Government of Nunavut

Dam Safety Review

Type of Document
Final

Project Name
Dam Safety Review
Sewage Lagoon and Water Reservoir
Hall Beach, Nunavut

Project Number
OTT-00209248-A0

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Date Submitted
September 9, 2013

Government of Nunavut

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Attention: Ralph Ruediger

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September 9, 2013

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Executive Summary

Exp Services Inc. (**exp**) undertook a dam safety review of the sewage lagoon and the water reservoir located in the Hamlet of Hall Beach, Nunavut during the site visit of July 24 and 25, 2013. This work was requested by the Community and Government Services of the Government of Nunavut to satisfy one of the requirements of the Water Licence issued by the Nunavut Water Board.

The sewage lagoon of the Hamlet is located approximately 1.8 km north of the Hamlet close to the Foxe Inlet. It consists of two cells, orientated in a north-south direction, each measuring approximately 110 m by 100 m in plan. The cells have been constructed with 3 to 3.5 m high berms. The crest width of the berms is 5 m to 6 m with side slopes varying between 2H:1V to 3H:1V. The south cell is referred to as cell #1 and the north cell as cell #2. The south berm of the south cell failed this year. **Exp** visited the site in June 2013 and provided recommendations regarding remedial measures to remediate the cell. The Government of Nunavut is currently reviewing the recommendations with a view to implementing a repair strategy. **Exp** has recommended that this cell should not be used until remedial measures have been implemented.

Examination of cell #2 did not reveal any signs of slope failure or erosion. Slight bulging of the north berm of cell #2 was observed which may be the result of settlements of the berm.

A review of the water reservoir was also undertaken. It revealed that the reservoir berms are 5 m to 8 m high with upstream slope inclination of 3H:1V and downstream slopes of 2H:1V. The berms have been constructed with sand and gravel fill. The reservoir has been lined with high density polyethylene liner. The review of the reservoir slopes did not reveal any signs of slope instability or erosion. The upstream slope of the west berm has been disturbed and should be re-instated. A slight bulge observed in the south berm close to the southeast corner is likely due to settlement of the berm.

Catastrophic failure of the lagoon cells is unlikely to present any danger to the human beings as there is no development downstream of the lagoons. However, it may have an adverse impact on fish habitat.

Failure of the reservoir may result in flooding of the surrounding area. However, majority of the water is expected to flow in a southerly direction to the ocean. It is not expected to have any impact on human life although it may impact aquatic life, e.g. fish habitats, etc.

The above and other related considerations have been discussed in greater detail in the report.

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1 Introduction

The Hamlet of Hall Beach was visited on July 24 and 25, 2013 at the request of the Community and Government Services (CGS) of the Government of Nunavut. The purpose of the visit was to review the water retaining structures of the Hamlet from a dam safety perspective. This is one of the requirements of the water licence issued by the Nunavut Water Board.

During the site visit, we were accompanied by Mr. Bhabesh Roy of the Government of Nunavut.

The following structures were reviewed:

1.) Sewage lagoon; and

2.) Water reservoir.

The locations of the sewage lagoon and water reservoir are shown on Figures 1 and 2 respectively. It is noted that design drawings were not available for any of the facilities examined.

2 Sewage Lagoon

2.1 Background Information

The sewage lagoon system at Hall Beach comprises of two cells orientated in a north-south direction (Figure 1). The southern cell is commonly referred to as cell #1 and the northern cell is commonly referred to as cell #2. It is noted that a set of design drawings of the proposed sewage lagoon system were prepared by FSC Group in 2002, however the lagoon system does not reflect the layout shown in these drawings, and a set of as-built drawings have not been made available to **exp**.

It is reported that the present lagoon system was constructed in the general vicinity of former lagoon. The design of the lagoon system was to decommission the existing cells and incorporate the land into the present lagoon system. However, whether the present lagoon was built according to the proposed plans is not known.

It was also reported that the berm connecting the two cells, and north and east berm of cell #2 were designed as exfiltration berms to facilitate flow of effluent from cell #1 to cell #2 and the discharge of the effluent to the wetlands located to the northeast of cell #2. The berm connecting the two cells is reported not to function as an exfiltration berm contrary to the intended design.

2.2 Site Review

On site observations of cell #1 and cell #2 revealed that both the cells measure 110 m by 100 m approximately. The invert of cell #2 is approximately 1 m lower than that of cell #1. At the time of the visit, cell #1 was completely empty whereas approximately 1 m of effluent was present in cell #2.

2.2.1 Cell #1

The berms of cell #1 are approximately 3 m to 3.5 m high with a crest width of 5 m to 6 m approximately and side slopes varying between 2H:1V and 3H:1V (Photos 1 and 2). Examination of the cell did not reveal any signs of erosion or slope failure. The exception to this is the south berm where a portion of the berm slope has failed and slid downhill by approximately 1 m (Photo 3). In addition, the soil adjacent to the toe of the berm has settled approximately 0.5 m over an area measuring approximately 5 m by 10 m. **Exp** visited the site in June 2013 to examine the failure and to make recommendations regarding the remedial measures. The **exp** report has been included in Appendix B and is briefly summarised below.

The report indicates that a number of holes were observed in the base of the cell in 2008. The upper 1 m of the material in the base of the lagoon was excavated and replaced with sand and gravel fill. In 2010, the cell started to leak close to the southwest corner. The repair comprised of lining the corner of the cell and extending the liner along the south and east sides for a distance of 20 m approximately. It is reported that in 2011 the cell started to leak again. The leak became progressively worse in 2012 and in 2013 a portion of the berm slid and settled by approximately 0.7 m to 1 m. **Exp** reported that the 2013

failure was adjacent to the area that was repaired in 2010. The failure exposed the presence of garbage under the lagoon and the berm.

The most likely cause of the failure was identified as the garbage fill located under the berm and the lagoon. Garbage fill typically contains large voids. Seepage of water through the voids resulted in removal of fines, softening of the garbage and its collapse into the voids.

Exp recommended that this cell should not be used until such time that the repairs have been implemented. It is noted that continued use of this cell without implementing satisfactory repairs may result in total collapse of the berm.

Three repair strategies were suggested. These include:

1.) Temporary remedial option of repairing the leak in a manner similar to the method used in 2010.

2.) Semi-permanent remedial measure of lining the entire cell #1 with a synthetic liner; and

3.) Permanent remedial option of removing all the garbage from underneath the cell and then lining the cell. This option would necessitate undertaking a geotechnical investigation to determine the extent of garbage present under the cell. If the geotechnical investigation indicates extensive presence of garbage under the cell, it may be desirable to construct a new cell north of cell #2.

Option #3 was recommended as the preferred option. It is understood that the Hamlet is currently considering these options with a view to repairing the cell.

2.2.2 Cell #2

The berms of cell #2 are also 5 m to 6 m wide with side slopes of 2H:1V to 3H:1V (Photo 4). The cell has been constructed with silty sand gravel fill.

A review of the slopes of the berm did not reveal any slope instability or erosion problems. However, it is noted that downstream slope of the north berm of the lagoon exhibits signs of some settlement and slight bulging of the slope close to the base of the berm (Photo 5). Since there have been no previous inspections, it is not possible to indicate whether the berm was constructed as such or it has settled. It is noted that this berm of the cell has been designed as an exfiltration berm and as such is subject to seepage forces. It is recommended that this berm should be monitored on a regular basis to determine if the settlements and bulging of the berm are progressive in which case remedial measures may be required.

A drainage channel and a berm are located north of the north berm of cell #2 (Photo 6). The wetlands are located north of cell #2 and consist of a land mass with several ponds. The effluent traverses through the wetlands and eventually drains into Foxe Inlet (Photos 7 and 8).

The discharge chute of cell #2 is located on the west berm close to the southwest corner of the cell. As the cell was partially full of effluent, it was not possible to determine if there is any erosion close to the toe of the berm at this location.

3 Water Reservoir

3.1 Available Design Information

The water reservoir is located south of the airport and west of the road leading to Fox M Long Range Radar Station in Hall Beach, Nunavut. It is noted that a geotechnical investigation was undertaken by Trow Associates Inc. (now **exp**) in 1996 for Frontec Corporation Ltd. for the design of the reservoir under consideration. The following information was provided to Trow at that time by the designers.

The reservoir will be located east of the existing reservoir and south of the east-west dyke road. The reservoir will be constructed with base dimensions of 145 m by 145 m. The berms of the reservoir will be 4 m wide except for the north berm which would be 6 m wide. The inside slopes of the reservoir would be constructed with overall inclination of 3H:1V. The outside slopes will be constructed with an inclination of 2H:1V. The reservoir berms will be constructed with silty sand and gravel fill.

The reservoir will be constructed partially by excavating into the natural ground and partially by construction of berms. The invert of the reservoir will be at Elevation 94.3 m and the crest of the berms at Elevation 100.55 m. It was proposed to use 80 mm thick Gundline HD high density polyethylene liner for base of the reservoir and 80 mm thick GSE Hyperfriction Flex textured high density polyethylene liner along the slopes of the reservoir.

It is noted that **exp** is not aware whether the above presented information was used for designing the reservoir or if any modifications were made to the proposed design or during construction of the reservoir.

3.2 Site Review

A visual examination of the reservoir was undertaken on July 24 and 25, 2013. At the time of the visit, it was reported that the reservoir was approximately three quarters full.

The review revealed that the berms of the reservoir have a crest width of 4 m to 6 m approximately. The downstream slopes of the berms were estimated to be at 2H:1V approximately. The upstream slopes of the reservoir are benched. It was not possible to estimate their inclination since the slopes were partially submerged. The height of the berms was estimated to vary between 5 m and 8 m approximately since the ground surface at the site slopes down towards the north and the west. The berms have been constructed with sand and gravel fill.

The water supply to the reservoir is from a lake located north of the reservoir. The water is drawn into the reservoir via a HDPE pipe. A 300 mm diameter corrugated steel pipe has been provided as overflow pipe and is located close to the southeast corner of the reservoir (Photo 11). The overflow pipe drains into the area located south of the reservoir.

The pump house, water treatment plant and truck fill station are located close to the northeast corner of the reservoir. Water treatment facilities comprise of chlorination and freeze prevention (Photos 12 and 13). The truck fill station is in good condition (Photo 14). The pump house and water treatment plant are in a reasonably good condition and it is reported that they function satisfactorily.

Examination of the reservoir did not reveal any signs of erosion or potential slope failures. The following minor defects were noted:

1.) The upstream slope of the west berm close to the northwest corner has been damaged.

2.) A slight bulge was observed in the south berm close so the southeast corner of the reservoir.

3.) Ponded water was observed close to the toe of the east berm. However, examination of the downstream slope of the berm did not reveal any signs of soil wetness or seepage from the berm. It is possible that the water has ponded in this area since it is low lying (Photo 15).

4 Consequences of Failure of the Facilities

Failure of any of the cells of the lagoon is not expected to endanger any humans since there is no development down gradient of the sewage lagoon. However, sudden release of large quantities of effluent may result in eutrophication of the wetlands and resultant impact on aquatic life, such as fish habitat, etc.

Failure of any berm of the water reservoir may result in flooding of the area in the immediate vicinity of the reservoir. The water is expected to flow in a southerly direction towards the Foxe Inlet. The Fox M Long Range Radar Station is located on higher ground east of the reservoir. As such, failure of the reservoir is unlikely to impact the Fox M Long Range Radar Station. Consequently, it is unlikely that there would be any impact on human life should the reservoir fail. However, it is anticipated that considerable erosion of the area in the vicinity of the failure and silting of the ocean may result.

5 Recommendations

Based on a review of the available design information, site visit and interview with Government of Nunavut and Hamlet of Hall Beach, **exp** makes the following recommendations/suggestions:

1.) Cell #1 of the sewage lagoon should be repaired by one of the three methods recommended in our letter report OTT-00213472-A0 dated June 27, 2013. This cell should not be used until it has been repaired. Continued use of the lagoon without repairs may result in complete collapse of the south berm of the lagoon.

2.) A slight bulge observed in the north berm of cell #2 is likely a result of settlement of the berm. This berm should be monitored to determine whether the settlements have stabilized. Continued bulging of the berm may necessitate remedial measures.

3.) The upstream slope of the west berm of the water reservoir should be re-instated.

6 Conclusions

Review of the sewage lagoon cell #2 did not reveal any signs of potential slope failure or erosion. Cell #1 is currently out of commission and should not be used until such time that it is repaired. The water reservoir berm slopes are currently stable and there is no evidence of any erosion.

Figures

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scale: NTS	CLIENT: GOVERNMENT OF NUNAVUT	project no.: OTT-00209248-A0
date: 20/08/2013	TITLE: WASTE DISPOSAL FACILITIES DAM SAFETY REVIEW HALL BEACH, NUNAVUT	FIG 01
drawn by: M.KELLEY		

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date: 20/08/2013	TITLE: WATER FACILITIES DAM SAFETY REVIEW HALL BEACH, NUNAVUT	FIG 02
drawn by: M.KELLEY		

Appendix A: Photos

Photograph No. 1
View of cell #1

Photograph No. 2
Another view of cell #1

Photograph No. 3
Failure of south berm of cell #1. Note: Crescent shaped scar and settlement at toe of berm.

Photograph No. 4
View of cell #2 from northwest corner of berm

Photograph No. 5
View of north exfiltration berm of cell #2, exhibiting some settlement and bulging close to the bottom of the berm

Photograph No. 6
Drainage channel and berm located north of cell #2

Photograph No. 7
View of drainage channel and wetlands

Photograph No. 8
Another view of drainage channel and wetlands

Photograph No. 9
View of water reservoir looking east

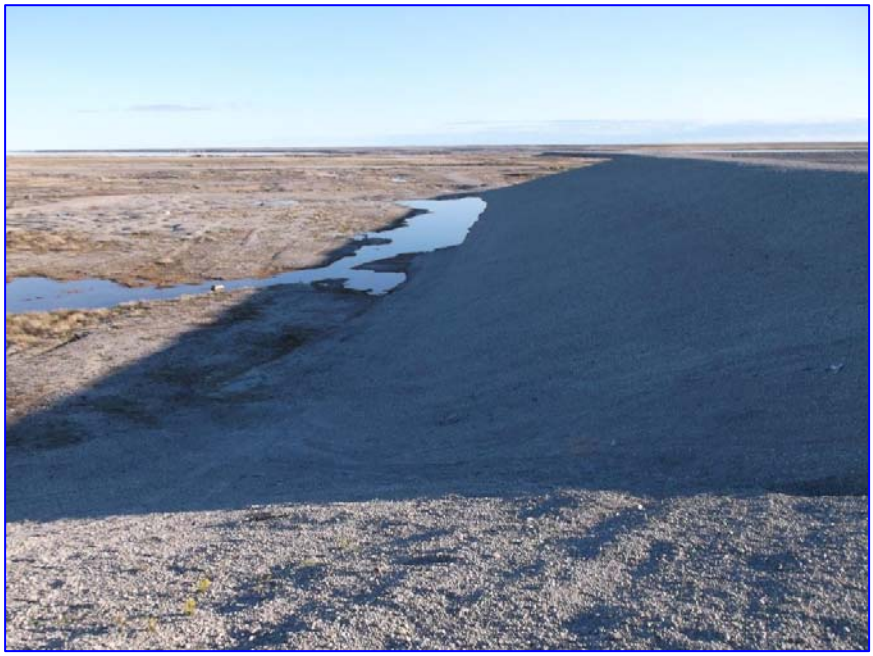
Photograph No. 10
View of water reservoir looking south from northwest corner

Photograph No. 11
Corrugated steel overflow pipe located at southeast corner of water reservoir

Photograph No. 12
Water ponding close to toe of east berm

Photograph No. 13
Interior view of water treatment plant

Photograph No. 14
Truck fill station



Photograph No. 15
Ponded water close to the toe of the east berm of the water reservoir

exp Services Inc.

Client: Government of Nunavut
Project Name: Dam Safety Review, Sewage Lagoon and Reservoir
Location: Hall Beach, Nunavut
Project Number: OTT-00209248-A0
Date: September 9, 2013

Appendix B: Exp Letter Report – Assessment of Sewage Lagoon Cell #1, Hamlet of Hall Beach, NU

June 27, 2013

Mr. Bill Westwell
Senior Manager Municipal Planning
Government of Nunavut
Department of Community & Government Services
PO Box 1000, Station 700
Iqaluit, NU X0A 0H0

Re: OTT-00213472-A0 – Assessment of Sewage Lagoon Cell #1
Hamlet of Hall Beach, Nunavut

Dear Mr. Westwell:

The Hamlet of Hall Beach's sewage lagoon cell #1 was reported to have developed a leak during the spring of 2013 and **exp** Services Inc. (**exp**) was requested to complete an assessment of the sewage lagoon cell with a goal of trying to determine the cause(s) of the leak and based upon the observations recommend remedial measures for the sewage lagoon cell.

On June 20th, 2013, Mr. Stephen Douglas and Mr. Surinder Aggarwal, P.Eng. of **exp** completed a site visit and assessment of sewage lagoon cell #1 in the Hamlet of Hall Beach as requested by the Department of Community & Government Services (CGS), Government of Nunavut (GN). At the time of site inspection, cell #1 was reported to completely empty while cell #2 still retained sewage. It should be noted that at the time of site visit cell #1 earth berms were void of any snow, therefore there is no impedance for visual inspection of the berms. There was however snow present in the drainage ditch leading away from the facility which restricted any observation as to the condition of cell #2 and if there was any sewage seeping from that cell.

Background Information

The sewage lagoon system at Hall Beach comprises of two cells orientated in a north south direction. The southern cell is commonly referred to as cell #1 and the northern cell is commonly referred to as cell #2. It is noted that a set of design drawings of the proposed sewage lagoon system were prepared by FSC Group in 2002, however the lagoon system does not reflect the layout shown in these drawings, and a set of as-built drawings have not been made available to **exp**.

It is reported that the present lagoon systems were constructed in the general vicinity of former lagoon. The design of the lagoon system was to decommission the existing cells and incorporate the land into the present lagoon system. However, whether the present lagoon was built according to the proposed plans is not known.

It was also reported that the berm connecting the two cells, and north and east berm in cell #2 were designed as exfiltration berm to facilitate flow from cell #1 to cell #2 and the discharge of the effluent to the wetlands located to the north east of cell #2. The berm connecting the two cells is report not to function as an exfiltration berm as per its intended design.

Site Assessment

On-site observations by the **exp** team revealed that cell #1 and cell #2 both measure approximately 110 m x 100 m. The berms are approximately 3 - 3½ m high, with their crests approximately 5 to 6 m and berm slopes varying between 2H:1V to 3H:1V.

It is reported that a portion of the east and south berms of cell #1 developed a leak in 2008. In 2010 this leak was repaired by lining the south and east berms of cell #1 at the south east corner, approximately 20 m in each direction. Information regarding the type of liner used was not available at the time of the site visit. The south berm of cell #1 started to leak again in 2013 which initiated the assessment of the facility by **exp**.

A visual examination of cell #1 revealed that leak appears to have formed on the southern berm immediately to the west of the end of the liner installed in 2010. The leak appeared to be a result of seepage under as opposed to through the berm. The seepage of effluent underneath the berm has resulted in washing of soil from underneath the berm and the area located immediately to the south of the berm. This in turn has resulted in part of the berm failing in a crescent-shape failure with soil slumping approximately 1 m on the outside face of the southern berm. In addition, soil on the outside toe of the berm has settled approximately 0.5 m over an area approximately measuring 5 x 10 m. The settlement of the soil in this area has exposed garbage comprising of metal pieces, timber, rags, paper etc. It was reported that a garbage dump was previously located in the area, although the exact location and extent is not known in relationship to the present sewage lagoon system. It has also been reported that some garbage was previously observed in the bottom of cell #1.

The seepage from cell #1 traverses in an easterly and northerly direction around cell #1 through a series of drainage ditches and ponds, eventually discharging to the wetlands identified as part of the wastewater treatment process for the Hamlet of Hall Beach.

Based on a review of the site conditions and review of the available information we are of the opinion that the primary cause of leakage from cell #1 is that the cell has been partially constructed on an old garbage dump. Garbage dumps fills typically have large voids due to wedging timber and metal pieces. These voids form a conduit for the effluent to flow through. The seepage of water through the garbage under the berm has led to a cave-in of the berm materials into the voids in the garbage fill resulting in failure of the berm slope and large settlement of the area immediately south of the berm slope failure.

At the time of the site visit effluent was observed being discharged in cell #1. The Hamlet was advised that effluent should not be discharged in cell #1 until the cell has been repaired. It was noted that continual discharge of effluent into the cell may result in a progressive failure of the slope berm, eventually leading to a complete collapse of the berm.

Recommended Remedial Measures

It is **exp**'s understanding that it is the GN's desire to repair the lagoon this year to provide for storage of effluent during the upcoming winter months. As part of our assessment of the sewage lagoon facility we have identified the following remedial measure options. Based upon unknown site conditions such as the extent of garbage fill present under cell #1, the lack of available information regarding geotechnical conditions at the site and whether the lagoon is subject to hydrostatic uplift pressures, it is considered difficult to recommend a specific remedial measure.

1. Temporary Remedial Option

A temporary solution would be repairing the leak in a manner similar to the method used previously in 2010. That is installing a liner across the area of the berm currently leaking. This solution may include sub-excavating beneath the berm or the sewage lagoon cell to remove the solid waste and replace with sand and gravel fill.

It is noted that this option is unlikely to perform satisfactorily in the long term as the leak may shift to the adjacent unlined area of the berm as occurred subsequent to the 2010 repair.

2. Semi-Permanent Remedial Option

The semi-permanent remedial option would entail lining the entire cell #1 with a synthetic liner. However, with the current lack of geotechnical information on the soil conditions throughout the base of the sewage lagoon cell and the presence of old garbage dump within the sewage lagoon, this option may be prone to settlement within the base of the lagoon due to the consolidation of either the soil or the garbage fill present under cell #1. Depending on the magnitude of the settlement, the liner may rupture resulting in the cell leaking.

This option would require a sand cushion being placed beneath and above the synthetic liner with additional fill placed on top of the sand cushion to provide protection from erosion and provide some ballast. In addition, a dead zone for the collection of sewage sludge is normally provided in a lined sewage lagoon cell. Therefore, the option of providing a fully lined sewage lagoon cell would result in the reduction of storage capacity of the sewage lagoon. An assessment of the required storage capacity within the Hamlet will have to be undertaken to determine if the sewage lagoon berms would have to be raised to accommodate this loss of storage capacity.

As a semi-permanent remedial option it is anticipated that this option may perform satisfactorily in the short to medium term, however, its long term performance cannot be assured due to the lack of information regarding the conditions of the base of the sewage lagoon cell.

3. Permanent Remedial Option

A permanent remedial option is similar to the semi-permanent option, i.e. it would entail lining the entire sewage lagoon with a synthetic liner. However, as part of the permanent remedial option an investigation of the condition of the bottom sewage lagoon cell would be undertaken. This investigation would be in the form of test pits and / or boreholes to determine the soil conditions and their suitability for the installation of a liner. In addition, the investigation would attempt to delineate the existing garbage dump located within the sewage lagoon cell. This information would determine if the soil conditions were prone to settlement and the extent of garbage fill that should be removed. Based on the information gather a decision regarding the suitability of this option and the scope of work required could be made.

Similar to the Semi-Permanent Remedial Option, this option would require a sand cushion being placed beneath and above the synthetic liner with additional fill placed on top of the sand cushion to provide protection from erosion and provide some ballast. In addition, a dead zone for the collection of sewage sludge would be provided. Therefore, the option of providing a fully lined sewage lagoon cell would result in the reduction of storage capacity of the sewage lagoon. An assessment of the required storage capacity within the Hamlet will have to be undertaken to determine if the sewage lagoon berms would have to be raised to accommodate this loss of storage capacity.

Estimated Costs

The estimated cost of the three remediation options are provided in the table below.

	Temporary	Semi-Permanent	Permanent
Capital cost	$310,000	$1,825,000	$2,008,000
Investigation			$125,000
Engineering (10%)	$31,000	$183,000	$201,000
Total Cost	**$341,000**	**$2,008,000**	**$2,334,000**

Conclusions and Recommendations

Based on **exp**'s understanding that it is the GN goal that cell #1 be repaired in 2013 and that any repair work provide a long term solution for the Hamlet, we provide the following conclusions and recommendations:

1. It is anticipated that the Temporary Remedial Option solution of installing a liner along a small section of the leaking berm will not perform satisfactorily in the long term and is not therefore recommended as a remedial action.

2. It is noted the Semi-Permanent Remedial Option is only marginally more costly than the Permanent Remedial Option, however, it does not provide the long term satisfactory performance desired by the GN. Therefore, it is recommended that this option not be considered unless no other viable options are present.

3. The Permanent Remedial Option, which is the most costly option, carries the risk that the geotechnical investigation reveals that either the soil conditions at the bottom of the sewage lagoon cell are unsatisfactory for the installation of a fully lined sewage lagoon cell, or that the extent of the old garbage dump is such that the remedial action of excavating and backfilling the solid waste becomes a very onerous and costly exercise. Either of which may result in the proposed permanent remedial option being unfeasible.

4. It is recommended that the Permanent Remedial Option be chosen as it has the highest probability of meeting the goals of the GN, i.e. repairing the leak in 2013 as well as providing a long term solution. This option does however entail the risk as previously referenced that the investigation may determine that this option is not feasible. If this is the case it would be recommended that the Temporary Remedial Option be implemented and the liner that has been purchased and shipped to Hall Beach as part of the Permanent Remedial Option be retained for the construction of a new sewage lagoon cell in 2014.

We trust that the above information is satisfactory for your purposes. Should you have any questions or require additional information or clarification of the above please do not hesitate to contact Steven Burden at 613-688-1899.

Sincerely,
exp Services Inc.

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Infrastructure Services

Surinder K. Aggarwal, M.Sc., P.Eng.
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Earth and Environment

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