Government of Nunavut

Dam Safety Review

Type of Document
Final

Project Name
Dam Safety Review
Sewage Lagoons and Water Reservoir
Cape Dorset, Nunavut

Project Number
OTT-00209248-A0

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Date Submitted
September 13, 2013

Government of Nunavut

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Executive Summary

A dam safety review of the sewage lagoons and the water supply system for the Hamlet of Cape Dorset, Nunavut was undertaken. This work was authorized by Community and Government Services of the Government of Nunavut.

The review comprised of an examination of the available documents, site visit, interview of Government of Nunavut personnel and documenting our findings and recommendations.

The sewage disposal facility of Hamlet of Cape Dorset comprises of the 2007 lagoon, active lagoon and emergency lagoon. The water supply system comprises of Tee Lake (water source), transmission pipe from Tee Lake, water treatment plant, and truck filling station.

In 2007, a new lagoon was constructed approximately 0.9 kms southwest of the community. It was built by constructing a berm (west berm) across a natural valley and small berms along other sides to fill in low lying areas. The west berm is approximately 6 m high with a crest width of 4 m. The upstream and downstream slopes are at an inclination of 2.5H:1V. Both the upstream and downstream slopes have been provided with rip rap. Part of the north and south berm roads are at steep grades. The north berm has a blind spot close to the top of the knoll and a bend in the berm resulting in dangerous driving conditions. The access road to the lagoon traverses through a mountainous terrain, is undulating, and contains several sharp bends.

To date the 2007 lagoon has not been commissioned as the Hamlet has various concerns regarding its operation. These concerns are 1) leakage of the west berm; 2) lack of heat tracer in decanting pipe; 3) unsafe berm road; 4) downwind location of the discharge chute; and 5) unsafe access road to the lagoon.

Currently, the Hamlet uses the active lagoon located approximately 730 m west of the community. The facility comprises of three natural ponds located at different elevations. The effluent is discharged into the upper lagoon and is decanted into subsequent lagoons by either overflow pipes or by pumping. From the third pond, the effluent is discharged into the ocean.

The emergency lagoon is located approximately 500 m west of the town. It comprises of a natural pond with a berm constructed on the west side. The lagoon is located approximately 225 m southeast of the ocean. The effluent from this lagoon percolates through the land mass located between the lagoon and the ocean and is discharged into the ocean, or during the summer months it evaporates. It is reported that the emergency lagoon is used only four to five times a year for a day or so when prevailing winds do not permit discharge into the active lagoon.

The water supply system of the Hamlet comprises of Lake Tee as the water source from where the water is pumped via a transmission pipe to the water storage tank, treatment plant and truck fill station. The water treatment plant provides chlorination, freeze prevention and truck filling facilities.

Based on the site review, apart from the 2007 sewage lagoon and access road, no other safety concerns were identified at the active lagoon, emergency lagoon, water source, water storage, water treatment and truck fill station locations.

Based on a review of the available documents, site visit, interview of Government of Nunavut and Hamlet of Cape Dorset staff, **exp** makes the following recommendations and suggestions:

1.) The leakage of the west berm of the lagoon should be remediated by installation of a new liner.

2.) Because of lack of heat tracer in the decanting pipe, consideration should be given to pumping the effluent.

3.) The north berm road should be lowered by 2 to 3 m and widened to make it safe for truck use especially in the winter months.

4.) Another discharge chute should be provided at the north west corner of the lagoon to enable discharge of effluent from the trucks into one of the two chutes depending on the prevailing wind direction.

5.) The access road to the lagoon should be widened at the hair pin bend, and passing lanes should be provided at strategic locations.

6.) Consideration should be given to providing power to the sewage lagoon so that the access road can be lit thereby providing safe working conditions, especially during the winter months.

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

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1 Introduction

Cape Dorset was visited on July 26 and 27, 2013. The purpose of the visit was to review water retaining structures from a dam safety perspective. The visit was in response to one of the requirements of the Water Licence issued by the Nunavut Water Board to the Hamlet of Cape Dorset, Nunavut.

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

The following structures were reviewed during the visit:

1.) 2007 Lagoon;

2.) Active Lagoon;

3.) Emergency Lagoon; and

4.) Water Reservoir and Truck Fill Station.

The locations of the various waste disposal facilities are shown on Figure 1. The locations of the various components of the water supply system are shown on Figure 2.

2 2007 Lagoon

2.1 Review of Lagoon Design Drawings

Design drawings for the lagoon prepared by Dillon Consulting in 2006 were made available and were reviewed. These drawings indicate that a new single cell lagoon was constructed in 2007 by Community and Government Services (CGS) of the Government of Nunavut (Figure 3). This lagoon is located approximately 0.9 kms southwest of the community. A new access road was built for the lagoon (Figure 4). The lagoon was built in a natural valley between two hills. A berm was constructed on the western limits of the sewage lagoon across the valley (west berm). A smaller berm was constructed at the northeast corner of the lagoon (See Appendix A: Photos 1 to 3). The sewage lagoon treatment facility incorporates a natural wetlands located to the west of the lagoon and includes P-Lake, a wetlands area and the rocky drop off to Foxe Channel.

The valley at the location of the west berm is approximately 170 m wide. The ground surface elevation of the valley floor at the west berm location varies from Elevation 123 m to Elevation 117 m approximately. The maximum height of the berm is therefore in the order of 6 m. The berm has been designed with crest elevation of 123.0 m. Its design upstream and downstream slopes are at an inclination of 2.5H:1V (Figure 5). The core of the berm comprises of sand and gravel fill (Type II Granular B). Design drawings also indicate 300 mm thick layer of rip rap to be placed along the downstream slope of the berm. The design drawings also required a bentonite liner to be installed vertically close to the centre of the cross-section of the berm extending from approximately 0.5 m below the crest of the berm into bedrock.

2.1.1 Lagoon Drainage Outfall Pipe (Discharge Pipe)

A 300 mm diameter High Density Polyethylene (HDPE) discharge pipe has been provided close to the bottom of the lagoon leading to a manhole located in the centre of the west berm and from the manhole to the wetlands (Figure 5). The pipe is at a grade of two percent. An operating valve has been installed in the manhole located on the west berm.

2.1.2 Spillway

A spillway has been provided in the west berm close to the mid-length of the west berm (Figure 5). This spillway consists of a 2000 mm wide trench with a clearance of 200 mm. The trench has been lined with bentonite liner and sand cushion and rip rap has been provided on top of the liner (Figure 5).

2.1.3 Discharge Flume

The discharge flume comprises of an 800 mm diameter heavy duty polyethylene (PE) pipe which discharges into a 1200 mm diameter nesting heavy duty PE pipe set on the berm slope. A galvanized base plate and rip rap has been provided at the location where the effluent is discharged into the lagoon by the trucks to prevent erosion (Figure 6).

2.1.4 Monitoring Wells

As per Water Board requirements, a number of monitoring wells have been installed at the site (Figure 7). Three monitoring wells are located in the vicinity of the lagoon. One monitoring well (Cap 16) is located at the north east corner of the lagoon. The other two monitoring wells (Cap 17 and Cap 18) are located downstream of the west berm. The depth of the monitoring wells is not known. The monitoring wells have been provided with protective casing, cover and locks.

2.1.5 Thermistors

Four thermistors (Cap 21 to Cap 24 inclusive) are located in the berms of the lagoon. Cap 21 is located at the north east corner of the lagoon whereas thermistors Cap 22 to Cap 24 are located on the west berm.

It is reported that the thermistors were installed to 18.5 m depth due to equipment limitations. However, under the water licence requirements, the thermistors should extend to 25 m depth. Also, it is reported that some of the thermistors are not working.

2.1.6 Lagoon Road

The road on top of the berms varies considerably in grade since the north and south berms have been constructed to follow the natural contours. The south berm elevation approaching the knoll varies from Elevation 125 m to Elevation 130 m with a gradient of 9 percent. The north berm road elevation approaching the top of the knoll varies from Elevation 125 m to Elevation 128 m at a grade of approximately 30 percent resulting in a blind spot (Photo 3). In addition, there is a bend in the berm on top of the hill.

2.1.7 Access Road to Lagoon

The access road from the Hamlet to the new lagoon is approximately 930 m long with an elevation difference of 50 m approximately. The road traverses through a mountainous terrain and has been constructed by partly cutting into the hillsides and partly filling the valleys. The design width of the road is 8.0 m in cut areas and 8.26 m in fill areas. Between Station 0+400 and Station 0-550 the road traverses a hairpin bend. Vehicle passing lanes have not been provided along the roadway.

2.2 Site Review

A visual review of the lagoon was undertaken. It revealed the following:

1.) The west berm is approximately 4 m wide and with side slopes of 2.5H:1V. It has been constructed with sand and gravel fill in accordance with the project specifications. The upstream and downstream slopes of the berm have been provided with rip rap.

2.) At the time of the visit, the west berm of the lagoon was leaking from an area south of the emergency overflow weir. The leak was observed to take place at the interface of the berm and the natural ground. However, a representative of the Government of Nunavut indicated that

during the spring melt, water was also observed to seep through the berm in this area. The representative also indicated that during construction, the design of the berm was modified and that the bentonite liner was not installed vertically in the centre of the cross section of the berm but along the downstream slope of the berm. Currently, it is not known whether the liner was sealed into the bedrock.

3.) Part of the emergency overflow weir has been backfilled to provide access to vehicular traffic.

2.3 Current Status of Lagoon

To date, the lagoon has not been commissioned since the Hamlet of Cape Dorset has a number of safety and operational concerns. These concerns are:

1.) Leakage of west berm;

2.) Lack of heat tracer in lagoon drainage outfall pipe;

3.) Downwind location of discharge flume;

4.) Unsafe north berm lagoon road; and

5.) Unsafe access road at the hair pin bend and lack of passing lanes along the access road.

3 Active Lagoon

Currently, the Hamlet is using a lagoon located approximately 730 m west of the community. This lagoon comprises of three natural ponds (Figure 1) located at different levels. The second pond is located approximately 5 m to 6 m lower than the first pond. The third pond is located approximately 3 m to 4 m lower than the second pond, and approximately 10 m higher than the water level in the ocean.

The effluent is discharged into the first pond by trucks (Photo 4 and 5). During the summer months, the effluent flows from the first pond to the second pond (Photo 6) via an overflow pipe. Similarly, the effluent from the second pond flows into the third pond through an overflow pipe (Photo 7). From the third pond, the effluent is discharged into the ocean via an overflow pipe (Photo 8). During the winter months when the decant and outlet structures are frozen, water is pumped from one sewage lagoon cell to the subsequent cell on an as-required basis. It is reported that this facility has to be decanted during the winter months due to insufficient storage capacity. A visual examination of the ponds and surrounding area was undertaken. The review did not raise any concerns related to slope stability or erosion.

4 Emergency Lagoon

The emergency lagoon is located approximately 500 m west of the town along access route to the solid waste site and the 2001 sewage disposal facility. It is located approximately 225 m southeast of the Tellik Inlet with a berm separating the lagoon from the inlet (Photo 9). It comprises of a natural pond. It is understood that this lagoon is used only four or five times a year, when the wind is blowing in the wrong direction such that the 2001 lagoon cannot be used to discharge the effluent. On such days, permission is given to discharge the effluent into the emergency lagoon for a day or so. The effluent discharged into the lagoon filters through the land mass between the pond and ocean and is discharged into the ocean. It is reported that during the summer months, most of the effluent evaporates.

Visual examination of the lagoon did not reveal any concerns related to slope stability or erosion.

5 Water Supply System

5.1 Water Reservoir

Tee Lake located approximately 1.0 km south of the Hamlet is used as the water supply. Tee Lake is surrounded by mountains on all the sides (Photos 10 and 11). The water from the Tee Lake is conveyed to the truck fill station through a 1.3 km transmission main (Photo 12). The Truck and Water Storage Station is located at the south central part of the Hamlet, a distance of 1.3 kms. The pipeline is 75 mm diameter heat traced stainless steel pipe with a secondary 50 mm HDPE pipeline as backup (Figure 1).

Water is drawn into the pump house from Tee Lake via a single inclined shaft intake. The pump house contains heating equipment to prevent freezing of the pipes.

A visual examination of the water reservoir was undertaken. It did not reveal any signs of slope instability or erosion.

5.2 Water Treatment Plant and Truck Fill Station

The water treatment plant and the truck fill station are located south of the community. The facility comprises of a water treatment plant and truck fill station and water storage tank (Photos 13 and 14). The truck fill station provides water treatment through chlorination, equipment for truck loading and freeze prevention for the water storage tank (Photo 15).

Visual observations indicated that the equipment is in reasonably good condition.

6 Consequences of Lagoon Failure

Currently, there are no consequences of failure of the west berm of the lagoon since the sewage lagoon is not operational.

When the sewage lagoon is operational, failure of the west berm may result in releases of a large quantity of effluent to the wet lands depending on the time of the year that the failure occurs. Release of large quantity of effluent to the wetlands may result in eutrophication of the wetlands, which may impact aquatic life, e.g. any fish habitats, etc. There is no development downstream of the sewage lagoon and failure of the west berm of the lagoon will not present any danger to human beings.

7 Recommendations

Based on a review of the design drawings, site visit and interview with Government of Nunavut and Hamlet of Cape Dorset staff, exp makes the following recommendations/suggestions:

7.1 Leakage of Lagoon

It is considered that the leakage of the lagoon is due to one or more of the following factors:

a.) The liner has been damaged during construction since the rip rap contains sharp edges;

b.) The liner was not sealed into the bedrock; and

c.) Joints in the liner may be defective or may have opened subsequent to installation of the liner since the joints of a bentonite liner are not sealed but are merely overlapped with bentonite beads placed in the overlap.

It is recommended that the liner should be replaced as soon as possible since side slopes of 2.5H:1V for a seepage berm are not considered stable. The downstream slope of the berm is susceptible to failure. It is recommended that the bentofix liner should be replaced as it cannot be repaired.

For this purpose, it would be necessary to pump the lagoon dry, remove the rip rap and any underlying materials to expose the liner. The liner should be removed and discarded. The new liner should be sandwiched between 150 mm thick sand layers. It should be embedded at least 0.5 m into the bedrock. A minimum of 300 mm of Type II granular material should be placed on the sand cushion on top of the liner prior to placing the rip rap. Extreme care should be exercised during the placement of the rip rap to ensure that the liner is not damaged.

7.2 Decanting Pipe

The Hamlet has expressed concern that heat tracer has not been installed in the decanting pipe and the effluent is likely to freeze in the pipe. **Exp** experience indicates that even with the provision of heat tracer, decanting pipes do not perform satisfactorily in the Arctic climate. Consideration shall be given to using pumps to decant the lagoon.

7.3 Emergency Overflow Weir (Spillway)

It is recommended that any fill placed in the emergency flow weir should be removed. Consideration should be given to providing a steel plate across the weir to facilities movement of vehicular traffic on the west berm. Alternatively, a culvert may be installed at this location.

7.4 Discharge Chute

The discharge chute and turning circle are located along the east berm where the access road approaches the lagoon. The Hamlet has indicated that the discharge chute is located downwind and as such, it would be difficult for the truck drivers to discharge the effluent. The Hamlet would like another discharge chute to be located in the north west corner of the lagoon and a turning circle in the south west area of the lagoon. This would enable the effluent to be discharged from one of the two discharge points depending on the direction of the prevailing wind.

It is recommended that these improvements should be implemented as they would result in safer operating conditions.

7.5 Thermistors

It is recommended that the Water Board should be consulted to determine if thermistors installed to 18.5 m depth would be acceptable for monitoring purposes. If they are acceptable, the thermistors that are malfunctioning should be replaced. If thermistors installed to 18.5 m depth are not acceptable, all the thermistors should be re-installed to 25 m depth. Since the existing thermistor borings have been backfilled with gravel, it would not be possible to install new thermistor strings in the same boreholes, but would require drilling of new boreholes.

The boreholes for the new thermistors should not be backfilled with gravel so that if any of the thermistor beads malfunction in the future, it will be easy to replace them.

7.6 Lagoon Road

The lagoon road located on the north berm is narrow and has been constructed at a very steep gradient, which has resulted in a blind spot until top of the hill is reached. At this location, there is also a bend in the road, which constitutes dangerous driving conditions, specifically during the winter months with snow and icy conditions. It is recommended that the road should be lowered by 3 m approximately so its elevation is close to that of the west berm. In addition, the road should be widened. It is noted that lowering of the elevation of the road would necessitate blasting of the bedrock.

7.7 Lagoon Access Road

It is recommended that the access road should be widened at the hair pin bend to enable the trucks to more easily manoeuver the bend, especially during winter months when due to snow and ice accumulation the roadway may be somewhat narrow, very slippery. In addition, passing lanes should be provided along the access road at strategic locations to facilitate passing of vehicles.

7.8 Power Supply to Lagoon

There is no power supply from the Hamlet to the 2007 lagoon. As a result, the roadway from the Hamlet to the lagoon is not lit. Considering that the access road to the lagoon is located in mountainous terrain with hair pin bend, the Hamlet considers the road to be unsafe especially during the winter months when it is covered with snow and ice. For safety reasons, it is recommended that power should be supplied to the lagoon so that the access road can be lit.

Supply of power to the lagoon will also facilitate the operation of electric pumps if the gravity flow decanting pipe freezes. There is a high potential for the decanting pipe to freeze since it has not been provided with heat tracer. **Exp**'s experience indicates that even with installation of heat tracers, gravity drained decanting pipes generally do not perform satisfactorily in the Arctic climate and that pumping is the most reliable method of decanting the lagoons. If power supply is available at the lagoon, electric pumps can be used to decant the effluent instead of diesel pumps.

8 Conclusions

Based on a review of the design drawings and site conditions, it is considered that the new sewage lagoon (2007 lagoon) in its present condition does not meet safety requirements. Therefore, this lagoon should not be used until such time that the liner has been replaced, and the lagoon and access roads have been improved.

No safety concerns related to the existing lagoon, emergency lagoon, and the water reservoir were identified during the site review.

It is recommended that all the monitoring equipment should be checked to ensure satisfactory performance. Any of the monitoring equipment found to be dysfunctional should either be repaired or replaced. Samples of the effluent and groundwater should be obtained, tested and results forwarded to the Water Board in accordance with the conditions of the water licence.

As-built drawings of the new sewage lagoon should be prepared. Operation and Maintenance Manual should be revised once the second chute has been installed. An annual report should be prepared and submitted to the Water Board as required by the water licence.

Figures

Photos

Photograph No. 1
View of upstream slope of west berm

Photograph No. 2
View of north and west berms of lagoon

Photograph No. 3
View of north berm of lagoon. Note hump in berm.

Photograph No. 4
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Photograph No. 5
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Photograph No. 11
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Photograph No. 14
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Photograph No. 15
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