APPENDIX A

1978 GEOTECHNICAL INVESTIGATION
REPORT TO
WILLIS CUNLIFFE & TAIT LIMITED
ON
SITE INVESTIGATION
NANAIMO DAMS
NANAIMO, BRITISH COLUMBIA

Distribution:

4 copies - Willis Cunliffe & Tait Ltd.
Victoria, British Columbia

2 copies - Golder Geotechnical Consultants Ltd.
Vancouver, British Columbia

May, 1978

V78040
October 5, 1978

City of Nanaimo
455 Wallace Street
NANAIMO B.C.
V9R 5J6

Attention: Mr. A.P. Leynard, P. Eng.

Reference: Nanaimo Dams Report - Our G325-1

Dear Mr. Reynard:

We are today forwarding under separate cover 8 additional copies of the Golder Associates Report for your use.

As a matter of interest, I also attach a copy of a letter from Professor S.O. Russell, P. Eng. of U.B.C. whose opinions on the Westwood siphon installation we solicited. These comments will be taken into consideration on the final design drawings and specifications.

In another letter to us from Golder Associates, they have indicated the need for a small amount of investigation to be done on the small dam on Westwood. As discussed with you on the telephone, a ball-park estimate for investigation and repair on this structure would be in the order of $10,000.

Mr. Gerry Cox of Water Rights has picked up one copy of our report and drawings from this office. He has not as yet received a copy of the Golder report.

We await the results of your presentation of this report to Council.

Yours very truly

WILLIS, CUNLiffe, TAIT & COMPANY LTD.


LDP/jc

cc: Mr. A.W. MacDonald, Director of Public Works
    Mr. B. Tait, P. Eng., Willis, Cunliffe, Tait & Co. Ltd., Nanaimo.
Mr. L.D. Perkins
Willis, Cunliffe, Tait & Company Limited
827 Fort Street
Victoria, B.C.
V8W 1H6

Westwood Lake Dam

Dear Mr. Perkins:

Thank you for your letter of September 14, 1978 and for the enclosed Drawing No. V16325 - 1 - 1. As we discussed by telephone on September 25, I have the following comments:

1. I see no reason why the siphon could not be actuated by a vacuum pump as well as by filling it with water and then opening the valve as shown in the drawing. If a vacuum pump is used, it may be necessary to have an air valve as well to prevent water being drawn into the pump, depending on the type of pump. (Some vacuum pumps could be damaged by water.)

2. With the arrangement shown, the pressure at the downstream edge of the dam crest would fall below the recommended 20-22 feet of vacuum (U.S.B.R. "Design of Small Dams", p.332) at minimum reservoir level. This can be avoided by making the upstream leg of the pipe larger than the downstream leg to increase the pressure at the crest. I would suggest a 21" pipe as far as the downstream edge of the crest, followed by the 18" pipe with a smooth reducing section in between.

3. With the design shown, a vortex could form at the intake and destroy the vacuum. I would suggest extending the intake leg for about another 2 diameters with a small hole about 1" diameter to break the siphon at the desired water level.

4. Provided the discharge box stays full it is not necessary to provide much submergence. 1 diameter should be ample.

I hope these comments will be helpful to you. If you have any questions about any of them please do not hesitate to get in touch with me.

Yours sincerely,

S. O. Russell

S. O. Russell

SEP 28 1978
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1.0 **INTRODUCTION**

Golder Associates were retained by Willis, Cunliffe, Tait and Company Ltd. to carry out a geotechnical investigation of five existing dams within the municipal boundaries of the City of Nanaimo. The dams are designated as the: Westwood Lake, Upper, Middle, Lower Chase River and Powerline Dams. The dams are located east and south of the center of the City of Nanaimo as shown in Figure 1.

A preliminary examination of the existing dams was carried out on January 26 and 27, 1978. Based on observations at that time, and in the absence of constructions records, a field investigation program was instigated to determine as much as possible about the foundation geology, the embankment conditions, zoning, materials used as fill and the quality of construction procedure. In addition to determining the composition of the dam embankments it was intended to determine, the seepage conditions within and beneath the dams. This information was required to permit an assessment of the stability of the dams and to form the basis of recommendations to the City of Nanaimo regarding the treatment and required upgrading of the dams.

2.0 **CONCLUSIONS**

The general conclusions we have drawn from our study of the five dams may be summarized as follows: -

1) The Upper Chase River dam is safe and requires no further work.

2) The Westwood Lake and Middle Chase River dams appear to be in satisfactory condition at present, but we have
recommended minor improvements to the dams including construction of a seepage control ditch.

3) The Lower Chase River dam is reasonably safe but requires some additional fill placement to improve the overall downstream slope stability.

4) The Power Line dam is not considered safe and it is strongly recommended that the reservoir should not be impounded to normal pool level but should be maintained at a lower level. In order to ensure this it is recommended that the dam be breached.

3.0 **SCOPE OF GEOTECHNICAL INVESTIGATION**

The site investigation work for the project was performed between March 7 and March 29, 1978. Within this period, boreholes and testpits were used to determine the soil and hydrology ground water condition at the Westwood Lake Dam, Middle and Lower Chase River Dams and at Power Line dam sites. No investigation work was considered necessary at the Upper Chase River dam.

In general the drilling work did not prove to be entirely satisfactory as the earthfill used in some of the dams was too coarse to permit sampling. As a result of the difficult drilling encountered it was not possible to install all of the piezometers we had intended, which would have provided a better definition of the phreatic surface within the embankments. However, the limited data which was obtained has provided a basis on which to assess the overall stability of the structures.
Because of access difficulties it was necessary to rely on manual boring (hand auger) at the Power Line dam. At the other sites a truck mounted rotary rig was used but where the embankment fill proved too difficult to advance a standard borehole, an airtrack machine was employed to provide an indication of the material types used in construction.

Testpits were excavated using a backhoe and in areas where access was not possible, hand excavation was used to put down the testpits.

3.1 Westwood Lake Dam

Two boreholes (BH1 & BH2) and five test pits were put down at the dam site at the locations shown on Figure 2. Two piezometers were installed in BH1 to monitor the phreatic surface within the dam. Two pits (TP1 & TP3) were excavated to investigate the fill placement at the abutments and the other three pits (TP2, TP4, & TP5) were positioned to examine points of seepage discharge observed on the downstream slope.

3.2 Upper Chase River Dam

No investigation was undertaken.

3.3 Middle Chase River Dam

Three boreholes (BH3, BH4, BH5) and four testpits were put down at the dam site at the locations shown in Figure 3. The first two holes were drilled with the rotary drill rig. The drilling did not reach foundation strata. The airtrack employed for the third borehole (BH5) was successful in advancing through the dam fills. Two pits (TP1 & TP2) were excavated at the abutments while, TP3 was located at a source of seepage and TP4 was excavated immediately adjacent to the upstream concrete wall at the dam.
3.4 **Lower Chase River Dam**

Four boreholes (BH6, BH7, BH8 & BH9) and four pits were put down at the dam site. The locations are shown in Figure 4. Only BH9 which was drilled with airtrack equipment was able to penetrate the dam fill material with any degrees of success. Three of the testpits were put down at sources of seepage while TP4 was excavated immediately adjacent to the upstream concrete wall.

3.5 **Power Line Dam**

Three hand auger holes and five test pits were put down at the dam site at the locations shown in Figure 5.

4.0 **DESCRIPTION OF DAMS**

4.1 **Westwood Lake Dam**

This dam is located on the eastshore of Westwood Lake, at the south end of Westwood Road.

The dam is an earthfill embankment about 11.0 m high with a crest width of 5.0 m, and a total crest length of about 97.0 m. The dam alignment is V-shaped, as shown in Figure 2. The downstream face slopes at 2.5 horizontal to 1 vertical while the upstream face is standing at 1.6 horizontal to 1 vertical. At the time of the investigation the lake level was 1.5 m below the crest.

The dam is situated in a steep sided ravine with valley side slopes varying between 1.25 and 1.75 horizontal to 1 vertical. The right
abutment of the dam when looking downstream appears to be founded on bedrock while the left abutment is founded on overburden. The exposed bedrock is massive and competent and the joints and fractures appear to be tight. Borehole 1 indicates that the right side of the dam is founded directly on bedrock and Borehole 2 indicates that the left side of the dam is founded on very dense sand with some silt and gravel.

The hydraulic control facilities are not well defined at the dam site but appear to consist of a conduit passing through the embankment. The inlet to the discharge system is not visible on the upstream side of the dam, however a conduit and control valves are located at the downstream toe of the dam near the north or left abutment. The exposed part of the conduit is a wood stave pipe. Water was flowing through the pipe under the dam at the time of the investigation and it appears that the valves could not be successfully opened or closed. The reservoir water levels are controlled by a spillway structure at the north end of the lake. The spillway was not inspected for this study.

The downstream slope was covered with grass and traces of miscellaneous garbage debris. It appears that recently the underbrush which was growing on the slope has been cut. It is understood that within the past few years, the dam was raised about 1.5 m above the original section and the concrete facing which extends from the crest to a depth of 0.9 m to 1.2 m below lake level was constructed to protect the upstream face from erosion due to wave action.

Based on information obtained from the field work it appears that the dam has a narrow impervious core zone of clayey silt with an upstream and downstream shell consisting of sandy silt with some gravel. An inferred section through the dam is shown in Figure 6. Atterberg Limits were performed on the clayey silt and gradation analysis of the sandy silt was carried out. The results of the testing are shown in Figure 10 and 11.
The field investigation indicates from the relative looseness of the materials penetrated that there was little or no effort made to compact the fill materials as they were being placed. There appears to have been some site preparation prior to placement of the fill materials as the boreholes indicated the foundation base area directly beneath the crest has been stripped of topsoil and organics. Test pits excavated at the abutments, downstream of the crest of the dam indicate, however, that not all of the topsoil and organics were stripped from the dam foundation base area prior to fill placement.

Seven sources of seepage were encountered at this dam site. Four seepage zones were noted at the downstream toe of the dam. Three of these areas were not investigated as two of them were considered to be the result of natural ground water seepage and the third was from surficial runoff. The four seepage zones at the downstream toe were investigated by test pits located as shown on Figure 2.

Seepage zone S1 was located at the toe of the dam and had an estimated discharge of about 0.5 gpm. Seepage zone S2 was located about 1.5 m above the control valve structure and minor seepage appeared to flow from the contact of the embankment fill to overburden. Gradation curves for material obtained from the above two areas are shown in Figure 12.

The third seepage zone S3 was located about 18.2 m from the left abutment and 1.8 m below the crest. Some minor seepage was flowing from a silty sand and gravel which was part of the embankment fill. It is significant to note that this seepage stopped when the level of the lake was lowered.
Seepage zone S4 was located adjacent to the wood stave pipe near the downstream toe of the dam. As mentioned in our report of February 3, 1978, the flow could be attributed to piping along the outside of the pipe, to uncontrolled seepage through the embankment or simply to a leak from the wood stave pipe close to that point. The investigation was unable to clarify this point further.

4.2 Upper Chase River Dam

The Upper Chase River Dam is located across the road from the Greater Nanaimo Water District offices. The structural composition of the Upper Chase River dam is not well defined. It is difficult to determine from visual observations the extend of the fill at this dam. The upstream face of the dam however consists of a 0.9 m thick vertical concrete buttressed wall. There is a wide granular fill berm downstream of the concrete wall. The pool level is controlled by a concrete spillway which discharges into two large diameter culverts which pass beneath Nanaimo Lakes Road. Following the preliminary inspection, this dam was considered safe and no further work was recommended for this site.

4.3 Middle Chase River Dam

This dam is situated about 1 km downstream of the Greater Nanaimo Water District offices on Nanaimo Lakes Road. It is understood that this dam was formerly the site of an old railroad crossing.

This structure appears to be an earth and rock fill dam with a 0.6 m thick vertical concrete wall upstream. Backfill material was placed
upstream of the wall in the reservoir area. The dam is approximately 10.0 m high with a crest width of about 8.0 m and a crest length of about 38.0 m. The downstream face stands at about 2 horizontal to 1 vertical.

The dam is situated in a steepsided ravine with both abutments founded on bedrock. Bedrock exposures on either abutment indicate a massive rock formation with tight joints and fractures and some weathering. Borehole 5 (BH5) indicates that the underlying foundation is a sandy silt.

Adjacent to the left abutment is a 14.0 m wide unregulated spillway which is founded on bedrock. A concrete wall, runs along the right side of the spillway channel and separates the embankment fill from the spillway. The dense sandy silt forming the left side of the spillway was being eroded in several areas. At the time of the investigation a log blocked the west part of the spillway intake.

Based on local information it is understood that there is a conduit under the dam. The intake and outlet to the pipe are not visible at present. The remains of what is thought to be the control valve structure is situated a few meters upstream of the concrete wall. There is the possibility that the conduit and control valve are still in place and that the outlet to the pipe was covered during additional fill dumping some 30 years ago.

The dam appears to be constructed with a vertical concrete core with fill and rockfill end dumped on either side of the wall. The fill apparently consists of sand and gravel with some silt. At the right abutment the contact between the bedrock and concrete wall shows signs of deterioration. An inferred section through the dam based on the results of the field work is shown in Figure 7.
At approximately chainage 0+30 m there is an opening in the concrete wall at or just below the reservoir level. This hole is covered by a wooden panel. It is understood that the opening in the wall was made about 1950 to increase the discharge capacity of the reservoir during a period of heavy rainfall which caused concern that the dam might be overtopped. At that time additional fill was end-dumped on the downstream side of the wall.

Three seepage zones were noted at the locations shown in Figure 3. Seepage zone S1 located at the downstream toe, flows at a moderate to heavy rate from a relatively clean gravel. The water was clear. The second seepage zone S2 located closer to the right abutment showed heavy flows. Significantly, this flow stopped when the level of the reservoir dropped by less than 0.5 m. Seepage zone S3, located in the valley bottom, appeared as a boil with some sand in suspension. It is considered that this seepage is related to the flows observed at S1. Gradation curves of the material taken from seepage zones S1 and S3 are shown in Figure 13.

4.4 Lower Chase River Dam

This dam is located approximately 450 m downstream of the Middle Chase River Dam. It is understood that this dam was formerly the site of an old railroad crossing.

The structure appears to be an earth and rock fill dam with an upstream concrete core wall. The dam is 24.0 m high with a crest width of 10.0 m and a crest length of about 50.0 m. The downstream face slopes at 1.6 horizontal to 1 vertical. The vertical concrete wall which forms part of the upstream face is 0.3 m thick to a level 0.6 m below the crest and then increased in thickness to 1.2 m.
The dam is situated in a steep-sided ravine which has been cut by the Chase River at this location. Both abutments are founded on the silty overburden material. Test pit 3 and borehole 9 indicate that the underlying foundation material is a dense sandy silt with some gravel. The spillway is founded on dense silt to sandy silt.

The hydraulic control facilities at the dam consist of an unregulated spillway on the right bank, and a conduit passing through the embankment fill. The outlet of the pipe projects out of the downstream face of the dam at about midheight. Water was flowing through the pipe at the time of the investigation. Three control valves are located on the upstream side of the dam. Two of the control valves are adjacent to the concrete wall and the third situated a few meters upstream of the dam face in the reservoir. It is unknown if the control valves are operating.

An inferred section through the dam is shown in Figure 8. Based on the results of the field work the dam appears to have been constructed with a concrete core wall with rockfill end dumped on either side of the wall to provide structural support. Fill consisting of slag, cinders, sand and gravel has been end dumped on the downstream side of the original dam cross-section to form the existing downstream slope of the dam. The results of the field investigation indicate the fill is very loose to loose. The results of the drilling through the rockfill indicates that some voids exist in the rockfill. These voids are up to 0.3 m size.

Seepage was noted at two points, at the locations shown on Figure 4. One seepage zone S1 was located approximately 50 m downstream of the toe on the left bank where a minor flow was observed flowing from a sand
and gravel stratum. This seepage was attributed to normal ground water discharging from the valley wall. The second seepage zone S2 was located a few meters to the left of the spillways channel on the top of the left abutment. Seepage was observed at several locations and was collected at a central low point. This water is associated with seepage flowing from under the spillway channel.

4.5 Power Line Dam

This site is located about one kilometer south east of Westwood Lake.

The embankment is 6.0 m high with a crest width of about 1.5 m and a crest length of about 60 m. Both the upstream and downstream faces slope at about 1.3 horizontal to 1 vertical with local areas as steep as 1 horizontal to 1 vertical.

The hydraulic control for this dam is apparently provided by a conduit passing under the embankment. The conduit was observed at the downstream toe at Station 0+20. The pipe outlet and control value could not be located. The system is operational as it is being used to maintain the pool level at about 3 m below the crest level.

The structural composition of this dam is difficult to define, but based on the shallow testpits and auger holes put down during the investigation, the dam is considered to be an earthfill structure with a timber crib maintaining the earthfill.

Trees of up to 0.6 m diameter were growing on the crest and downstream slope. On the upstream face at station 0+32 a beaver hole was observed at pool level. It was not possible to determine how far this hole
extended into the face of the dam. A beaver's lodge was observed adjacent to this hole on the east abutment.

Both abutments are founded on overburden at the site. The general embankment fill consists of sandy silt with some gravel, roots and organics. The investigation holes indicated the fill is underlain by 0.3 to 0.6 m of burnt topsoil and organic matter. The topsoil layer is underlain by a soft to firm clayey silt. On the left abutment bedrock was encountered at a depth of 0.2 to 0.9 m.

An inferred section through the dam is shown in Figure 9. The results of the investigation indicate that a minimum of site preparation was carried out prior to placing the fill material for the dam.

A small amount of water was observed discharging at seepage zone S1. This flow was apparently flowing through the conduit under the dam. No undefined sources of seepage were observed along the downstream toe of the dam. The area immediately downstream of the dam was swampy due to poor general site drainage.

5.0 ASSESSMENT OF DAM SAFETY

5.1 General

The case histories of unsatisfactory earth and rockfill dam performances show that the major number of failures are associated with overtopping of the embankments, erosion along conduits or concrete structures passing through the fill, uncontrolled under-seepage; or to instability of the slopes during certain loading conditions.
5.3 Stability Analyses

Stability analyses were performed for the Westwood Lake, Middle and Lower Chase River dams. The analyses are based on the soil conditions as encountered from the drilling program and the cross-sections as shown in Figures 6, 7 and 8.

The slope stability of an embankment is usually considered at four critical times in the life of the dam: immediately after construction, during rapid reservoir drawdown, during earthquakes, and finally under the seepage pressures which exist on the downstream slope with the reservoir full. Because all of these dams have been operating successfully for many years we consider it reasonable to discount the first two possibilities. In addition available records show that tremors up to 7.3 on the Richter scale have occurred within a 120 Kilometer radius of the site. We have therefore not considered earthquake loading as a new stress condition, provided the other cases are not marginal. Consequently we have narrowed our examination of stability to the case normally referred to as "steady state seepage".

The Janbu and Bishop stability methods were used for calculating the factors of safety. The Bishop analysis was used to assess the stability of the rockfill section of the Lower Chase River dam. The soil properties and parameters used in the analyses and the resulting factors of safety are summarized in Table V.

Our analyses indicate that the downstream slope of the Westwood Lake and Middle Chase River Dams generally have a factor of safety above 1.5 but range from 1.4 to 1.7 against a deep seated overall failure. The downstream slope of the Lower Chase River dam has the lowest computed factor of safety against a deep seated failure since the failure surface examined was mainly through the loose slag fill. A factor of safety of 1.2
was calculated for the rockfill, assuming that the loose slag fill did not exist. This is a very conservative assumption as the overall stability does include the effect of the slag fill. The factor of safety, considering the total dam section, is 1.4.

To define the factor of safety for each dam to a greater degree of accuracy would require more field work and monitoring of the phreatic surfaces in the dams for an extended time period. This is not considered necessary at this time as the resulting refinement to the analyses would not alter the overall results significantly.

6.0 RECOMMENDATIONS

6.1 General Maintenance

We believe that the following precautions and maintenance be undertaken on a routine basis in order that any deterioration in the present conditions of the dams does not go undetected and that the dams will not be subjected to unusually high loading.

1) The vegetation on the downstream slope, toe, and abutments be cleared so that any erosion, excess seepage or other deterioration does not go unnoticed.

2) The seepage be collected and measured wherever possible at one point, to determine if there is an abnormal (with reference to reservoir level) increase in underseepage.

3) The crest be inspected to detect localized settlements or cracking.

4) The spillways be kept clear to prevent build up in pond level above the normal storage level.
5) Inspection be made at the outlet end of conduits passing through the embankments to ensure that retrogressive erosion of the fill in contact with the pipe is not occurring.

6.2 Westwood Lake Dam

We recommend that the seepage water leaking from the downstream slope of the embankment be collected by an interceptor ditch cut parallel to the downstream toe. The flow in the interceptor ditch should be carried to the creek through a simple flow measurement device such as a V-notch weir. Construction details are shown in Figure 14. The backfill filter material should be a 40 mm minus pit run sand and gravel with less than 8 per cent passing the No. 200 sieve. The proposed gradation of the material is shown in Figure 15.

The conduits and control valve system at the dam site should be fully defined and repaired. The reservoir level is controlled by a spillway at the north end of the lake. This spillway should be checked on a regular basis to ensure it is operating so the dam will not be overtopped.

The piezometers which were installed during the drilling program should be read on a monthly basis for the next year to provide information on the phreatic surface within the dam with respect to reservoir level.

6.3 Upper Chase River Dam

This structure appears quite safe and we have no specific recommendation regarding methods to enhance its security. However, this dam also should be subject to routine inspections to ensure a deterioration in the facility does not go undetected.
6.4 Middle Chase River Dam

We recommend that a downstream seepage interceptor ditch similar to that described in section 6.2 be used to collect water passing through the embankment. Details of the ditch are shown in Figure 14. The backfill filter material should be a 40 mm minus gravel with less than 10 per cent passing No. 10 sieve. The proposed gradation of the material is shown in Figure 16.

The conduit and control valve system should be properly defined and made functional. The spillway concrete should be repaired to prevent further deterioration and possible leakage along the embankment—concrete contacts. It is recommended that the spillway chute right wall should be extended further downstream to prevent discharge water from the spillway flowing into the valley near the toe of the dam. The exposed soil on the left wall of the spillway should be faced with concrete or protected to prevent possible erosion of the exposed soil at high discharge flows.

The hole which was cut in the upstream concrete wall should be plugged with concrete or otherwise permanently sealed.

6.5 Lower Chase River Dam

We recommend that the seepage water from beneath the spillway should be located and the source covered with a designed granular filter. The discharge should then be channelled to the spillway chute or some other point which is remote from the dam.

The conduit and control valve system should be examined and made functional.

The safety against shear failure of the steep downstream face is considered to be adequate for normal operation. It is recommended
that due to the location and presence of a residential development
downstream, the factor of safety should be upgraded to a minimum of 1.5
against rotational failure. In order to achieve this, fill should be
placed against the downstream slope. It is considered desirable to
decrease the overall slope of the downstream face from its present
inclination of 1.6 horizontal to 1 vertical to a slope of 2 horizontal to 1
vertical. Alternatively, a weight berm may be used to achieve the same
end. The dimensions of the berm have not been determined at this time as
further study would be required. A preliminary estimate indicates a berm
11 m high, from the valley bottom up the existing downstream slope, with a
top width of 5 m, would be sufficient to provide the desired increase in
stability. The downstream slope of the berm would be constructed at 2
horizontal to 1 vertical. This berm would be constructed with a clean pit
run sand and gravel with a designed toe drain along the valley bottom to
collect any seepage which may enter the berm.

6.6 Power Line Dam

We consider that this structure is unsafe for the following
reasons:

1) Unsatisfactory site preparation prior to construction.
2) Poor embankment construction containing degradable materials
3) Inadequate crest width.
4) Sideslopes which are overly steep.
5) Large trees growing on dam face and crest.
6) Beaver holes in the upstream slope fill.
7) Discharge facilities which are ill-defined and could lead
to overtopping.

Golder Associates
8) Difficulty of access to site if maintenance required.

We recommend that positive measure be taken to prevent the Power Line dam from being reimpounded to normal reservoir level. The pool level should be maintained at about 3 m to 5 m below present crest level by whatever means are considered most economic. The discharge conduit should not be relied upon in this regard as it might become plugged by debris or inoperative. Breaching the dam is probably the most direct means of dealing with the problem.

It is not considered practical to attempt to improve the safety of the existing embankment as the foundation conditions are poor. It is recommended that if it is decided to maintain a dam at this location a new structure should be built. Based on field observations a suitable site appears to be immediately downstream of the present dam. It is recommended however that a more detailed appraisal for a new site and an investigation of sub-surface conditions be carried out before a decision is made on construction of a new dam to impound the reservoir at this location. In addition the two saddle dams at the other end of this reservoir would have to be investigated and probably rebuilt.
We trust this provides the information you require at this time.
We would be pleased to assist you if additional work for this project is required.

Yours very truly,

GOLDER GEOTECHNICAL CONSULTANTS LTD.

R.M. Wilson, P. Eng.

J.A. Hull, P. Eng.

RMW/JAH/ld

V78040
### TABLE I
**RECORD OF TEST PITS**

**A. Westwood Lake Dam**

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<tbody>
<tr>
<td>1</td>
<td>0 - 0.3</td>
<td>TOPSOIL &amp; ROOTS</td>
</tr>
<tr>
<td></td>
<td>0.3 - 0.8</td>
<td>Firm, rust brown, sandy SILT, some gravel &amp; roots. (Fill)</td>
</tr>
<tr>
<td></td>
<td>0.8 - 1.2</td>
<td>Loose, silty SAND, some gravel, burnt wood and roots. (Fill)</td>
</tr>
<tr>
<td>2</td>
<td>0 - 0.5</td>
<td>Loose, brown SAND &amp; GRAVEL, some silt.</td>
</tr>
<tr>
<td>3</td>
<td>0 - 0.6</td>
<td>Loose to compact, rust brown silty SAND, some gravel, occ. cobble, many roots. (Fill)</td>
</tr>
<tr>
<td></td>
<td>0.6 - 0.8</td>
<td>Burnt TOPSOIL &amp; ORGANICS</td>
</tr>
<tr>
<td></td>
<td>0.8 - 1.2</td>
<td>Compact, rust brown, fine to coarse SAND, some silt, gravel, occ. cobble.</td>
</tr>
<tr>
<td>4</td>
<td>0 - 0.3</td>
<td>Loose, SAND &amp; GRAVEL, some silt &amp; roots. (Fill).</td>
</tr>
<tr>
<td>5</td>
<td>0 - 0.3</td>
<td>Loose SAND &amp; GRAVEL, some silt &amp; roots (Fill).</td>
</tr>
</tbody>
</table>
# TABLE II
## RECORD OF TEST PITS

### B. Middle Chase River Dam

<table>
<thead>
<tr>
<th>Testpit No.</th>
<th>Depth (meters)</th>
<th>Strata Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 - 0.5</td>
<td>Sandy SILT, some clay, gravel cobbles, many roots. (Fill)</td>
</tr>
<tr>
<td></td>
<td>0.5 - 0.6</td>
<td>Black TOPSOIL &amp; ORGANICS</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>BEDROCK</td>
</tr>
<tr>
<td>2</td>
<td>0 - 0.2</td>
<td>TOPSOIL &amp; ORGANICS</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>BEDROCK</td>
</tr>
<tr>
<td>3</td>
<td>0 - 0.3</td>
<td>Loose, fine to coarse GRAVEL, trace sand &amp; silt. (Fill)</td>
</tr>
<tr>
<td>4</td>
<td>0 - 2.4</td>
<td>Loose to compact, brown SAND &amp; GRAVEL, some clayey silt, cobbles &amp; boulders. (Fill)</td>
</tr>
</tbody>
</table>
### TABLE III
**RECORD OF TEST PITS**

#### C. Lower Chase River Dam

<table>
<thead>
<tr>
<th>Testpit No.</th>
<th>Depth (meters)</th>
<th>Strata Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 - .3</td>
<td>Loose SLAG, CINDERS, COAL (Fill)</td>
</tr>
<tr>
<td></td>
<td>.3 - .6</td>
<td>TOPSOIL &amp; ORGANICS</td>
</tr>
<tr>
<td></td>
<td>.6 - 1.2</td>
<td>Firm, brown sandy, gravelly SILT roots, occ. cobble</td>
</tr>
<tr>
<td>2</td>
<td>0 - 1.2</td>
<td>Loose slag, some SAND &amp; GRAVEL (FILL)</td>
</tr>
<tr>
<td>3</td>
<td>0 - .9</td>
<td>Loose SLAG, CINDERS &amp; ROOTS (Fill)</td>
</tr>
<tr>
<td></td>
<td>.9 - 1.2</td>
<td>Dense, grey brown, silty gravelly SAND, some cobbles (Till-like).</td>
</tr>
<tr>
<td>4</td>
<td>0 - 1.5</td>
<td>Loose CINDERS, SLAG, sand roots. (Fill)</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>ROCKFILL</td>
</tr>
</tbody>
</table>

*Golder Associates*
<table>
<thead>
<tr>
<th>Testpit No.</th>
<th>Depth (meters)</th>
<th>Strata Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 - 0.2</td>
<td>ORGANICS &amp; ROOTS</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>BEDROCK</td>
</tr>
<tr>
<td>2</td>
<td>0 - 0.6</td>
<td>Loose, rust brown silty SAND, some roots, organics, burnt wood (Fill)</td>
</tr>
<tr>
<td></td>
<td>0.6 - 0.9</td>
<td>Firm, grey green, clayey SILT some sand, gravel, trace organics.</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>BEDROCK</td>
</tr>
<tr>
<td>3</td>
<td>0 - 0.5</td>
<td>Rotten TIMBER OR LOGS.</td>
</tr>
<tr>
<td></td>
<td>0.5 - 0.7</td>
<td>ORGANICS &amp; ROOTS</td>
</tr>
<tr>
<td></td>
<td>0.7 - 1.4</td>
<td>Soft to firm, brown sandy SILT, many roots (Fill)</td>
</tr>
<tr>
<td>4</td>
<td>0 - 0.5</td>
<td>Rotten TIMBER OR LOG</td>
</tr>
<tr>
<td></td>
<td>0.5 - 0.9</td>
<td>ORGANICS &amp; ROOTS</td>
</tr>
<tr>
<td></td>
<td>0.9 - 1.4</td>
<td>Soft to firm, brown sandy SILT, many roots (Fill)</td>
</tr>
<tr>
<td>5</td>
<td>0 - 1.1</td>
<td>Soft to firm, rust brown sandy SILT, some burnt wood &amp; gravel. (Fill)</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td>Broken ROCK, burnt WOOD, etc.</td>
</tr>
</tbody>
</table>
### TABLE V
Summary of Stability Analysis

<table>
<thead>
<tr>
<th>Dam</th>
<th>Friction Angle $\theta$</th>
<th>Cohesion</th>
<th>Unit Weight Kg/m$^3$</th>
<th>Calculated Factor of Safety</th>
<th>Depth of Selected Failure Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Westwood Lake</td>
<td>27°</td>
<td>0</td>
<td>2002</td>
<td>1.9</td>
<td>Shallow</td>
</tr>
<tr>
<td></td>
<td>27°</td>
<td>0</td>
<td>2002</td>
<td>1.4</td>
<td>Deep</td>
</tr>
<tr>
<td>B. Middle Chase River</td>
<td>35°</td>
<td>0</td>
<td>2002</td>
<td>2.5</td>
<td>Shallow</td>
</tr>
<tr>
<td></td>
<td>35°</td>
<td>0</td>
<td>2002</td>
<td>1.9</td>
<td>Deep</td>
</tr>
<tr>
<td></td>
<td>32°</td>
<td>0</td>
<td>2002</td>
<td>1.7</td>
<td>Deep</td>
</tr>
<tr>
<td>C. Lower Chase River</td>
<td>30°</td>
<td>0</td>
<td>1282</td>
<td>1.9</td>
<td>Shallow in slag, etc.</td>
</tr>
<tr>
<td></td>
<td>33°</td>
<td>0</td>
<td>1282</td>
<td>1.7</td>
<td>Shallow in slag etc.</td>
</tr>
<tr>
<td></td>
<td>38°</td>
<td>0</td>
<td>2243</td>
<td>1.2</td>
<td>Deep rockfill</td>
</tr>
<tr>
<td></td>
<td>30°</td>
<td>0</td>
<td>1282</td>
<td>1.4</td>
<td>Deep through slag and rock fill.</td>
</tr>
<tr>
<td></td>
<td>38°</td>
<td>0</td>
<td>2243</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Factors of safety are calculated for static loading conditions.
SITE PLAN
MIDDLE CHASE RIVER DAM

Leak from spillway

Spillway
Approx. end of concrete wall

A

Toe of embankment
Crest of earthfill

TR3

TR1

TR2

TR4

BH2
BH3

Baseline

Concrete wall

Poor bedrock-concrete contact

Reservoir

Approx. location of opening in the concrete wall

Scale: 1:500

LEGEND
Hand Dug Test Pits
Test Pit Excavated by Backhoe
Borehole
Approx. location of seepage

REFERENCE
Taken from Willis Cunliffe Tait dwg. V16325-1-1

Golder Associates
LEGEND
- Hand Dug Test Pits
- Test Pits Excavated by Backhoe
- Borehole

REFERENCE
Taken from Willis Cunliffe Tait
dwg. VI 6325-1-1
SITE PLAN
POWERLINE DAM

Approx. location of conduit

Reservoir

Crest of earthfill

Baseline

Toe of embankment

Scale: 1:500

LEGEND

📍 Hand Auger Hole
📍 Hand Dug Test Pit
📍 S1 Approx. location of seepage.

NOTE
Location of control valve unknown.

REFERENCE
Taken from Willis Cunliffe Tait dwg. VI-6325-1-1

Golder Associates
INFERRED SECTION THROUGH
WESTWOOD LAKE DAM

SECTION A-A
Scale horiz. (vert. 1:100

Loose sandy silt with some gravel (FILL)

Water level in piezometer Pl - March 29/78

Firm to stiff silt (impervious core ?)

Bedrock

Assumed phreatic surface

Westwood Lake

Lake bottom

Elevation, meters

Drawn R.P.
Reviewed M.
Date Apr '78
Golder Associates
Loose cinders, slag, sand & gravel (FILL)

Selected stability surface

Assumed water table

Concrete wall

Reservoir

Reservoir bottom

Rockfill

Dense sandy silt, some gravel (fill-like)

SECTION A-A

Scales horiz. & vert. 1:100

REFERENCE
Willis, Cunliffe, Tait, dwg. VI-6325-H

Golder Associates
Golder Associates

Elevation, meters

UPSTREAM

1.3m
Normal reservoir level

Reservoir

March 15, 1978

1.5

AH 3

DOWNSTREAM

1.5

Loose silty sand, sandy silt

Loose burnt material
Soft to firm clayey silt

SECTION A-A

Scales horiz. & vert. 1:100

REFERENCE
Willis, Cunliffe, Tait dwg. VI 6325-1-1
PLASTICITY CHART
Westwood Lake Dam

SAMPLE OF CORE (2)
MATERIAL FROM WESTWOOD LAKE DAM

Low  Medium  High

Plasticity (Clays) or Compressibility (Sills)

Liquid Limit, w_L

Inorganic clays of low plasticity
Inorganic clays of medium plasticity
Inorganic silts of low compressibility
Inorganic silts of medium compressibility
Inorganic clays
Organic clays
Clayey silts
Silty clay
Cohesionless soils

V78040  R.D.  Apr. '78

Golder Associates
M.I.T. GRAIN SIZE SCALE

Size of opening, inches  U.S.S. Sieve size, meshes/inch
24"  12"  6"  3"  1 1/2"  3/4"  3/8"  4  10  20  40  60  100  200

LEGEND

Middle Chase River Dam
- Location 51
x Location 53

PERCENT FINER THAN

GRAIN SIZE, MM

<table>
<thead>
<tr>
<th>BOULDER SIZE</th>
<th>COBBLE SIZE</th>
<th>COARSE</th>
<th>MEDIUM</th>
<th>FINE</th>
<th>COARSE</th>
<th>MEDIUM</th>
<th>FINE</th>
<th>SILT SIZE</th>
<th>CLAY SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAVEL SIZE</td>
<td>SAND SIZE</td>
<td>FINE GRAINED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTES
1. Westwood Lake Dam - see fig. 15
   Middle Chase River Dam - see fig. 16
2. Height of fill determined by highest point of seepage.
   Should be at least 1.0m above seepage source.
3. Westwood Lake Dam - Fill to be placed as shown.
4. Middle Chase River Dam - Fill to be placed as shown.
   Fill to extend a minimum of 3.0m past downstream edge of ditch.
RECORD OF BOREHOLE 1
WESTWOOD LAKE DAM

LOCATION (See Figure 1)
BORING DATE March 13, 1978
BOREHOLE TYPE Rotary
BOREHOLE DIAMETER 114 mm
SAMPLER HAMMER WEIGHT 63.6 kg DROP 762 mm
DATUM Willis, Conilffe, Tait
Dwg No VI 625-1-2

SOIL PROFILE

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.5</td>
<td>Ground Surface</td>
</tr>
<tr>
<td>0.0</td>
<td>Loose, rust brown sandy SILT, some gravel, occ. cobble trace burnt organics (FILL)</td>
</tr>
<tr>
<td>92.7</td>
<td>Firm to stiff grey green clayey SILT, trace sand, gravel organics &amp; burnt organics (impervious core)</td>
</tr>
<tr>
<td>87.7</td>
<td>Hard bedrock</td>
</tr>
<tr>
<td>10.8</td>
<td>End of Borehole</td>
</tr>
<tr>
<td>86.9</td>
<td></td>
</tr>
<tr>
<td>11.6</td>
<td></td>
</tr>
</tbody>
</table>

PIEZOMETER OR STANDPIPE INSTALLATION

WATER CONTENT PERCENT

VERTICAL SCALE 1:100

Golder Associates

DRAWN
CHECKED
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
<th>STRATIGRAPHY PLOT</th>
<th>SAMPLE TYPE</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.5</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>Loose, rust brown fine to coarse SAND, some silt, gravel, trace burnt wood (FILL)</td>
<td>1</td>
<td>0.0 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94.1</td>
<td>Dense to very dense grey brown to grey fine to coarse SAND, some silt, gravel, occ. cobble &amp; boulder (TILL-LIKE)</td>
<td>2</td>
<td>3 lost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.6</td>
<td>End of Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# RECORD OF BOREHOLE 3
## MIDDLE CHASE RIVER DAM

**LOCATION** (See Figure 3)  
**BORING DATE** March 16, 1978

**BOREHOLE TYPE** Rotary  
**BOREHOLE DIAMETER** 114 mm

**SAMPLER HAMMER WEIGHT** 63.6 kg  
**DROP** 762 mm  
**DATUM** WCT Dwg. VI 6325-1-1

<table>
<thead>
<tr>
<th>ELEV. DEPTH</th>
<th>DESCRIPTION</th>
<th>STRATIGRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT %</th>
<th>PIEZOMETER OR STANDPIPE INSTALLATION</th>
<th>ADDITIONAL LAB. TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.8</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- drill with air, no sampling</td>
<td></td>
</tr>
</tbody>
</table>
| 0.0         | Loose to compact brown SAND & GRAVEL  
              Some silt.  
              *(FILL)* |                 |               |             |              |                |                | - lost air circulation at 4.6m      |                         |
| 94.1        | ROCKFILL    |                 |               |             |              |                |                | - hole open to 7.6m  
              no water encountered  |                         |
| 91.7        | End of Borehole |             |               |             |              |                |                |                                     |                         |

**VERTICAL SCALE**  
1 cm to 1 m

_Golder Associates_  
DRAWN  
CHECKED
**RECORD OF BOREHOLE 4**

**MIDDLE CHASE RIVER DAM**

**LOCATION** (See Figure 3)  
BORING DATE March 17, 1978

BOREHOLE TYPE Rotary  
BOREHOLE DIAMETER 114mm

SAMPLER HAMMER WEIGHT 636kg. DROP 762mm DATUM WCT Dwg. VI 6325-1-1

<table>
<thead>
<tr>
<th>ELEV. DEPTH</th>
<th>DESCRIPTION</th>
<th>STRATIGRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT PERCENT</th>
<th>ADDITIONAL LAB. TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.8</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>drilling with air</td>
</tr>
<tr>
<td>0.0</td>
<td></td>
<td></td>
<td>1</td>
<td>Do 31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loose to compact</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAND, GRAVEL,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>COBBLES, BOULDERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(FILL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>&quot; 13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>&quot; 100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90.1</td>
<td>End of Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- rods stuck in hole</td>
</tr>
<tr>
<td>10.7</td>
<td>End of Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**VERTICAL SCALE 1:100**

Golder Associates

DRAWN  
CHECKED
<table>
<thead>
<tr>
<th>ELEV. DEPTH</th>
<th>DESCRIPTION</th>
<th>STRATIGRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>BLOWES / FOOT</th>
<th>ELEVATION SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.8</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>Loos to compact</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sand &amp; gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(FILL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>ROCKFILL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.3</td>
<td>TILL-LIKE MATERIAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.8</td>
<td>End of Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Additional Notes:**
- Lost air circ. at 6.1m no return
- Rods stuck in hole

**Golder Associates**

**Record of Borehole 5**

**Middle Chase River Dam**

**Location:** (See Figure 3)

**Borehole Type:** Air Track

**Sample Hammer Weight:** Lb. Drop - in.

**Sample Diameter:** 50 mm

**Datum:** WCT Dwg. VI 6325-1-1

**Vertical Scale:** 1:100
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.3</td>
<td>Ground Surface</td>
</tr>
<tr>
<td>0.0</td>
<td>Very loose cinders, slag, etc. (Fill)</td>
</tr>
<tr>
<td>97.8</td>
<td>Loose to compact SANDS, GRAVELS, COBBLES (Fill)</td>
</tr>
<tr>
<td>96.6</td>
<td>Loose gravels, cobbles &amp; boulders (ROCKFILL)</td>
</tr>
<tr>
<td>88.7</td>
<td>End of Borehole</td>
</tr>
</tbody>
</table>

**Additional Notes:**
- Lost mud circulation
- Hole cased to 103.5 m
- Hole cased at 10.3 m, no return
- Stopped because possibility of jamming rods in hole, also casing damaged from driving into rockfill.
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
<th>STRATIGRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT PERCENT</th>
<th>ADDITIONAL LAB. TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.3</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>Loose, rust brown fine to coarse SAND, some gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>98.8</td>
<td>Trace silt to cinders (FILL)</td>
<td></td>
<td>1</td>
<td>00.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Very coarse gravels with cobbles (Rockfill)</td>
<td></td>
<td>2</td>
<td>16 lost</td>
<td></td>
<td></td>
<td></td>
<td>- Lost mud circ. at 1.5m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Drill with air to 4.6m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- No return</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Stopped because of possibility of jamming rods in hole</td>
</tr>
<tr>
<td>95.7</td>
<td>End of Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Record of Borehole 8
## Lower Chase River Dam

**Location (See Figure 2)**

**Boring Date** March 16, 1978

**Borehole Type** Rotary

**Borehole Diameter** 114 mm

**Sampler Hammer Weight** 63.6 kg, Drop 762 mm

**Datum** W.C.T. Dwg. VI 6325-1-1

## Soil Profile

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.3</td>
<td>Ground Surface</td>
</tr>
<tr>
<td></td>
<td>Loose block SAND GRAVEL, SLAG, CINDERS (FILL)</td>
</tr>
<tr>
<td>96.9</td>
<td>Loose coarse GRAVELS COBBLES &amp; BOULDERS (ROCKFILL)</td>
</tr>
<tr>
<td>92.2</td>
<td>End of Borehole</td>
</tr>
<tr>
<td>8.1</td>
<td>End of Borehole</td>
</tr>
</tbody>
</table>

**Piezometer or Standpipe Installation**

Drill with air

**Additional Lab. Testing**

- Hole cased to 6.7 m. No return from 6.7 - 8.1 m. Driving shoe for casing damaged.
**Record of Borehole 9**  
**Lower Chase River Dam**

**Location:** (See Figure 2)  
**Boring Date:** March 28, 1978  
**Borehole Type:** Air Track  
**Borehole Diameter:** 50 mm  
**Datum:** WCT Dwg. VI 6325-1-1

<table>
<thead>
<tr>
<th>ELEV. DEPTH</th>
<th>DESCRIPTION</th>
<th>STRATIGRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT PERCENT</th>
<th>PIEZOMETER OR STANDPIPE INSTALLATION</th>
<th>ADDITIONAL LAB. TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.3</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>Loose cinders, sand, gravels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- lost air circ. at 4.6m</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- no return</td>
<td></td>
</tr>
<tr>
<td>85.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.9</td>
<td>Till-like material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.5</td>
<td>End of Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Vertical Scale:** 1:100  
**Drawn by:**  
**Checked by:**  

**Golder Associates**
# Record of Auger Hole 1

**Powerline Dam**

**Location (See Figure 4)**

**Boring Date** March 15, 1978

**Borehole Type** Manual Auger

**Borehole Diameter** 50 mm

**Sampler Hammer Weight - LB. DROP - IN.**

**Datum** WCT Dwg. VI - 6325-1-1

## Soil Profile

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
<th>STRAT/GRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT PERCENT</th>
<th>PIEZOMETER OR STANDBPIPE INSTALLATION</th>
<th>ADDITIONAL LAB. TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>Loose, rust brown sandy silt, some gravel, many roots.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99.1</td>
<td>End of Auger Hole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Difficult to auger cast 0.9m</td>
</tr>
</tbody>
</table>

**Vertical Scale** 1 : 20

Golder Associates

**Drawn**

**Checked**
**RECORD OF AUGER HOLE 2**

**POWER LINE DAM**

**LOCATION (See Figure 4)**:  
**BORING DATE**: March 15, 1978  
**BOREHOLE TYPE**: Manual Auger  
**BOREHOLE DIAMETER**: 50 mm  
**SAFETY HAMMER WEIGHT - LB. DROP - IN.**:  
**DATEM**: WCT Dwg. VI 6325-1-1

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION</th>
<th>STRAT/GRAPHY PLOT</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>BLOWS / FOOT</th>
<th>ELEVATION SCALE</th>
<th>WATER CONTENT PERCENT</th>
<th>PIZZOMETER OR STANDPIPE INSTALLATION</th>
<th>ADDITIONAL LAB. TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.1</td>
<td>Ground Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>Sand &amp; Gravel (managed to penetrate to 15 cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**VERTICAL SCALE**: 1:20  
**Golder Associates**
### Record of Auger Hole 3

**Power Line Dam**

**Location**: (See Figure 4)

**Boring Date**: March 15, 1978

**Borehole Type**: Manual Auger

**Borehole Diameter**: 50 mm

**Sampler Hammer Weight**: - lb. drop - in.

**Datum**: WCT Dwg. VI 6325-1-1

---

**Soil Profile**

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.1</td>
<td>Ground Surface</td>
</tr>
<tr>
<td>97.2</td>
<td></td>
</tr>
<tr>
<td>96.3</td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>Loose, burnt appearance silty SAND, burnt wood cinders, trace organics and roots.</td>
</tr>
<tr>
<td>2.4</td>
<td>Soft to firm clayey SILT, Some sand</td>
</tr>
<tr>
<td>2.7</td>
<td>End of Auger Hole</td>
</tr>
</tbody>
</table>

---

**Additional Lab. Testing**

**Water Level**

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**Vertical Scale**: 1:20

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**Golder Associates**