GOVERNMENT OF NUNAVUT
DEPARTMENT OF COMMUNITY &GOVERNMENT SERVICES
PROJECTS DIVISION- BAFFIN REGION
P.O. BOX 379, POND INLET NUNAVUT X0A 0S0
Telephone Number: (867) 899-7312 Facsimile Number: (867) 899-7328

Date: June 7, 2004

Phyllis Beaulineu
Manager
License Administrator
Nunavut Water Board
PO Box 119,Gjoa Haven NU X0B 1J0

Dear Ms. Beaulineu,

Re: Notification of Design Modification
Water License NWB3PON0308
Sewage Lagoon Project, Pond Inlet, Nunavut.

The Department of Community and Government Services, Pond Inlet requests your approval of the attached design modifications for the Sewage Lagoon Project in Pond Inlet. The submitted design modifications have been made in pursuant to the findings and recommendations of the investigative study of the Pond Inlet Sewage Lagoon site completed by Golder Associate. The study identified several areas of risk and corresponding recommendations for corrective actions to minimize possible environmental risks.

Please note that the modifications are limited to design and construction only and do not affect the treatment process in general and physical pathway and location of discharge point.

BACKGROUND:

During the construction process in the summer and fall of 2003, it was observed that the base of the lagoon area was substantially wetter than expected. The ground water from an up-gradient source is suspected of flowing into the sewage lagoon base material via a subsurface pathway and by-passing the lagoon berms and collecting in the bottom of the lagoon.

The contractor carried out dewatering by pump for most of the construction season, however even with this operation, portions of the base remained saturated and unstable. As a result, the construction could not be completed in 2003 as originally planned. This wet area represents an operational issue as the lagoon base may experience frost heaving and be unable to provide sufficient support to the Geosynthetic Clay Liner (GCL) planned for installation in the sewage lagoon. This represents a serious issue to the GN for the operation of the sewage treatment facility in a sustainable manner.

In order to assess the on-site conditions and to address the problem of wet areas within the base, the GN authorized Golder Associates to complete an independent investigative study of the site.

GOLDER REPORT & RECOMMENDATIONS:

In the fall of 2003, Golder Associates completed the study and provided the Government of Nunavut with a final report dated October 29, 2003. Golder report provided several alternatives and recommendations within their work.

A copy of Golder Report is enclosed herein for your reference.

The Study Recommendations:

- Installation of the French Drains to facilitate construction;
- Plugging the French drains after construction and operation begins;
- Maintaining a minimum level of water cover of 1.0 meters over the GCL;
- Improvement of area drainage to divert external water from reaching the lagoon base.

DESIGN MODIFICATIONS:

Design modifications have been made accordingly, based on recommendations of the Golder Study with an objective to minimize the risk of failure of GCL liner and possible leakage of unacceptable effluent to the environment.

These modifications include:

1. the installation of a sub-drain system;
2. the use of a manhole to monitor and control sub drain system;
3. the installation of riprap to protect the sand liner cover as an improvement to original design in order to stabilize berms;
4. construction of a cut off ditch and catchment basin (Please *refer to drawing).*

The sub-drain system underneath the base of lagoon shall be a French Drain system consisting of 150 mm perforated HDPE piping wrapped in a geo- textile sock. The crown of the drain will be located 500 mm below the base of the liner system which consists of 300 mm of sand, one layer of GCL and 300 mm of sand. The perforated pipe is bedded in a granular material of approximately 20 to 50 mm particles.

Where the under drain system goes under the berm wall, the piping is changed to solid wall piping. To prevent short circuiting, a bentonite clay plug shall be installed (10 meter length) with the berm wall. The outlet to the under drain system is controlled by a valve within an access manhole and the discharge of the under drain system is directed to a rip rap lined ditch.

Seepage cut off ditch with catchment basins is to be constructed on the down gradient side of the berm. This ditch is to be used to monitor for seepage and any seepage found in the ditch and collected in the catchment basin, will be pumped back into the lagoon.

In the wet area at the bottom of lagoon, where the water accumulation problem is predominant, GCL can be installed in more than one layer as required in direction perpendicular to each other as a reinforcement of the GCL system.

OPERATION & MONITORING ASPECT:

Golder report identified a number of concerns with respect to the installation of the French drains. These are outlined above, and in the attached Golder report. The basic points of consideration are:

- Plugging the under drain system will allow the pore water pressure within the lagoon base within the lagoon base below GCL to equalize against the hydrostatic head resulting from the wastewater in the lagoon.

- When the lagoon is decanted, there is a possibility for there to be an uplift force equal to the pore pressures that develop in the lagoon base material when the drains are blocked. This will occur at each lagoon decanting (annually)

To provide for an under drain system and prevent the high static head, a manhole and valve system is to be installed. The lagoon operator will monitor the level of the sewage in the lagoon and the level of the water in the under drain system. Opening and closing the valve on the under drain system to lower the pore pressures under the lagoon liner will be required annually prior to decanting the lagoon. This will need to be done carefully to maintain sufficient back pressure under the liner to prevent the build up of static head pressures exceeding the liners capacity. The operator will make sure that the valves are closed once the level of the lagoon reaches 1.0 meters as outlined in the Golder report.

While this proposed operation would work to minimize the risk of a liner breach due to the hydrostatic head, and minimize the risk of the liner being lifted by the base pore water pressure, there are some operational issues to be considered.

- There is the risk that the under drain system freezes or is blocked by silt. The drains will then be inoperable. The use of a hot water flusher system to verify the drains are operating on an annual basis is to be undertaken by the operator.

The Golder report indicates that some amount of seepage out of the base of the lagoon liner system, and through the sub-soils should be expected as part of the operation of the system.

A down gradient seepage cutoff and under drain ditch with catchment basin will be constructed and will be monitored. Seepage water that appears along the seepage cut-off ditch will be collected in catchment basin and pumped back into the lagoon.

The operational changes proposed will include the weekly monitoring of the seepage cutoff ditch, and the operation and monitoring of the under drain system. The monitoring will be weekly during the few years of operation in the non-freezing months. Once the lagoon system has stabilized (3 to 5 years) monitoring will be monthly. Should any seepage paths develop, remedial actions will be required.

These design changes relating to the construction and the operation need to be approved.

IMPACT ON CONSTRUCTION SCHEDULE

Despite the design modifications, the construction work as discussed with the contractor is expected to be complete in the 2004 for the given scope of work.

IMPACT ON WATER LICENSE

The proposed modifications to the current sewage lagoon design are design and operation related only and do not affect the treatment process and physical pathway of the discharge point. The outlined modification to the design will minimize the amount of seepage, and provide for a means to monitor and collect any seepage to avoid unapproved discharge to the environment.

We seek your approval for the above modification as part of the license originally issued by NWB for the construction of the said facility and should you require further information please contact the undersigned at (867) 899-7312 at your convenience.

In closing, as we plan to resume the construction work very soon and expect to complete the project this season, your prompt response in this regard will be highly appreciated.

I thank you in advance for your efforts in addressing this request,

Yours Truly,

Anjan Joshi
Project Officer

Enclosure:

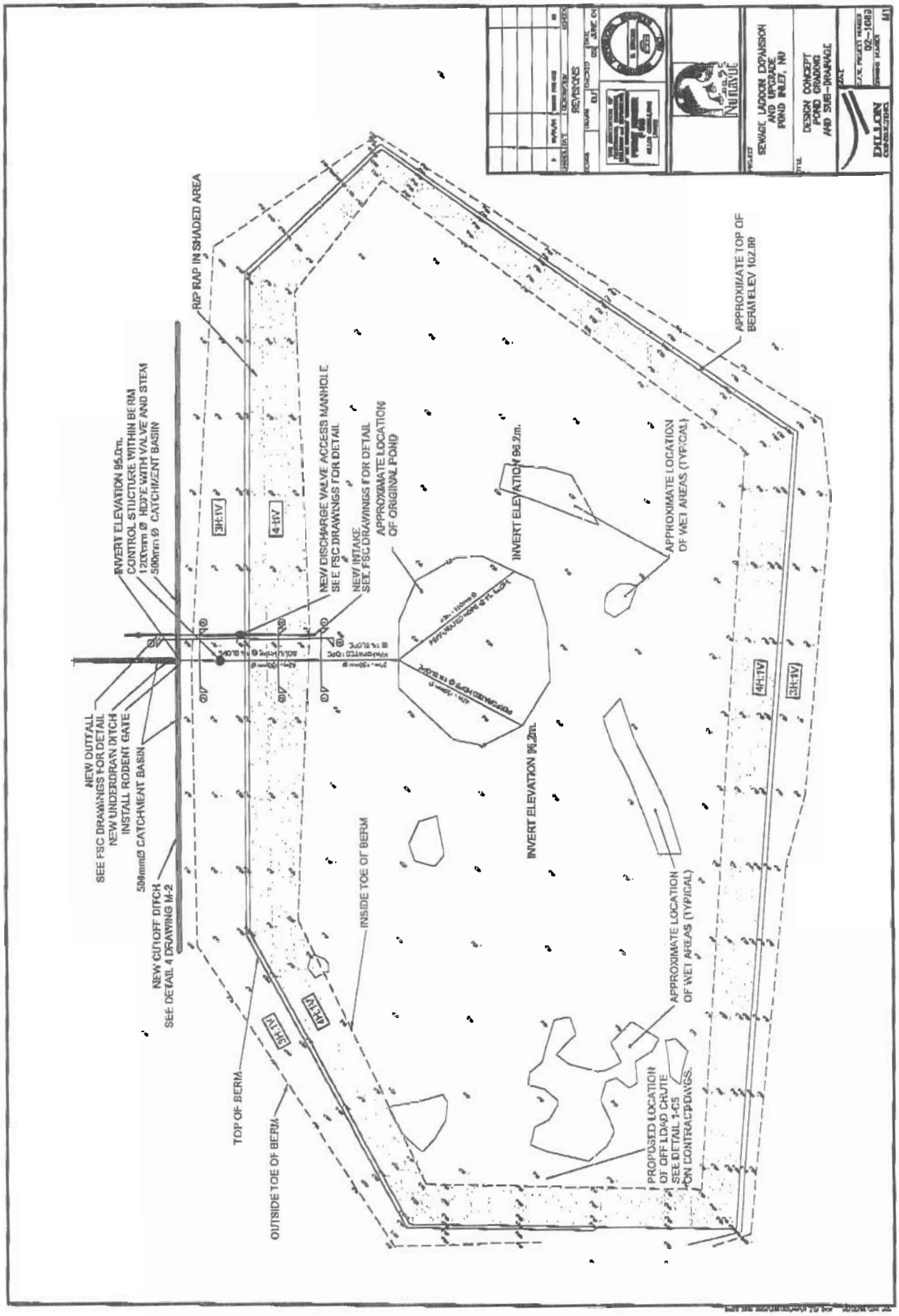
1. A copy of Golder Report
2. Drawings

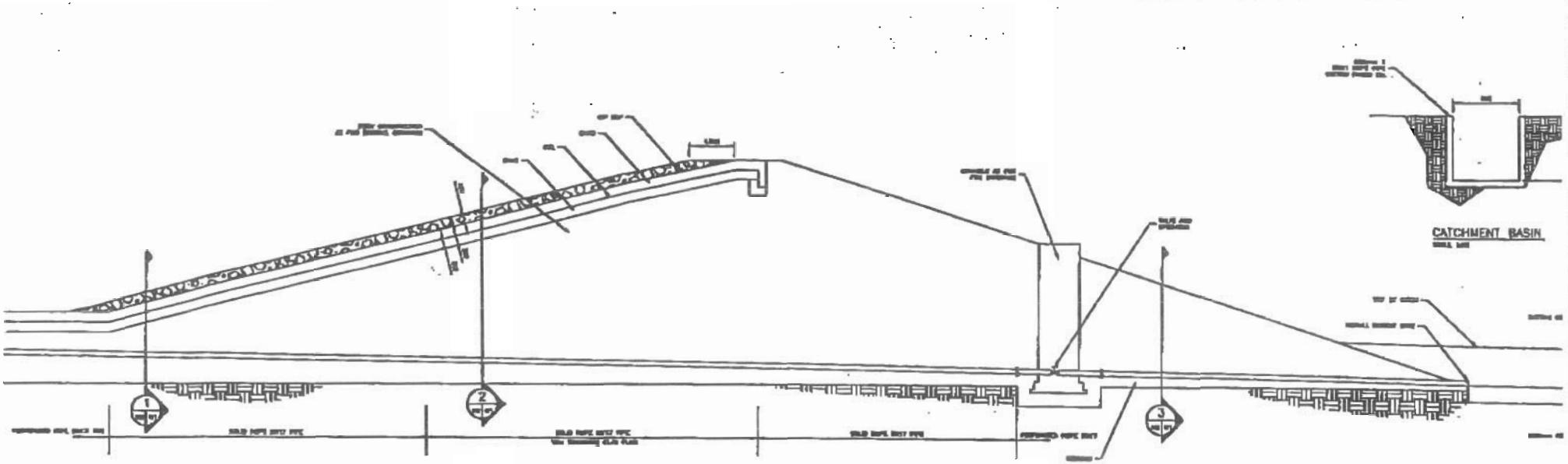
CC: i) Kriss Sarson
Manager, Capital Program
CGS Headquarter, Iqaluit.

ii) Lori Nash
Senior Administrative Officer
Hamlet of Pond Inlet
Pond Inlet.

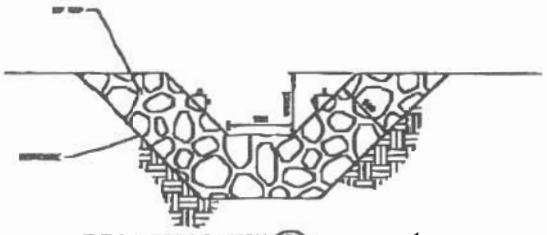
iii) Nelson Pisco
Regional Projects Manager
CGS, Regional Office, Pond Inlet.

Nunavut

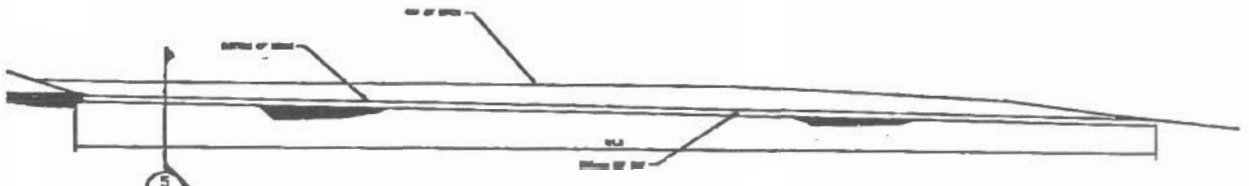

SEWAGE LAGOON EXPANSION AND UPGRADE POND INLET, NU
DESIGN CONCEPT POND GRADING AND SUB-DRAINAGE
DILLON CONSULTING
NUNAVUT
REVISIONS
RIP RAP IN SHADED AREA
APPROXIMATE TOP OF BERM ELEV 102.0m
INVERT ELEVATION 95.0m. CONTROL STUCTURE WITHIN BERM 1200mm Ø HDPE WITH VALVE AND STEM 900mm Ø CATCHMENT BASIN
NEW DISCHARGE VALVE ACCESS MANHOLE SEE FSC DRAWINGS FOR DETAIL
NEW INTAKE SEE FSC DRAWINGS FOR DETAIL
APPROXIMATE LOCATION OF ORIGINAL POND
INVERT ELEVATION 96.2m.
APPROXIMATE LOCATION OF WET AREAS (TYPICAL)
NEW OUTFALL SEE FSC DRAWINGS FOR DETAIL
NEW UNDERDRAIN DITCH
INSTALL RODENT GATE
500mmØ CATCHMENT BASIN
NEW CUTOFF DITCH SEE DETAIL 4 DRAWING M-2
INSIDE TOE OF BERM
TOP OF BERM
OUTSIDE TOE OF BERM
PROPOSED LOCATION OF OFF LOAD CHUTE SEE DETAIL 1-C5 ON CONTRACT DWGS.
3H:1V
4H:1V



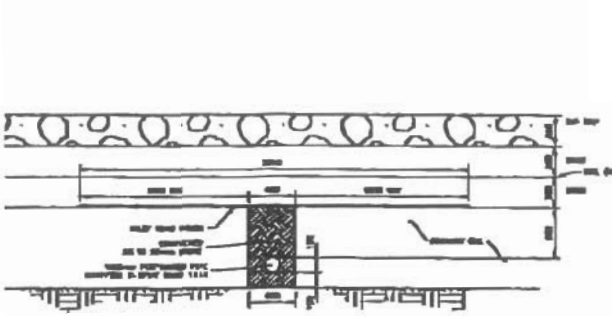
BERM CROSS SECTION 4



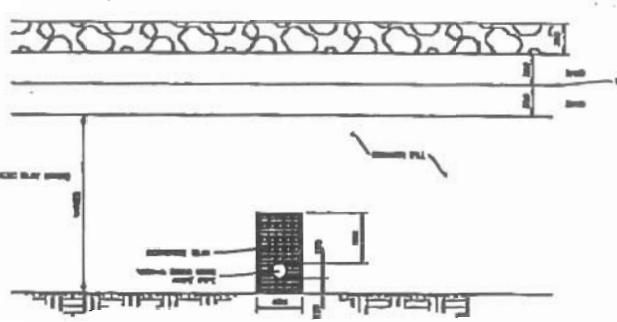
TYPICAL DITCH SECTION 5



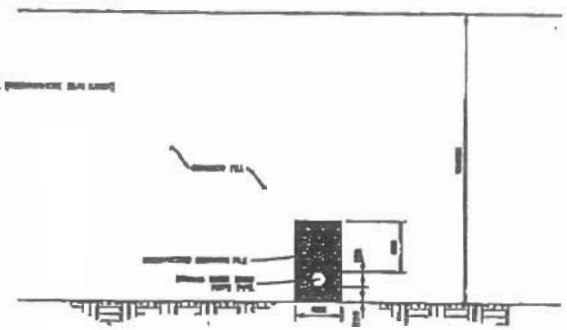
DITCH CROSS SECTION 4



SECTION 1



SECTION 2



SECTION 3

PERMIT HOLD
F 010

SEWAGE U
AND
POND

SUB
CATCH

DILLON
CONSULTIN

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Golder Associates

October 29, 2003 03-1221-310

Dillon Consulting
4920 47th street
Yellowknife, NWT
X1A 2L8

Attention: Mr. Gary Strong, P. Eng.

RE: REHABILITATION OF THE SEWAGE LAGOON, POND INLET (REV. 1)

Dear Sir,

Dillon Consulting (Dillon) mandated Golder Associates Ltd. (Golder) to provide technical guidance during the rehabilitation of a sewage lagoon in Pond Inlet, Nunavut. A first letter was issued on September 10, 2003 following a review by Dillon. The current version of this letter addresses comments made by the Government of Nunavut following their review of the September 10 letter.

The lagoon has been active around 1993 and has experienced progressive problems since approximately 1995. The government of Nunavut mandated Ferguson, Simek & Clark Engineers and Architects (FSC) of Yellowknife to design the rehabilitation of the pond in 2002. Mosher Engineering Ltd. of Halifax initiated on-site construction activities in early July 2003 under the supervision of Dillon.

1.0 INTRODUCTION

The rehabilitation program calls for the drainage of the existing lagoon, placement of a sufficient thickness of granular material to stabilize the accumulated sludge, a 0.3 m thick

sand layer, a geocomposite clay liner (GCL), and a 0.3 m thick surficial layer of sand. Re-compaction of the existing north dyke and raising of all perimeter dykes are also part of the construction program. The pond will service the community of Pond Inlet once the rehabilitation is completed. The pond is irregularly shaped, with overall equivalent dimensions of approximately 300 m x 150 m.

Problems encountered by the contractor are related to the instability of the current pond base. In order to obtain a stable pond base for his equipment and achieve the 1 % specified base slope the contractor has to put a minimum thickness of 500 to 1000 mm of cobbly gravel and sand onto the existing pond base (see photograph 1). This layer is being spread as a single lift over the pond sludge and the active layer of permafrost. Both the contractor and Dillon site personnel are worried that the specified compaction of 95 % Proctor will not be achieved within the lower portion of this single lift layer resulting therefore in potential settlement problems and failure of the GCL membrane at the joints. The difficulty of compacting the imported gravel is further complicated by persistent water seepage from the underlying active layer of the permafrost. It is assumed that placement of fill material will not result in mud wave where the sludge could be extruded and flow.

We understand the Government of Nunavut requested an opinion from an independent geotechnical expert, and the Government obtains clarification from FSC from time to time as and when needed.

2.0 SITE OBSERVATIONS

Mr. Michel Lemieux of Golder was on site on August 30, 2003 to assess conditions of the lagoon with Dillon personnel. At Golder's request, the contractor agreed to conduct some additional surveys of surrounding site topography and to perform a series of three (3) test pits. The purpose of the survey was to help define the direction of surface flow and the probable direction of underground flow within the active layer of the permafrost. The test pits were undertaken to assess the thickness and composition of the active layer of permafrost. Survey elevation at the test pit locations was also performed by the contractor.

Survey information and site observations indicate the lagoon is located in a low spot with higher ground on the east, south and west faces. A 1992 geotechnical report, prepared by Thurber Consultants, was consulted and indicates the presence of a natural pond at the time prior to construction. The pond had an overflow to the ocean in 1992. Observations made in August 2003 indicate the occurrence of former water ponding immediately outside the east end of the south dyke. The contractor reported this water disappeared when he pumped the central portion of the basin, suggesting a direct hydraulic connection between the pond and this area outside the lagoon.

The pond at the time of the site visit was quite low with an approximate elevation of 96.0 m. The contractor reported that daily pumping was required to maintain the water level at the current elevation. Despite the relatively low water level in the pond at the time of the site visit, the presence of surficial seepage was observed outside the lagoon roughly 100 m north of the north dyke. Ground surface at this location is much lower than the toe of the dyke.

These last two observations tend to indicate that preferential channels capable of carrying large flows of water could exist within the active layer of permafrost. The last two observations also indicate the existing dykes have naturally thawed sufficiently in the last few weeks to become permeable and allow water to flow through their foundations.

The location of the three (3) test pits undertaken at the site is shown on Figure 1. The results are described in the following table:

Depth (m)	Elevation (m)	Soil Description
Test Pit N° 1		
0-1.0	98.5-97.5	Gravel, cobbles and boulders with some sand and silt infilling, wet to saturated
1.0	97.5	Permafrost (end of test pit) Stabilized water level after 30 minutes is located at a depth of 0.75 m (elev. 97.75 m)

Depth (m)	Elevation (m)	Soil Description
Test Pit N° 2		
0-0.2	96.3-96.1	Cobbles
0.2-1.1	96.1-95.2	Black sludge
1.1	95.2	Permafrost (end of test pit) Little water accumulation in the test pit after 2 hours despite the presence of an adjacent pond at elevation 96.0 m (approx.)
Test Pit N° 3		
0-1.25	98.3-97.05	FILL: brown, moist compact sand and gravel with numerous cobbles and boulders
1.25-1.28	97.05-97.02	Black sludge, saturated
1.28-2.1	97.02-96.2	Brown, saturated compact silty sand with some cobbles and boulders
2.1	96.2	Permafrost (end of test pit) Slight water seepage was noted at the interface with the black sludge.

The contractor reported he has dug a test pit adjacent to our Test Pit N° 2 and encountered very high water inflow conditions that filled the test pit rapidly. The contractor also exhibited photographs showing how he backfilled the base of the lagoon so far. It appeared that three (3) east-west oriented channels were left open for some time adjacent to various fill zones in order to allow seepage water to flow to the central pond where it was pumped out. These channels were subsequently filled up with compacted pit run material. At the time of the site visit, the area around Test Pit N° 3 was found to be soft and wet and slightly unstable, with indications that subsurface pore pressure conditions were significant enough to obtain somewhat quick conditions. Loaded trucks could, however, still travel over these areas.

The material used for backfilling was encountered in the upper portion of Test Pit N° 3 (see description above). This material is obtained from the active layer of the permafrost located on a high ridge some 2 km south of the site.

3.0 DISCUSSION

The project is now suspended for the winter season and will resume next summer.

3.1 2003 Construction Season

It is our opinion that current water inflow problems will continue to prevail within localized areas of the pond base for the remainder of the construction season. These wet areas, as delineated by Mosher Engineering, are shown on Figure 1. They are believed to result from the actual location of the pond in a low lying area combined with anticipated natural pockets or tongues of high permeability material within the active layer of the permafrost and the lack of perimeter drainage outside the pond.

The contractor's suggestion of adding French drains or ditches in specific areas within the pond is supported and recommended by Golder. Such drains or ditches will reduce the risk of further deterioration of the newly constructed raised pond base during the remaining weeks of the 2003 construction season. These features will also help control any inflow during the 2004 thawing season prior to and during the installation of the GCL.

French drains or ditches should connect any wet zones occurring within the pond to the central low point of the basin. A similar French drain or an open ditch should then connect the pond central low point to the exterior topography north of the north dyke. This means a portion of the north dyke will have to be breached open to accommodate the new ditch or drain.

French drains

The use of a geotextile and clear stone are recommended for the construction of the French drains. Such drains should be totally wrapped with the above noted geotextile, with 300 mm minimum overlap at the top joint to prevent migration of sand and fines into the drain which could potentially result in the plugging of the drain and loosening of the adjacent soil.

The top of the French drain should not be set too deep within the base of the pond in order to remain active for the next construction season and not be incorporated within the permafrost following the raise of the permafrost line within the next 12 months. It is therefore recommended that the top of the French drain be set 0.5 m below the level of earthworks to be attained at the end of the 2003 construction season. The longitudinal profile of these drains and/or ditches should be as regular as possible to avoid any intermediate points of water ponding.

Instrumentation

Under proper circumstances, it may be useful to consider instrumentation of the pond new basal layer upon completion of construction activities in 2003. Instrumentation consisting of thermistors could be installed within the surficial 1.5 to 2 m of soils this year, and could be monitored during the installation of the GCL next summer. Such monitoring would be useful in determining how much thawing of the subgrade is taking place during the summer 2004. Under proper circumstances, such information may help predict long term performance of the GCL. It is believed, however, that the information gained would be quite limited since the contractor will most probably want to complete GCL installation as soon as possible in the 2004 construction season before the subgrade undergoes substantial thawing. The contractor may also be interested in demobilizing his crew and equipment as soon as possible in 2004 for the benefit of other projects.

Placement of the GCL itself will also compromise the ability to further monitor the thermistors since surface leads will be covered during the deployment of the GCL and will no longer be accessible. Ways to alleviate this difficulty include the provision of a more complex wiring system reaching the top of the dykes.

Based on the assumptions made in the previous paragraphs regarding the contractor's schedule and the limited amount of information to be expected from the thermistors, instrumentation of the subgrade is not viewed as a valuable undertaking to help complete construction. Such instrumentation is not recommended if monitoring is not to be extended beyond summer 2004.

3.2 2004 Construction Season and Long Term Operational Period

As mentioned before, the presence of French drains and/or ditching leading to the outside of the north dyke should help control basal stability during the installation of the GCL in summer 2004. The remainder of this section addresses the question whether these French drains should be maintained operational over the long term, i.e. after the GCL is installed, or should be plugged.

The risk of maintaining the French drain system operational over the long term is related to the possible failure of the GCL. According to the contractor, the top of the rip rap within the emergency outlet spillway will be at an elevation of 101.75 m while the GCL in the lowest area of the pond will be at an elevation of approximatety 97.3 m. If the pond is not operated properly in the future and ever gets full of waste water and precipitation, the GCL will have to resist to a 3.45 m maximum water head. Assuming the French drains remain fully efficient over the long term, the proposed 500 mm thickness of subgrade material (sand and gravel) placed over a French drain thaws out every summer and the permeability of this material to be high, then the pore pressure differential through the GCL located immediately over the location of French drains will be as high as 34 kPa. Concerns are expressed that this head may be a source of leak for the GCL especially along the joints. If such leaks occur, the French drains would then act as preferential channels and would rapidly carry the waste outside the limits of the dyked area.

However, maintaining the French drains operational over the long term may be beneficial to minimizing the risk of developing groundwater pressure beneath the GCL. The site is recognized to be located in a natural low spot, subject to collect water from the outside. The amount of water anticipated from the neighboring areas cannot be assessed with any certainty. Such amounts will depend on the future ability of the raised and enlarged dykes to become permanently frozen and to act as efficient water barriers against the flow of surface water and groundwater occurring within the thawed zone outside the pond area. The amount of water reaching the pond will determine how much pore pressure will develop within the subgrade and be felt by the GCL. Excess pore pressure, when combined to high permeability soil conditions, could result in uplifting of the GCL and top 0.3 m cover, and eventual failure at the joints. The confining pressure of the cover

sand is expected to be 8 kPa. The natural soil surface east of the pond is at elevation 101 m while pond base is at 97.3 m. If the perimeter dyke does not remain frozen and does not stop the outside flow, the potential exists for a 36 kPa pore pressure to develop beneath the liner, in excess of the 8 kPa effective confining pressure. If such conditions were to prevail, uplifting of the membrane would occur. Such conditions are more susceptible to occur during the first few years of operation when little sludge weight is available to further confine the GCL.

The combined presence of the lower sand layer beneath the GCL and active French drains would considerably decrease the risk of such pore pressure development beneath the membrane.

On the other hand, if French drains are plugged at the north dyke outlet but remain in place beneath the rest of the pond, the drains could act as preferential channels to transfer pore pressure conditions toward more detrimental locations beneath the base of the pond causing uplifting problems of the GCL. The same negative occurrence could also result from the presence of the lower sand layer beneath the GCL. We are assuming in this case that the French drains or lower sand layer will become fully saturated some time after the drain outlet is plugged in 2004, and that the active layer within the permafrost would continue to reach, seasonally, the soil beneath the GCL resulting in the development of pore water pressures.

Globally, the disadvantages related to the long term fate of the French drains are as follows:

<u>Leaving the French drains active:</u>

- The active pond will maintain permanent substantial water pressure over the GCL with the risk of leakage over the drains and contamination of the exterior environment