for later water quality analyses. Only PVC plastic materials will be used in order to provide relatively uncontaminated water samples. The piezometers which are to be installed downstream of the toe will be the same, but they will communicate with only one zone within the foundation stratigraphy. Probable depth is about 10 meters below ground surface.

The purpose of the thermister and piezometer abutment instrumentation is to observe the geotechnical performance of these areas with time, and to provide assurance that the performance of the structure is consistent with that which has been anticipated by the design.

2.3.2 Intermediate Dam

The instrumentation of the Intermediate Dam will also consist of complimenting pneumatic piezometers, settlement plates, and the settlement plate slotted risers which have already been installed towards the south end of the structure where the old creek channel has been filled.

Installations which must be made consist of three pneumatic piezometers and one thermistor situated in the left (south) abutment, plus the installation of three bailable slotted PVC piezometers. These piezometers will be installed from the crest of the dam to an elevation some 10 to 15 meters below original creek channel level, and with reference to the stratigraphy encountered during their installation. Further instrumentation will be installed as the embankment is sequentially raised in accordance with tailings storage requirements.

2.3.3 Reading and Interpretation

The observation of all of the instrumentation for both the Cross Valley and Intermediate Dams must be on a planned and scheduled basis. While it is anticipated that the embankment structures will perform at least as well as anticipated by the design, the initial frequency of instrumentation readings should not be less than once per week during initial filling, and once a month thereafter. Data must be analyzed immediately after it is taken, and as trends confirming design expectations develop, the frequency of observation can be reduced. However, a minimum of four sets of readings per year must be obtained, these readings being in mid-June, early October, mid-January, and late March. Further, observations of toe and abutment seepage conditions and winter glaciation must also be made, and pictures taken in order that a photographic file of year-to-year and season to season history can be developed.

It is anticipated that Cyprus Anvil personnel will obtain the thermistor and piezometer readings and that Underhill Engineering of Whitehorse will do the levelling necessary to maintain the plate records. However, Golder Associates should maintain responsibility for reduction of the data, its interpretation with reference to design, and further, an experienced engineer from Golder Associates should inspect the installations once in the summer and once in late winter. Cyprus Anvil should undertake to observe seepage and glaciation, and to compile the related photographic record.

2.4 Equipment Suppliers

The instrumentation hardware which is to be installed will come from three sources. Westbay Instruments of Vancouver will be supplying the inclinometer casing. Slope Indicator Company of Seattle, Washington, will be supplying the inclinometer readout apparatus the incremental settlement monitor apparatus and its readout equipment. The latter will be owned by Cyprus Anvil Mining Corporation. Petur Instruments of Vancouver will be supplying the pneumatic piezometer hardware and associated leads and readout equipment, and Cantech Controls Limited of Calgary will be supplying the thermistor strings. The readout equipment for these installations will also be owned by Cyprus Anvil.

Protective surface casings will be installed to provide some security of installation, and these will be fabricated by Midnight Sun Drilling of Whitehorse from old drill casings to the limit of their availability. The horizontal and vertical movement pins will be fabricated by the same firm.

It is proposed that the installations will be made using Whitehorse-based Midnight Sun Drilling Limited, using their CME 750 carrier-mounted drill equipment. It is capable of rotary wet drilling, hollow stem and solid stem auger drilling, as well as air flush drilling. These various methods will be used depending on the type of ground being encountered. All the installations will be made under the full time supervision of a Golder Associates' field engineer experienced in installation of geotechnical instrumentation.

2.5 Hydraulic Instrumentation

It is considered important to attempt development of a water balance for the canal and the entire project. Accordingly, a flow monitoring section should be established at a convenient location within the canal just downstream of the water supply pump house, and another established on the gently graded section midway along the outfall reach of the canal. Likewise, the Intermediate Dam and Cross Valley Dams should have their decant flows monitored, and the foundation seepage from the Cross Valley Dam should also be monitored. This data can be used to establish an approximate water balance which should prove to be valuable in the future. Staff gauges and flow calibrated sections should serve the function adequately provided stable sections are chosen. It is considered most practical that Cyprus Anvil undertake this work as an in-house project in view of the need to make almost daily measurements at some times of the year, and because Cyprus Anvil already has an interest in general stream flows related to water quality managemenent and storage.

3.0 SITING OF INSTRUMENTATION UNITS

3.1 Diversion Canal

The site locations for the various types of instrumentation to be installed along the diversion canal are listed on Table III and are shown on Figures 2, 3, and 4. The criteria used to determine the locations of the various types of instrumentation for the inclinometer casings, piezometers and incremental settlement casings are reviewed briefly below. The movement hubs are generally complimentary to these primary performance instruments.

a. Inclinometer Casings - By priority, the most important locations for inclinometers are those of immediate geotechnical concern, i.e. those areas where the natural slopes are steep and of relatively lower stability, where permafrost is relatively ice rich, or where depth to bedrock is relatively great. At each inclinometer casing site, companion installations will consist of a vertical and horizontal movement hub, a string of thermistors, and a piezometer. These criteria apply to both the backslope and canal dyke aspects of the total canal section.

b. Piezometers - Backslope piezometers are situated to observe both shallow and deep backslope seepage pressures related to permafrost degradation and the groundwater regime which is either present or is expected to develop. On the top of the dyke, the piezometers are situated where significant localized downslope seepage has been observed and at the downstream face and at critical points adjacent to the two dams. Double piezometer installations are preferable for dyke instrumentation in order to observe seepage conditions at the interface between the fill and the stripped natural ground, and to provide information concerning near-vertical seepage from the diversion canal. In most cases the piezometer installations are complimented with other types of instrumentation (see Figure 1a).

c. Incremental Settlement Casings - These installations are being made where there is reason to expect larger than average settlement due to permafrost melting and high dyke section loading, and also adjacent to the Cross Valley and Intermediate Dams where knowledge of canal dyke performance is particularly important from the point of view of embankment proximity.

d. Thermistors - In addition to the thermistor string installations that are companion to inclinometer casings, incremental settlement casings, etc, other locations of permanfrost meltback interest in the backslope, dyke, and the spoil piles are to be instrumented.

Although the installation locations will be field-tuned with reference to detailed construction records, the layouts are to be generally as shown on Figures 2 to 4 in the field. Slope indicators, incremental settlement monitors and thermistors will be installed generally to predetermined depths in the range of 10 meters. Settlement hubs are also of a standard design and they will be set 1.5 meters into the ground. Only the piezometer depths will be varied to satisfy the section in question. The depth of installation will be determined in the field and will depend on the depth to the contact between fill and natural ground and the contact between frozen and unfrozen ground. As a general rule, instrument drill holes will be terminated at a shallow depth where rock is encountered.

3.2 Spoil Piles

Locations for instrumentation of the spoil piles have not been laid out on the drawings or included in Tables IIIA and IIIB because spoil pile accessibility, conditions, and location must be field assessed. However, it is proable that, in the vicinity of stations 1+400 and

2+800, slope indicators, incremental settlement casings, surface movement hubs vertical and horizontal and thermistors will be installed. At approximately station 1+900, a slope indicator, a surface movement hub, and a thermistor will be installed, and at approximately stations 2+200, 2+700, and 2+800, only surface movement hubs will be installed.

3.3 Cross Valley Dam

Instrumentation proposed for the Cross Valley Dam is shown on Figure 5. It consists of two pneumatic piezometers and two thermistors in the north abutment, one pneumatic piezometer and two thermistors in the south abutment, and nine hydraulic piezometers (three along the downstream toe and six extending from the crest into the foundation). These installations compliment settlement plate/standpipe piezometer units and pneumatic piezometers that were installed during construction.

The piezometers have been positioned in order to better define seepage flow under and around the dam, while the thermistors will be used to observe changes in abutment thermal regime.

3.4 Intermediate Dam

Instrumentation proposed for the Inter-ediate Dam is shown on Figure 6. It consists of one thermistor and three pneumatic piezometers in the south abutment and three hydraulic piezometers each installed along the crest and into the foundation soils. Again, this instrumentation compliments settlement plate/standpipe piezometers and pneumatic piezometers installed during construction.

The objectives in instrumenting the Intermediate Dam are as have been as described above for the Cross Valley Dam.

4.0 ENGINEERING SURVEY (UNDERHILL ENGINEERING)

Engineering surveys are to be provided by Underhill Engineering of Whitehorse. A copy of their procedures, equipment, and services proposed is provided in Appendix A.

5.0 INSTALLATION TECHNIQUES

Installation of the instrumentation will be done by Midnight Sun Drilling Company of Whitehorse. The following sections give the procedures for the installation of each instrument. The manufacturers' literature for each is shown in Appendix B. All instrument installation and drilling will be done under the supervision of Golder Associates' personnel.

5.1 Inclinometer Casing

Installation of the inclinometer casing supplied by Westbay Instruments shall be done by drilling a minimum 4 inch diameter hole to a depth of approximately 10 meters, preferably using the air rotary or auger method to save time. Once drilling is complete, the SI casing will be assembled using watertight couplings and installed in the drill hole. Then the annular space around the casing will be filled with a dry sand in such a way that no voids are left between the casing and the wall of the hole. The top of the inclinometer casing will be covered with the protective casing and attached lid.

5.2 Sondex Incremental Settlement Casing

Incremental settlement will be measured by the Sondex tube method. Two types of installation will be used. At most locations where inclinometer casings are installed, steel rings will be attached to the outside of the casing in such a manner that once installed, the ring will move with the soil and relative to the inclinometer casing. The distribution of settlement with depth will be determined by knowing the elevation of the top of the casing and the changing position of each of the rings with time.

The second type of installation for measuring incremental settlement is based on use of a 10 m long 3 inch diameter corrugated plastic casing equipped with steel rings spaced at one meter intervals. The casing shall be installed as has been described for the inclinometer casing in paragraph 5.1 above. Protective casings will also be used for these settlement monitoring installations.

5.3 Vertical and Horizontal Movement Hubs

Vertical and horizontal movement will be observed by installing a riser pipe and protective casing as shown on Figure 7. The minimum 6 in diameter hole will be air rotary or auger drilled to a minimum depth of 5 feet. The apparatus will then be installed and backfilled with dry, fine to medium sand, the protective casing being placed to leave acceptable clearance for the device at the top of the hole.

5.4 Thermistors

Thermistor strings having sensors spaced at 1 m intervals will be installed to a depth of 10 meters by drilling a 4 inch diameter hole by the air rotary method installing the thermistor string and then backfilling the hole with dry, fine to medium sand. Casings will be installed to protect the installations.

5.5 Piezometers

Pneumatic piezometers are to be installed to depths determined by the Golder Associates' field engineer based on drill hole and section information. They will be installed in minimum 4 inch diameter air rotary holes. Then the piezometer will be bedded in a 0.5 m column of sand topped with 1/3 m bentonite balls, followed by either sand or grouting depending on the location, weather conditions, etc. Each of the piezometer tips will be placed in a plastic bag of diesel fuel or antifreeze to protect it against frost damage where the installations are in permafrost strata which are expected to thaw.

In ten of the holes, a second piezometer shall be installed. This shall be done by the following method. Once the bentonite layer for the first piezometer is in place, dry sand shall be installed to within 1/2 m of the location of the second piezometer. Next, a 1/3 m layer of bentonite balls followed by 1/3 m of sand will be placed and then the piezometer installed. Then 1/3 m of sand backfill is placed around the piezometer followed by another 1/3 m layer of bentonite balls. The installation will then completed as noted above and a protective surface casing installed.

6.0 PERFORMANCE OBSERVATIONS

In order to ensure that all instruments are in working order, an initial set of readings shall be taken as soon as possible after installation of each instrument. Additionally, at the completion of the installation program, the Golder Associates field engineers will work together with the designated Cyprus Anvil instrumentation technician to take a complete set of readings. This will permit the Cyprus Anvil technician to become familiar with the locations, to become competent in operation of the instruments, to be able to recognize the difference between good and bad readings, and what to do should abnormal readings be repeatable.

Field data sheets for each type of installation have been provided in Appendix C.

After obtaining the initial set of readings, future readings will be taken by the member of Cyprus Anvil Mining Corporation who has been trained in the use of the instruments. After each set of readings has been taken, copies of te field recording sheets shall be transmitted to Golder Associates for interpretation and Cyprus Anvil Mining will be immediately notified of any problems.

It is also recommended that, on an annual basis, a member of Golder Associates take a set of readings to make sure that all instruments are working properly and that there are no major problems. This time would also be used to make an inspection of the canal and dams to determine if there are any potential problems that have not been identified by the instrumentation or the on-going site inspections being made by Cyprus Anvil staff.

TABLE I

Canal Instrumentation Summary

Item/Location	Top of Backslope	Top of Dike	Waste Pile	Total Requirement
Settlement Hubs	20	30	6	56
Horizontal Movement Hubs (1)	10	10	6	26
Inclinometer Casings	7	6	3	16
Pneumatic Piezometers (2)	8	13	-	21
Incremental Settlement Monitor	2	6	2	10
Thermistor Strings	10	15	3	28
Total Installations	57	80	20	157

Notes: (1) The hardware for both the horizontal and vertical movement hubs is synonomous; the associated survey operations are different.

(2) Eight of these piezometer locations will have double tips along the dike and two piezometer locations along the top of the backslope will have double tips.

General: Each of the installations will require a protective casing cap and a total of 123 are required.

TABLE II

Observation Frequency and Timing For Canal Instrumentation

Item/Timing	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Settlement Hubs			x					x				
Horizontal Movement Hubs			x					x				
Inclinometer Casings			x					x				
Pneumatic Piezometers			x			x		x				
Incremental Settlement Monitors			x			x		x			x	
Thermistor Strings			x			x		x			x	

TABLE IIIA

BACKSLOPE INSTRUMENT LOCATIONS

Baseline Chainage	Reference Line Chainage	Slope Indicator	Incremental Settlement	Vertical Settlement	Horizontal Settlement	Thermistor	Piezometer
0+020	0+115	X		X	X	X	X
0+300	0+410			X			
0+430	0+540	X	X	X	X	X	X
0+600	0+710			X	X		X
0+750	0+860			X			
0+900	1+010			X		X	
1+050	1+160			X			
1+250	1+350	X		X	X	X	X
1+350	1+450			X			
1+500	1+605			X	X	X	
1+650	1+755			X			
1+850	1+960	X		X	X	X	X (2)
2+030	2+140	X	X	X	X	X	X
2+200	2+310	X		X	X	X	X (2)
2+350	2+460			X			
2+470	2+585	X		X	X	X	X
2+630	2+740			X			
2+780	2+900			X	X	X	
2+930	3+045			X			
3+080	3+195			X			

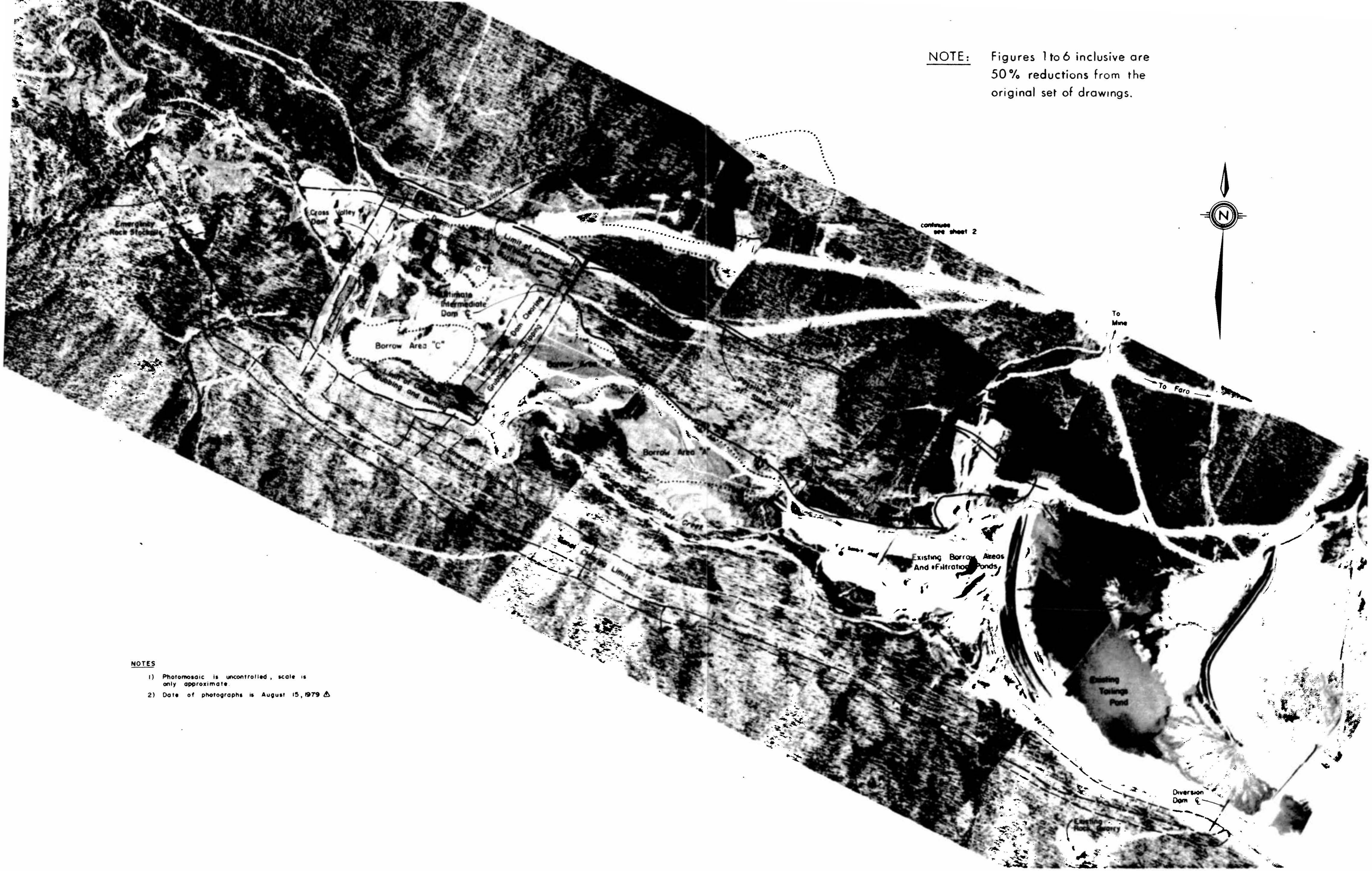
TABLE IIIB

TOP OF DYKE INSTRUMENT LOCATIONS

Baseline Chainage	Reference Line Chainage	Slope Indicator	Incremental Settlement	Vertical Settlement	Horizontal Settlement	Thermistor	Piezometer
0+000	0+100			X	X	X	X
0+100	0+200			X			
0+200	0+300			X			
0+275	0+385	X	X	X	X	X	X (2)
0+400	0+510			X			
0+500	0+610			X			
0+600	0+710			X	X	X	X
0+800	0+910			X			
0+880	0+990	X	X	X	X	X	X (2)
1+000	1+110			X			
1+100	1+210			X			
1+200	1+300			X		X	
1+300	1+405	X	X	X	X	X	X (2)
1+450	1+555			X		X	
1+520	1+625			X			
1+620	1+725			X		X	X
1+720	1+830			X			
1+820	1+930	X	X	X	X	X	X (2)
1+920	2+030			X			
2+020	2+130			X	X	X	X
2+160	2+270			X			
2+255	2+365	X		X	X	X	X (2)
2+350	2+460		X	X		X	X (2)
2+450	2+565			X			
2+550	2+665		X	X	X	X	X (2)
2+650	2+765			X			
2+750	2+870			X			
2+840	2+960	X		X	X	X	X (2)
2+950	3+070			X		X	X
3+050	3+170			X			

Note: In addition to the above, there will be spoil pile instrumentation as detailed in Table I.

NOTE: Figures 1 to 6 inclusive are 50% reductions from the original set of drawings.



NOTES

1) Photomosaic is uncontrolled, scale is only approximate.
2) Date of photographs is August 15, 1979 ⚠

············ Borrow Area Boundary

———— Possible Slashing Boundary

— — Clearing, Grubbing and Burning Boundary

NO	DESCRIPTION	DATE	BY
2	Instrumentation Layout	Sept. 81.	
⚠	CORRECTION OF DATE OF PHOTOGRAPHS	Sept. 1/1980	D G

REVISIONS

PROFESSIONAL ENGINEER H G GILCHRIST

Scale Approx 1 : 5000
Job No 792 - 2025
Drawing No 7922025 - 1

Drawn by	Reviewed by
B	D G
Date August, 1980	Date August, 1980

CYPRUS ANVIL

Faro
Yukon Territory

Cyprus Anvil Mining Corporation

SITE PHOTOMOSAIC, LIMITS OF CLEARING, BORROW AREAS

DOWN VALLEY TAILINGS PROJECT

Golder Associates

Figure . 1.

Golder Geotechnical Consultants Ltd.

Sheet 1 of 12

Project No. 812-2041 Drawn [illegible] Reviewed [illegible] Date Sept.'81

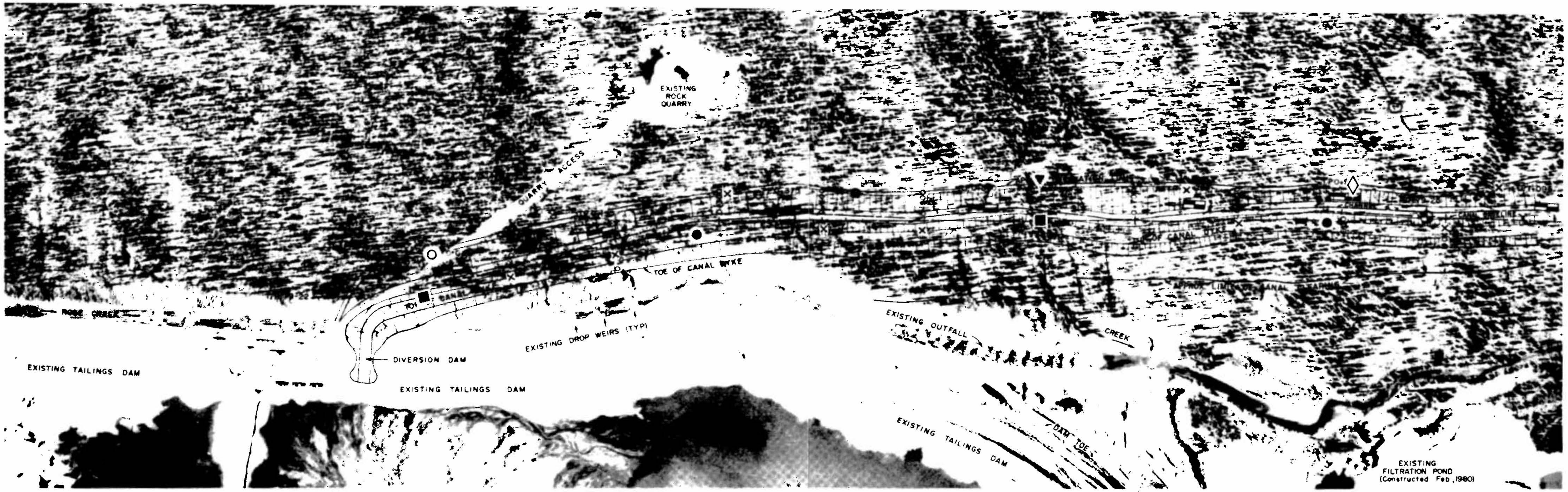
LEGEND FOR FIGURES 2 to 6 INCLUSIVE

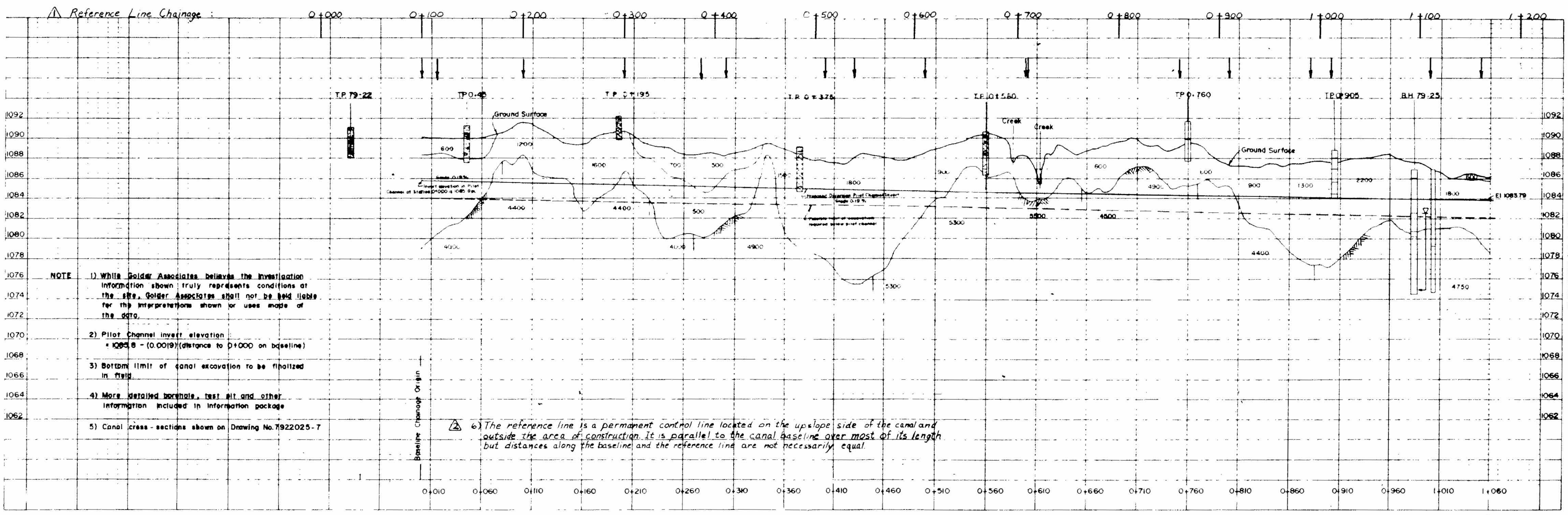
Figure . 1a.

SYMBOL	Inclinometer Casing	Incremental Settlement.	Vertical Settlement.	Horizontal Movement	Thermistor.	Piezometer.
○	×		×	×	×	×
●	×	×	×	×	×	×
□			×	×	×	
■			×	×	×	×
△			×		×	×
▲		×	×	×	×	×
×			×			
▽		×	×		×	×
▼			×	×		×
◇			×		×	
◆					×	
+						×
*					×	×

Location of instruments shown as ↓ on profile

Golder Associates





NOTE

1) While Golder Associates believes the investigation information shown truly represents conditions at the site, Golder Associates shall not be held liable for the interpretations shown or uses made of the data.

2) Pilot Channel invert elevation
= 1085.8 − (0.0019)(distance to 0+000 on baseline)

3) Bottom limit of canal excavation to be finalized in field.

4) More detailed borehole, test pit and other information included in information package

5) Canal cross-sections shown on Drawing No. 7922025-7

⚠2 6) *The reference line is a permanent control line located on the upslope side of the canal and outside the area of construction. It is parallel to the canal baseline over most of its length but distances along the baseline and the reference line are not necessarily equal.*

Legend

- Fill
- Organics & Debris
- Organic Silt
- Volcanic Ash
- Boulders & Cobbles
- Gravel
- Sand & Gravel (Alluvium)
- Sand
- Silt
- Clay
- Till or Colluvium
- Bedrock
- Seismic Boundary
- Seismically inferred bedrock surface
- 2000 Denotes seismic velocity m/sec.
- Thermistor — frozen / — unfrozen
- Piezometer — water level / — tip location
- T.P. Test Pit
- B.H. Borehole

NO.	DESCRIPTION	DATE	BY
3	*Instrumentation Layout – Sept. 81*		
⚠2	*Reference Line Note 6*	Nov. '80	D.G.
⚠1	*Reference Line Chainage Added*	Nov. '80	P.C.

REVISIONS

PROFESSIONAL ENGINEER H.G. GILCHRIST YUKON TERRITORIES

Scale: as shown
Job No. 792-2025
Drawing No. 7922025-3

Drawn by	Reviewed by
R.W.	D.G.
Date August 1980	Date August 1980

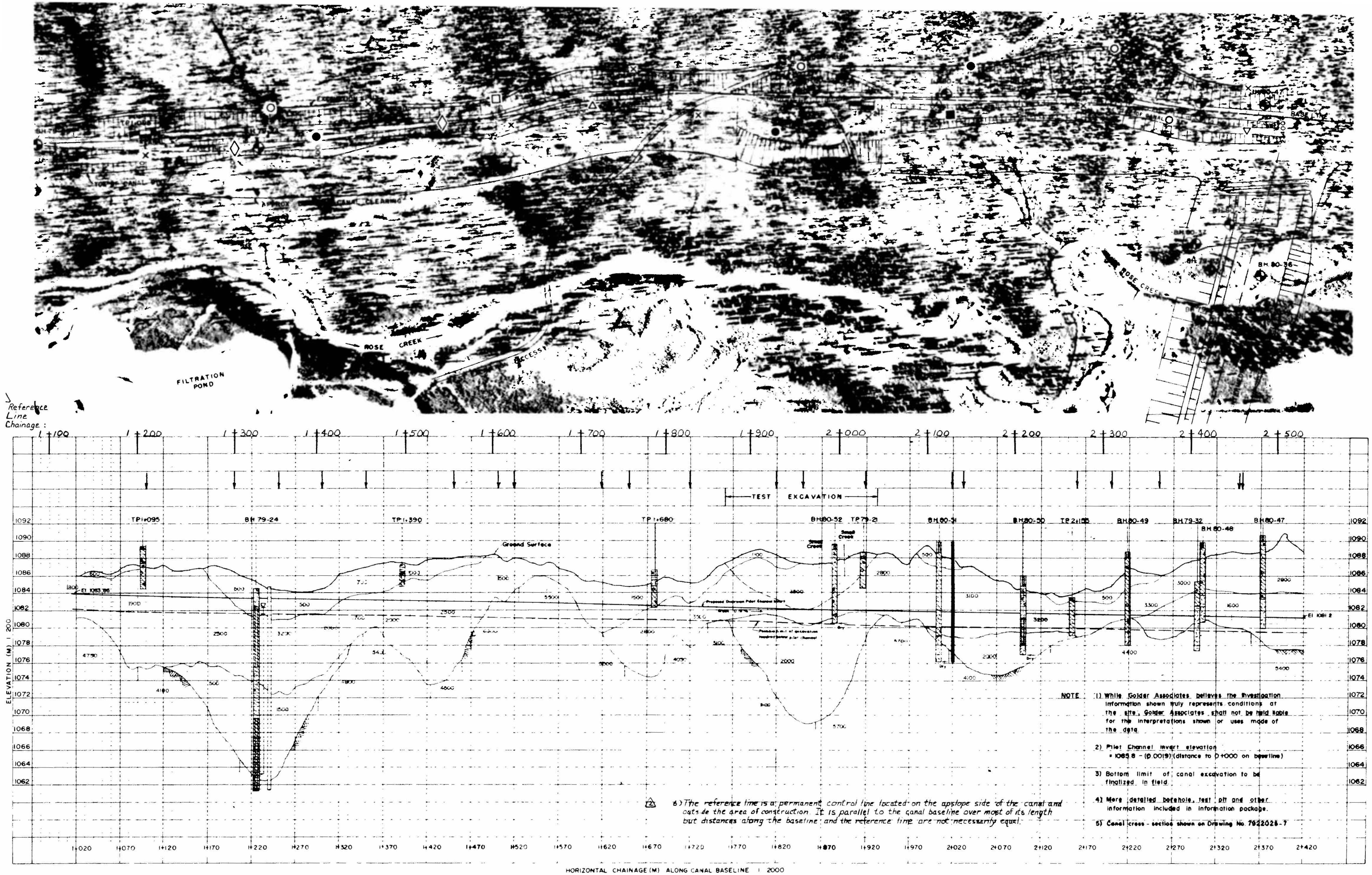
CYPRUS ANVIL

Faro
Yukon Territory
Cyprus Anvil Mining Corporation

CANAL PLAN AND PROFILE BASELINE CHAINAGE 0+000 to 1+060

DOWN VALLEY TAILINGS PROJECT

Golder Associates
Figure . 2.
Golder Geotechnical Consultants Ltd.
Sheet 3 of 12



Fill	Gravel	Till or Colluvium	Thermistor — frozen, — unfrozen
Organics & Debris	Sand & Gravel (Alluvium)	Bedrock	Piezometer
Organic Silt	Sand	Seismic Boundary	water level
Volcanic Ash	Silt	Seismically inferred bedrock surface	tip location
Boulders & Cobbles	Clay	2000 Denotes seismic velocity m/sec	TP Test Pit / BH Borehole

NO	DESCRIPTION	DATE	BY
3	Instrumentation Layout – Sept '81.		
2	Reference Line Note 6	Nov '80	D.G.
1	Reference Line Chainage Added	Nov '80	P.C.

REVISIONS

Scale as shown
Job No. 792-2025
Drawing No. 7922025-4

Drawn by	Reviewed by
R W	D G
Date August 1980	Date August 1980

CYPRUS ANVIL

Faro
Yukon Territory

Cyprus Anvil Mining Corporation

CANAL PLAN AND PROFILE
BASELINE CHAINAGE
1+020 to 2+420

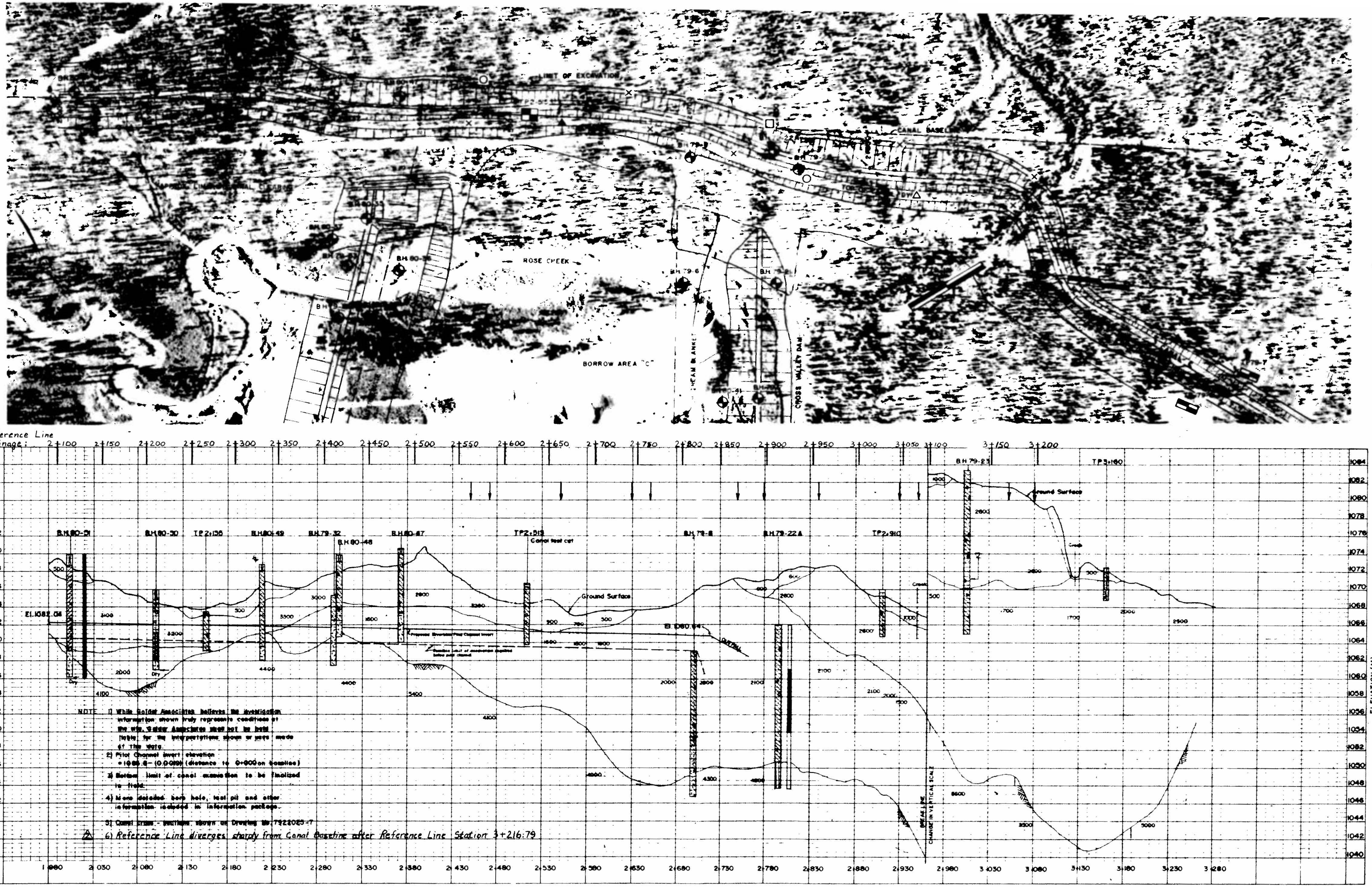
DOWN VALLEY TAILINGS PROJECT

Golder Associates

Figure . 3 .

Golder Geotechnical Consultants Ltd.

Sheet 4 of 12



Legend		
Fill	Gravel	Till or Colluvium
Organics & Debris	Sand & Gravel (Alluvium)	Bedrock
Organic Silt	Sand	Seismic Boundary
Volcanic Ash	Silt	T.P. Test Pit
Boulders & Cobbles	Clay	B.H. Borehole

Thermistor: ← frozen, ← unfrozen
Piezometer: ← water level, ← tip location
Seismically inferred bedrock surface
2000 Denotes seismic velocity m/sec.

NO.	DESCRIPTION	DATE	BY
3	Instrumentation Layout - Sept '81		
2	Reference Line Note 6	Nov. '80	P.C.
1	Reference Line Chainage Added	Nov. '80	P.C.

Scale: as shown
Job No. 792-2025
Drawing No. 7922025-5

Drawn by	Reviewed by
R.W.	D.G.
Date August 1980	Date August 1980

CYPRUS ANVIL

Faro
Yukon Territory

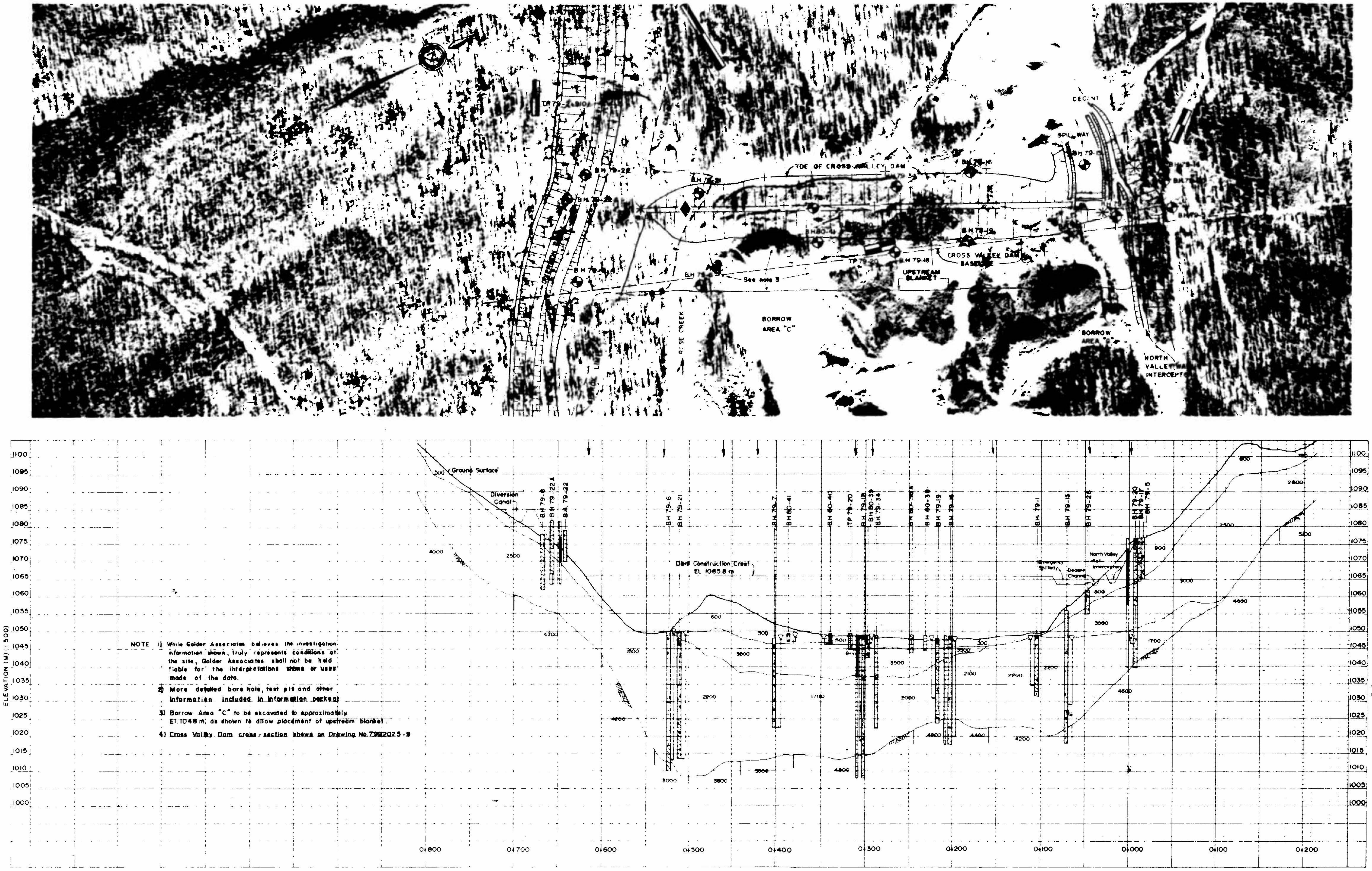
Cyprus Anvil Mining Corporation

CANAL PLAN AND PROFILE
BASELINE CHAINAGE
1+980 to 3+280

DOWN VALLEY TAILINGS PROJECT

Golder Associates
Figure . 4 .
Golder Geotechnical Consultants Ltd.

Sheet 5 of 12



NOTE

1) While Golder Associates believes the investigation information shown, truly represents conditions of the site, Golder Associates shall not be held liable for the interpretations shown or uses made of the data.

2) More detailed bore Hole, test pit and other information included in information package

3) Borrow Area "C" to be excavated to approximately ET. 1048 m, as shown to dllow placement of upstream blanket.

4) Cross Valley Dam cross-section shown on Drawing No. 7992025-9

Fill
Organics & Debris
Organic Silt
Volcanic Ash
Boulders & Cobbles
Gravel
Sand & Gravel (Alluvium)
Sand
Silt
Clay
Till or Colluvium
Bedrock
Seismic Boundary
T P Test Pit
B H Borehole
Thermistor
← frozen
← unfrozen
Piez meter
water level
tip location
Seismically inferred bedrock surface
2000 Denotes seismic

1 Instrumentation Layout - Sept 81

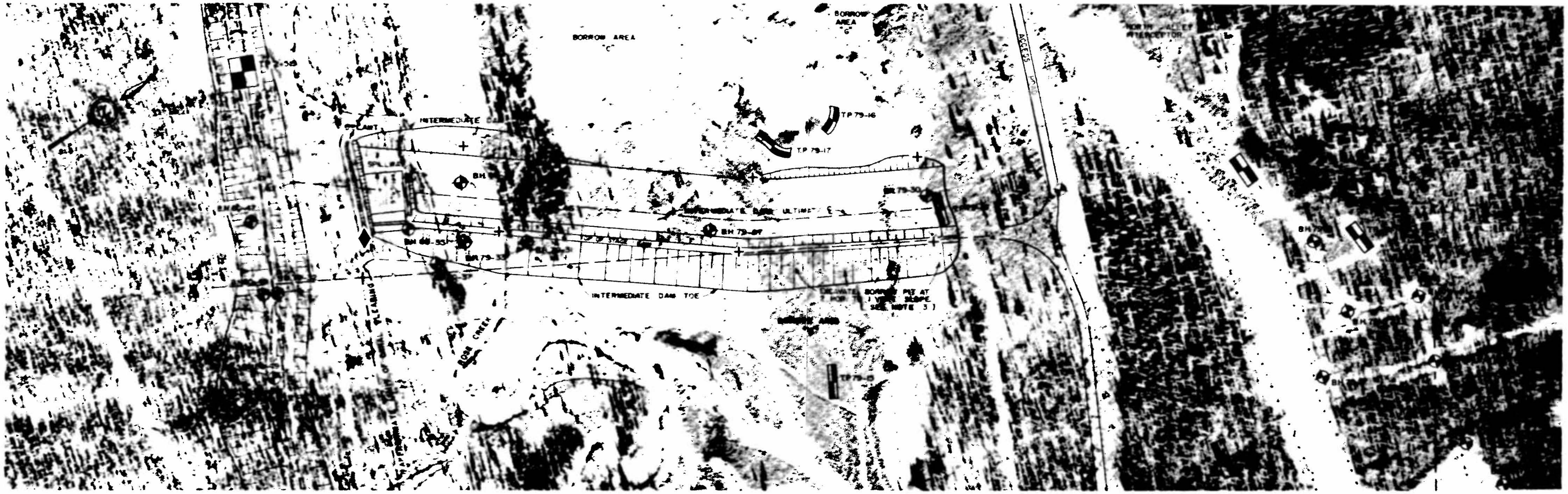
PROFESSIONAL ENGINEER
H.G. GILCHRIST

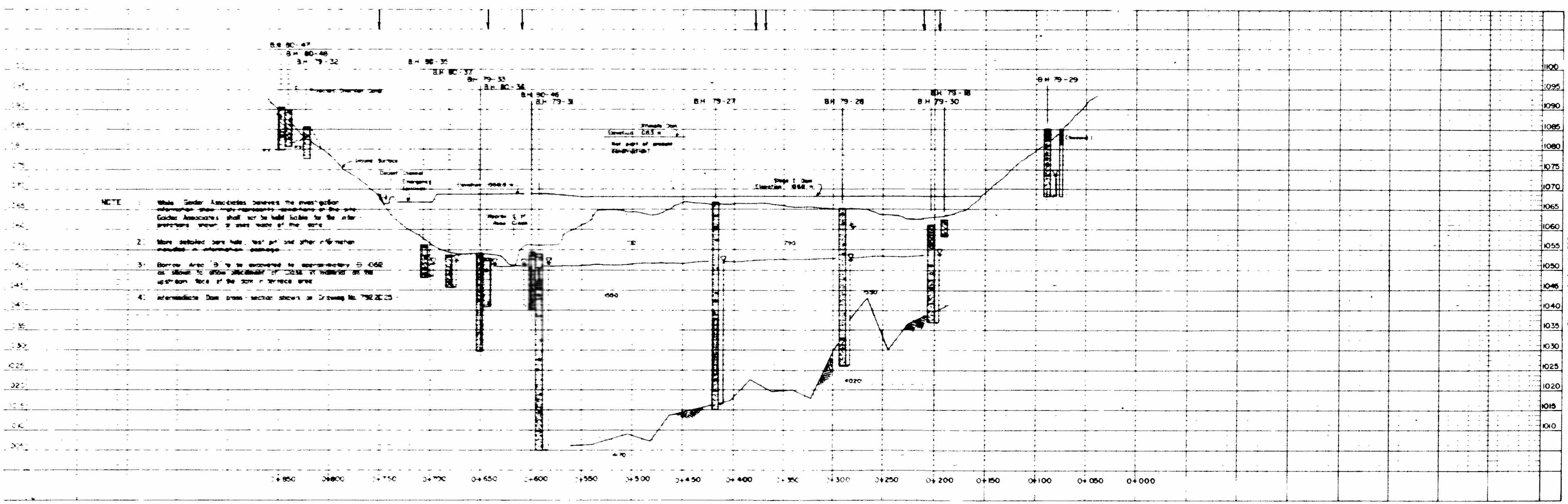
Scale: as shown
Job No. 792-2025
Drawing No. 7922025-8
Drawn by R.W.
Reviewed by D.G.
Date
Date

CYPRUS ANVIL
Faro
Yukon Territory

CROSS VALLEY DAM
PLAN AND PROFILE

Golder Associates
Figure 5
Golder Geotechnical Consultants Ltd.





Legend			
Ice	Gravel	Till or Colluvium	Thermistor: ■ frozen, □ unfrozen
Organics & Debris	Sand & Gravel Alluvium	Bedrock	Water level
Organic Silt	Sand	Seismic boundary	T.P. location
Volcanic Ash	Silt	Seismically inferred bedrock surface	T.P. Test Pit
Boulders & Cobbles	Clay	2000 Denotes seismic velocity m/sec	B.H. Borehole

NO	DESCRIPTION	DATE	BY
1	Instrumentation Layout Sept 81		

PROFESSIONAL ENGINEER H.G. GILCHRIST YUKON TERRITORIES

Scale as shown
Job No 792-2025
Drawing No. 7922025-0
Drawn by RW
Reviewed by DG
Date
Date

CYPRUS ANVIL

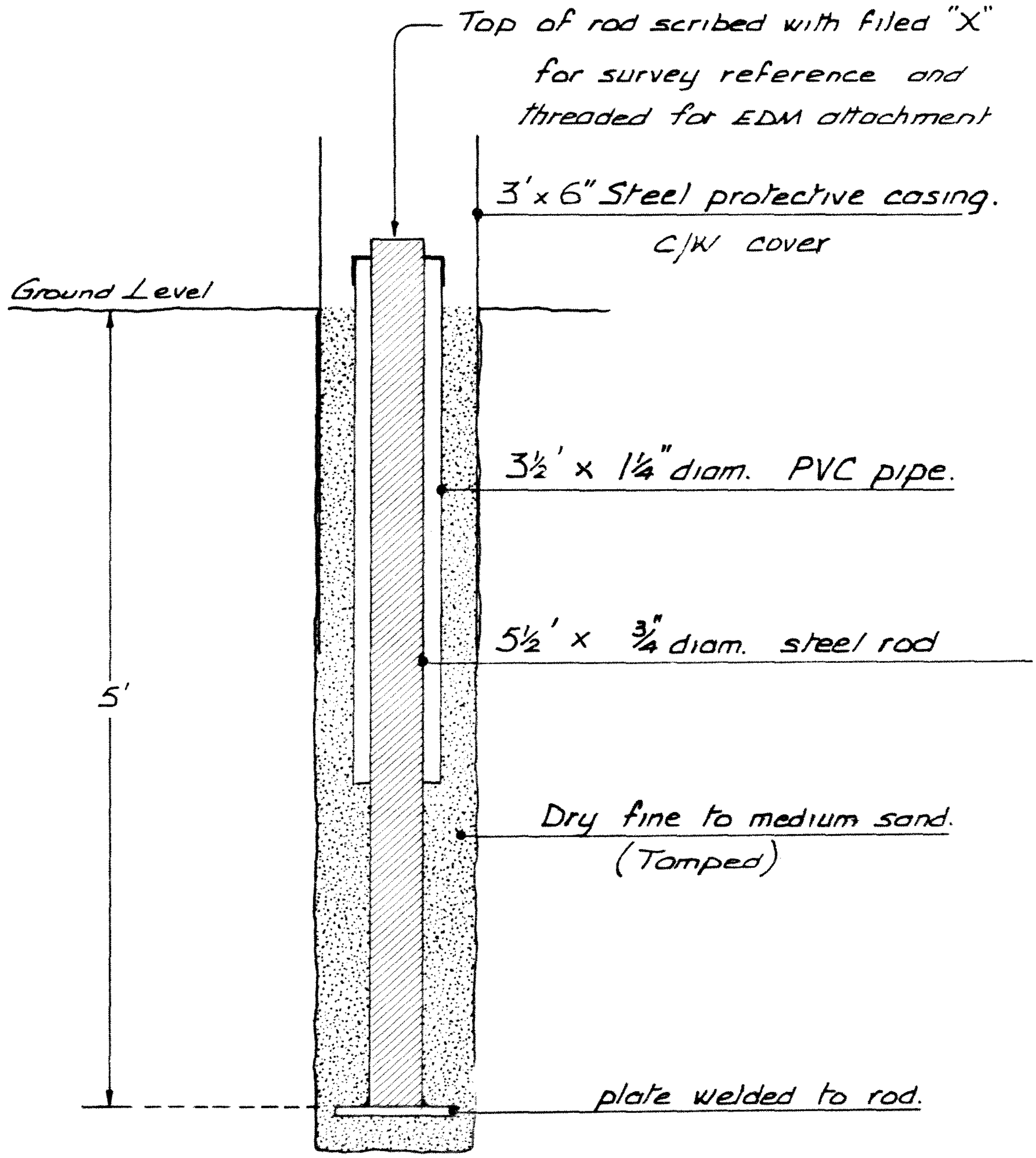
Faro
Yukon Territory

INTERMEDIATE DAM PLAN AND PROFILE

Golder Associates
Figure .6.
Golder Geotechnical Consultants Ltd.

VERTICAL & HORIZONTAL MOVEMENT HUB DETAIL

Figure .7.



NOT TO SCALE

NOTES:

1. Threaded pipe cap over PVC pipe is drilled to take ¾" smooth pipe; slip fit, top & bottom.
2. Backfill hole with dry fine to medium sand to ground level

Project No. 812-2041 Drawn GP Reviewed JS Date Sept '81

Golder Associates

PROPOSAL FOR

SETTLEMENT STUDY SURVEYS
DOWN-VALLEY TAILINGS CONTAINMENT PROJECT
CYPRUS ANVIL MINE
FARO, YUKON

to

GOLDER ASSOCIATES
Consulting Geotechnical Engineers

October, 1981

by

UNDERHILL ENGINEERING LTD.
Engineers and Surveyors
Whitehorse, Yukon

File Y-2678

PROPOSAL FOR
SETTLEMENT STUDY SURVEYS
DOWN-VALLEY TAILINGS CONTAINMENT PROJECT
CYPRUS ANVIL MINE
FARO, YUKON

1. INTRODUCTION

This proposal has been prepared at the request of Mr. H.G. Gilchrist, P.Eng. of Golder Associates - Consulting Geotechnical Engineers, Calgary Alberta. The general requirements for the project have been discussed with Mr. Gilchrist by the writer and this proposal and its methodology is based on information known to us at this time.

Field conditions may require modification of specific methodology items with the general terms outlined. We will take into consideration the factors of survey accuracies and inherent costs associated with achieving these accuracies.

2. LOCATION OF THE PROPOSED WORK

The Down-Valley tailings containment project is located at the Cyprus Anvil Mine at Faro, Yukon and has consisted of the design and construction of a series of tailings dams and diversion dams together with a diversion canal for Rose Creek. Underhill Engineering Ltd. has supplied support survey services to Golder Associates periodically on various aspects of design evaluation and construction since August, 1974 and most recently by providing resident survey services for the latest construction program which commenced in October, 1980 and is presently in the final stages of completion.

.../2

3. SCOPE OF THE PROPOSED WORK

In order to evaluate the long-term stability of the dams, waste piles and canal, Golder Associates will be having installed in October and November, 1981 approximately 90 settlement gauges to be used for monitoring vertical and horizontal movement on key elements of the completed construction. It is understood that 5 foot long steel rods attached to a metal foot-plate will be installed in drilled holes which are to be backfilled and protected with an embedded casing protruding above the top of the steel rod.

The positions of these settlement gauges are to be determined initially and re-measured in March and August each year to check for horizontal and vertical movement. The results of each re-measure will be portrayed as incremental displacement vectors for each gauge measured.

The following methodology will be employed to achieve measurement accuracies in the order of 1 centimetre.

4. SURVEY METHODOLOGY

4.1 Criteria Governing Final Accuracies

In evaluating the approach to horizontal distance measurement and elevation determination, the following factors must be considered.

- stability of the "fixed" reference control points from which control measurements to the settlement gauges are made.

- ease of access for personnel and equipment to the reference control points in both summer and winter conditions.

- intervisibility of control stations and configuration of the reference point framework.

- lack of line-of-sight to gauges on the outer toe of the canal dyke from control positions on the south bank.

- accuracies of various electronic distance measuring (EDM) systems, both constant and proportional to distance.

- measuring range of various EDM systems.

- effects of varying air conditions on the index of refraction for vertical angle determination and correction of EDM measurements for speed of light in ambient conditions.

.../3

4.2 Network Pre-Analysis

During installation of the settlement gauges, field reconnaissance would commence for the selection of locations for reference control stations. All gauge and control stations would be plotted on available mapping and a network strength analysis would be performed by computer to point out weaknesses in the net and areas where additional control reinforcement by redundant measurements are necessary. Installation of the control stations would commence thereafter.

4.3 Control Station Installation

Control stations would be installed at required locations and in consideration of the factors noted in Section 4.1 preceding. It will be highly desirable to set points in solid bedrock where it can be found and consisting of either

- iron bars drilled and grouted into 30 cm deep holes, or

- bronze discs grouted flush with the surface into 10 cm deep drilled holes.

In both situations, non-shrinking grout would be used. The control points set would be centre-punched and painted and referenced to nails in nearby trees or other features for assisting retreival in winter conditions. We would recommend that the control station locations otherwise be kept as inconspicuous as possible to avoid attracting vandalism or disturbance.

In areas where competent bedrock cannot be found and used, we would install 9 cm diameter galvanized steel pipe by driving to refusal, and embed a bronze disc into the top with grout and anchor wire. We have had excellent results with this type of monument in past installations in areas of permafrost and unstable ground, generally using a 1.5 metre length of heavy-walled pipe. A coordinate control network established by the writer in Ross River for the Department of Energy, Mines and Resources in 1976 using this type of monument has shown virtually no evidence of monument upheaval since installation. Where these monuments are set in frost susceptible material, movement possibility must be considered and the measurement program tailored accordingly to test the stability of the point.

It is anticipated that a series of stations will be established on the north and south sides of the valley and we would attempt to keep as many as possible at the same general elevation to minimize atmospheric adjustment corrections for temperature and barometric pressure.

.../4

In addition to the reference control network to be established along the valley sides, we would also suggest installation of two reference monuments located in stable rock well away from the dam and canal construction sites. These would be connected by strong ties to the valley control network and would reference also some distance point for azimuth orientation. These monuments would be used to confirm any detected movement of the "fixed" control stations.

Figure 1 following shows a typical control net layout.

4.4 Horizontal Measurement Methods

The initial measurement of the net will be made using KERN DKM3 theodolites for angulation and various EDM systems for distance, depending on range. The KERN DKM3 can be read to 0.1" of arc and we have had excellent results with the instrument on precise tunnel control work and other deformation studies. Directions would be observed several times on each face of the instrument. Simultaneous reciprocal vertical angles would be measured on each line to give good vertical values for the remote control points.

The distance measurements would be made using Geodimeter, Hewlett-Packard or Tellurometer MA100 EDM systems, depending on range. The Geodimeter and Hewlett-Packard systems generally have a single measurement accuracy in the range of 5 mm $\pm$ 5 to 10 ppm; the Tellurometer MA100 system has a mean accuracy of 2 mm $\pm$ 4 ppm but has less range than the other systems. Repeated measurements will improve the accuracies somewhat.

In order to improve measurement accuracies additional steps will be taken, namely:

- calibration of EDM equipment on the Whitehorse Test Base prior to each survey.

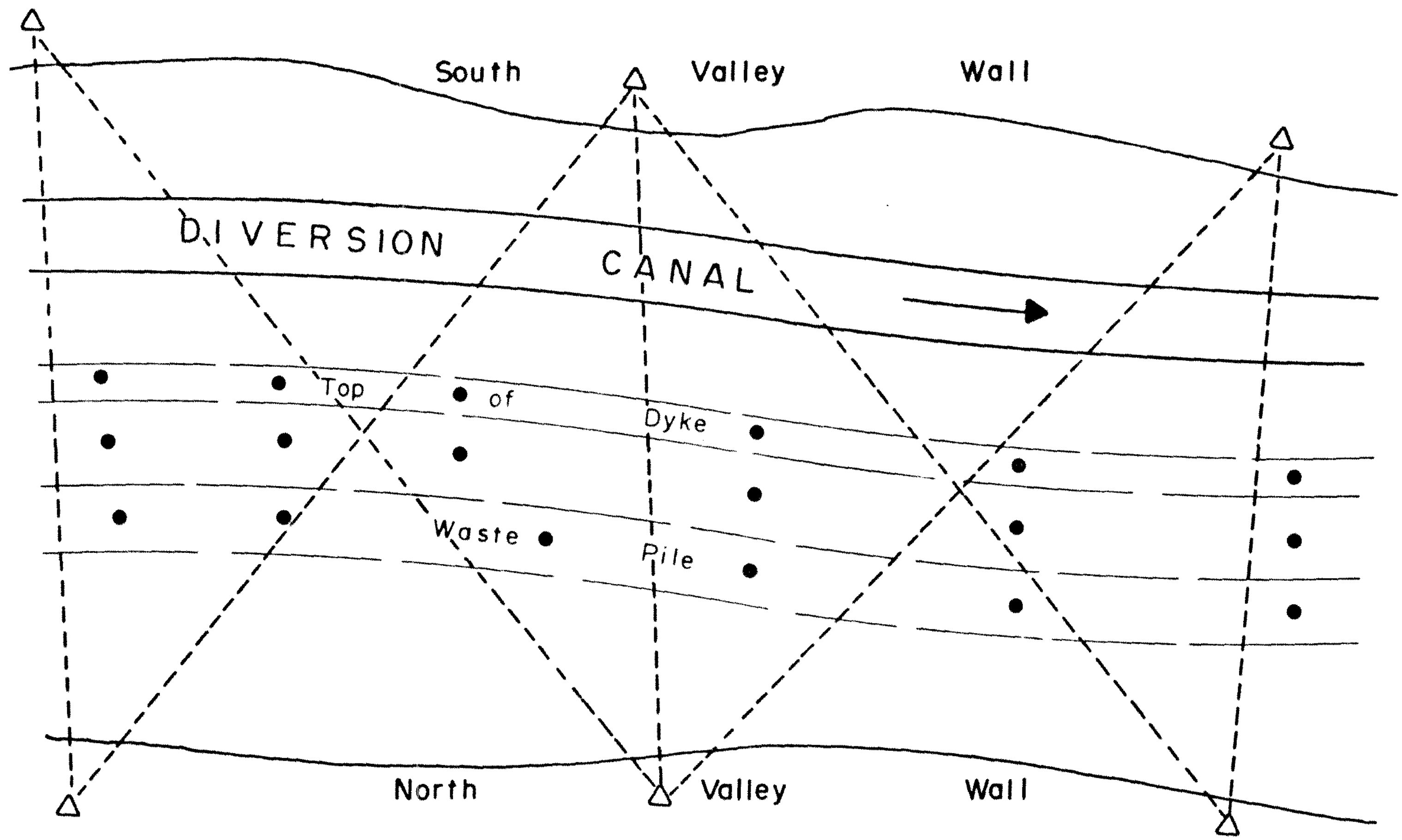
- use of forced-centering tribrachs over each station, with optical plummets.

- measurement of temperature and pressure at each end of lines measured, for best atmospheric compensation.

Once the control network is measured, the measurements will be reduced, computed and adjusted to best mean values relative to the co-ordinates of the remote monuments.

.../5

Figure 1



Settlement Gauges shown thus ●
Control stations shown thus △
Control lines shown thus - - - - - - - - - -

TYPICAL CONTROL NET LAYOUT

The settlement gauge measurements will be made by KERN DKM3 and EDM from control stations on one or the other walls or to the valley wall stations from the settlement gauges, depending on line of sight and measuring distance accuracy. The gauges along the toe of the slopes may present some problem in visibility to the near-wall stations and some temporary eccentric stations may have to be employed to measure these efficiently.

A combination of precise traverse and trilateration methods will provide redundant conditions for the position analysis of these gauges.

Using the confirmed control station coordinates, the settlement gauge positions will be similarly calculated, analyzed and adjusted. Displacement vectors from original and last previous measurements can then be computed and tabulated.

4.5 Vertical Measurement Methods

In the process of obtaining the horizontal measurements on the control points, it was mentioned that simultaneous reciprocal vertical angles would be measured to give a good elevation value for each control station. Because of atmospheric variations this method cannot deliver the necessary vertical accuracies required and accordingly, we would determine the elevations of all settlement gauges by differential spirit levelling using a WILD NA3 first-order level. Closed loops would be run along the dyke top, tying into the south valley wall control stations for reference checks at each re-measure and as required by vertical difference limitations, similar lines run to pick up elevations on settlement gauges on the toes of the slopes.

Specific requirements for vertical monitoring frequency can be discussed with Golder personnel and the field procedure modified accordingly.

Elevation values would be determined and adjusted with the final result and differences from initial and last previous measurements tabulated in the same manner as for the horizontal position values.

.../6

It must be emphasized that the procedures outlined are general in nature and will be modified accordingly as field conditions and end-use requirements permit.

5. PROJECT PERSONNEL

It would be our intention to undertake the initial reconnaissance and planning work in consultation with Golder personnel. The survey work would be coordinated by Mr. T.E. Koepke P.Eng., CLS and alternatively by Mr. T.L. Bidnak P.Eng. The monument installation and referencing would be undertaken by a party headed by Mr. Brent C. Walker CET, who has been resident surveyor on the Down-Valley Project for Underhill Engineering Ltd. for the past 12 months. Mr. Walker's thorough knowledge of the project area will be a benefit to ensuring maximum economy of control station selection.

The measurement program would be undertaken by Mr. J.C. Iles EIT, or Mr. Robert Gray EIT, both graduates in Surveying Engineering from the University of New Brunswick. Both of these individuals have a strong background in error analysis related to deformation studies, coupled with related field experience. Mr. Walker would assist in the measurement program and an additional assistant familiar with the project would be assigned from our Whitehorse staff.

Resumes for these senior Underhill personnel are enclosed as Appendix A.

6. EXPERIENCE IN RELATED WORK

Over its 68 year history, the Underhill firm has been engaged for many major control and deformation surveys for hydro electric projects, resource developments and major civil and structural construction projects.

These include:

Monenco Consultants Pacific Ltd.	Deformation Study of Rock Bluff at Mayo Hydro Plant - Wareham Lake (1980-1981)
Public Works Canada	Robert Campbell Bridge Failure and New Robert Campbell Bridge Monitoring (1974-1979)

Northern Canada Power Commission	Settlement Study - Aishihik Switchyard 1981
Dominion Bridge Co. Ltd.	Kootenay River Hydro Project Penstock Positioning and Monitoring
CBA Engineering Ltd.	Deformation of Piers and Abutments Port Mann Bridge - New Westminister, B.C.
Canadian Pacific Limited	Deformation Studies on Steel and Stone Railway Bridges - Fraser Canyon, B.C.

A Professional Profile of the Underhill firm is enclosed as Appendix B.

7. BASIS OF CHARGES FOR SERVICES

Services would be provided for the project based on the following schedule of fees

(a) Professional Staff

T.E. Koepke, P.Eng.,C.L.S. (Principal)
Project Coordinator — $60.00 per hour

T.L. Bidniak, P.Eng. (Principal)
Project Supervisor — $55.00 per hour

Senior Staff Surveyor, P.Eng., C.L.S.
$45.00 per hour

(b) Sub-Professional Staff - Senior Personnel

"Payroll Cost" plus 100% where "Payroll Cost" is defined as basic rate of pay plus 25% for fringe benefits and statutory assessments

(c) Seasonal Staff - Junior Assistants

"Payroll Cost" plus 85%, with Payroll Cost as defined above.

.../8

Note - overtime hours are charged at the same rate as regular hours for all personnel

(d) Vehicles

Underhill vehicles - all inclusive	$ 40.00 per day + 30 cents per mile
Rental vehicles	(Total rental cost + fuel + 10%

(e) Disbursements and Expenses

Sundry supplies, LD calls, travel expenses, paint, stakes, flagging, steel supplies, room and board, outside reproduction, etc.	Cost + 5%

(f) Field Equipment

Standard Field Equipment	$ 10.00 per day
Short Range EDM Equipment	$ 45.00 per day
Geodimeter 700 Total Station Equipment	$ 90.00 per day
KERN DKM3 Theodolite	$ 50.00 per day per unit
WILD NA3 Level	$ 35.00 per day
VHF Radios (Set of 3)	$ 20.00 per day
Chainsaw - fuel included	$ 10.00 per day
Power auger - fuel included	$ 20.00 per day

(g) Reproduction (In house)

Mylar base material	$ 2.00 per sq.ft
Dylar Blackline	$ 3.00 per sq.ft
Whiteprinting	$ 0.25 per sq.ft
Photocopying	$ 0.10 each

(h) Computer and Word Processor

APPLE II Computing System (Operator as required on Payroll Cost basis additional)	$ 25.00 per hour
AES Word Processor and Operator (Report Preparation)	$ 25.00 per hour

Invoicing for services would be presented at month end intervals and would include Field Reports and Project Diary Sheets detailing hours worked, equipment and vehicles used. Full documentation by receipts or invoices for all disbursement and expense items would also be included.

8. BUDGET COSTS

It is not possible at this time to make a reasonable estimate of total project costs as the field program will be dependent on the final survey network configuration, access and other variables.

We would be pleased to make an estimate at a later date after detailed reconnaissance of the project site.

9. SUMMARY

We trust that this proposal adequately outlines our general approach to this project and will suit your present requirements. We would be pleased to discuss specifics with you further as the field program commences. Please contact the writer if any further information is required.

We thank you for inviting our firm to present this proposal to you and look forward to a continuation of our past involvement in this project.

Respectfully submitted,

UNDERHILL ENGINEERING LTD.

ORIGINAL SIGNED BY
T.E. KOEPKE

T.E. Koepke, P.Eng.,CLS
Director

APPENDIX A

RESUMES OF SENIOR PERSONNEL

T I M E. K O E P K E

P.Eng., CLS, BCLS, RLS (Alaska)

PRINCIPAL AND SENIOR CONSULTANT

RESPONSIBILITIES

Special consultant on legal and engineering survey problems.
General Manager, Northern Operations - 1970 to present.

EDUCATION

University of British Columbia - B.A.Sc. (Civil Engineering), 1967.

PROFESSIONAL QUALIFICATIONS

Commissioned as British Columbia Land Surveyor, 1968
Registered as Alaska Land Surveyor, 1970
Registered as Professional Engineer - British Columbia, 1970 and Yukon Territory, 1970.
Commissioned as Canada Lands Surveyor, 1971.

PROFESSIONAL, TECHNICAL AND OTHER AFFILIATIONS

Member of Canadian Institute of Surveying; Chairman of C.L.S. Professional Affairs Committee, 1975 to present; Councillor-at-Large.
Member of Engineering Institute of Canada
Member of American Society of Photogrammetry
Member of Executive - Association of Professional Engineers of Yukon Territory, 1971 to present.
Member of Board of Examiners for Canada Lands Surveyors (Department of Energy, Mines and Resources).

TIM E. KOEPKE

EXPERIENCE

1962 - 1966	**Underhill & Underhill, Vancouver, B.C.** Summer work on major land surveys for power line rights-of-way and mineral resource developments.
1967 - 1970	**Underhill & Underhill, Vancouver, B.C.** Project work as engineer-in-training and land surveyor in land development projects, resource projects and engineering control surveys.
1970 - present	**Underhill & Underhill, Whitehorse, Yukon.** Management of northern operations and direction of major engineering and survey projects. Consultant to federal and territorial governments on residential, industrial and recreational land development. Management of engineering and survey assignments for mining developments, hydroelectric projects, highway reconstruction and industrial developments. Management of photo control surveys and photogrammetric mapping projects for transportation studies, mineral property evaluation and land management studies. Special consultant on land and mineral rights matters for federal and territorial governments, utility companies and mining industry.

T E R R Y L. B I D N I A K

P.Eng.

PRINCIPAL AND SENIOR PROJECT ENGINEER

EDUCATION

University of Alberta - B.Sc. (Civil Engineering), 1972.

PROFESSIONAL QUALIFICATIONS

Registered as Professional Engineer
- Province of Alberta, 1974
- Yukon Territory, 1974
- Province of British Columbia (applied for)

OTHER AFFILIATIONS

Member of Canadian Institute of Surveying
Articled student - B.C. Land Surveyor
- Canada Lands Surveyor

EXPERIENCE

Engineering Surveys: Preliminary and construction surveys for roads, airports, hydroelectric projects, transmission lines, municipal works and related facilities; topographical surveys.

Resource surveys: Land and Marine Seismic Exploration.

Legal Surveys: Various surveys throughout Yukon and Northern British Columbia.

Municipal Engineering: Design and construction inspection of water and sewer projects; Drainage studies; Project Management.

Highway Design

Airport Design

TERRY L. BIDNIAK

Land Development: Soil investigations, pre-engineering design and specification preparation, construction inspection, contract preparation and administration for country residential and townsite subdivision developments.

Building Construction: Site Planning, design and specification preparation, testing and inspection, cost estimating, related services for residential, commercial and industrial buildings of wood frame, steel, and concrete construction.

J O E C. I L E S

E.I.T.

JUNIOR ENGINEER/PARTY CHIEF

EDUCATION

University of New Brunswick
B. Sc. (Surveying Engineering), 1980

AFFILIATIONS

Member of Canadian Institute of Surveying

EXPERIENCE

Engineering Surveys: Preliminary and Construction surveys for pipelines and roads
Legal Surveys: Cadastral surveys, boundary retracements, pipeline rights-of-way, residential and cottage lot subdivision layout
Municipal Engineering: Road design

R O B E R T   W.   G R A Y

E.I.T.

JUNIOR ENGINEER/PARTY CHIEF

EDUCATION

University of New Brunswick
B. Sc. (Surveying Engineering), 1981

AFFILIATIONS

Member of Canadian Institute of Surveying

EXPERIENCE

Engineering Surveys: Preliminary and Construction surveys for roads; control surveys; topographical surveys, second order levelling projects
Resource Surveys: Land Seismic Exploration
Legal Surveys: Various surveys throughout Ontario and Saskatchewan

D A N A. C A R E W

SURVEY TECHNOLOGIST

EDUCATION

British Columbia Institute of Technology -
Diploma Survey Technology, 1977.

EXPERIENCE

1977 - present	**Underhill Engineering Ltd., Whitehorse, Yukon** - party chief and articled CLS student. - experienced as senior party chief on a variety of engineering and control surveys. - general legal survey experience related to land development, utilities, construction and resource development.

B R U C E D. M a c L E A N

SENIOR PARTY CHIEF

EXPERIENCE

1967 - 1970	**Underhill Engineering Ltd., Vancouver, B.C.**
1970 - present	**Underhill Engineering Ltd., Whitehorse, Yukon** - legal surveys for land development, highways, transmission lines, construction, and mineral claims. - engineering surveys for mine development, hydrographic works, construction, dam sites, utilities construction.

APPENDIX B

PROFESSIONAL PROFILE

A PROFESSIONAL PROFILE

UNDERHILL & UNDERHILL

UNDERHILL ENGINEERING LTD.

UNDERHILL SURVEYS & MAPPING LTD.

January 1981

HISTORY OF THE FIRM

The Underhill & Underhill partnership was founded in Vancouver, B.C. in 1913 by Messrs. F.C. and J.T. Underhill, both Professional Engineers and Land Surveyors. It has functioned continuously since that time, providing integrated civil engineering and surveying services to industry, government and the private sector. The firm has played a major role in resource development projects throughout western and northern Canada. To meet the increasing demand of our growing economy, the firm has continuously expanded its base of operations and the scope of services offered.

Underhill Engineering Ltd. and Underhill Surveys and Mapping Ltd. are two wholly-owned companies which provide specialized engineering and survey services.

The firm's Whitehorse office was established in 1970 to serve Yukon, northwestern British Columbia and the western Northwest Territories. This office has specialized in legal surveys of Crown Lands, management services for land development, and route surveys for telecommunications systems, highways and transmission lines. It also supplies services for building design, soils testing, structural engineering and construction inspection.

In the summer of 1980, a computing facility with 48K capacity was installed in the Whitehorse office together with a 36 inch high-speed drum plotter. Development of programs for coordinate geometry, field survey reduction, geodetic control, planimetric plot control, graphic mapping control, road design and quantity determination is in various stages of progress. Presently, field survey reductions, cross section plotting, and cross sectional area computations are being carried out on several ongoing projects. A second identical computing system is retained for field office installation and data disks can be forwarded to Whitehorse from the field for plotting of information and return.

In 1979, a third office was established at Fort Nelson, B.C. to provide survey services to the Petroleum Industry and the expanding Land Development of the region. This office has resident B.C. Land Surveyors and experienced support staff fully equipped with modern survey equipment. Complete engineering services of the Underhill group are also available through support and communication with the Whitehorse and Vancouver offices.

The firm's head office in Vancouver provides senior management for the companies in addition to the wide range of traditional surveying and engineering services. Areas of particular specialization include hydrographic surveying of major rivers for hydro-electric studies, services for major land development and services for building developments. Computing and data processing of surveys are done on our computer system, complete with automatic plotting and drafting.

Over the years, the Underhill firm - its principals and staff, has established and maintained a reputation for efficiency and innovation and for the application of the latest techniques, technology and equipment to engineering survey challenges. The firm pioneered the introduction of precise electronic distance measuring equipment and techniques in British Columbia in the early 1960's and since that time has been engaged for many precise measurement assignments for construction control, resource projects and commercial developments.

OPERATIONS AND MANAGEMENT

The daily operations of the Underhill group are managed by Wm. G. (Bill) Robinson in Vancouver, Tim E. Koepke in Whitehorse and David A. Le Patourel in Fort Nelson.

All offices are connected by Telex for coordination of manpower and equipment use, with the Vancouver and Whitehorse offices having Telecopier facilities and Loomis Bonded Courier Service for efficient transmission and transportation of documents and plans between offices.

Because of the varying seasonal workloads of our operational areas, personnel are interchanged from time to time on assignments at other offices, thereby better utilizing their specialities and individual skills. This policy also broadens their experience and provides efficient services to the client.

Our permanent staff comprises professional land surveyors and professional engineers; engineering and survey technologists and technicians; design draftsmen and draftsmen; field assistants, and administrative/clerical staff.

SCOPE OF SERVICES

The Underhill group has established a record of high performance for the following categories of services:

1. Cadastral Surveys
   - legal surveys of lands, subdivisions, rights-of-way, roads, mineral claims, etc. in British Columbia, Yukon and the Northwest Territories, under respective acts and regulations for lands, minerals, petroleum and natural gas
   - title searches and reviews

2. Engineering Surveys
   - photogrammetric ground control
   - topographic surveys
   - rivers and harbours
   - highways
   - transmission lines
   - hydro power projects
   - pipelines
   - control surveys
   - airports

3. Civil Engineering
   - project management
   - design of small buildings, foundations, shopping centres
   - subdivisions - highways, roads, sewer and water design
   - construction inspection and materials testing services
   - airport evaluation and design

4. Reconnaissance Surveys
   - route location for roads, transmission lines and pipelines
   - microwave sites

5. Computing
   - full range of engineering and legal survey computations and co-ordinate geometry with in-house computing.
   - automated drafting/plotting with flatbed and drum plotters interfaced to computer system

PRINCIPALS OF THE FIRM

The principals of the Underhill group of companies are listed below, together with the professional qualifications and number of years of affiliation with the firm.

C.D. Underhill	P.Eng., BCLS	36 years
Wm. G. Robinson	P.Eng., BCLS, CLS, RLS (Alaska)	33 years
J.M. Parnell	BCLS, CLS, MLS	23 years
T.E. Koepke	P.Eng., BCLS, CLS, RLS (Alaska)	17 years
F.B. Underhill	BCLS, CLS	12 years
T.L. Bidniak	P.Eng.	9 years

PARTIAL LIST OF CLIENTS BY CATEGORY

GOVERNMENTS

a) Government of Canada

Department of Energy, Mines & Resources
Department of Indian Affairs and Northern Development
Ministry of Transport
Department of Public Works
Department of National Health & Welfare

National Harbours Board
Canada Mortgage and Housing Corporation
Canadian Broadcasting Corporation

b) Province of British Columbia

Ministry of Lands, Parks and Housing
Ministry of the Environment
Ministry of Highways, Transportation and Communications

c) Government of the Yukon Territory

Department of Municipal and Community Affairs
Department of Highways and Public Works
Department of Tourism
Yukon Housing Corporation

d) Civic

City of Vancouver
Corporation of District of Burnaby
Corporation of District of Richmond
District of North Vancouver
Village of Fort Nelson
City cf Whitehorse
City of Dawson

e) Commissions and Boards

Vancouver Parks Board
Greater Vancouver Sewage and Drainage District
North Fraser Harbour Commission
Peace River-Liard Regional District
Atlin District Board of Trade

UTILITIES

Westcoast Transmission Co. Ltd.
Trans Mountain Oil Pipe Line Co.
Foothills Pipe Lines (South Yukon) Ltd.

B.C. Electric Co.
B.C. Hydro and Power Authority
Northern Canada Power Commission
The Yukon Electrical Company Limited.

NorthwesTel
Canadian National Telecommunications

OIL AND NATURAL GAS

Imperial Oil Limited
Gulf Canada Ltd.
Esso Resources Canada Ltd.
Shell Canada Ltd.
Chevron Canada Ltd.
Union Oil Co. of Canada Ltd.
Aquitaine Company of Canada Ltd.
American Trading and Production Corporation
Columbia Gas Development of Canada Ltd.
Hudson's Bay Oil and Gas
D & S Petroleum Services Ltd.

MINING AND EXPLORATION

Amax Northwest Mining Company Limited
American Smelting and Refining Co.
Anaconda Canada Exploration Ltd.
Brameda Resources Ltd.
Brenda Mines Ltd.
B.C. Molybdenum Ltd.
Bralorne Pioneer Mines Ltd.
Canadian Exploration Ltd.
Craigmont Mines Ltd.
Climax Molybdenum (B.C.) Ltd.
Conwest Exploration Co. Ltd.
Cassiar Asbestos Corp. Ltd.
Cyprus Anvil Mining Corporation
Canada Tungsten Mining Corporation Ltd.
Canex Placer Ltd.
Imperial Metals and Power Ltd.
Kennco Explorations (Western) Ltd.
Kaiser Resources Ltd.
Noranda Exploration Co. Ltd.
Placer Development Limited
United Keno Hill Mines Ltd.
Utah Mines Ltd.
Whitehorse Copper Mines Ltd.

FORESTRY

Canadian Forest Products Ltd.
Crown Zellerbach Ltd.
Celgar Ltd.
Skeena Craft Ltd.

TRANSPORTATION

British Columbia Railway
Canadian Pacific Railway
Canadian National Railway
Great Northern Railway
White Pass and Yukon Route

CP Air
Trans North Turbo Air Ltd.
Yukon Airways Ltd.

INDUSTRIAL AND MANUFACTURING

Ford Motor Company
Ideal Cement Company
Carling Breweries (B.C.) Ltd.
Burrard Terminals Ltd.
Safeway Stores Ltd.
Woodward Stores Ltd.
Electric Reduction Company of Canada
Hooker Chemicals Ltd.
Deeks McBride Ltd.
Canadian Fishing Co. Ltd.
Nelson Brothers Fisheries Ltd.
B.C. Packers Ltd.
Chemetics International Ltd.
Finning Tractor and Equipment Co. Ltd.
General Enterprises
Kelly Douglas Co. Ltd.

EDUCATIONAL

University of British Columbia
British Columbia Institute of Technology
Vancouver School Board
North Vancouver School Board
Fort Nelson School District
Stikine School District

FINANCIAL

Bank of Montreal
Bank of Nova Scotia
Canadian Imperial Bank of Commerce
Royal Bank of Canada

BUILDING AND DEVELOPMENT

Marathon Realty Company Limited
Dominion Construction Company Limited
Trizec Equities Ltd.
Pacific Centre Ltd.

ARCHITECTS/ENGINEERS/CONSULTANTS

Thompson, Berwick, Pratt & Partners
Peter Cole
Killick Metz Bowen Rose
Paine and Associates
Stanley Associates Engineering Ltd.
Associated Engineering Services Ltd.
EPEC Consulting Western Ltd.
Acres Consulting Services Ltd.
Monenco Consultants Pacific Ltd.
Crippen Consultants
Golder Geotechnical Consultants Ltd.
Klohn Leonoff Consultants Ltd.
Pacific Survey Corporation
J.R. Paine & Associates Ltd.
James F. MacLaren Limited

COMPANY ORGANIZATIONS

a) Company Names

Underhill & Underhill
Underhill Engineering Ltd.
Underhill Surveys & Mapping Ltd.

b) Offices

Head Office
1646 West 7th Avenue
Vancouver, B.C. V6J 1S5
Telephone 604-732-3384
Telex 04-53339
Telecopier 604-732-5812

Manager - Bill Robinson, P.Eng., BCLS, CLS, RLS

Northern B.C. Office
(Suite 1, Fort Hotel Plaza)
P.O. Box 2050
Fort Nelson, B.C. VOC 1RO
Telephone 604-774-3141
Telex 036-73184

Manager - David LePatourel, BCLS

Yukon Office
(312B Hanson Street)
P.O. Box 4068
Whitehorse, Yukon Y1A 3S9
Telephone 403-668-2048
Telex 036-8-465
Telecopier 403-668-4456

Manager - Tim Koepke, P.Eng., BCLS, CLS, RLS

c)	Bankers	Royal Bank of Canada Broadway and Granville Branch Vancouver, B.C. V6H 1H7
		Royal Bank of Canada 4110 - 4th Avenue Whitehorse, Yukon Y1A 4N7
d)	Accountants	Culver & Co. Chartered Acountants 1730 Guiness Tower 1055 West Hastings Street Vancouver, B.C. V6E 2E9
e)	Solicitors	Twining, Vertlieb & Anderson 1005 - 750 West Pender Street Vancouver, B.C. V6C 2T8
		Anton, Asquith & Campion # 200 - 204 Lambert Street Whitehorse, Yukon Y1A 1Z4
f)	Insurance Agents	Cypress, Christie & Co. 890 West Pender Street Vancouver, B.C. V6C 1J9
		Tomenson, Saunders, Whitehead Ltd. 404 Main Street Whitehorse, Yukon Y1A 2B7

Slope Indicator 1000 Inclinometer

A new economical inclinometer featuring biaxial servo-accelerometers and electronics used in our current line of costlier Digitilt® Inclinometers.

New Features:

- Waterproof, dual LCD digital display for mounting on a data sheet clipboard.
- Simultaneous display of both sensor axes.
- No switches or control buttons on display panel.
- Operator replaceable standard D-cell batteries or rechargeable NiCad D-cell batteries. (Charger is supplied.)
- Low battery voltage indicator.
- Compact, cushioned carrying case contains both sensor probe and indicator components.
- Sensitivity 1 in 1,000 parts over ±30° (0.0286 DEG sensitivity).
- System has approximately same accuracy as Digitilt® System for near vertical casing installations, i.e., ±0.02 feet per 100 feet (±6 mm per 30 m).
- Probe may be used in all sizes of Slope Indicator Inclinometer Casing, except the smallest size, 1.90-inch O.D. (48 mm O.D.).

sinco
Slope Indicator Co.
3668 ALBION PLACE N., SEATTLE, WA. 98103 U.S.A.
phone: (206) 633-3073 cable: SINCO SEA TWX: 910-444-2205 (SINCO SEA)

Self-Aligning Couplings for Plastic Slope Indicator Casing

Slope Indicator Company announces new ABS plastic SELF-ALIGNING, WATER-TIGHT couplings for its three sizes of plastic Slope Indicator Inclinometer Casing - 1.90 inch O.D., 2.75 inch O.D. and 3.34 inch O.D. The new couplings and casing are parts of the SINCO/WESTBAY CPI (Combined Piezometer-Inclinometer) System.

FEATURES:

1. SELF-ALIGNING

2. WATER-TIGHT

3. RAPIDLY INSTALLED

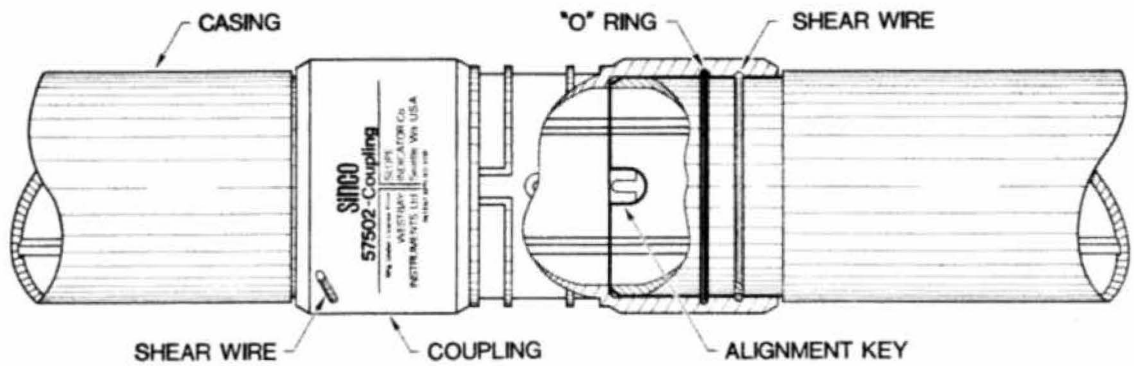
This SELF-ALIGNING coupling provides the user with an injection molded coupling which has internal tracking grooves to maintain sensor alignment through the coupling to the next section of inclinometer casing. The inclinometer casing used with the coupling is cut to length, English or Metric. A slot is machined in each end to match the mating alignment key in the coupling, thereby providing positive groove alignment between casing sections.

The WATER-TIGHT coupling is self-sealing by means of pre-assembled O-ring seals.

RAPID INSTALLATION is accomplished by means of a nylon shear wire inserted in the coupling to lock the casing to the coupling.

Utilization of this coupling will significantly reduce field assembly and installation time because aligning tools, pop-rivets and ABS solvents are not required.

slope indicator company SINCO



COUPLING DETAIL

ADVANTAGES:

1. RAPID AND ACCURATE ASSEMBLY - Couplings and casing can be quickly connected by hand with little or no training and with no risk of groove misalignment. The assembly record to date using this coupling is 900 feet of casing placed in a drillhole in 1½ hours.

2. CLIMATIC INSENSITIVITY - The plastic coupling and casing assembly is unaffected by temperature, moisture or by oil and grease introduced by handling.

3. DISASSEMBLY POSSIBLE - Disassembly and reassembly can be accomplished if, for example, a hole caves in prior to or during an installation or if temporary inclinometer casing is required for borehole surveys.

4. ADDITIONAL FEATURES - The casing and couplings are part of the SINCO/WESTBAY CPI (Combined Piezometer-Inclinometer) System which allows multiple piezometer and inclinometer measurements in a single drill hole. Valved measurement couplings can be inserted in place of regular couplings wherever pressure measurements or samples are required. Special packers adapted to the inclinometer casing are used to seal the borehole between couplings. A variety of probes are used to take the pressure measurements, inclinometer readings, and water samples.

This unique coupling (U.S. Patent No. 4,204,426, other patents pending) was developed by Westbay Instruments Ltd. of West Vancouver, B.C. The Slope Indicator Company is licensed to manufacture and sell this coupling.

SPECIFICATIONS

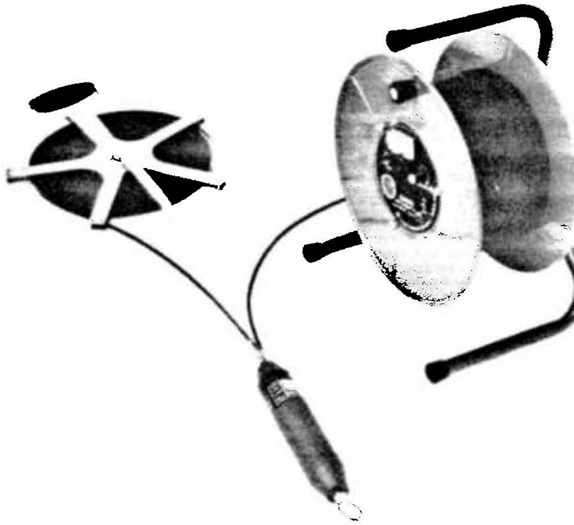
CASING (CPI) ABS Plastic w/Internal Grooves			
MODEL NUMBER	57521	57511	57501
DIAMETER O.D.	1.90 in	2.75 in	3.34 in
	48.3 mm	69.9 mm	84.8 mm

COUPLINGS (CPI) ABS Plastic w/Internal Grooves			
MODEL NUMBER	57522	57512	57502
DIAMETER O.D.	2.12 in	3.07 in	3.70 in
	53.9 mm	78.0 mm	94.0 mm
OVERALL LENGTH	5.00 in	6.00 in	7.00 in
	127.0 mm	152.4 mm	177.8 mm
EFF. LENGTH	2.00 in	2.00 in	2.00 in
(All Couplings)	5.10 mm	5.10 mm	5.10 mm

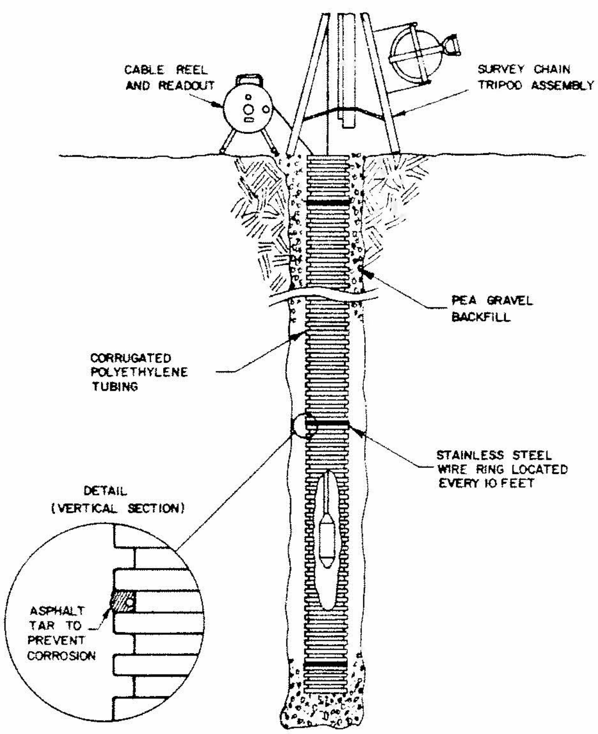
Printed in USA (9-80)

SINCO
Slope Indicator Company
3668 Albion Place North, Seattle, Washington 98103 U.S.A.
TWX: 910-444-2205 (SINCO SEA) cable: SINCO SEA phone: (206) 633-3073

model 50819
SONDEX Settlement Probe



50819 SONDEX System



Typical SONDEX Installation

The Model 50819 SONDEX Settlement Probe provides an accurate, yet inexpensive, technique for measuring earth stresses and strains. The SONDEX Probe is especially useful for measuring settlement and heave associated with excavation, plant construction, and backfill operations. Lateral movement of embankments and earth-filled dams can also be monitored very effectively.

The readout is an integral assembly consisting of probe, electrical cable reel, batteries, and controls. A steel tape with tripod assembly can be attached to the probe for the purpose of making depth measurements.

Electronic circuitry within the probe detects the location of metal rings by induction principle. The readout meter is peaked whenever the probe is centered on the cross axis of a detector ring. A buzzer helps to locate rings quickly.

To construct a measurement point, a metal ring, plate, or wire loop is placed around plastic casing. The ring or plate should be installed so as to move with the surrounding soil. Several designs of rings, plates, and wire loops along with suitable plastic casing are available from SINCO to meet the particular requirements of an individual project.

The rings can be installed along either a horizontal or vertical casing, either in boreholes or by direct burial. Installation in boreholes prior to excavation provides heave measurements accompanying excavation, and settlement measurements during subsequent plant construction and backfill. Buried installations provide settlement, heave, and lateral deflection or strain measurements of embankment or dams during earth fill operations and subsequent loading of the earth fill.

Additional economics in instrumentation can be achieved by using grooved Digitilt casing in order to combine lateral Digitilt measurements with settlement or heave SONDEX measurements.

Since this is a scientific instrument, measurements should be taken, recorded, and interpreted by qualified personnel. SINCO is not responsible for errors or ommissions of the personnel used.

SPECIFICATIONS

System Accuracy: ±.05 inches

Probe: 1.687" OD STD, other sizes available on request

Survey Chain: 200 feet STD, other lengths available on request

Cable: 250 feet STD, other lengths available on request

Batteries: three NEDA 1306A

DETECTOR RINGS

50820 Corrugated Polyethylene Detector ring 9" long to fit either 2.75" or 3.34" Plastic Slope Indicator Casing (specify casing size).

50815 Inductance coupling with steel rings 4" ID PVC x 12" long with 5" DIA x .25" Sq. steel ring

50816 Flexible Corrugated Pipe (with sensing rings) 3" ID polyethylene with S.S. wire rings located at 10 ft. intervals (STD)

50817 Flexible Corrugated Pipe (with sensing rings) 4" ID polyethylene with S.S. wire rings located at 10 ft. intervals (STD)

Additional rings may be specified for 3" or 4" ID flexible corrugated pipe

Slope Indicator Company
3668 ALBION PLACE N., SEATTLE, WA. 98103 U.S.A.
phone: (206) 633-3073 cable: SINCO SEA
TWX: 910-444-2205 (SINCO SEA)

SINCO

Printed in USA (6-78)

CYPRUS ANVIL DOWN VALLEY PROJECT

SLOPE INDICATOR FIELD DATA SHEET

Figure C.1.

Date: ______________ Technician: ______________

Location: ______________ Instrument No: ______________ k = ______________ c = ______________

DEPTH	DIFF.	AZ =		DIFF.	CHANGE	DIFF.	AZ =		DIFF.	CHANGE

Project No. 812-2041 Drawn GP Reviewed W Date

CYPRUS ANVIL DOWN VALLEY PROJECT

INCREMENTAL SETTLEMENT FIELD DATA SHEET

Figure C.2.

Date: ______________ Technician: ____________________

Ring No	1	2	3	4	5	6	7	8	9	10
Location / Elevation	Depth to Ring									

Project No. 812-2041 Drawn GP Reviewed LS Date

Golder Associates

CYPRUS ANVIL DOWN VALLEY PROJECT

SETTLEMENT FIELD DATA SHEET

Figure C.3.

Date: ______________ Technician: ____________________

LOCATION	VERTICAL ELEVATION	HORIZONTAL LOCATION

Project No 812-2041. Drawn GP Reviewed JS Date

CYPRUS ANVIL DOWN VALLEY PROJECT

THERMISTOR READING FIELD DATA SHEET

Figure C.4.

Date: ______________ Technician: ____________________

LOCATION \ TIP No.	1	2	3	4	5	6	7	8	9	10

Project No 812-2041 Drawn GP Reviewed Date

CYPRUS ANVIL DOWN VALLEY PROJECT

PIEZOMETER READING FIELD DATA SHEET

Figure C.5.

Date: ____________ Technician: ________________

LOCATION	Reading p.s.i.	Tip Elevation	Ground Surface Elevation	Piezometric Elevation

Project No 812-2041. Drawn GP Reviewed Date

Golder Associates