Colliery Dam Preservation Society

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Dec. 17, 2012
Options  Pg 39 of 2010 EBA report

- Option 1 - Eliminate the seismic hazards by removing the dams;

- Option 2 - Conduct seismic upgrades to the existing dams that bring the dams to a state where they safely impound their reservoirs during and shortly after the design seismic event but will need an engineering inspection immediately thereafter to assess the damage that has occurred, possibly followed by major maintenance or removal and, if necessary, evacuation of the potential inundation area; or

- Option 3 – Bring the impoundments into a state where not only do the dams safely impound the reservoirs during and after the design seismic event, but also require minimal maintenance after the design seismic event. This will require construction of new dams or extensive improvement of the fill in the existing dams with jet grouting or other in-situ treatment.
Classified by number of possible fatalities

- Extreme – over 100 fatalities
- Very high – 10 to 100 fatalities
- High – less than 10 fatalities

- Extreme means 1:10000yr seismic & PMFlood
- V high means 1:5000yr seismic & 1:7500yr flood
- High means 1:3000yr seismic & 1:1000yr flood
If the “mode of failure” that was used to condemn the dams was eliminated (i.e., toppling of the wall) then it all changes.

- Dam will not breach
- Flood inundation now governed by a flood event and not a seismic event resulting in much lower fatalities
- Dam classification changes from “extreme” to “high”
  - 1:3000yr seismic upgrade is satisfactory
  - 1:1000yr flood capacity is satisfactory
Options  Pg 39 of 2010 EBA report

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In this option, the dams would be seismically rehabilitated to survive the design seismic event and safely impound the reservoir for a short period of time to allow the City to respond to the damage caused by the seismic event. However, the rehabilitation works conducted would be such that major maintenance or removal, with associated dewatering of the reservoir, may be required upon post-seismic event inspection. The Westwood Lake Dam seismic stabilization conducted in 2008 would fall into this class of rehabilitation in that the downstream toe berm was for stabilizing the dam until the repairs could be made to the dam or the dam removed given that the upstream slope of the dam was expected to fail. That repair is similar to the Option 2 repairs described herein.

In the case of Middle Chase Dam, Option 2 rehabilitation measures include:

- Excavation of the upstream rock fill berm and replacing it with a compacted rock fill buttress (this will require sequential excavation and backfilling techniques)(Figures 18 and 19); and
- From the upstream side, decommission the low level conduit where it passes through the concrete wall and cast a concrete bulkhead over the existing wall.

In the case of Lower Chase Dam, Option 2 rehabilitation would include constructing a rock fill buttress upstream of the concrete wall to minimize the deformations and associated cracking experienced by the wall during the design seismic event. Although it seems
The Recommendation  Fig 19 from 2010 EBA Report

NOTE: Normal operating level of reservoir based on survey data of spillway
Flood Discharge Options

Pg 46 of 2010 EBA report

- Spillway Option A - Construction of a heavy rock rip rap, armoured channel over the crest and downstream slope of each dam; and
- Spillway Option B - Construction of a concrete spillway over the crest and downstream slope of each dam.

Pg 15 of 2002 Spillway Study

Given the high construction cost of the proposed emergency spillway, it would be worthwhile considering alternatives at the next stage of design. Depending on the foundation conditions along the alignment, a lower cost alternative may be construction of two emergency spillways, one for each dam. The Middle Chase River Dam emergency spillway would discharge into the Lower Chase River Reservoir. A second spillway would be excavated in the right abutment of the Lower Chase River Dam. To compare costs, detailed site surveys and foundation conditions along the proposed alignments would be required.
Individual spillways (increase size of current spillways)

\[ q = 3.33(w - 0.2d)d^{3/2} \]

Spillway is 12.5m wide would need to be deepened by 4.5m (15') to flow 200m^3/s
so 944 X 4.5 = 4300m^3
Costs:

- **Seismic upgrade based upon Westwood** pg 50 of 2010 EBA report
  - Middle Chase Dam (upstream berm, 2,800 m$^3$) - $0.5$ million, not including dewatering, environmental or public interaction costs; and
  - Lower Chase Dam (upstream berm, 1,100 m$^3$) - $0.5$ million, not including dewatering, environmental or public interaction costs.

- **Spillway upgrade**
  - Excavation & disposal of ~7000m$^3$ of rock (@ $100/m^3$) > $700,000
  - Spill gates - 2 @ $500,000 > $1M
  - Dewatering (~340m of 700mm Ø pipe & valving & install) > $100,000
  - 10% for engineering > ~$200,000

- **Total: ~$3M**
Summary

- Eliminate risk NOW by emptying dams
- If no risk then ample time to pursue options
- Study of options should be completed prior to continuing with demolition plans to ensure best use of tax payers’ dollars
- Study to be done by a previously uninvolved firm for a fresh perspective of the options
IF THE RISK CAN BE MITIGATED TO A NEARLY NEGLIGIBLE AMOUNT (<1.6%/50YR) AND FOR A SUBSTANTIALLY LESSER COST THAN DEMOLITION AND WE GET TO RETAIN A JEWEL IN OUR CITY THEN IS THAT NOT A REASONABLE SOLUTION?

THANK YOU
SUPPORT SLIDES IF NEEDED
CAVEATS

- **Unknowns – more detailed analysis req’d**
- **Thin on resources….**

- If Option #2 seismic rehabilitation works is selected, consideration should be given to the following:
  
  1. The potential that the dams may need major maintenance or removal after the design seismic event and the City’s resources and abilities may be allocated to address damages to three structures (Westwood, Middle and Lower Chase Dams) that have been designed to survive the design seismic event with subsequent major maintenance;

  2. Implementing repairs at Middle Chase Dam first consisting of reconstruction of the upstream rock fill buttress and possibly construction of a new concrete wall at Middle Chase Dam, in addition to decommissioning of the low level conduit; and

  3. Construction of an upstream and downstream rock fill buttress at Lower Chase Dam or installing reinforcing steel in boreholes drilled through the concrete wall, evaluation of a cushion zone upstream of the concrete wall to limit loading on the wall, consideration of existing filter integrity in response to settlement of the 1918 fill under loading from the downstream toe berm and inclusion of a rock fill key trench excavated to bedrock beneath the downstream buttress.
The potential for toppling of the Middle Chase Dam wall upon experiencing modeled seismic events with peak ground accelerations of 0.1 to 0.2 $g$ is unclear. However, assuming the concrete remains rigid above the basal crack (assumed to be 8 m below crest of wall); the vertical force of the cracked wall will be located within the middle third of the wall section for the 0.1g case and just inside of the middle third of the wall section for the 0.2g case. This leads EBA to conclude the following:

- The wall has a remote chance of toppling some time after the 0.1g peak ground acceleration seismic event; and

The wall could possibly topple near the end of a seismic event with a 0.2 $g$ peak ground acceleration.

The potential for wall toppling depends on a number of factors such as cold joint bond strength, segregation, variability in concrete strength. Given the potential for variability in these features and given the overall poor state of the Middle Chase Dam concrete wall it is reasonable to conclude that any prediction on the exact level of ground shaking required to topple the Middle Chase Wall and at what time during the seismic event will be subject to a low degree of reliability. It is EBA’s opinion that any possibility of wall toppling during the seismic event should be accompanied by the expectation that sufficient fill deformations will occur that will permit overtopping during the late stages of the seismic event or shortly after it ends.

The data available from the Pacific Geoscience Centre in Sidney, BC indicates that a 1:475 year seismic event (10% chance in 50 years) will have a peak ground acceleration of 0.27$g$ and a 1:100 year event (40% chance in 50 years) will have a peak ground acceleration of 0.13$g$. Given the variability associated with the Middle Chase Dam concrete wall, it is not reasonable to predict the exact return period of the seismic event that will result in toppling. However, seismic events generation peak ground accelerations of 0.1g and 0.2 $g$ will occur with a 15% and just over 40% chance in 50 years respectively.
5.1 FLOODING

**Scenario 1 – 1000-year flood (no breach)**

This scenario assumes that the 1000-year flood event occurs without the failure of the Lower or the Middle Dams and is a reference event to allow an estimate of incremental damages due to dam failure. The peak of the flood hydrograph passes over the dam crests and continues downstream along the Chase River channel.

Significant debris generation is not expected as part of this scenario. As a result, we believe that loss of conveyance capacity at the bridges and culverts will not occur. The model in this scenario assumes full conveyance capacity for the bridges and culverts. The estimated maximum flood depth and the full extent of flooding are presented in Figures 5-1A and 5-1B.

Note that the figures do not feature an overlapping area between them as the ravine contains the flows for all scenarios. As a result, the figures show areas where flooding occurs beyond the banks of the Chase River. This applies to all figures in this report.

Overbank flooding occurs in a number of locations and impacts several properties.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Damaged Structures</th>
<th>Building Damage</th>
<th>Contents Damage</th>
<th>Total Damage</th>
<th>Incremental Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000-year flood with no breach</td>
<td>28</td>
<td>$2,800,000</td>
<td>$1,400,000</td>
<td>$4,200,000</td>
<td>$4,200,000</td>
</tr>
</tbody>
</table>
Worst case once dams reclassified
### Pipe Diameter Calculator

#### Flow Rates and Velocities

<table>
<thead>
<tr>
<th>q (m³/s)</th>
<th>w (kg/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.5999972E+007</td>
</tr>
</tbody>
</table>

#### Fluid Properties

<table>
<thead>
<tr>
<th>p (kPa)</th>
<th>( \rho ) (kg/m³)</th>
<th>( c_p ) (kJ/kgK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Selection

1. Volumetric flow rate \( q \):
   \( q = 10 \text{ m}^3/\text{s} \)

2. Mass flow rate \( w \):
   \( w = 3.5999972 \times 10^7 \text{ kg/h} \)

3. Diameter \( D \): 969.65393 mm
4. Velocity \( v \): 13 m/s
5. Cross section area \( A \): 769230.8 mm²
6. Density \( \rho \): 1000 kg/m³

**Calculation Report**

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- Mass flow rate \( w \): \( w = 3.5999972 \times 10^7 \text{ kg/h} \)
- Diameter \( D \): 969.65393 mm
- Velocity \( v \): 13 m/s
- Cross section area \( A \): 769230.8 mm²
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Thank you for using this software.

www.pipeflowcalculations.com
Seismic Hazard Assessment
Middle and Lower Chase River Dams

Societal Risk Criteria for Dam Safety

Effect of smaller seismic event causing failure
Effect of greater number of people dying due to failure
Unacceptable Risk
ALARP
Broadly Acceptable Risk

Probability of more than N Fatalities
Number of Fatalities N

NOTES
1. CURRENT ESTIMATE OF PROBABILITY OF PIPING POTENTIAL FOR MIDDLE CHASE DAM = 1.25E-05 PER ANNUM
2. CURRENT ESTIMATE OF PROBABILITY OF PIPING POTENTIAL FOR LOWER CHASE DAM = 3.08E-05 PER ANNUM
3. POST SEISMIC EVENT PROBABILITY OF PIPING POTENTIAL FOR MIDDLE CHASE DAM = 1.59E-04 PER ANNUM
4. POST SEISMIC EVENT PROBABILITY OF PIPING POTENTIAL FOR LOWER CHASE DAM = 2.73E-04 PER ANNUM
5. PROBABILITY OF 1:5000 YEAR SEISMIC EVENT = 3.30E-04 PER ANNUM
THE RESULT:
Dams safe from an extreme flooding event and dams safe from a 1:3000 yr seismic event (less than 1.6% chance in 50 years)

Are we ok with that level of risk?