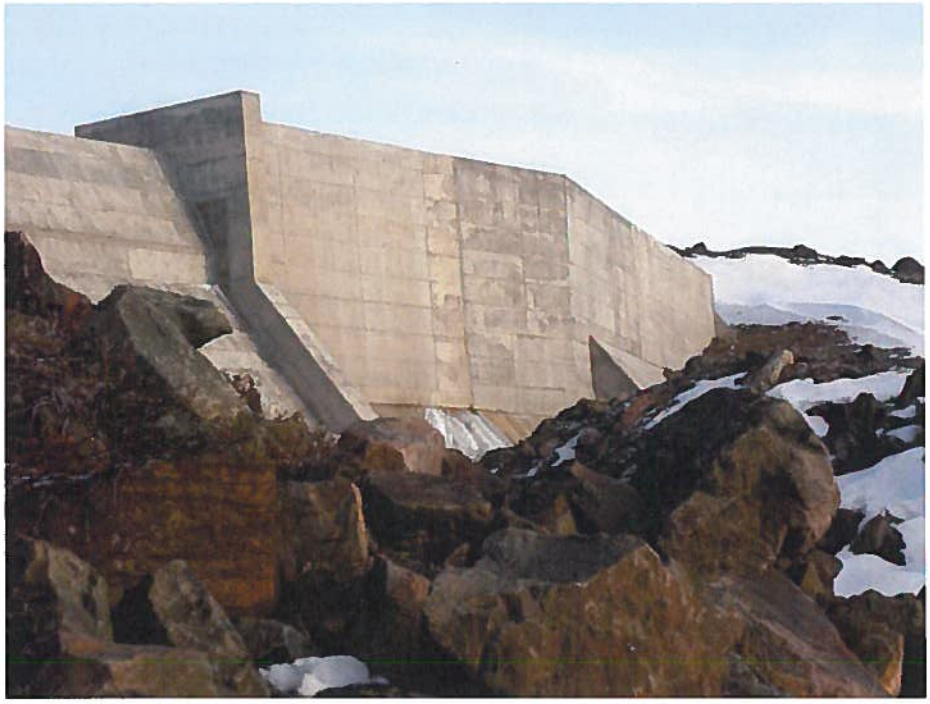
Concentric Associates International Incorporated

Lake Geraldine Dam
Iqaluit, Nunavut
Dam Safety Inspection

November 23, 2010
REPORT



Produced For:
THE CITY OF IQALUIT

Produced By:
CONCENTRIC ASSOCIATES INTERNATIONAL INCORPORATED

Concentric Project Reference Number:
10-3496

Lake Geraldine Dam
Iqaluit, Nunavut
Dam Safety Inspection

CONTENTS

1. EXECUTIVE SUMMARY

Concentric Associates International Inc., (Concentric) was retained by the City of Iqaluit, to undertake a Dam Safety Inspection (DSI) of the Lake Geraldine Dam. The scope of work for the assignment has been undertaken in accordance with Concentric's proposal 10-3496 dated October 27, 2010.

The site inspection was conducted on November 1, 2010, by Allan Murray, P.Eng., and Chileab Yue, of Concentric.

It is recommended that the next DSI be conducted prior to November 2010.

OBSERVATIONS:

With the exception of the following items, no significant changes in condition of the concrete dam structure and retention berms were observed since the previous DSI, which was conducted in 2009.

- A significant leak has developed in the north berm in the vicinity of the vehicular access ramp.
- Localized wash outs along the north berm have developed due to wind events in October 2010.

Representative existing conditions have been documented by photographs in Appendix A.

The required documentation (discussed further below) under the Canadian Dam Safety Guidelines is not up to date, and remains incomplete.

RECOMMENDATIONS:

1. A grouting program should be implemented in 2011 to address observed leakage. This program was originally recommended for 2010 but the construction phase was deferred to 2011 at the request of the City and after dialogue with Concentric.
2. Repairs to the north berm are required in the short term, and in 2011 to address localized wash outs.
3. Leakage through the north berm requires assessment and repair in 2011.
4. Preparation of the required Operation & Safety Manual, Logbook, and Permanent File was completed in 2007; however, the documents require updating.
5. The Emergency Preparedness Plan has not been completed. This is considered a high priority.
6. Complete the next DSI prior to November 2011.

2. INTRODUCTION

Concentric Associates International Inc., (Concentric) was retained by the City of Iqaluit, to undertake a Dam Safety Inspection (DSI) of the Lake Geraldine Dam located in Iqaluit, Nunavut.

This assignment and the scope of work described herein have been undertaken in accordance with Concentric's proposal 10-3496 dated October 27, 2010.

The site visit was conducted on November 1, 2010.

This report summarizes our terms of reference for the assignment, observations, conclusions and recommended action.

3. BACKGROUND

The Canadian Dam Safety Guidelines (DSG) requires that all structures exceeding prescribed height and volume minimums be subject to Dam Safety Reviews (DSR's) and Dam Safety Inspections (DSI's) at regular intervals.

A DSR is a comprehensive, formal review process that involves completion of checklist items in accordance with the Dam Safety Guidelines. The DSR forms a baseline of dam history, condition, repair requirements, and extensive documentation of monitoring, operating, safety and emergency procedures.

The Lake Geraldine Dam requires a DSR every seven (7) years. The last DSR was conducted in 2006 by Concentric; another DSR should not be required until 2013 unless the structures are significantly altered.

It is required in the DSG document that in the interval between DSR's, a Dam Safety Inspection be performed on an annual basis. The DSI is a much less comprehensive review, comprising a visual inspection only to identify any changes in condition, or any observed concerns.

A detailed historical perspective may be referenced in the DSR on file with the City of Iqaluit.

4. SCOPE OF SERVICES

Our directive has been to undertake a Dam Safety Inspection (DSI) in accordance with the DSG, for the Lake Geraldine Dam. The inspection consisted of an on-site visual assessment, notation of any significant changes in condition since the last available DSI, preparation of a written report in a format compatible with the DSR, and a photographic record.

The following is a summary of the scope of work for this assignment. The DSI report is the primary deliverable, and has been prepared in accordance with the DSG document.

- Review available record documentation.
- Conduct a visual on-site assessment of the sewage lagoon
- Prepare a photographic record documenting general and representative conditions
- Identify, characterize, and risk-assess any actual or potential concerns
- Prepare a written report summarizing our observations, items of concern, and recommendations
- Indicate any recommended repairs
- Prioritize action items
- Submit final documents in electronic format and hard copy

Limitations

The DSI is based on visual assessment; no invasive inspection/assessment was done.

This report has been prepared for the sole use of The City of Iqaluit.

5. SUMMARY OF PREVIOUS DSI

The original DSR was conducted in 2001. In 2005, a major alteration to the dam was designed, and implemented over a two (2) year period. The major alteration triggered the requirement for a revised DSR. The DSR was prepared by Concentric in late 2006.

The previous DSI's were conducted by Concentric in 2006 and 2009.

This DSI should be read in conjunction with the current DSR, which contains the historical record, the bulk of which is not repeated here.

A summary of observed conditions and recommendations from the 2009 DSI (in italics; with updated information added in non-italics as appropriate) is as follows:

- *A grouting program should be designed for implementation in 2010 to address the observed leakage. The grouting program should include injection of the vertical and transverse joints in the vicinity of the above grade leak in the concrete section south of the spillway.*

  This program was originally recommended for 2010 and the design documents were completed in 2010 by Concentric. The construction phase was deferred to 2011 at the request of the City and after dialogue with Concentric.

- *A grouting program should also target the upwelling source. It is possible that the underwater survey (recommended below) will assist in assessing the source and developing a repair strategy.*

  This area will be included in the 2011 grouting program as appropriate.

- *Preparation of the required Operation & Safety Manual, Logbook, and Permanent File was completed in 2007; however, the documents require updating.*

  To our knowledge no updating has been done since 2007.

- *The Emergency Preparedness Plan (EPP) has not been completed. Given the vertical extension of the dam in 2006, we view this requirement as high priority. The Emergency Preparedness Plan should be completed in 2010.*

  To our knowledge the EPP has not been completed.

- *In concert with the EPP above, and the DSG's, remote, and possibly site based monitoring equipment should be installed at the dam. This will require some research, and a design/specification process.*

The requirement for monitoring equipment will be determined by the EPP.

- *An underwater survey should be conducted prior to August 2010.*

  The underwater survey was completed in the summer of 2010.

- *Complete the next DSI prior to October 2010.*

  The DSI was completed in 2010.

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6. COMMENTARY ON DAM SAFETY GUIDELINES

The Canadian Dam Association publication, Dam Safety Guidelines (DSG), governs the nature and frequency of inspection and review activities for structures which fall under its umbrella criteria.

The DSG applies to those structures that are at least 2.5 meters in height, and which have at least 30,000 cubic meters of storage capacity.

The DSG document is far reaching in terms of applicability and requirements for conformance. This is understandable as the type and complexity of structures that fall under the jurisdiction of the document varies considerably, from relatively small and simple embankments or dikes to massive and complex dams associated with hydroelectric generating facilities, irrigation, flood control, etc.

The DSG requires that all structures exceeding the height and volume minimums described above be classified according to their "consequence category", that is, the consequence of dam failure in terms of life safety, and socio-economic impact. The category assigned may range from very low to very high. The consequence category dictates the requirement and frequency of Dam Safety Reviews.

A Dam Safety Review (DSR) is a comprehensive, formal review process, conducted at regular intervals, that involves completion of checklist items in accordance with the Dam Safety Guidelines.

The DSR forms a baseline of dam history, condition, repair requirements, and extensive documentation of monitoring, operating, safety and emergency procedures.

The frequency of DSR's varies depending on consequence category. For structures where significant life safety and/or socio-economic consequence exist, the DSR is usually conducted every five (5) to ten (10) years. The Lake Geraldine Dam requires a DSR every seven (7) years. The current DSR for the Lake Geraldine Dam was conducted in 2006; therefore, the Lake Geraldine Dam is due for an updated DSR in 2013. If significant alterations (not including repairs that do not change the height or volume of the structure) to the structure take place before this date, an updated DSR would be required.

It is required in the DSG document that in the interval between DSR's, a Dam Safety Inspection (DSI) would be performed on an annual basis. The DSI is a much less comprehensive review, comprising a visual inspection to identify any changes in condition, or any observed concerns. The results of the DSI are incorporated into the DSR documentation. A DSI may trigger repairs, or changes in standard operating procedures.

7. OBSERVATIONS

The Lake Geraldine Dam was accessed on foot. Based on our visual assessment we have the following comments:

- The visible concrete portions of the dam structure are in general unchanged from that observed for the 2009 DSI.
- The level of the Lake Geraldine reservoir has increased at least 0.6 metres since October 2009. The water level was within approximately 0.2m of the spillway crest at the time of our recent inspection; i.e. close to capacity.
- The berm structures exhibit the following issues:
    - Through leakage has developed in the north berm in the vicinity (both north and south sides) of the vehicular access ramp. The location is coincident with a change in direction of the berm.
    - Localized wash-outs have occurred on the upstream face of the north berm. It was reported that these wash outs developed as a result of wind events during the week of October 18, 2010. The larger armour stone remains however sections of the roadbed have been washed out.
- The leak in the concrete dam structure south of the spillway section that was identified in the 2009 DSI has not changed significantly.
- Upwelling along the south concrete wing wall appears has not changed significantly since the 2009 DSI.

To our knowledge, the required documentation (discussed previously) under the Canadian Dam Safety Guidelines is not up to date, and remains incomplete.

Specifically, the Permanent Record File, Logbook, and Operation & Safety Manual have not been updated.

To our knowledge, the Emergency Preparedness Plan (EPP) has not been completed.

8. DISCUSSION

The following issues are discussed in more detail:

Localized Wash Out

It was reported that, at times during the wind events, waves were overtopping the berm. High winds from the east were reported over several days.

Wave action as a result of high winds caused the erosion of granular material and the exposure of the concrete cutoff wall within the north berm.

A review of design drawings for the north berm wall, (Trow Associates Inc. Drawing BD2, Lake Geraldine Earth & Concrete Work 2006, June 2006) noted that the proposed construction of the north berm of the Lake Geraldine reservoir comprises a 200 mm thick concrete cutoff wall with rock fill on the upstream face (at a slope of 2:1 from the top) and 250 mm minus granular covered with 600 mm rip rap on the downstream face (at a slope of 2:1 from the top). The top of the berm is approximately 2.4 metres wide with a 2% slope towards the downstream face of the berm.

A cursory visual inspection of the north berm wall noted that, in general, the berm is constructed in accordance with the Drawing BD2.

In general, the rock fill is an effective barrier against erosion along the north berm wall. Only in extreme cases will wave action erode the granular material in this area.

As a short term solution, all areas of erosion should be filled with rock of similar size to the existing rock fill.

As per the design, the vehicular roadbed extends over the cut-off wall on the upstream side of the berm a distance of perhaps 1.2 metres. The roadbed material is a much finer granular than the rip rap, with the visual appearance of pit run gravel. This material was what washed out during the wind events.

The vehicular roadbed on the downstream side of the cut-off wall has adequate width for vehicular traffic.

In the longer term, we recommend filling the upstream berm with rock up to and slightly above the top of the cutoff wall and thus eliminate a 1.2 metre width of the vehicular roadbed.

Leakage at Vehicular Access Ramp

Through leakage in the north berm was observed on both the north and south sides of the vehicular access ramp.

This leakage was not observed at the time of the 2009 DSI, however, at that time there was more snow and ice cover.

There are several potential sources for the water flow at the base of the downstream face of the berm.

Given the wave overtopping during the wind events there would have been a significant amount of water that crossed over the concrete cut-off wall and then made its way through and out the base of the berm on the downstream side. One would expect that outflow to have ceased shortly after the waves subsided, and certainly within a few days.

The dam vertical extension in 2006 included a corresponding vertical extension to the concrete cut-off wall; details on the record drawings show a proprietary (Sika) product placed as a waterstop between the older and newer sections. This detail could be a source of leakage.

There could be leakage (upwelling) at the interface between the cut-off wall and the bedrock that it is reportedly founded in. The reservoir is at its highest levels ever and thus hydrostatic pressures are as well.

A workmanship or durability detail may exist in the cut-off wall in the vicinity; perhaps at the change in direction of the berm, which is coincident with the vehicular access ramp.

The actual cause of the leakage cannot be determined without considerably more investigation, and invasive assessment.

9. RECOMMENDATIONS

The following actions are recommended:

1. The grouting program originally designated for implementation in 2010 was designed in 2010; however, the implementation phase was deferred to 2011 by the City, and after dialogue with Concentric.
2. The localized wash outs from the wind events of 2010 require repair. As a short term interim measure all areas of erosion should be filled with rock of similar size to the existing rock fill. In the longer term, the upstream berm should be filled with rock up to and slightly above the top of the cutoff wall, and thus eliminate a 1.2 metre width of the vehicular roadbed.
3. The through leakage in the north berm at the vehicular access ramp requires investigation and repair in 2011. An investigative program will be prepared if requested by the City.
4. Preparation of the required Operation & Safety Manual, Logbook, and Permanent File was completed in 2007; however, the documents require updating. To our knowledge this has not been done.
5. The Emergency Preparedness Plan (EPP) was recommended for completion in 2010. To our knowledge the EPP has not been completed. The Emergency Preparedness Plan should be completed in 2011.
6. Complete the next DSI prior to November 2011.

We would be pleased to discuss this report with you. Should there be any questions, please contact the undersigned.

Yours truly,

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APPENDIX A
Photographs

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Photograph 1
Overview of Dam Structure; from the Northwest.

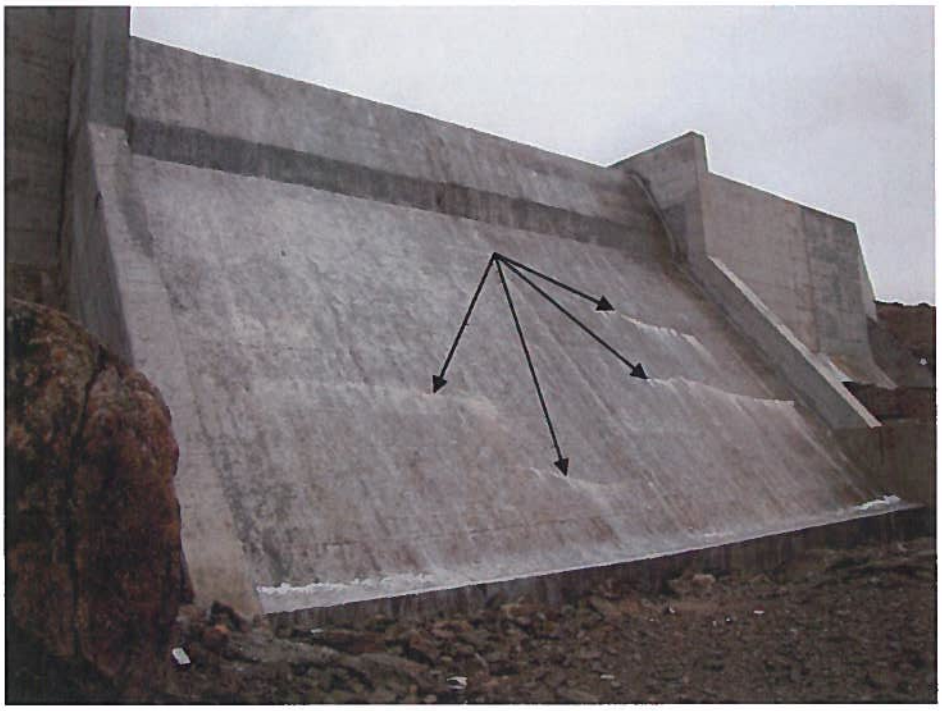
Photograph 2
Overview of North Berm, Downstream Face. Note leakage just north of ramp access.

Photograph 3
North Berm at South side of ramp access; note leakage.

Photograph 4
Southern portion of North Berm, upstream face; note localized washouts due to wave action.

Photograph 5
Overview of spillway; note water level near capacity; approx. 0.6m higher than October 2009.

Photograph 6
Leakage at North end of Spillway; similar to 2009 DSI.



Photograph 7
Leaching cracks in Spillway face; Similar to 2009 DSI.

Photograph 8
Leakage at South Gravity section; Similar to 2009 DSI.