Plugging of the French drains:

- A risk of causing the uplift of the GCL exists every summer if the saturated drains act as preferential channels and transmit high pore pressure conditions to the centre of the pond. Such high pore pressure conditions could either result from the perimeter of the base or from the external site conditions. Such a risk also exists from the presence of the sand basal layer which is part of the current design. These phenomena are described on Figure 2.

Altogether, it is believed the French drains should be plugged prior to the deployment of the membrane in 2004, and a minimum water pressure should be maintained at all time afterwards to avoid uplifting of the GCL as a result of pore pressure transmission through the basal sand layer and/or French drains.

4.0 RECOMMENDATIONS

4.1 2003 Activities

The contractor's suggestion of adding French drains or ditches in 2003 at specific areas within the pond is supported and recommended by Golder. Work procedures for the implementation of such drains are provided in Section 3.

4.2 2004 Activities

In view of the discussion presented in Section 3 regarding the long term fate of the French drains, the solution to minimize long term risks includes the implementation of the following measures:

- Plug the outlet of the French drains to minimize the risk of creating a downward gradient that could cause failure of the GCL over the drains;
- Provide permanent minimum weight on to the GCL to minimize the risk of uplifting the GCL; and
- Minimize the risk of having external water reach the base of the basin by diverting external runoff away from the site.

Plugging of the drain

The use of an open trench through the north dyke in 2003 seems to become more attractive than building a French drain at this location since it will be easier to plug the open trench in 2004.

Extra weight on the GCL

Permanent minimum weight on the GCL could be obtained by pumping fresh water into the basin once construction is completed in 2004. A minimum of 1.0 m thick layer of water is recommended in the shallowest perimeter points of the pond base. Such minimum weight should be maintained over the long term. Salt water shall not be used to obtain the minimum water cover since salt water will react with the sodium bentonite and could result in the degradation and loss of efficiency of the GCL. Over the long term, the recommended minimum weight can also be provided with sludge. When sludge is being added, the recommended minimum water cover can be reduced accordingly. The intent is to have at least 30 kPa total stress applied at all time in the lower part of the basin.

The presence of a large body of water over the basal permafrost in August 2004 will not differ from the long term site condition when wastewater and precipitation will accumulate within the pond. If[1] the active layer of the permafrost is to thicken as a result of water placement in 2004, the same will also occur over the long term as a result of improved impermeability and water retention capability of the basin. If the dyke fill material is initially properly compacted and if the GCL maintains its efficiency as a water barrier, then it is expected the dykes will perform satisfactorily when the presence of the large body of water induces additional seasonal thawing.

[1] The increased thawing effect resulting from a shallow pond can not be concluded without the benefit of a proper thermal analysis. The presence of a shallow pond may have the opposite effect of creating a thermal barrier against deep summer thaw.

Diversion of external runoff

Ditches should be excavated in 2003 and possibly deepened in 2004 to drain as much water as possible away from the site. The east side of the pond could be drained toward the south east corner of the pond. From there, a shallow ditch could be extended southward over the height of land. The material resulting from excavation of the ditch located at the toe of the dyke should be cast onto the toe of the dyke to widen the dyke width and improve the likelihood the dyke core will remain frozen during the summer period. A ditch should also be excavated along the west side of the basin. Such excavation within the permafrost will require more effort.

4.3 Instrumentation

Although the use of thermistor instrumentation within the pond may be interesting for long term monitoring, such instrumentation would not provide substantial information to be used in a timely fashion for the 2004 construction season. The owner may still decide to put instrumentation for long term monitoring if he wishes to do so.

4.4 Risk Assessment

Risk # 1: The GCL membrane has been stored on site for two years and may have undergone partial hydration with time. Premature hydration could make deployment operations more difficult and could result in a loss of efficiency. It is recommended that the actual condition of the membrane be assessed as part of any future risk assessment.

Risk # 2: Despite the implementation of the proposed measures (Sections 4.1 and 4.2), some risks remain concerning the long term behavior of the GCL. The risks are related to the presence of organic soft sludge beneath the current pond base, the difficulty of properly compacting the 500 to 1000 mm thick single layer of cobbly soil put by the contractor, and the occurrence of areas of instability within the new fill of the pond base. Any of these three factors may result in future differential settlement of the base of the pond. Such differential settlement may impair the joints of the GCL and create some localized leaks. This is especially true if the future active layer of the permafrost is to reach the existing sludge layer located beneath the new fill. The risk of developing localized leaks as a result of future differential settlement is considered as high. It is therefore important that the owner be advised of this risk and be willing to adjust his performance expectations accordingly. The fact that some localized leaks occur in the future should not be interpreted, however, as a complete failure of the system.

If the owner wants a solution with a lower risk level, the addition of rigid insulation may have to be considered. The addition of thermal insulation will increase the likelihood of keeping the sludge layer permanently frozen in the future, therefore reducing future differential settlement. Thermal modeling analysis of the pond base using varying thicknesses of rigid insulation and water cover could prove helpful in defining the risk of undergoing substantial seasonal basal thaw and settlement. The idea of adding supplemental GCL strips and/or bentonite powder along the joints should also be discussed with the manufacturer to see how much risk reduction could be achieved out of this undertaking. Otherwise, relocation to a more favorable new site may have to be contemplated.

We should implement

Overall risks cannot be defined at this stage with any absolute percentage numbers. A quantitative risk assessment could only be derived from a thorough estimation of settlement following a thermal analysis of the pond. This assessment also needs to define what is considered as a " 100% failure of the GCL ".

No valuable discussion can be put forth at this point in time regarding the cost effectiveness of risk reduction alternatives, including relocation of the pond to a different site. Such discussion could only follow the completion of a risk assessment and the definition of the costs of the various corrective scenarios. A schematic of the decision making process is presented in Figure 3.

4.5 Operational Manual

We recommend that the pond operator be provided with operational guidelines to make sure future pond operation will not compromise pond performance.

5.0 CLOSURE

The current project does not include a review by Golder of the design documents prepared by FSC. Even though such a review is not part of this mandate and has not been performed, some issues were noted and deserve to be further clarified or reconsidered by the owner. A non-exhaustive list of these points includes the following:

- No provision for an erosion protection layer is included along the interior slopes of the pond. It is anticipated that wave action could lead to progressive erosion of the surficial 0.3 m thick layer of sand over the GCL;
- The outlet emergency spillway seems close to the dyke's crest; and
- There appears to be confusion on site with respect to the reference Proctor value to be used (standard or modified).

We trust the information provided will help you provide the best long term solution to the site owner. Please do not hesitate to contact us for any queries related to this presentation.

GOLDER ASSOCIATES LTD.

Michel Lemieux, Eng., M.Sc.
Associate

Michel R. Julien, P. Eng., Ph.D.
Principal

ML/MRJ/lr

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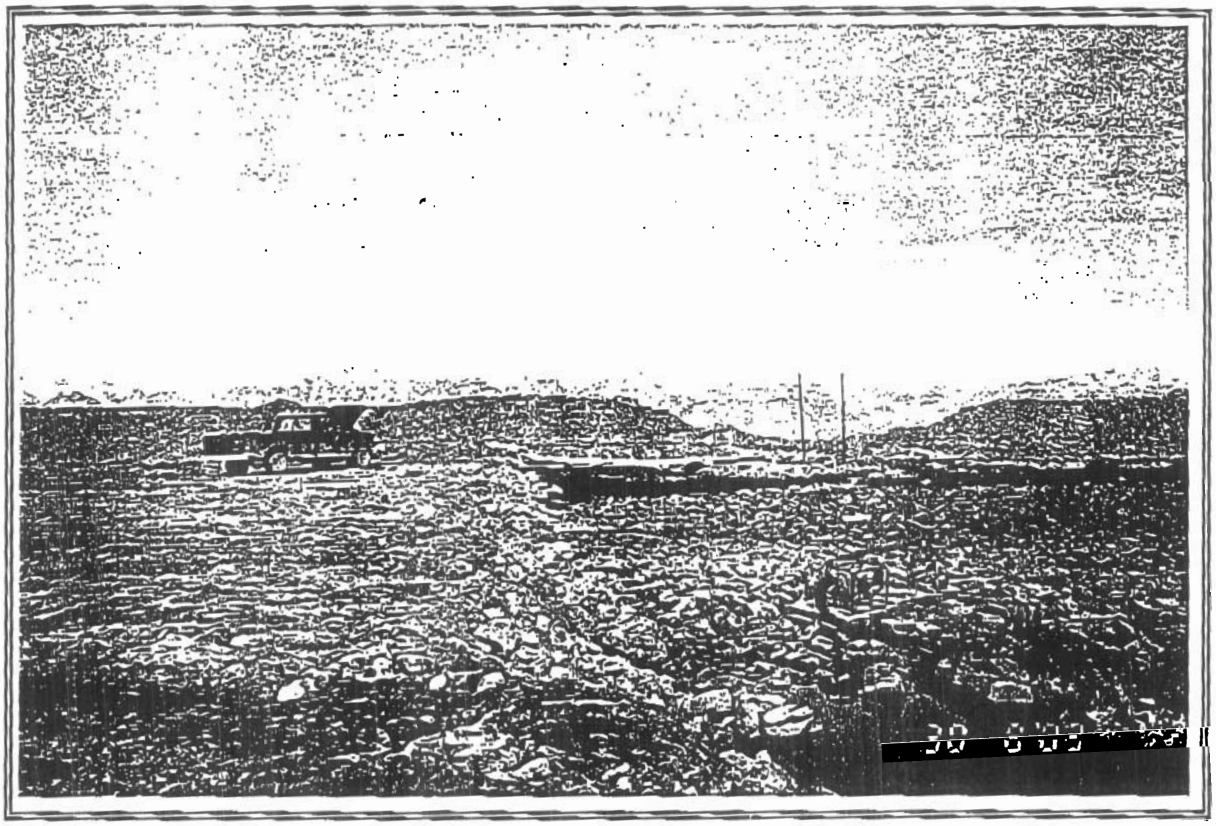
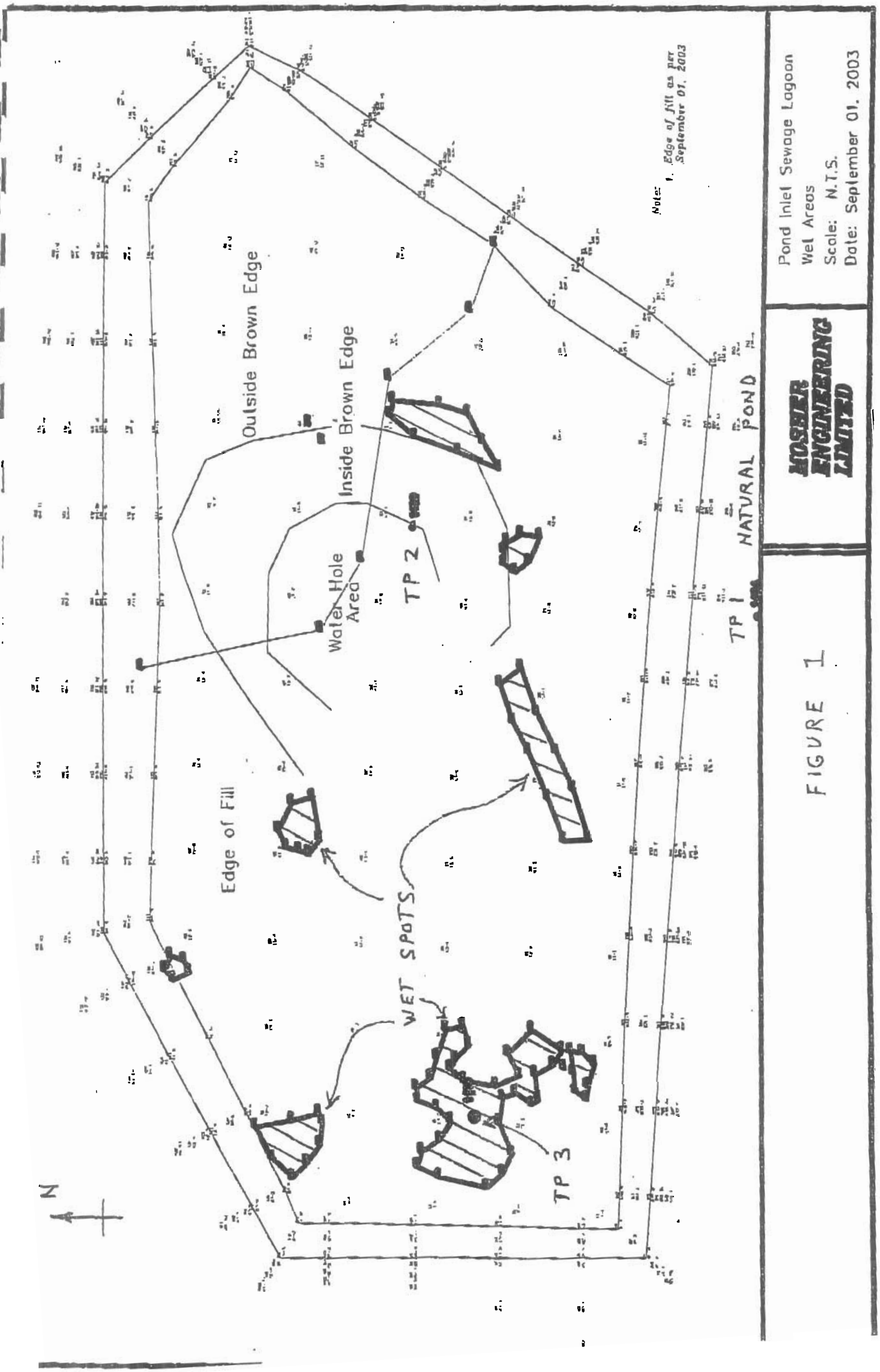
Att. Reference List
Photograph 1
Figure 1 Pond Inlet Sewage Lagoon - Drawing From Mosher Engineering Limited (September 01, 2003)
Figure 2 Mechanisms That Could Cause Upward Failure of the CGL
Figure 3 Schematic of the Decision Making Process

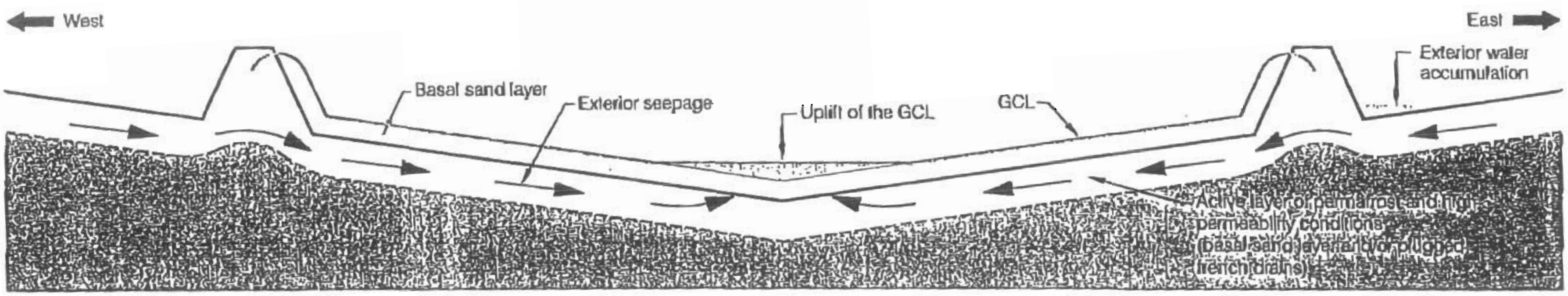


PHOTOGRAPH 1: View of the edge of new fill (left), north breached dyke (facing) and remaining water hole (right) within the pond.

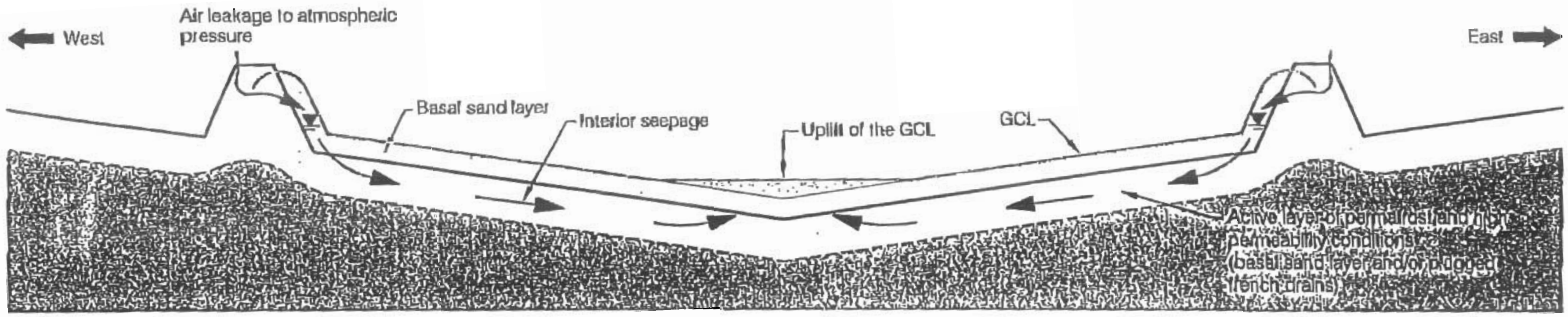
The current revised document follows a series of questions prepared by Government of Nunavut officials. These questions were transmitted to Golder on September 12, 2003. The following list identifies where to find, in the current revised letter, additional information on each specific question:

- Question 1: Last paragraph of Section 1
- Question 2: Second paragraph of Section 3.1 and Section 4.1
- Questions 3 and 4: Second paragraph of Page 10. The recommendation does not impact the effective capacity or life expectancy of the lagoon
- Question 5: Third paragraph of Page 10
- Question 6: Second paragraph of Page 11. The thickness of insulation depends on the results of a risk analysis
- Question 7: Second paragraph of Section 4.4
- Question 8: Section 4.3
- Question 9: Top of Page 9
- Question 10: Section 4.4 and Figure 3.


Pond Inlet Sewage Lagoon
Wet Areas
Scale: N.T.S.
Date: September 01, 2003
MOSHER ENGINEERING LIMITED
FIGURE 1
Notes
1. Edge of fill as per September 01, 2003
Outside Brown Edge
Inside Brown Edge
Water Hole Area
TP 2
TP 1
TP 3
NATURAL POND
Edge of Fill
WET SPOTS
N



CAUSE No. 1: EXTERIOR SOURCE OF WATER



CAUSE No. 2: INTERIOR SOURCE OF WATER

Notes:

1- Refer to page 8 of the letter.
2- Protection layer of sand was intentionnally omitted to improve clarity.

Date:	2003-09-22	Scale:	Not to scale
Drawn by:	M. Tremblay	Planned by:	M. Lemieux
Checked by:	M. Lemieux	Approved by:	M. R. Julien
Drawing no:	031221310-01	Project no:	03-1221-310

Dillon

REHABILITATION OF THE SEWAGE LAGOON POND INLET

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MECHANISMS THAT COULD CAUSE UPWARD FAILURE OF THE GCL

FIGURE 2

FIGURE 3: Schematic of the Decision Making Process

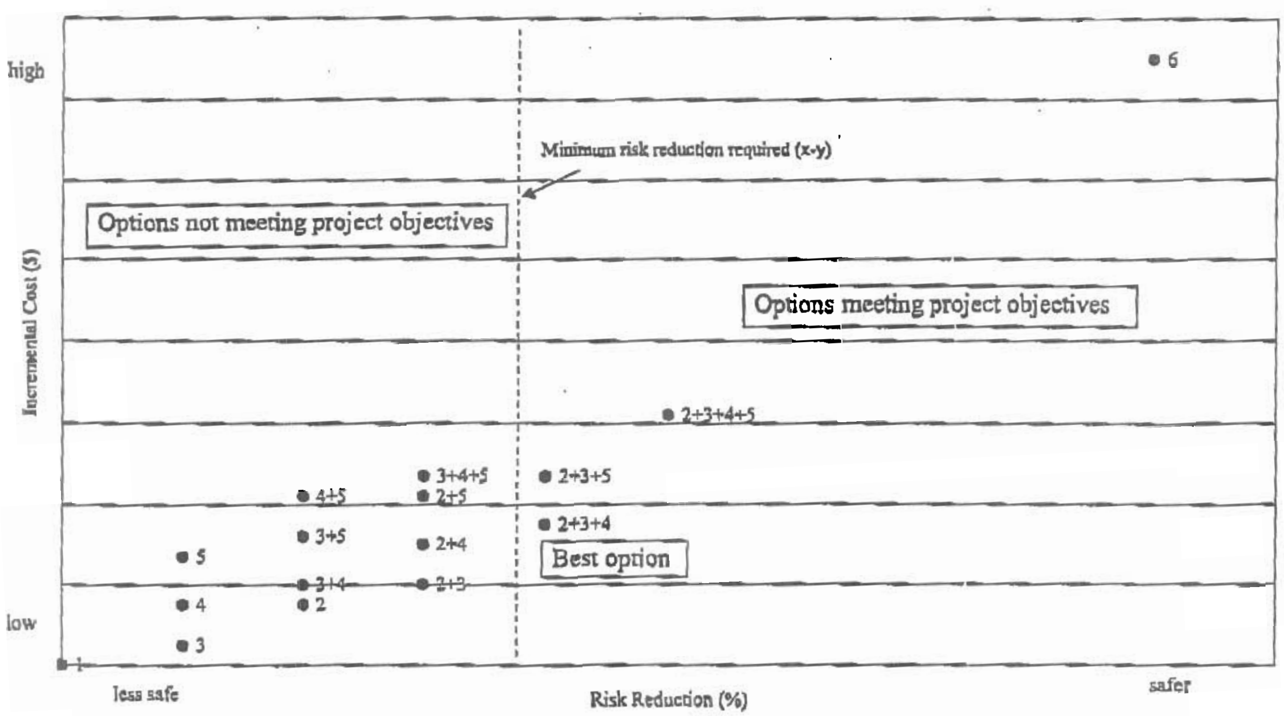
Various options are available to address the risk issues at the Pond Inlet sewage storage site:

Option 1: Do nothing;
Option 2: Implement recommendations contained in this letter;
Option 3: Minimize thaw penetration by adding thermal insulation;
Option 4: Minimize risk of GCL failure at the joints by adding GCL strips along the joints;
Option 5: Other option to be defined;
Option 6: Relocate to another site.

The following steps can be used to perform a cost/risk analysis:

Step 1: Determine the risk (x) associated with the site completed as designed (thermal analysis and settlement prediction analysis are required)
Step 2: Determine the maximum risk level (y) acceptable by the owner;
Step 3: Determine the cost of implementing each option and the amount of **risk reduction** (rr) resulting from each option;
Step 4: Detemine if any option (other than #6) provides rr > (x-y). If yes, relative costs / benefits of such options can be derived directly; if not, options have to be combined to provide improved risk reduction.

Following is a typical schematic of a possible assessment;



In this exemple, combining options 2, 3 and 4 provides a lower additional cost while achieving the minimum risk reduction requ this project.