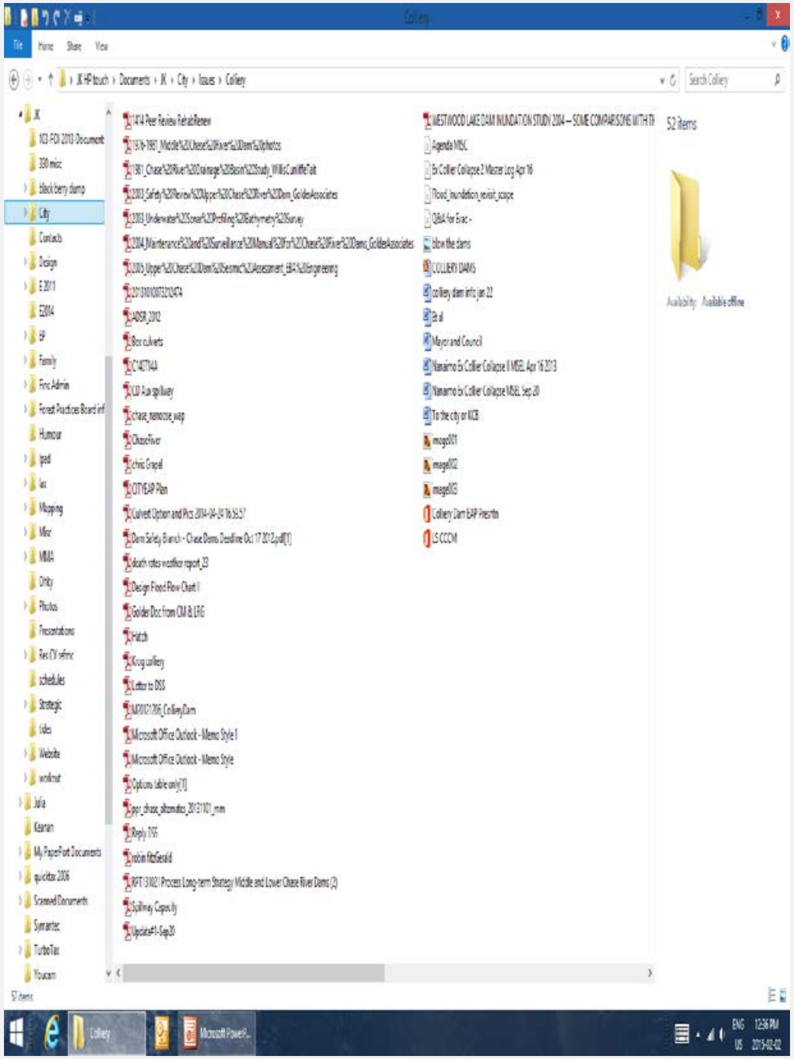
COLLIERY DAMS

HISTORY, EMERGENCY MANAGEMENT
REGULATION AND FUTURE

HISTORY OF COMPLIANCE

COLLIERY DAMS
100 YEARS
OF COMMUNITY
History, Culture,
Recreation,
Natural Environment,
Social Equity
and
Risk

Decades of Colliery Dam files and studies



Chase River Study 5 August, 1980

HOWARD DAM NUMBER THREE

Upstream concrete wall on structure

LIKELIHOOD OF OCCURRENCE	HAZARD SEVERITY				
	Negligible (1)	Slight (2)	Moderate (3)	High (4)	Very high (5)
Very Unlikely (A)	LOW	LOW	LOW	LOW	MEDIUM
Unlikely (B)	LOW	LOW	LOW	MEDIUM	MEDIUM
Possible (C)	LOW	LOW	MEDIUM	MEDIUM	HIGH
Likely (D)	LOW	MEDIUM	MEDIUM	HIGH	HIGH
Very Likely (E)	LOW	MEDIUM	HIGH	HIGH	HIGH

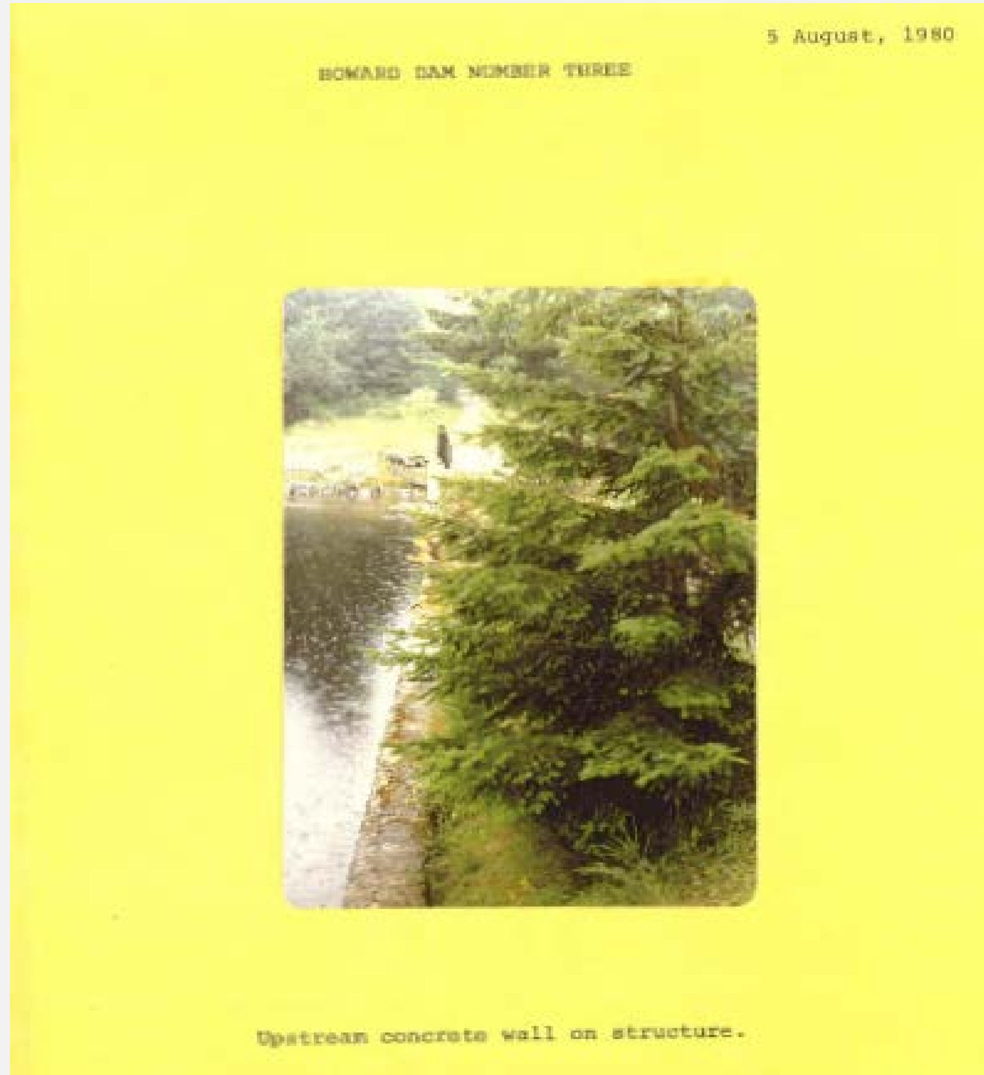
Chase River Drainage Basin Study
February 1981

a proposal to

THE CITY OF NANAIMO

Willis Cunliffe DeLCan Tait

CONSULTING ENGINEERS & PLANNERS



Watershed study 1981

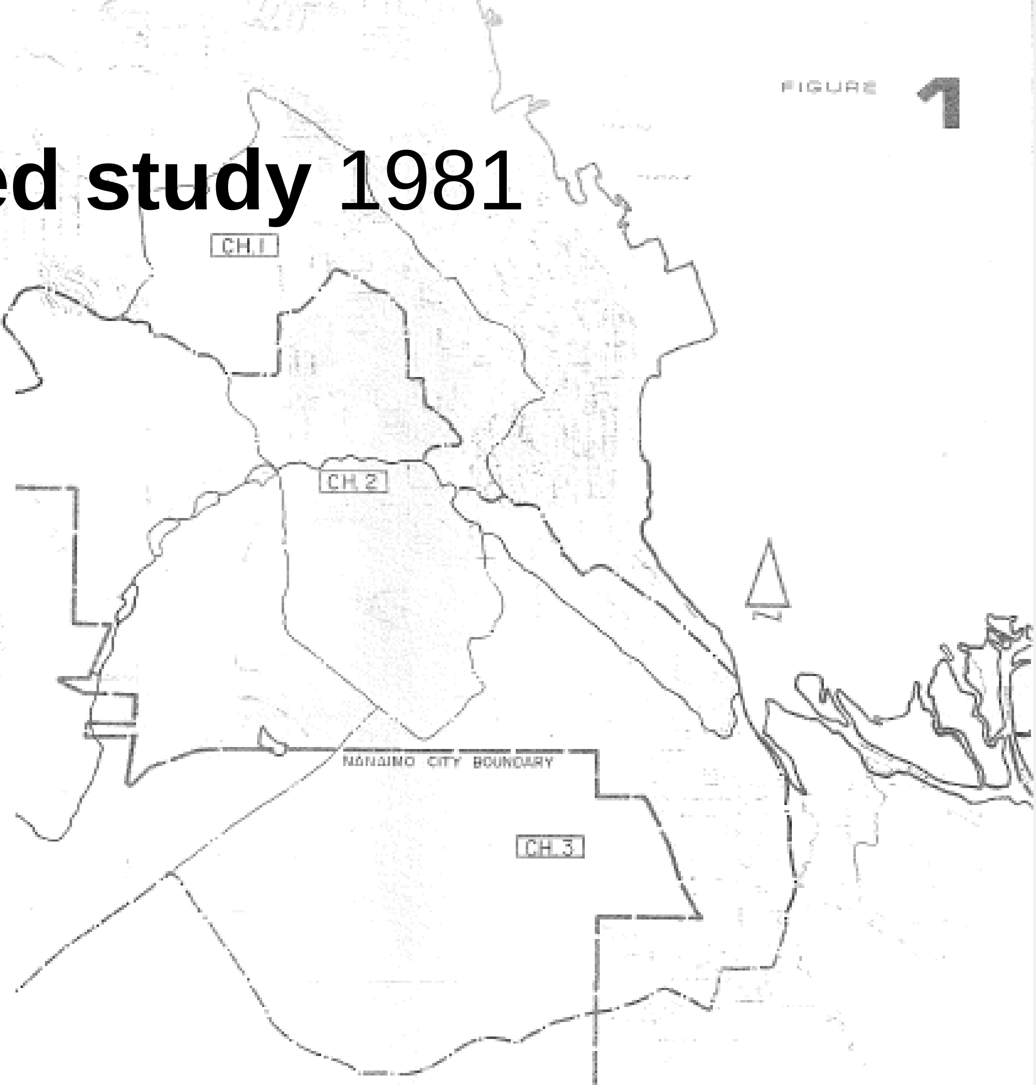
Chase River Drainage Basin Study

a proposal to
THE CITY OF NANAIMO

February 1981
34 - 822

Willis Cunliffe Tait | DeLCan
CONSULTING ENGINEERS & PLANNERS

FIGURE 1



CH.1 —— CATSTREAM SUB-BASIN DRAINAGE DESIGN BY OTHERS.
CH.2 —— DETAIL DESIGN AREA FOR TRUNK STORM SEWERS BYLAW # 2256

STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY

CITY OF NANAIMO
CHASE RIVER WATERSHED
STORM WATER MANAGEMENT STUDY AREA

Upper chase river dam safety review 2003

Golder Associates Ltd.

500 - 4260 Still Creek Drive
Burnaby, British Columbia, Canada V5C 6C6
Telephone (604) 296-4200
Fax (604) 298-5253

Golder Associates

REPORT ON

UPPER CHASE RIVER DAM
2003 DAM SAFETY REVIEW

Submitted to:

Greater Nanaimo Water District
455 Wallace Street
Nanaimo, B.C. V9R 5J6

Revision	*Status*	*Issued*
0	Issued for comment by Water Management Branch	24 Nov 03
Final	Added plan from 1944 as revised Fig 1.2.; and revised Fig 3.2.	18 Mar 04

DISTRIBUTION:

3 Copies - Greater Nanaimo Water District
1 Copy - City of Nanaimo, Engineering Library
1 Copy - City of Nanaimo, Public Works Library
1 Copy - Land and Water British Columbia, Victoria Water Management Branch, Dam Safety Office
1 Copy - Land and Water British Columbia, Nanaimo Vancouver Island Region Office
2 Copies - Golder Associates Ltd, Burnaby.

March, 2004 03-1411-103

R.O.B. BEST COMPANIES TO WORK FOR IN CANADA

50 BEST MANAGED COMPANIES

OFFICES ACROSS NORTH AMERICA, SOUTH AMERICA, EUROPE, AFRICA, ASIA AND AUSTRALIA

Underwater Sonar Profiling Survey Of Westwood, Middle and Lower Chase Lakes November 4th and 18th 2003

December 5, 2003

For The City of Nanaimo

November 4th and 18th 2003

- Information regarding survey techniques and processing

Approval for disclosure of these practices to third parties must first be obtained in writing from

Prepared by

AquaCoustic Remote Technologies Inc..

Underwater Sonar Profiling Survey
Of Westwood, Middle
and Lower Chase Lakes
for
The City of Nanaimo

November 4th and 18th 2003

Information regarding survey techniques and processing contained within this report is proprietary information. Approval for disclosure of these practices to third parties must first be obtained in writing from AquaCoustic Remote Technologies Inc..

Prepared by
AquaCoustic Remote Technologies Inc
888 379 7601

December 5, 2003

OPERATION, MAINTENANCE AND SURVEILLANCE (OMS) MANUAL for CHASE RIVER DAMS

December 5, 2003

THE CITY OF NANAIMO

- •Upper Chase River Dam
- •Middle Chase River Dam
- •Lower Chase River Dams

Golder Associates

THE CITY OF NANAIMO

OPERATION, MAINTENANCE AND SURVEILLANCE (OMS) MANUAL for CHASE RIVER DAMS

•Upper Chase River Dam
•Middle Chase River Dam
•Lower Chase River Dams

Revision	*Date*	*Remarks*
0	Nov/03	Draft for review
1	Apr/04	Issued for use, superseding 1992 "Data Books"

Distribution of this manual shown on next page

2003 DAM SAFETY REVIEW

REPORT ON UPPER CHASE RIVER DAM

Submitted to: Greater Nanaimo Water District Nanaimo, B.C. V9R 5J6

Issued for comment by Water Management Branch

Added plan from 1944 as revised Fig 1.2.; and revised Fig 3.2.

DIS1RIBUTION:

- 3 Copies- Greater Nanaimo Water District
- 1 Copy - · City of Nanaimo, Engineering Library
- 1 Copy - City of Nanaimo, Public Works Library
- 1 Copy - Land and Water British Columbia, Victoria Water Management Branch, **Dam Safety Office**
- 1 Copy- Land and Water British Columbia, Vancouver Island Region
- 2 Copies- Golder Associates Ltd, Burnaby.

March, 2004 24 Nov03 18 Mar04

03-1411-103

EBA Engineering Consultants Ltd.

Creating and Delivering Better Solutions

UPPER CHASE DAM SEISMIC ASSESSMENT
NANAIMO, BC

Submitted To:

CITY OF NANAIMO
NANAIMO, BC

Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

Project No. 0802-2800097

May 2005

Q:\Edmonton\Secretary\0802\Projects\2004\2800097R01.doc

14940 - 123 Avenue, Edmonton, Alberta T5V 1B4 - Tel: (780) 451-2121 - Fax: (780) 454-5688
Email: edmonton@eba.ca - Web Site: www.eba.ca

UPPER

CHASE

DAM

SEISMIC

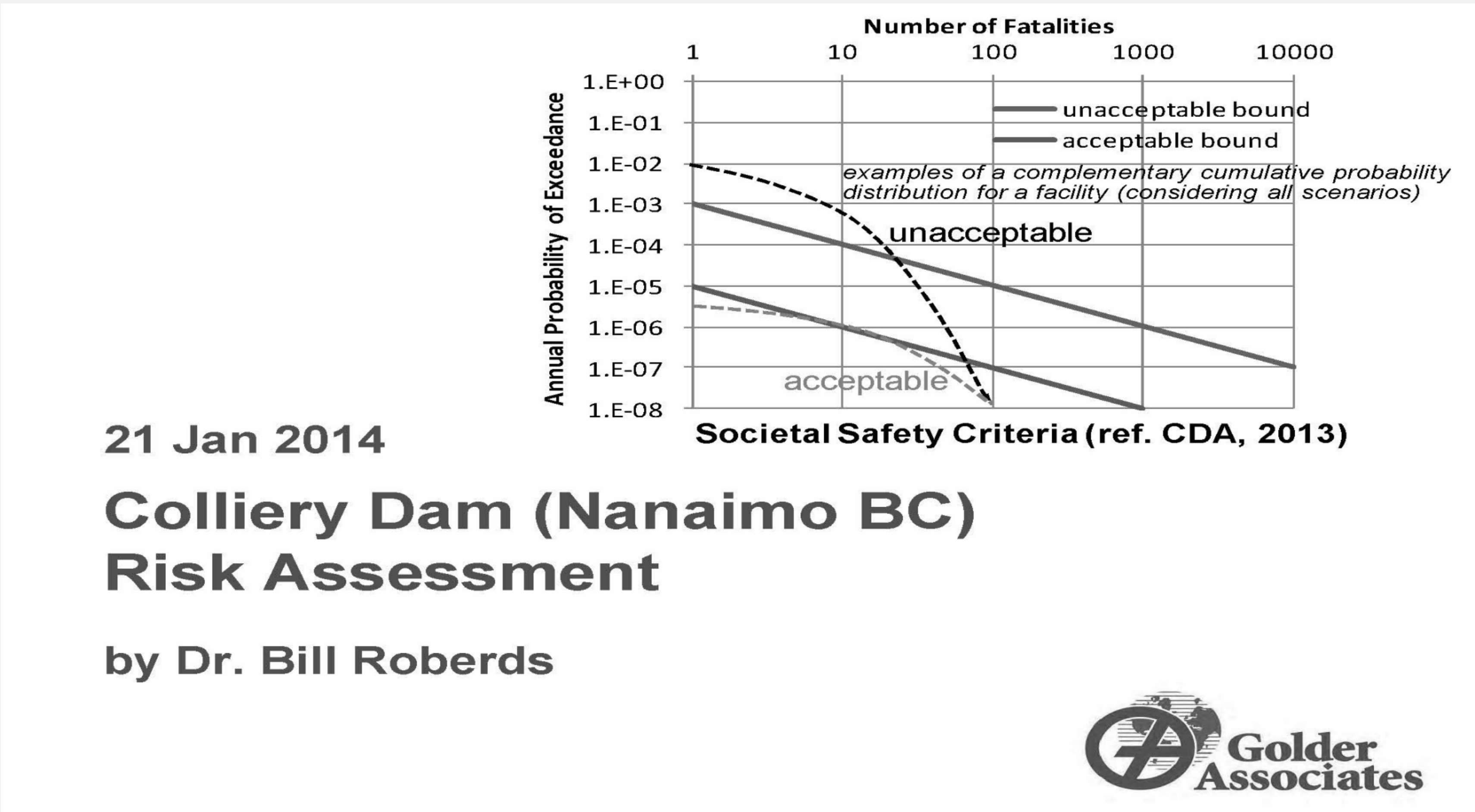
ASSESSMENT

2005

INVESTIGATIONS OF THE RISK

CATASTROPHY,
MANIFEST DESTINY
OR
ACCEPTABLE RISK

Risk Assessment January 2014



Risk assessment 2014 January

Develop Colliery Dams (Nanaimo BC) Plan

- **13 Dec 2013 Meeting**
  - **Objectives -** identify *optimal* dam rehab option plan
  - **Criteria -** including (but not limited to) *safety* and *financial performance*
  - **Process -** conduct *risk assessment* to appropriately evaluate potential performance (rather than worst-case scenario) of any plan, per recent *dam safety guidelines*
  - **Risk assessment**
    - *performance model* translates *inputs* ➔ *outputs*
    - inherent uncertainties in inputs and in model result in uncertainties in outputs
    - quantify uncertainty in terms of *probability*
    - assess probability *objectively* or *subjectively*

Golder Associates

Risk assessment 2014 January

Risk Inputs (3 of 10)

- **Dam "Failure" (cont.)**
  - Dam failure/breach – overtopping (flow rate/duration) relationship
    - Middle Dam
    - Lower Dam

    Status: We do not have any overtopping "breach" analyses for either dam from previous studies. We need breach analyses at several overtopping values for each dam in order to subjectively develop the complete relationship (by interpolation/extrapolation), and subjective assessment of the uncertainty in that relationship.
  - Dam failure/breach – other causes (e.g., piping) relationship
    - Middle Dam
    - Lower Dam

    Status: We do not have any other failure analyses for either dam from previous studies nor reliable models to do such analyses. We need subjective assessment of probability of dam failure by other causes (not seismic or overtopping, e.g., piping).

Golder Associates

Risk assessment 2014 January

Risk Inputs (2 of 10)

- **Seismic Load**
  - Exceedance Frequency – Magnitude (pga) relationship

    Status: We have this relationship from previous studies, but need to develop site-specific seismic inputs and subjectively assess uncertainties.
- **Dam "Failure"**
  - Dam failure – seismic (pga) relationship
    - Middle Dam
    - Lower Dam

    Status: We have "performance" of each dam for several pga values from previous studies. However, we will collect additional geotechnical data from the ongoing investigation (geophysics & drilling), which will be used to develop parameters for re-analysis. We need performance at several pga's for each dam (also considering previous results) in order to subjectively develop the complete relationship (by interpolation/extrapolation), and subjective assessments of: a) the uncertainty in modeled performance; and b) the probability of failure - performance relationship and the uncertainty in that relationship. Note: not differentiating degree of dam failure.

Golder Associates

Risk assessment 2014 January

Risk Inputs (5 of 10)

- **Lower Dam Release (cont.)**
  - Magnitude (flow rate/duration) for Lower Dam overtopping failure in combination with
    - No Middle Dam failure
    - Middle Dam overtopping failure
    - Middle Dam seismic failure
    - Middle Dam failure by other causes (e.g., piping)

  Status: We do not have any overtopping "breach" analyses to determine the magnitude of release for either dam if breached, from previous studies. We need breach analyses at several overtopping values for each dam (done elsewhere) in order to subjectively develop the complete relationship (by interpolation/extrapolation) of dam release magnitude to overtopping value, and subjective assessment of the uncertainty in that relationship, for each dam.

Golder Associates

Risk assessment 2014 January

Risk Model

- Algorithms (outputs from inputs in chains) implemented in *MS Excel* with @*Risk* (commercial add-in) to do probabilistic analysis:
  - Inputs expressed probabilistically (representing their uncertainties)
  - Outputs calculated probabilistically (representing their uncertainties) via *Monte Carlo simulation* (many possible sets of input values are generated, each with known probability, from which outputs with known probability are generated)
- Simulation Sequence:

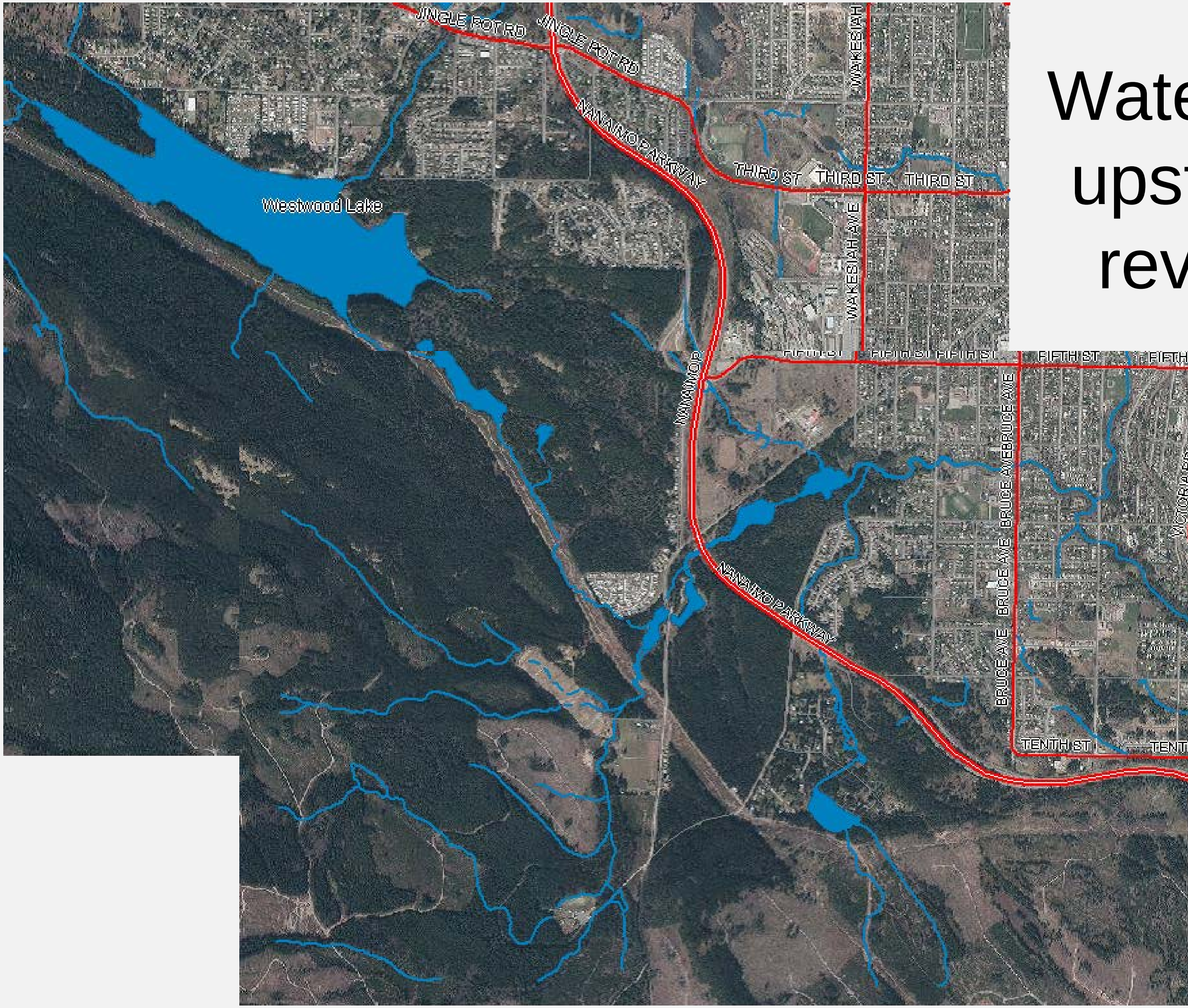
  Maximum precipitation and seismic events

  ➔ Dam(s) failure mode (each with particular lower dam release, timing and warning/no warning)

  ➔ Downstream inundation and downstream population/property

  ➔ Downstream damage and casualties
- *Status:* In development

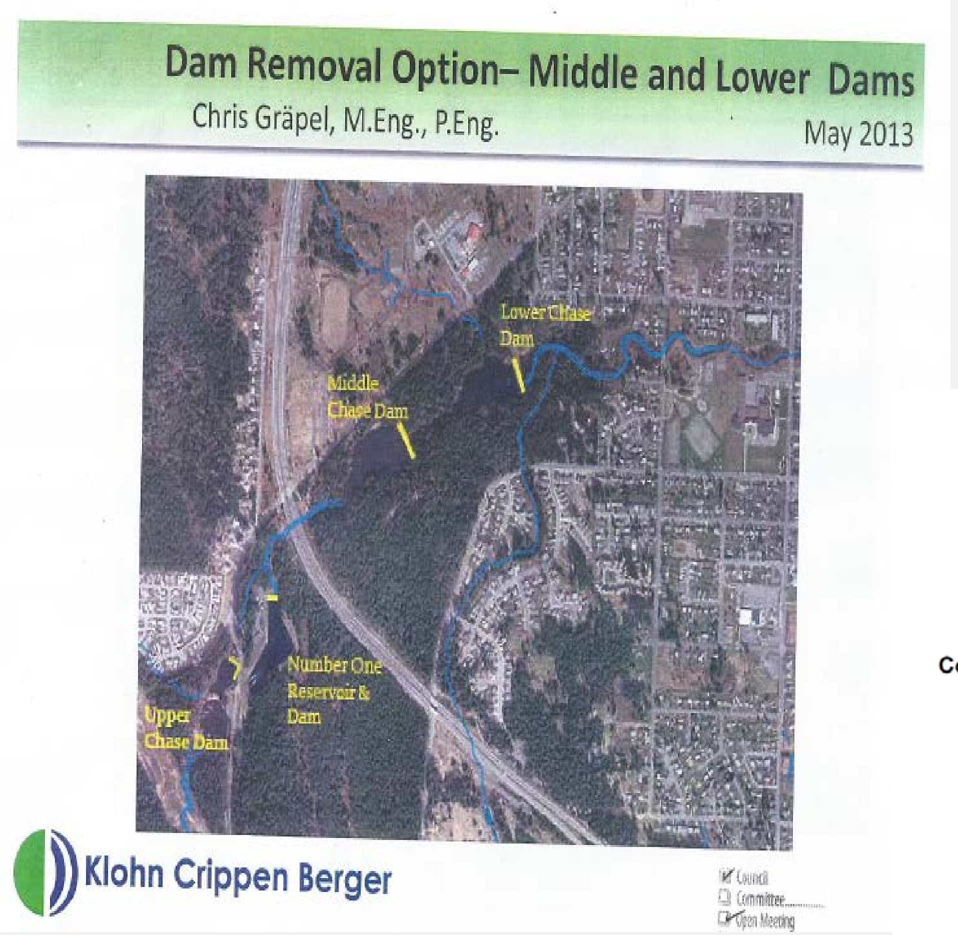
Maximum precipitation and seismic events



Watershed upstream reviews

Has the watershed be studied – hydrology and volumes of water calculated

LONG TERM INVESTMENT AND INVESTIGATION



Design Data 12

American Concrete Pipe Association

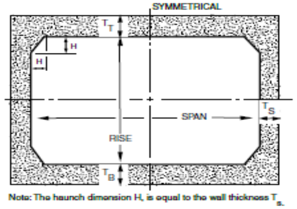
Hydraulic Capacity of Precast Concrete Boxes

Under certain conditions the hydraulic or structural characteristics of reinforced concrete box sections offer advantages over the circular and non-circular pipe shapes commonly used for sewers and culverts. The cost-effective advantages of precast concrete pipe productions and construction methods are available in a product manufactured in accordance with the ASTM Standard C1433, Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains and Sewers and Standard C1577, Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD. The American Concrete Pipe Association's CP Info, Precast Concrete Box Sections, presents the development and verification of the design method and standard sizes.

STANDARD DESIGNS

The standard precast concrete box section produced under Standards C1433 and C1577 is shown in *Figure 1*, and the standard sizes and wall thicknesses are shown in *Tables 1 and 2*. The standard sizes have 45-degree haunches with a leg dimension equal to the wall thickness. The availability and construction details of box sections should be discussed with local concrete pipe producers. Precast box designs other than standard are available through American Concrete Pipe Association member companies.

Figure 1 Standard Box Section



Note: The haunch dimension H, is equal to the wall thickness T_S.

Table 1 Standard Box Sizes

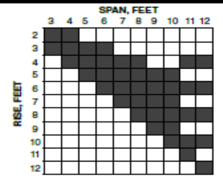


Table 2 Standard Thicknesses

Span Feet	T_T, Inches		T_B, Inches		T_S, Inches	
	> 2' cover	< 2' cover	> 2' cover	< 2' cover	> 2' cover	< 2' cover
3	4	7	4	6	4	4
4	5	7½	5	6	5	5
5	6	8	6	7	6	6
6	7	8	7	7	7	7
7	8	8	8	8	8	8
8	8	8	8	8	8	8
9	9	9	9	9	9	9
10	10	10	10	10	10	10
11	11	11	11	11	11	11
12	12	12	12	12	12	12

HYDRAULICS OF SEWERS

The hydraulic characteristics of precast concrete box sections are similar to those for circular, arch and elliptical pipe. The most widely accepted formula for evaluating the hydraulic capacity of non-pressure conduit is the Manning Formula. This formula is:

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2} \quad (1)$$

Where:

Q = discharge in cubic feet per second
n = Manning's roughness coefficient
A = cross-sectional area of flow, square feet

CITY OF NANAIMO
THE HARBOUR CITY

REQUEST FOR PROPOSAL No. 1414

Cost Estimate Peer Review – Colliery Dams Rehabilitation/Renewal

Issue date: January 30, 2013

Closing Location:
Purchasing Department
2020 Labieux Road
Nanaimo, BC V9T 6J9

Many Spillway investigations

Lower Dam Existing Spillway Capacity

- WMC 2002 report:
  - 14 cross section HEC-RAS Model described and results tabulated, but details about model not available
  - Reference to prior EBA 1992 study that indicates maximum capacity of 55 m^3/sec
  - 35.0 m^3/sec capacity at elevation 73.4 (dam crest)
  - 25.0 m^3/sec maximum capacity without overtopping chute walls due to hydraulic jump
- Golder 2014 simple broad crested weir calculation:
  - This is a rough approximation presented only for reference
  - Equation: $q = clh^{1.5}$
  - c = 1.45 (from King and Brater)
  - l = 11 m (existing spillway width excluding center pier)
  - h = 1.8 m (vertical distance from low point in dam crest to spillway crest)
  - q = 38.5 m^3/sec (maximum discharge capacity of existing spillway)
- Golder 2014 HEC-RAS Model:
  - Created independently of description of WMC's 2002 model
  - Created using best available topographic information and photographs (to approximate bridge deck geometry)
  - 39.0 m^3/sec maximum discharge capacity (at elevation 73.38)
  - Hydraulic jump is observed in model similar to WMC's 2002 findings, but our mode indicates that a 39 m^3/sec flow is contained (barely) by the existing spillway walls
- Summary
  - There is very close correlation to each of these three efforts to determine the existing Lower Dam spillway capacity
  - We have a good handle on the capacity and performance of the existing spillway at the lower dam

After numerous reports confusion on spillway size

Golder Associates

CALCULATIONS

Date:	08/18/2014	Made By:	JCD
Project No.:	1314470518	Checked By:	JKM
Subject	Rating Curves for Existing Conditions	Reviewed By:	GWH
Project Short Title:	Nanaimo/Colliery Dams/Nanaimo, BC		

Lower Dam Methodology

HEC-RAS Version 4.1.0 was used to develop a rating curve for the existing Lower Dam spillway. The 1-meter contours presented in plan drawings prepared by Klohn Crippen Berger and provided by the Client were referenced to create representative cross sections of the spillway. Additionally, field measurements of the pedestrian bridge were taken and is modeled as such. Note, this rating curve only accounts for flows through the spillway. The flow overtopping the dam has been modeled as a non-level "Dam Top" in HEC-HMS using coefficient and cross section parameters. This cross section is represented by 8 points along the dam and accounts for the Lower Dam's irregular dam top. Flows from 5 to 105 m^3/sec in 5 m^3/sec increments were analyzed and the resulting headwater depths recorded to create the rating curve.

The HEC-RAS model results were compared to the rating curve developed in 2001 by WMC and provided in Table 3.1: Middle Chase River Dam Spillway Capacity in the "City of Nanaimo Middle and Lower Chase River Dams Spillway Hydrology Study" by Water Management Consultants (WMC). The modeling results show some variation to the WMC Lower Dam rating curve. For example, Golder found that 55 m^3/sec will pass through the existing spillway without overtopping the dam at 73.4 meters (msl); WMC reported the Lower Dam spillway capacity to be 35 m^3/sec. However the WMC study then references previous studies that indicate a spillway capacity of 55 m^3/sec. Similar to the WMC study, the Golder HEC-RAS model also shows that certain flows are causing a hydraulic jump in and upstream of the converging section of the spillway.

Lower Dam Spillway Rating Curve

W.S. Elev. Meters (msl)	Q* (m^3/sec)	Head (meters above crest)	Notes
71.60	0.0	0	Crest Elevation
71.99	5.0	0.4	
72.21	10.0	0.6	
72.40	15.0	0.8	
72.57	20.0	1.0	
72.73	25.0	1.1	
72.87	30.0	1.3	
73.02	35.0	1.4	
73.04	36.0	1.4	
73.06	37.0	1.5	
73.10	38.0	1.5	
73.12	39.0	1.5	
73.14	40.0	1.5	
73.24	45.0	1.6	
73.33	50.0	1.7	
73.43	55.0	1.8	Top of dam elevation: 73.4 m-msl
73.54	60.0	1.9	
73.65	65.0	2.0	
73.75	70.0	2.1	
73.85	75.0	2.2	
73.95	80.0	2.3	
74.05	85.0	2.4	
74.15	90.0	2.5	
74.26	95.0	2.7	
74.37	100.0	2.8	
74.50	105.0	2.9	

*Does not include dam overtopping.

II. SPILLWAYS

There also appears to be some doubt, confusion or uncertainty as to the capacity of the lower dam spillway. The following examples support this:

a. From the Dam Safety Program Summary Report: "The hydrological aspects of the Chase River System were assessed and reported in the 1978 Storm Drainage Study. The inflow to the Lower Chase River reservoir was estimated to be 57.8 m3/s, for a 100 year storm in the 1978 study. The spillway capacity with a 0.9 m discharge depth (determined by the top of the concrete wall) was

Originally 35 M3 P/Sec then determined to be 55 M3 P/Sec

Other method of calculation puts the spillway over 100 M3

Studies on flows and capacity

Explanation of difference in 1,000 year flow increase vs. PMF flow decrease:

WMC performed a detailed hydrologic analysis for their PMF storm, but used seemingly highly conservative values without providing many elements of supporting information. This has been discussed in great detail in the power point presentation we prepared for the January TC meeting. Golder did the same analysis, using the same methodology, but using refined inputs and generated PMF results that were significantly less than WMC determined.

Golder used the same methodology to perform a detailed hydrologic analysis to determine the flows associated with various return frequency storm events (2 through 1,000-year). WMC's 2002 study presented a single return frequency (1,000-year) that was determined by scaling 1,000-year values from other watershed, most of which were much, much larger than the watersheds that exist at the Colliery Dams, and determined a flow for the 1,000-year storm. This is a crude method using extrapolated data (gage data is not available for anywhere near 1,000 years of time) and not taking into account other potential variations in basin characteristics (landuse, soils, terrain, elevation, vegetation, location, riverine storage, manmade storage, etc.). Section 4.3 on page 12 of the 2012 WMC report describes their methodology.

THE COMMUNITY EXCEPTS MANY RISKS AND STANDARDS

It is staff's professional obligation to provide accurate and relevant technical, financial and legal advice

From: Susan Clift
Sent: January 22, 2013 11:09
To: Mayor&Council; SENIOR LEADERSHIP TEAM
Cc: Philip Cooper; Bill Sims
FW: Engineering Work for the Colliery Dams Removal Project

Whether the dams will be remediate or removed or reconstructed is a decision that will be completely up to Council. **It is staff's professional obligation to provide accurate and relevant technical, financial and legal advice from which Council can make an informed decision**. Council has asked for more detailed costing information on the alternatives to dam decommissioning. In considering whether to change the current course of action, Council may weigh such factors as:

- public safety and Council's liability,
- tolerance for short term and long term risk,
- initial capital cost,
- tolerance for park disruption,
- tolerance for ongoing costs to upgrade the dams **as standards change over time**,
- the likelihood of professional assurance and regulatory approvals,

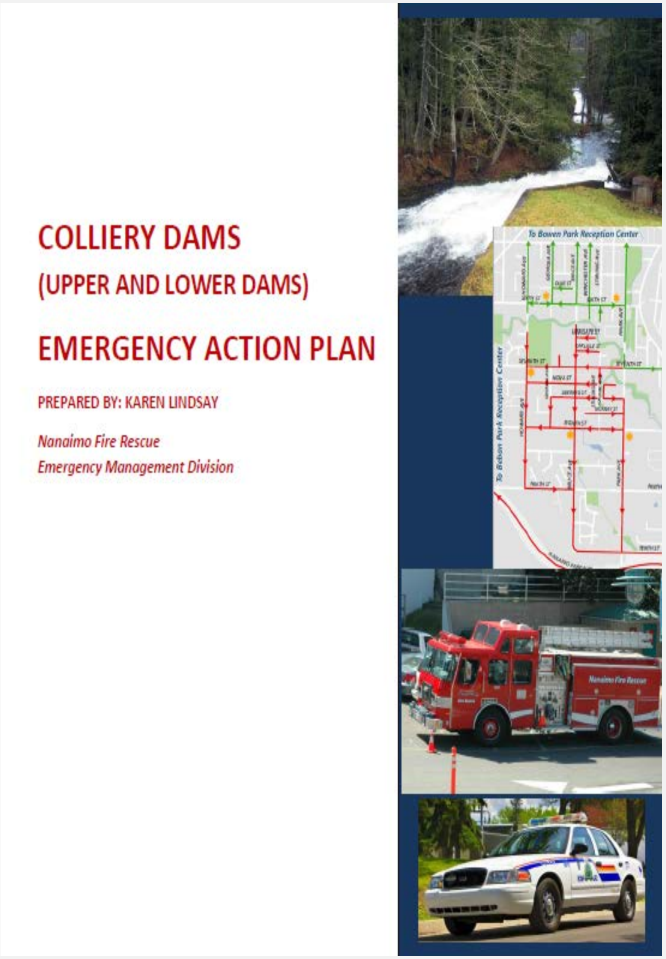
the desires of the affected communities: those that are in the inundation zone, those that are park users, and the SFN perspective. Staff will use best efforts to pull all of this information together and provide recommendations in an expeditious manner.

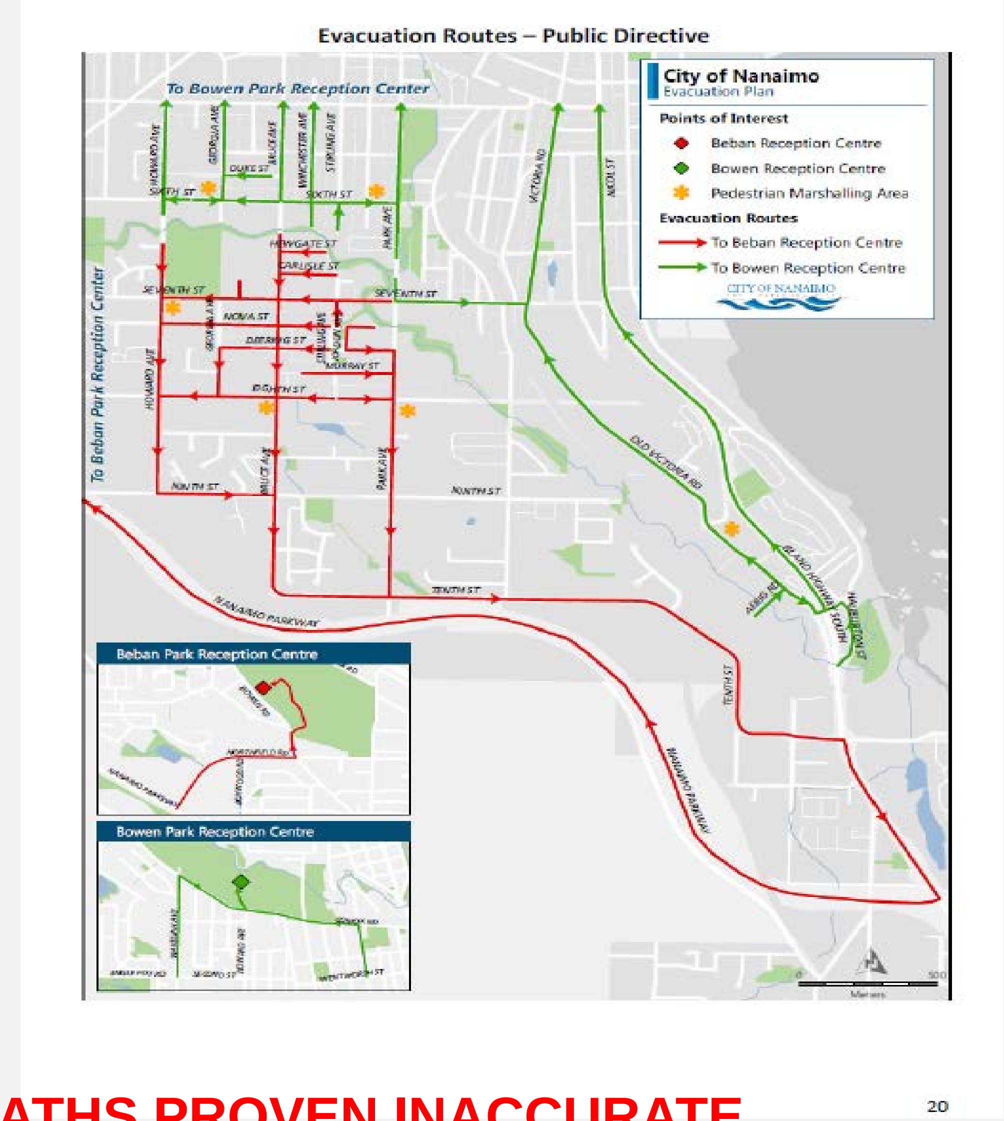
Susan Clift, P.Eng.
Director, Engineering & Public Works
(250) 756-5301 susan.clift@nanaimo.ca

3 MIN FAILURE 150 DEATHS

PROVEN INACCURATE

Planning based on catastrophic failure





3 MIN FAILURE 150 DEATHS PROVEN INACCURATE

EXERCISE COLLIER COLLAPSE
MASTER SEQUENCE OF EVENTS LIST
SEPTEMBER 20, EXERCISE COLLIER COLLAPSE

EXERCISE COLLIER COLLAPSE_MASTER SEQUENCE OF EVENTS LIST

- **Set Time From To Input Expected Action or Prompting Questions Teaching Points**
- 1300 **Exercise Introduction**:; Review of exercise goal, objectives and conduct;
- Goal: To practice the ECC Planning Section in managing information and conducting action planning
- Objectives: To review the following:The action planning process;Preparation of a Situation Report;Management of a master log; andManagement of graphic displays (maps, etc)
- Conduct: This exercise will be conducted using the tabletop exercise format. Over approximately a three-hour period various “vignettes” will be presented to exercise participants describing specific events. Participants will consider the event, describe their response, and the exercise director will facilitate a discussion of this response among the other exercise participants.This exercise will commence with a shift-change at the beginning of the second operational period. Rather than starting from the beginning of a response, the ECC Planning Section will plan the third and fourth operational periods. At the same time, they will continue to update the master event log and graphic displays.
- Exercise controllers will simulate non-Planning Section ECC functions.
- **Review the scenario:**
- ***Heavy rainfall threatened the dam structures and in anticipation of a possible collapse*** *an evacuation of the inundation area was ordered. Predications were accurate and approximately 30 minutes after ordering the evacuation the dams failed. Although the evacuation of the inundation area was generally successful and most residents were safely moved to higher ground some people refused to evacuate and a search-and-rescue operation is in progress. Fortunately the evacuation occurred outside school hours so staff and school evacuation was not required, however the school has suffered flood damage.Approximately*
- ***1000 persons have been evacuated to various locations outside the inundation area.***

Risk based on flawed information

no catastrophic collapse

October 17, 2012

File: D720001-00/Middle Chase
D720002-00/Lower Chase

Bill Sims, A.Sc.T.
Manager, Water Resources
City of Nanaimo
2020 Labieux Road
Nanaimo BC V9T 6J9

Dear Bill:

Re: Chase River Dam Breach Flood Inundation Study

Thank you for inviting Monty Miedriech, John Baldwin and myself to your Dam Safety Table Top Exercise on September 20th and 21st and for forwarding to us the Associated Engineering report entitled Chase River Dam Breach Flood Inundation Study (Inundation Study), dated July 2012. The Inundation Study has been reviewed by our office and its conclusions and recommendations were briefly discussed with you and your staff.

The Inundation Study has highlighted an unacceptable deficiency in both the Middle Chase River Dam and Lower Chase River Dam and states the probability of an extreme failure of these dams is very high. The Inundation Study concludes a 'do-nothing' option is unacceptable and recommends modifications to the dam that include upgrading, replacement or removal of the dams. The Inundation Study also recommends reclassifying both the Middle Chase River Dam and Lower Chase River Dam to an extreme consequence rating based on the estimated number of casualties resulting from a probable seismic event. Our records have now been updated to reflect this recommendation.

At this time we are asking for a decision on your course of action for the Middle Chase River Dam and Lower Chase River Dam by November 30, 2012. Please refer to Section 4 of the BC Dam Safety Regulation on requirements for upgrading or replacement of the dams and Section 9 on the requirements for dam removal.

.../2

Ministry of Forests, Lands & Natural Resource Operations **Resource Stewardship Division**	Water Management Branch Dam Safety Section	Mailing Address: PO Box 9340 Stn Prov Govt Victoria BC V8W 9M1 Telephone: 250-387-3265 Facsimile: 250-952-6792	Location: 3rd Floor, 395 Waterfront Cres Victoria BC V8T 5K7

We are pleased with the level of response the City of Nanaimo has shown towards the findings of this Inundation Study to date. We look forward to continuing our close working relationship with you and your staff in resolving this issue.

Yours truly,

Scott Morgan
Dam Safety Section Head

pc: John Baldwin, Dam Safety Officer, West Coast Region

Dam Safety based their risk on the catastrophic collapse that was proven false.

From: Morgan, Scott FLNR:EX [Scott.Morgan@gov.bc.ca]
Sent: November-24-14 7:47 AM
To: 'cliffmarcil@telus.net'
Subject: Middle Chase River Dam and Lower Chase River Dam, Colliery Park

2014 November DSS still classified as extreme

Ref: 210330
Cliff Marcil
Nanaimo, BC
Email: cliffmarcil@telus.net
Dear Cliff Marcil:

Re: Middle Chase River Dam and Lower Chase River Dam, Colliery Park

Thank you for your email of November 13, 2014 regarding the dams in Colliery Park, Nanaimo. I have been asked to respond on behalf of Glen Davidson, Comptroller of Water Rights.

In the Province of British Columbia, dams are regulated under the *Water Act*, BC Dam Safety Regulation. The objective of the Regulation is to minimize the risk of loss of life and damage to property and the environment from a dam breach by requiring dam owners to inspect their dams, undertake proper maintenance and ensure that these dams meet current engineering standards. The *Act* and Regulation are available under the “Legislation” section of the Dam Safety Program website: http://www.env.gov.bc.ca/wsd/public_safety/dam_safety/index.html .

Our office is awaiting new information from the City of Nanaimo regarding the consequence classification based on recent engineering studies. Failure consequence classification is based on the potential for loss of life and impacts to infrastructure and the economy should one of the dams fail. Until we are able to review the new information, both of the Colliery Park dams remain classified as extreme failure consequence under the BC Dam Safety Regulation.

As you mention, many engineering studies have been undertaken by the City of Nanaimo on the Colliery Park dams. Undertaking these studies is consistent with the requirements for a dam owner under the BC Dam Safety Regulation. The studies have determined there are potential safety hazards for both the Lower and Middle Colliery dams. The Regulation requires that should a potential safety hazard be revealed, the dam owner must prepare a plan that identifies and prioritizes any actions required to correct the potential safety hazard in a timely manner. The City of Nanaimo has identified a plan and is currently moving forward to address the potential safety hazards found with the Colliery Park dams. Although our office has not issued specific timelines, we are working closely with the City of Nanaimo to resolve the issue with the Colliery Park dams in a timely manner.

Yours truly,
Scott Morgan
Head, Dam Safety Section

DSS, Never retracting letters to the newspaper on catastrophic collapse, 1800 impacted and 150 deaths

2010 INSPECTION COMPLIANCE FORM FOR OWNERS OF HIGH & VERY HIGH CONSEQUENCE DAMS

SUBMIT FORM TO:

By email at: dam.safety@gov.bc.ca

By Mail at: Dam Safety Section, Water Stewardship Division
395 Waterfront Cres.
Ministry of Environment, Victoria BC, V8T 5K7

Will

By Fax at: 250-952-6792

OFFICE USE ONLY:
Region: HQ, VI, SR, KM, PN, NL, WK, PG
Consequence: AG, DA

Dam Name: Middle Chase River Dam

Please include contact: name, address, phone # & e-mail:

Name: Scott Pamminger, Water Resources Technologist

Address: City of Nanaimo, Public Works Yard, 2020 Labieux Rd., Nanaimo, BC, V9T 6J9

Phone: (250) 756-5338

E-mail: scott.pamminger@nanaimo.ca

D72 0001-00

Please read the information overleaf (page 2) before completing this form. You will find more information on our website: www.env.gov.bc.ca/wsd/public_safety/dam_safety/.

1. Has your Formal Inspection for 2010 been completed? Yes ☒ No ☐
   Inspected By: Owner ☐, Other ☒ - Who? BAM Engineering Ltd.
   Comments:
2. Have any Dam Safety Concerns been identified? Yes ☐ No ☒ If yes please elaborate.
3. *If yes to #2;*
   Has a plan been prepared to address the safety concern(s)? Yes ☐ No ☐ N/A ☒
   Comments:
4. Did you undertake *regular* (see page 2) Site Surveillance? Yes ☒ No ☐
   Comments:
5. Status of your Dam Safety Review? Complete ☒ Started ☐ Not Started ☐
   Expected Completion Date: City will be undertaking next Dam Safety Reviews in 2013.

Additional comments or suggestions:

Submitted by: Scott Pamminger Date: 18-Jan-2011

Position: Water Resources Technologist Phone: 250-756-5338

E-mail: scott.pamminger@nanaimo.ca

JAN. 18 2011 DAM INSPECTION FOR 2010 RECEIVED AT DAM SAFETY

NO CONCERNS

1. Has your Formal Inspection for 2010 been completed? Yes ☒ No ☐
   Inspected By: Owner ☐, Other ☒ - Who? BAM Engineering Ltd.
   Comments:
2. Have any Dam Safety Concerns been identified? Yes ☐ No ☒ If yes please elaborate.

BRITISH COLUMBIA

2011 INSPECTION COMPLIANCE FORM FOR OWNERS OF HIGH, VERY HIGH & EXTREME CONSEQUENCE DAMS

Water Management Branch
Date Received:
JAN 11 2012

SUBMIT FORM TO:

By Mail at: Dam Safety Section, Water Management Branch
Ministry of Forests, Lands and Natural Resource Operations, ~~Victoria BC~~
Please use pre-paid, self addressed envelope, or address below

By Fax at: 250-952-6792
By email at: dam.safety@gov.bc.ca

OFFICE USE ONLY:
Region: HQ, VI, SR, NW, PW, NE, WL, FC
Consequence: AG, DA

LOWER CHASE RIVER DAM

SCOTT PAMMINGER
CITY OF NANAIMO
PUBLIC WORKS YARD
NANAIMO BC V9T 6J9

File Number for correspondence: D720002-00

Is Contact Name and Address correct?
YES ✓ NO___ Please correct below:

Please include contact phone # & e-mail:
Phone: 250 · 756 · 5338
E-mail: scott.pamminger@nanaimo.ca

Please read the information overleaf (page 2) before completing this form. You will find more information on our website: www.env.gov.bc.ca/wsd/public_safety/dam_safety/.

1. Has your Formal Inspection for 2011 been completed? Yes ☑ No ☐
   Inspected By: Owner ☐, Other ☑, Who? BMA Engineering Ltd.
   Comments:
2. Have any Dam Safety Concerns been identified? Yes ☐ No ☑ If yes please elaborate.
3. *If yes to #2;*
   Has a plan been prepared to address the safety concern(s)? Yes ☐ No ☐ N/A ☑
   Comments:
4. Did you undertake *regular* (see page 2) Site Surveillance? Yes ☑ No ☐
   Comments:
5. Has a Professional Engineer completed your Dam Safety Review? Y ☑ No ☐ Started ☐
   If "Started DSR"; scheduled completion date is:
6. Have you submitted your Dam Safety Review? Yes ☑ No ☐
7. Do you have a current OMS & EPP? Yes ☑ No ☐
8. Have you completed the annual EPP review? Yes ☑ No ☐ Year last updated: 2012

Additional comments or suggestions: Updating EPP in progress.

Submitted by: Scott Pamminger Date: January 5, 2012
Position: Water Resources Specialist Phone: 250. 756. 5338

Water Management Branch
3rd Floor, 395 Waterfront Crescent, Victoria BC Tel (250) 952-6790 Fax (250) 952-6792
Mailing Address: PO Box 9340 STN PROV GOVT Victoria BC V8W 9M1
Website: www.env.gov.bc.ca

Page 1 of 2
FNR-2014-00046

JAN. 8 2012 DAM INSPECTION FOR 2011 RECEIVED AT DAM SAFETY

NO CONCERNS

1. Has your Formal Inspection for 2011 been completed? Yes ☑ No ☐
Inspected By: Owner ☐, Other ☑, Who? BMA Engineering Ltd.
Comments:
2. Have any Dam Safety Concerns been identified? Yes ☐ No ☑ If yes please elaborate.

From: Bill Sims [mailto:Bill.Sims@nanaimo.ca]
Sent: Friday, February 24, 2012 11:31 AM
To: Morgan, Scott FLNR:EX
Subject: RE: Reservoir No 1 and Colliery Dams Roundtable

Hi Scott - Ouch - too bad! I had scheduled the meeting to be before spring break in this area, hoping that we would capture most people. I think it's important that we have DS reps there to help keep the focus and perspective on the seriousness of failure vs the potential conflicting objective of environmental value of the ponds.

I understand that Will is hanging around for a bit of time, so hopefully he is available that day, and John as well.

We will be definitely having further meetings on this system; we've just received a draft inundation study. It will be a challenge to communicate the implications of failure in the face of the community's love of the park.

Take care!
Bill

FEB 24 2012 EMAIL FROM CITY DESCRIBES THE PONDS AND

DSS ASKED… HELP NEEDED TO KEEP FOCUS ON RISK… THAT DID NOT EXIST

From: Morgan, Scott FLNR:EX
Sent: Friday, February 24, 2012 12:34 PM
To: 'Bill Sims'
Cc: Baldwin, John FLNR:EX
Subject: RE: Reservoir No 1 and Colliery Dams Roundtable

Hi Bill,

I haven't talked to John but know Will won't be able to attend the meeting either. Not Responsive

Not Responsive

These dam's of yours do pose an interesting problem and we will definitely do our best to help out. Thanks for the invite, hopefully I will be available for the next round,

Cheers,
Scott-

FEB 24 2012
EMAIL FROM
DSS

DAM SAFETY
OFFER TO
DO OUR BEST
TO HELP
OUT

RISK THAT DID
NOT EXIST

BRITISH COLUMBIA
The Best Place on Earth

DEFICIENCY CHECKLIST

If you find deficiencies with any component of your dam, use the following table to guide you to the relevant section of the ***SELF-HELP GUIDE*** in the Appendix of the Inspection and Maintenance of Small Dams booklet.

IS THERE ANY APPARENT...	YES	NO	IF YES THEN...
CRACKS			
• embankment cracks on the crest?	☐	☐	section 2.4, 2.5 & 2.6
• embankment cracks on the u/s slope?	☐	☐	section 3.5
• embankment cracks on the d/s slope?	☐	☐	section 4.1
VEGETATION GROWTH AND DEBRIS			
• excessive vegetation growth on the embankments?	☐	☐	section 2.1, 3.4 & 5.2
• floating debris?	☐	☐	section 1.2
• vegetation or debris blocking the spillway channel?	☐	☐	section 8.2
STRUCTURAL PROBLEMS			
• settlement on the crest?	☐	☐	section 2.7
• slough, slides or bulges on the u/s slope?	☐	☐	section 3.6
• slough, slides or bulges on the d/s slope?	☐	☐	section 4.2
• slough, slides or bulges on the reservoir shore?	☐	☐	section 1.1
• slough, slide or erosion of spillway channel?	☐	☐	section 8.1
• sinkhole on crest?	☐	☐	section 2.8
• sinkhole on u/s slope?	☐	☐	section 3.7
• sinkhole on d/s slope?	☐	☐	section 4.4
• displaced or broken down riprap armor?	☐	☐	section 3.2
SEEPAGE			
• wet areas or seepage on the d/s slope or toe?	☐	☐	section 4.3 & 5.1
• ponded water at the downstream toe?	☐	☐	section 5.2
• wet areas or seepage along d/s abutments?	☐	☐	section 6.1
ANIMAL ACTIVITY			
• signs of livestock traffic across dam embankment?	☐	☐	section 4.5
• rodent burrows in dam embankment?	☐	☐	section 2.2 & 3.3
• beaver dams in reservoir or across spillway channel?	☐	☐	section 1.3
OUTLET PROBLEMS			
• outlet operating problems?	☐	☐	section 7.1
• deterioration of the outlet conduit?	☐	☐	section 7.2
SPILLWAY PROBLEMS			
• spillway blockage?	☐	☐	section 8.3
• channel blockage?	☐	☐	section 8.2
• inadequate capacity?	☐	☐	section 8.3

Show me the money

by

doing the right thing

No deficiencies can be determined by DSS self help guide checklist

EMERGENCY MANAGEMENT

In the Business of Emergencies and Emergency Management

There is usually no next time, no 2nd chance
And there is no time out

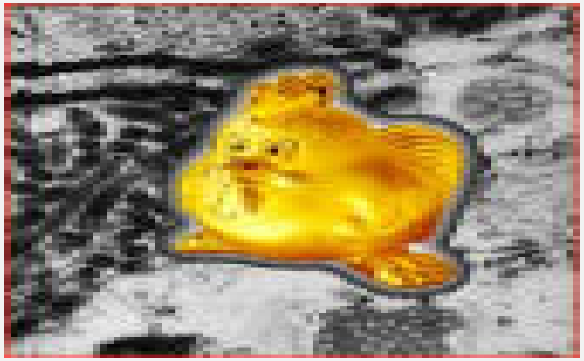
We know some events build slowly!

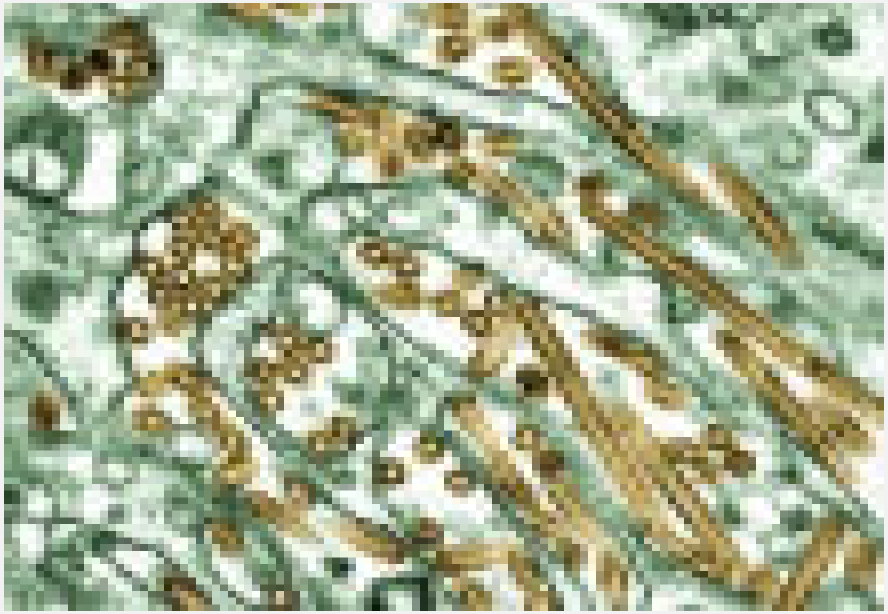
With FLOODING for example:

there will be a next time, but still no 2nd chance,

or time out

And some events just build!

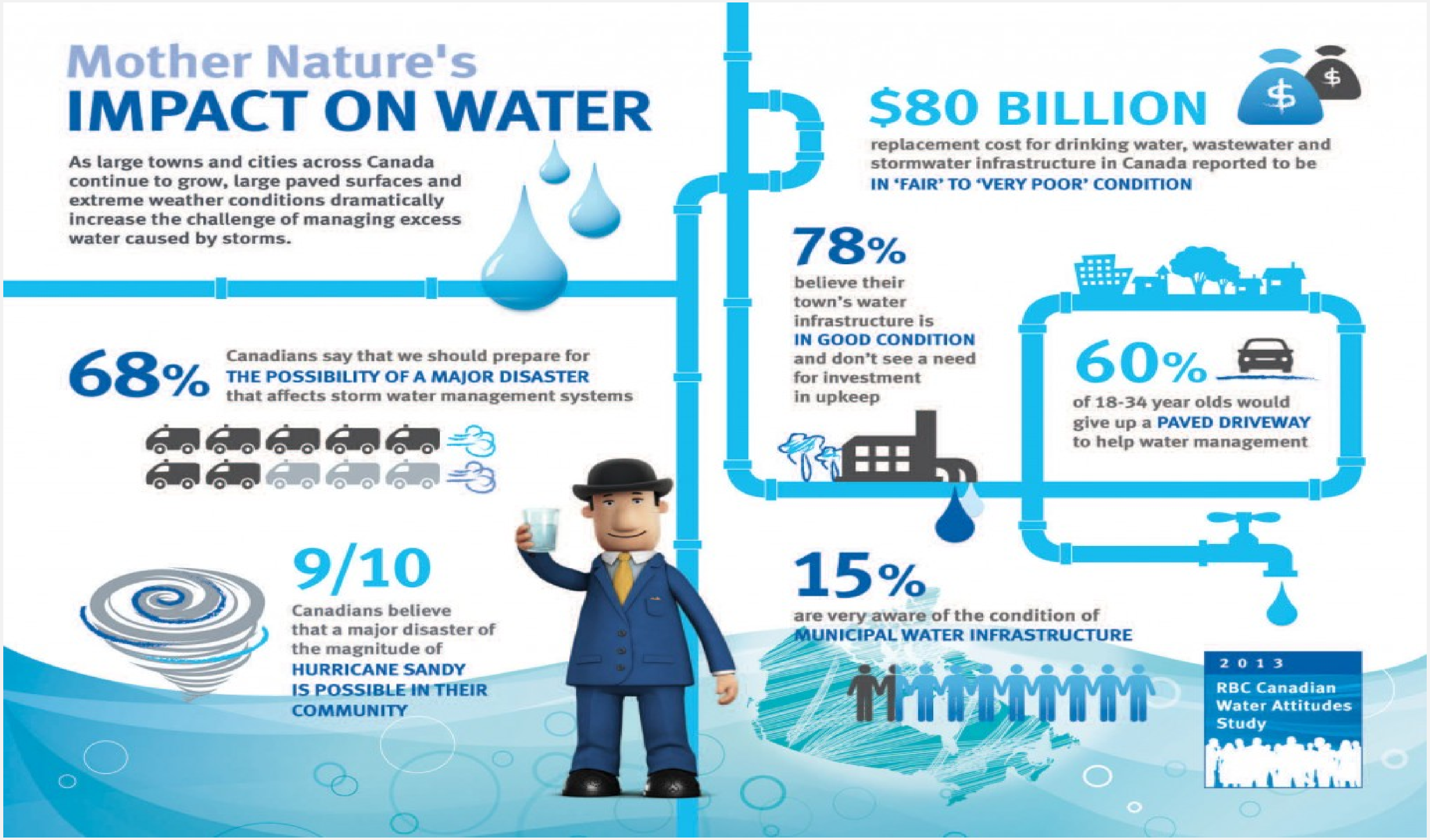




With Pandemic Influenza for example:

there will be a next time, but still no 2nd chance, or time out

There are far greater concerns facing Nanaimo drought, water interruptions, earthquakes



Categorized Disasters

Natural

Earthquake

Flood
Forest Fire
Landslide
Severe Weather
Wind Storm

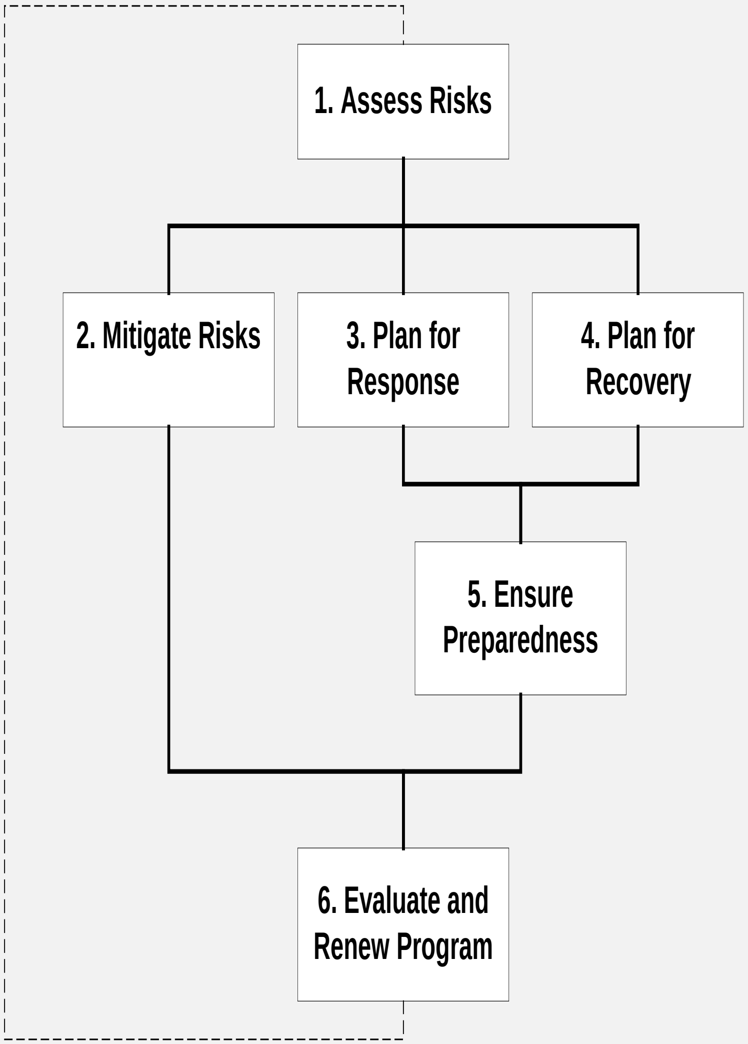
Industrial

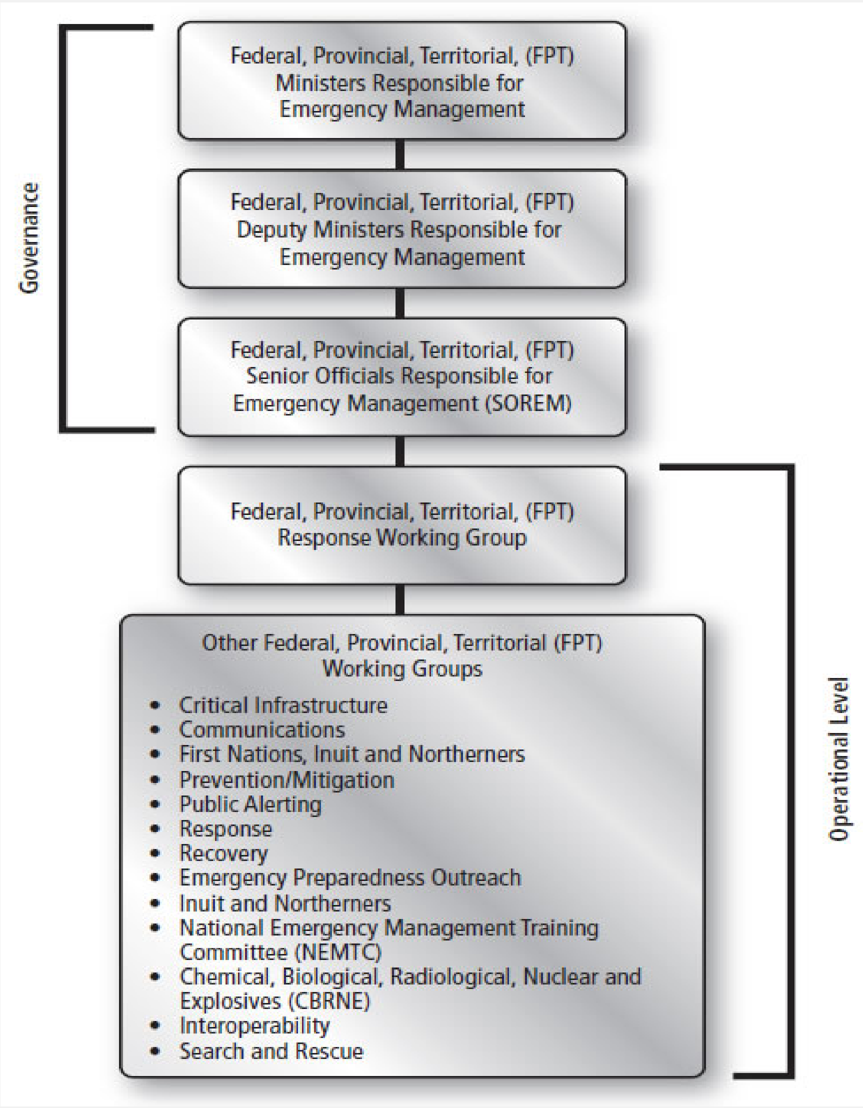
Urban Fire
Hazardous Materials
Explosion
Structural Collapse
Transportation

Social/Political

Bomb Threat
Sabotage/Terrorism
Riot

EMERGENCY PLANNING OBJECTIVES





LOCAL AND INTERGOVERNMENTAL PLANNING OBJECTIVES

Emergency Program Guide

Strategies for the Six objectives.

Objective 1 — Assess Risks 1-1 Identify and Map Vulnerabilities 1-2 Research Risk Questions, Record Results 1-3 Identify and Map Risk Areas 1-4 Upgrade Risk Assessment Report	**Objective 4 — Plan for Recovery** 4-1 Establish Recovery Procedures 4-2 Identify Sources of Assistance 4-3 Adopt Community Redevelopment Plans
Objective 2 — Mitigate Risks 2-1 Identify Mitigation Options 2-2 Promote Fire Safe Community Program 2-3 Mitigate Dangerous Goods Risks 2-4 Facilitate Flood, Landslide Program 2-5 Revise Land Use Plan to Mitigate Risks	**Objective 5 — Ensure Preparedness** 5-1 Identify ECC Members and Alternates 5-2 Establish ECC Facilities and Equipment 5-3 Train ECC and Other Personnel 5-4 Conduct Exercises and Debrief 5-5 Advise Public on Preparedness
Objective 3 — Plan for Response 3-1 Verify Resource Contact Information 3-2 Update Agency Plans and Agreements 3-3 Plan for Evacuations 3-4 Facilitate ESS Program 3-5 Update Plan 3-6 Verify Response Capabilities	**Objective 6 — Evaluate & Renew Program** 6-1 Develop Record-Keeping Systems 6-2 Design Annual Report 6-3 Develop and Recognize Volunteers 6-4 Upgrade Program Guide

There are far greater concerns facing our NANAIMO and region

- Aircraft Crash
- Atmospheric Hazards
- Dam Failure
- Disease and Epidemics
- Drought
- Explosion
- Fire
  - Urban
  - Industrial
- Flooding
- Hazardous Materials
- Landslide or Debris Flows
- Lost Persons
- Marine incident
- Motor Vehicle crashes
- Power Outages
- Rail Crashes
- Seismic Event
- Social disturbance
- Structural Collapse
- Telecommunications failure
- Terrorism
- Volcanic Ash Fallout
- Wildfires

Manifest Local Threats

Getting back to Life or Business as usual.

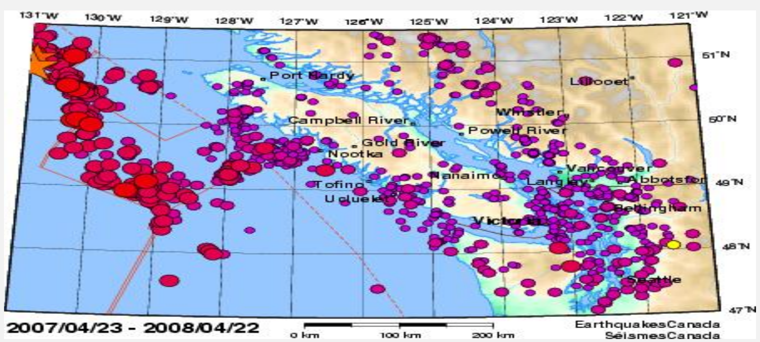
Simple subjective numeric risk calculations

Consequence

- 4 Catastrophic
- 3 Major
- 2 Serious
- 1 Minor

Probability

- 4 Certain
- 3 Probable
- 2 Possible
- 1 Unlikely



Earthquake 4 x 2 = 8

Hazmat 3 x 3 = 9

Simple subjective numeric risk calculations for ***dams***

Consequence

- 4 Catastrophic
- 3 Major
- 2 Serious
- ***1 Minor***

Q 1000 yr 1 x 1 = 1

Probability

- 4 Certain
- 3 Probable
- ***2 Possible*** worst
- ***1 Unlikely***

at worst 1 x 2 = 2

Risk Assessment - WTSHTF

- Aircraft Crash
- Atmospheric Hazards
- ***Dam Failure***
- Disease and Epidemics
- Drought
- Explosion
- Fire
  - Urban
  - Industrial
- Flooding
- Hazardous Materials
- Landslide or Debris Flows
- Lost Persons
- Marine incident
- Motor Vehicle crashes
- Power Outages
- Rail Crashes
- ***Seismic Event***
- Social disturbance
- Structural Collapse
- Telecommunications failure
- Terrorism
- Volcanic Ash Fallout
- Wildfires

Getting back to Life or Business as usual!

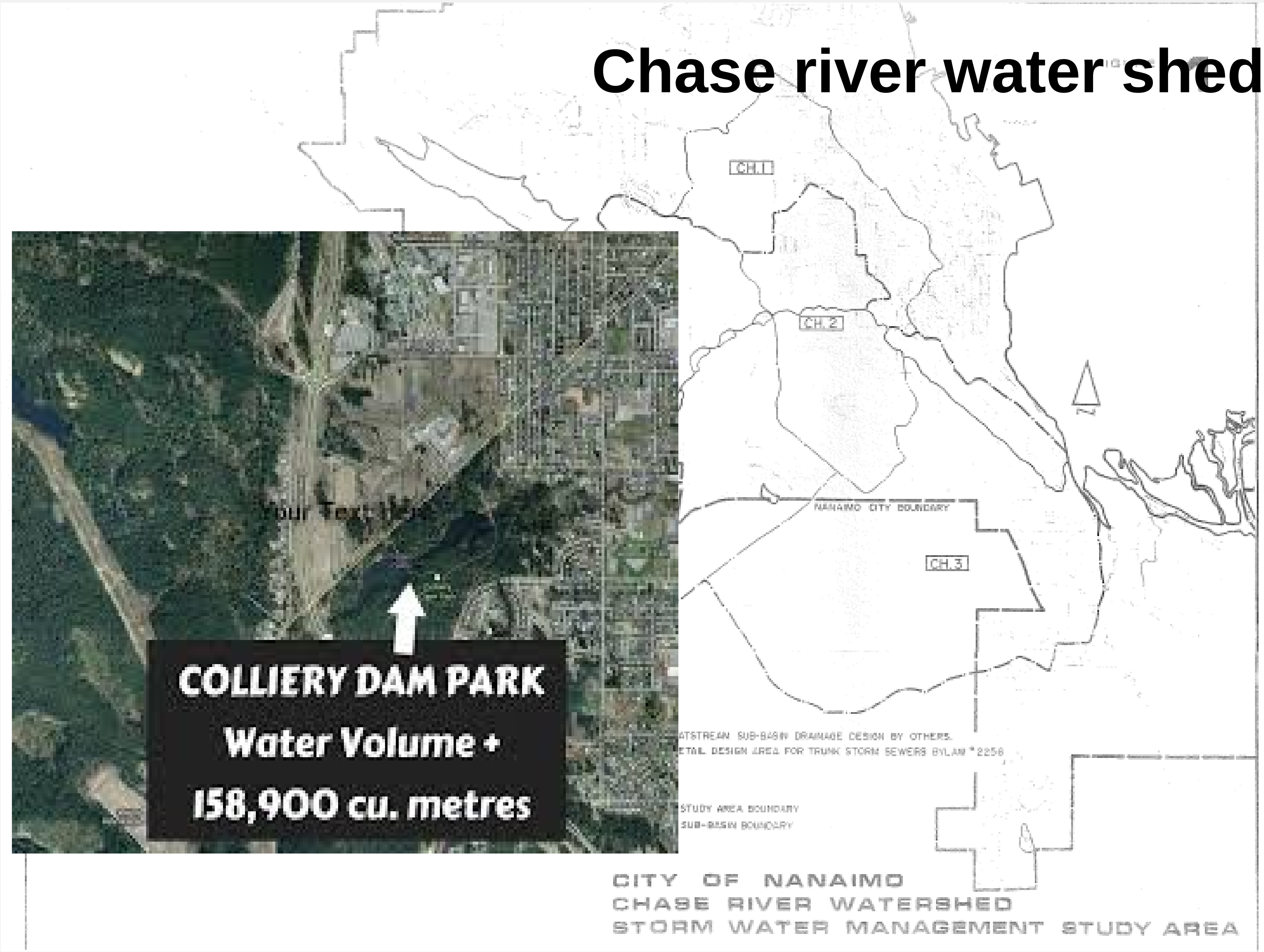
RISK IS ACCEPTABLE

- Under this BC regulation, emergency plans prepared by local authorities must reflect an:

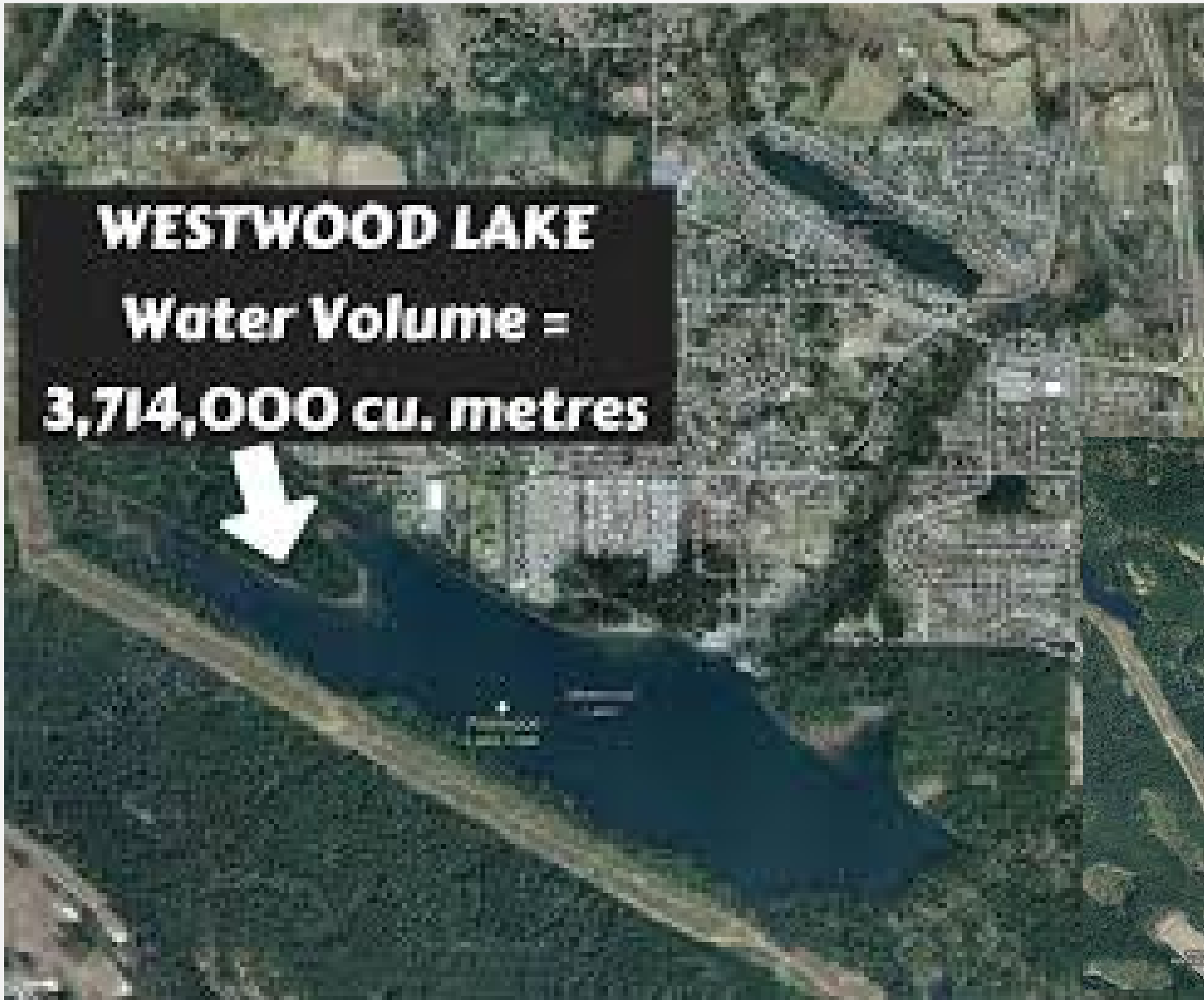
...assessment of the relative risk of occurrence and the potential impact on people and property of emergencies or disasters...

- Identify threats
- To Provide framework for identifying and managing risks.
- Identify risks associated with a particular course of actions designed to deliver a particular outcome.
- Once identified those risks are managed to limit the potential of adverse results and achieve the desired outcomes.
- Risk management is a cyclical process.

Chase river water shed



REMINDER OF WESTWOOD LAKE, COLLIERY DAM

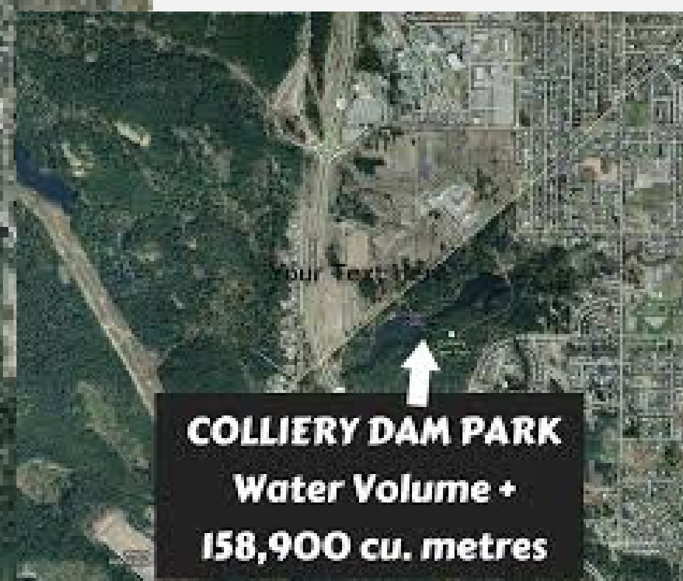


9 DAMS

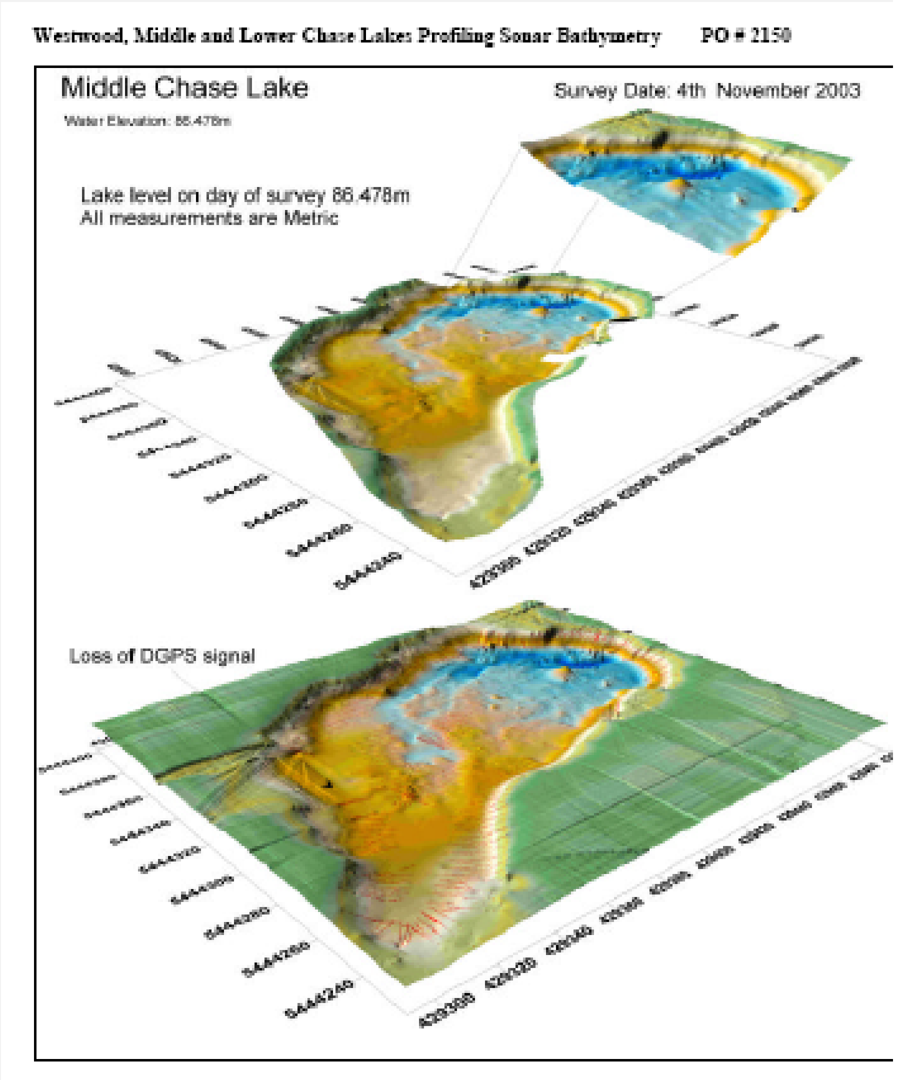
EXIST

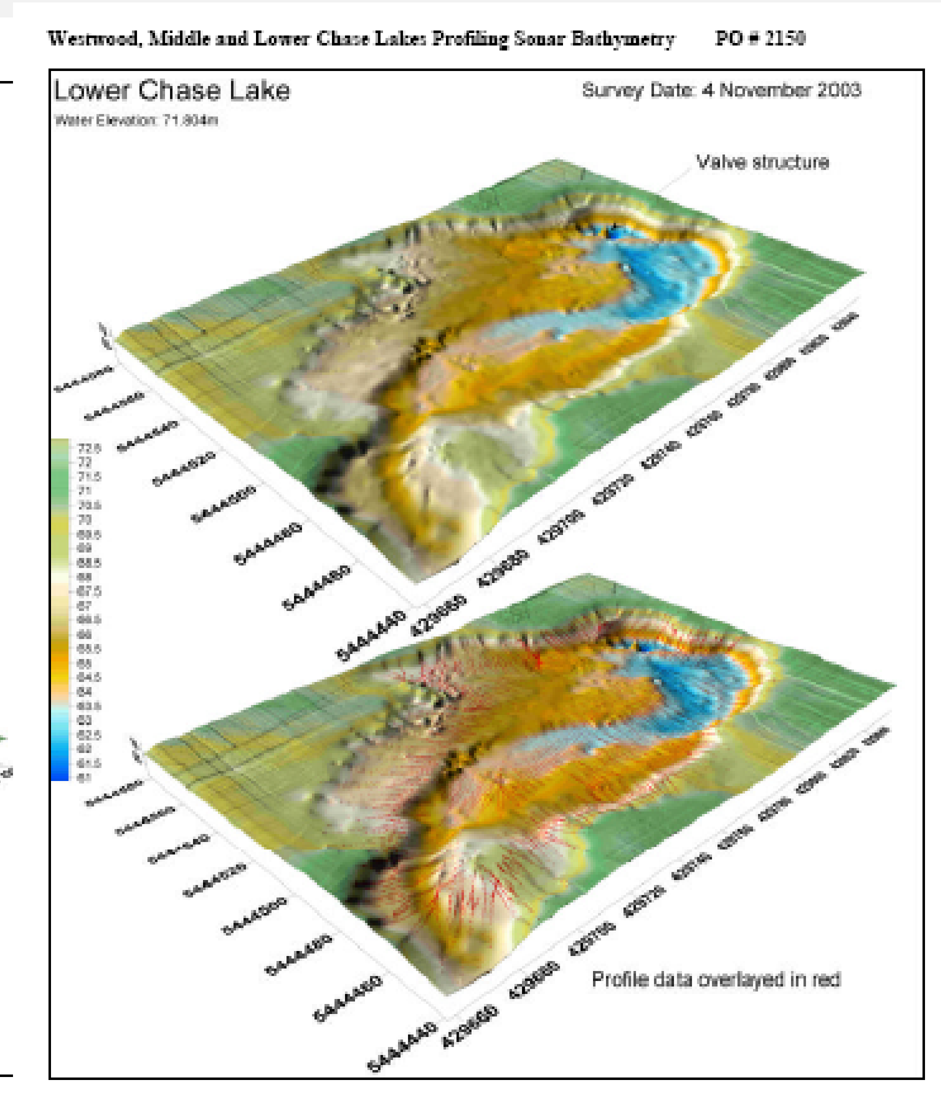
IN

THE CITY



Watershed catchments the ponds





7 Principles of Risk Management

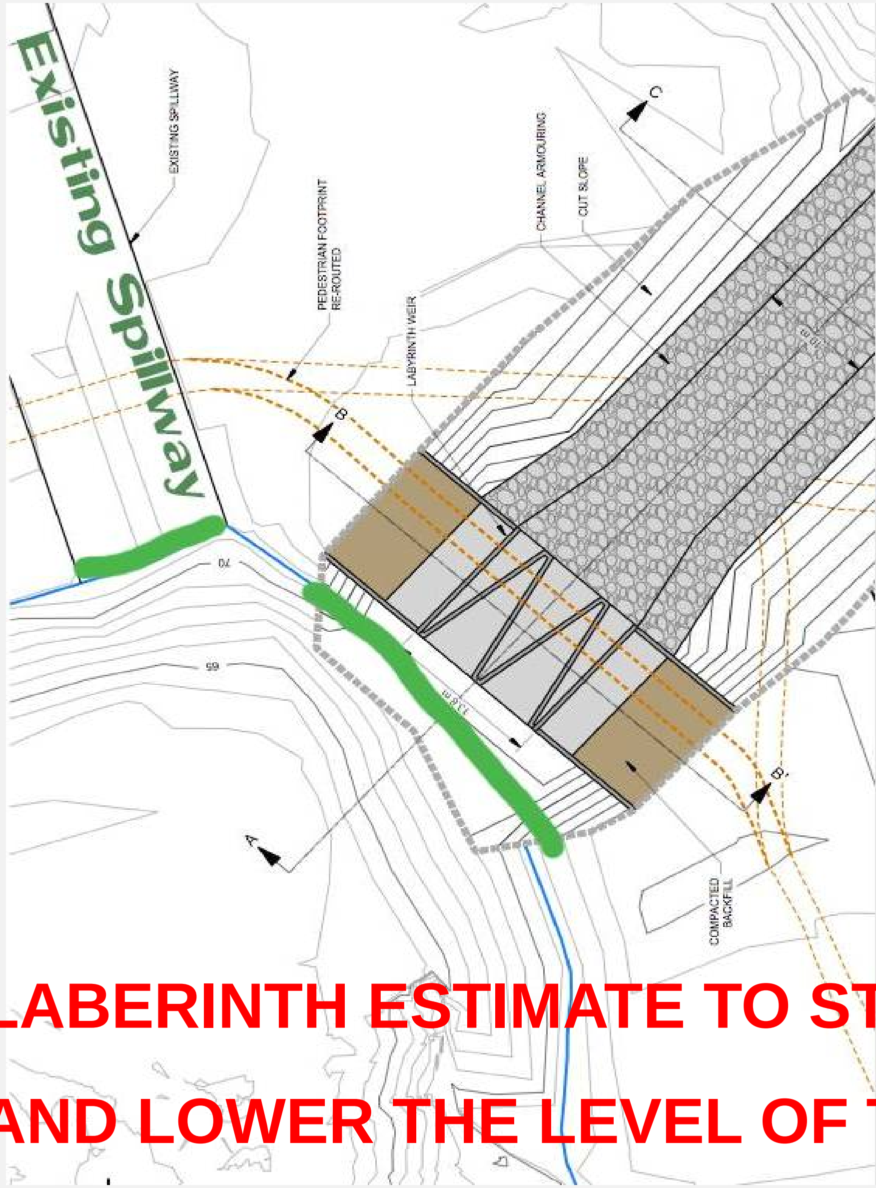
1. Global perspective
2. Forward-looking view
3. Open communication
4. Integrated management
5. Continuous process
6. Shared product vision
7. Teamwork

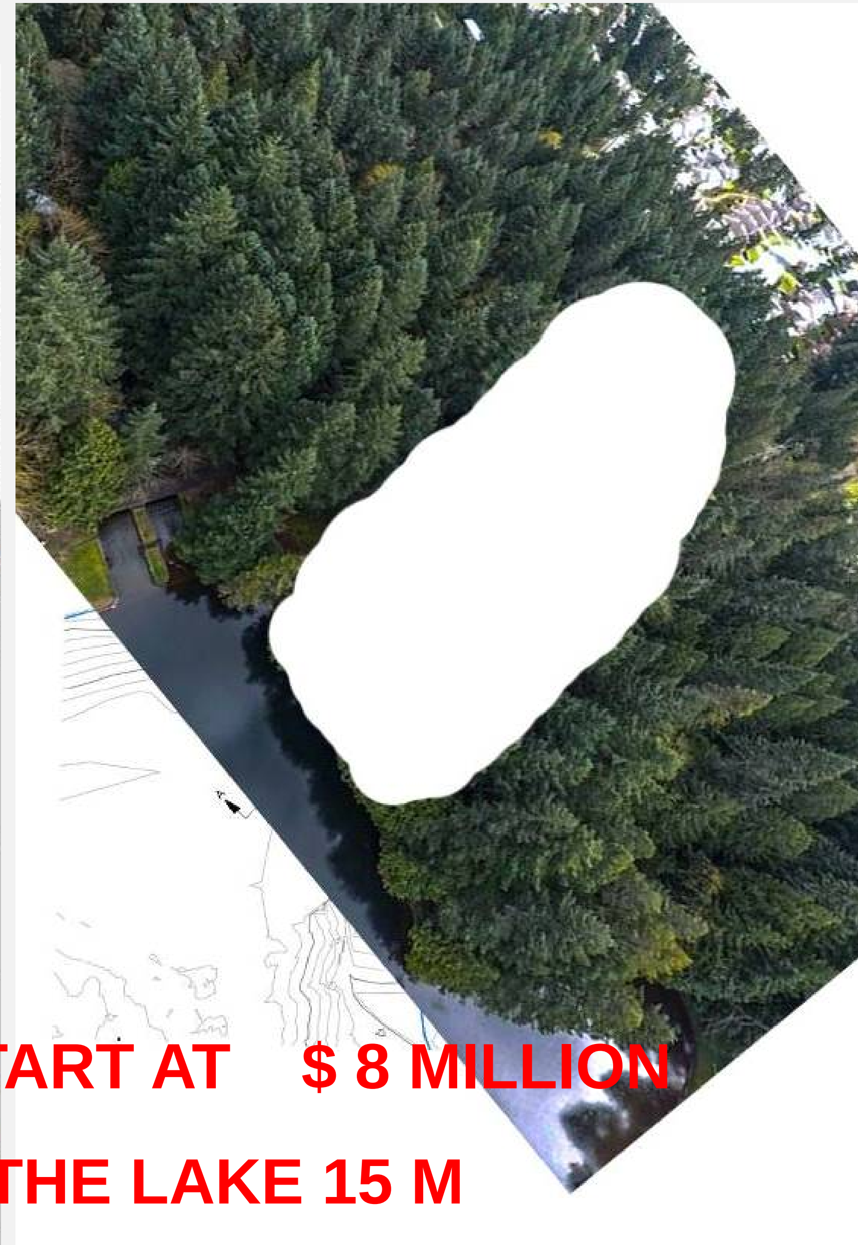
ASK YOURSELF IF A FEW PRINCIPALS GOT MISSED IN THE PROCESS??

DO THE LEAST INTRUSIVE

CULTURALLY SIGNIFICANT TREES AND AREA…

SPILLWAYN PLAN MILLIONS OF $'S PLUS VERY INTRUSIVE



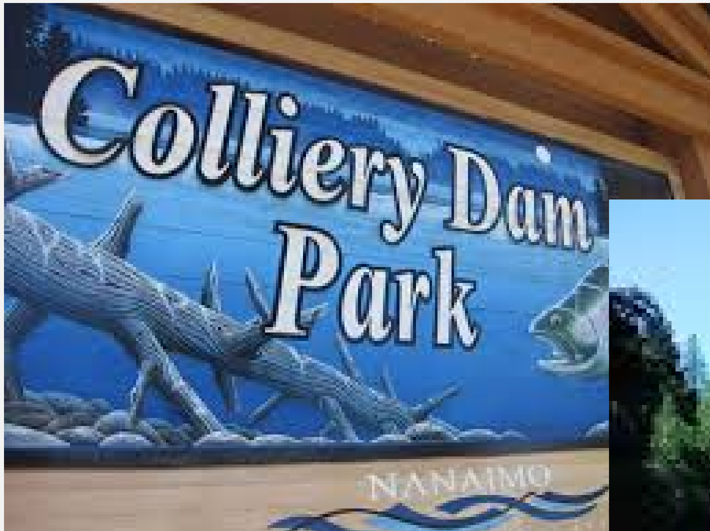


LABERINTH ESTIMATE TO START AT $ 8 MILLION

AND LOWER THE LEVEL OF THE LAKE 15 M

THAT’S THE HISTORY

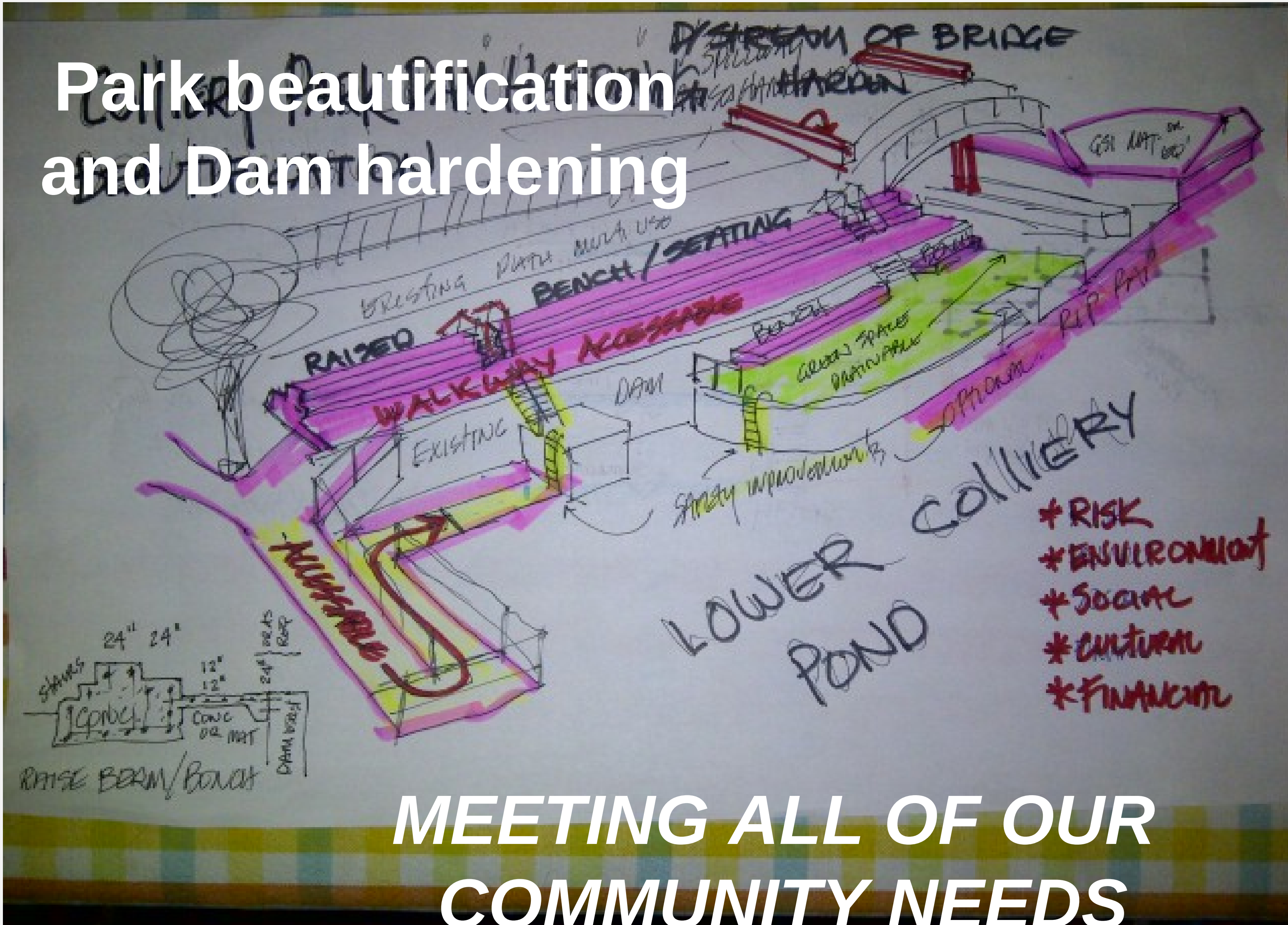
NOW THE FUTURE



MANAGE THE OVERTOPPING???

BY MASSIVE EXCAVATION AND WIDENED SPILLWAY?

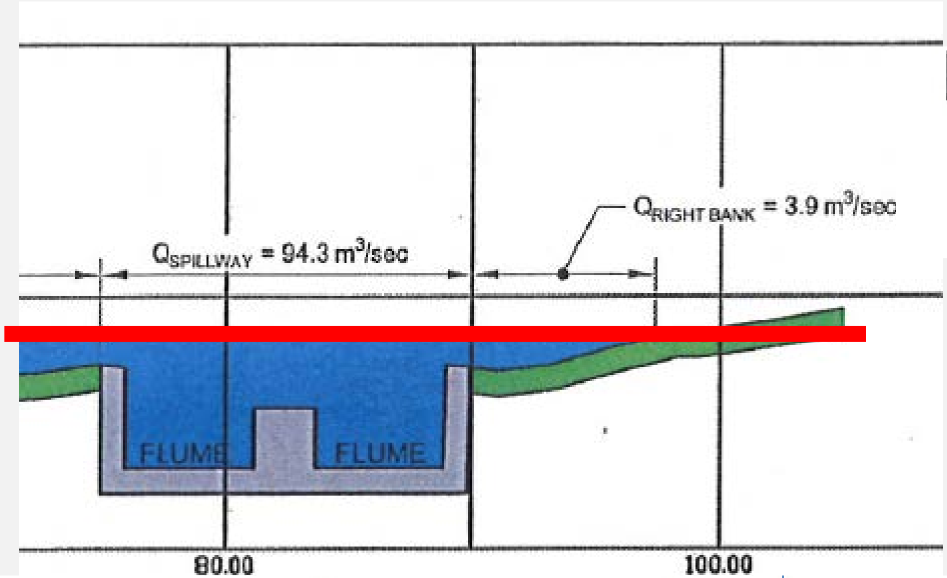
Park beautification and Dam hardening



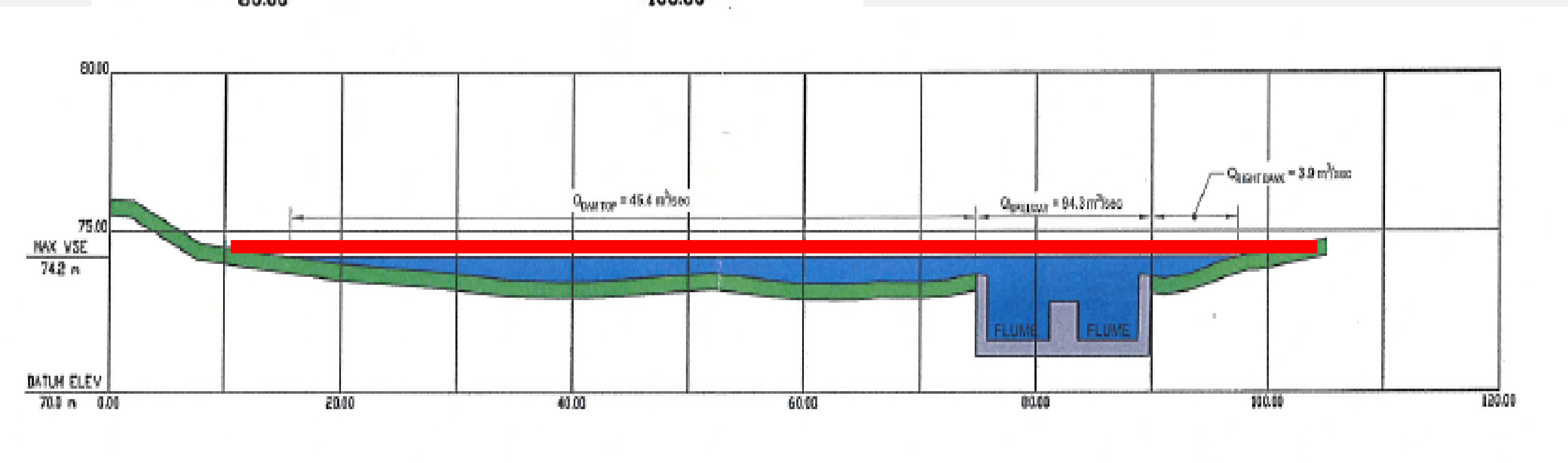
MEETING ALL OF OUR COMMUNITY NEEDS

LOWER COLLIERY DAM OVERTOPPING

$Q_{1000\text{-YR}}$ + 2/3 ~~P~~MP

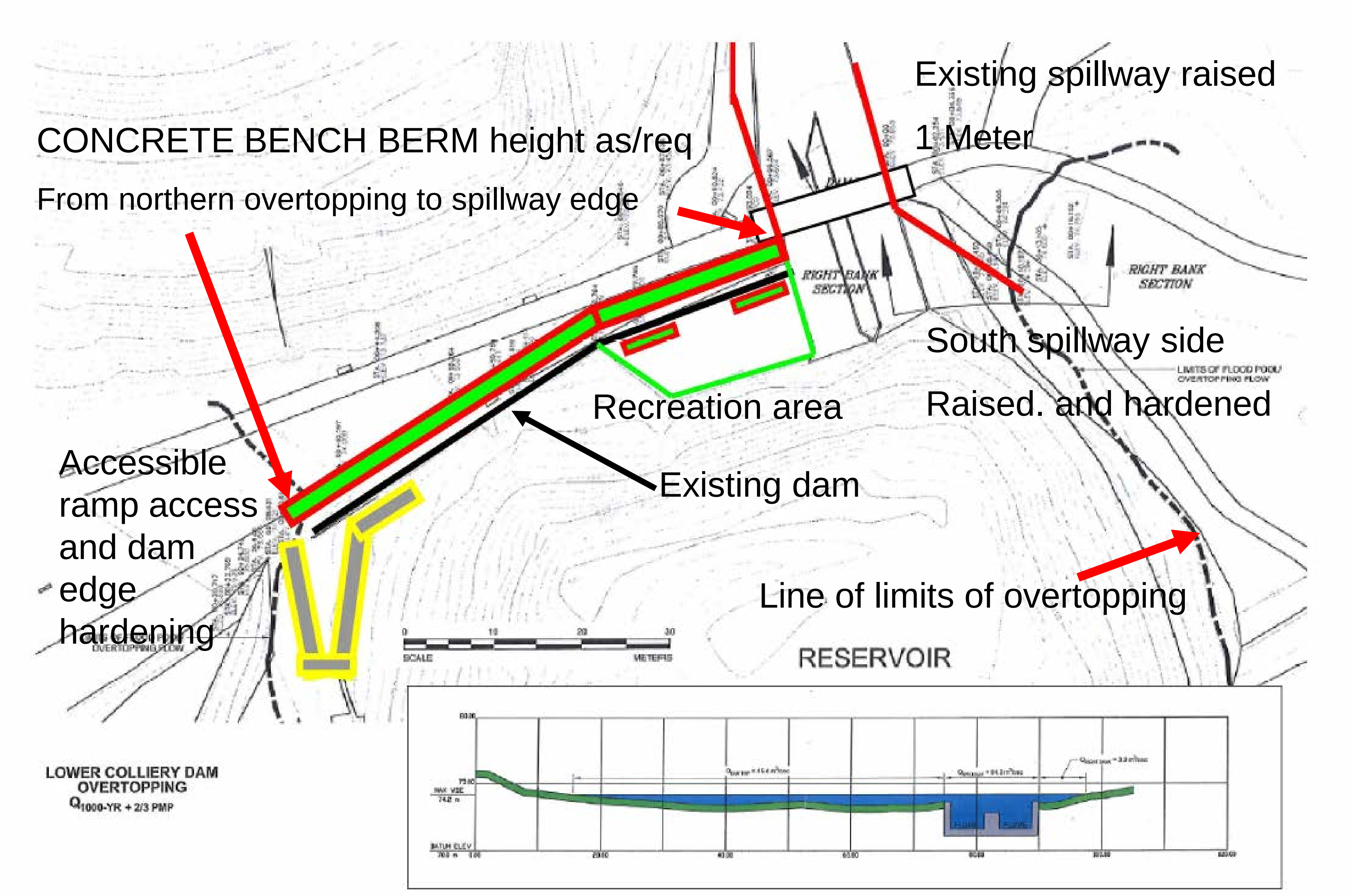


BASICALLY RAISE THE DAM MAX. HEIGHT 1 M.



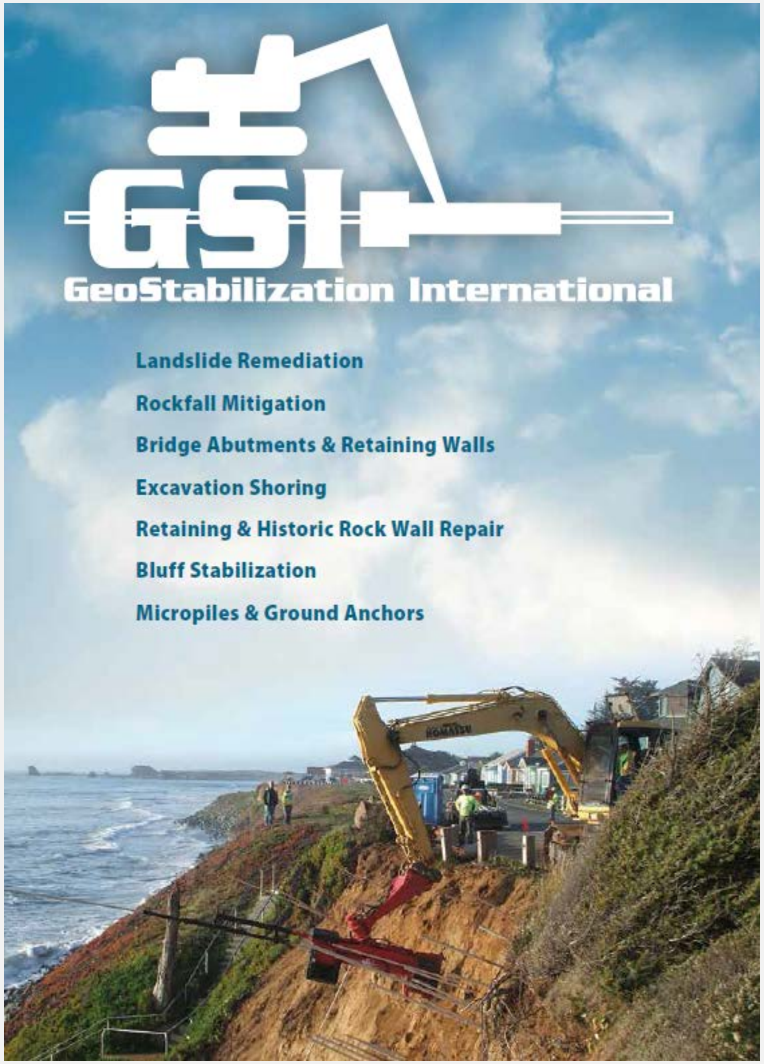
Q1000 AS ACCEPTABLE COMMUNITY RISK

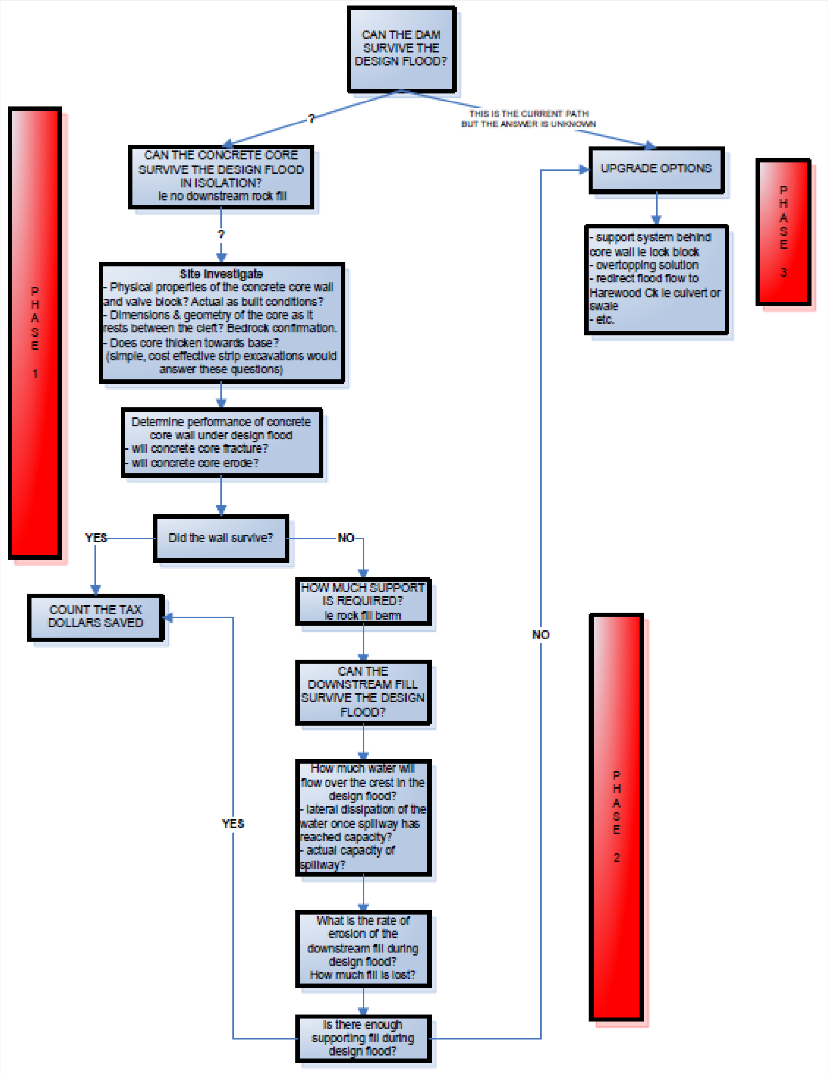
Hardening. Stabilization and Beautification



DAM BENCH/BERM SPILLWAY ENHANCMENT

Example of bench Berm in California for flooding from global warming.





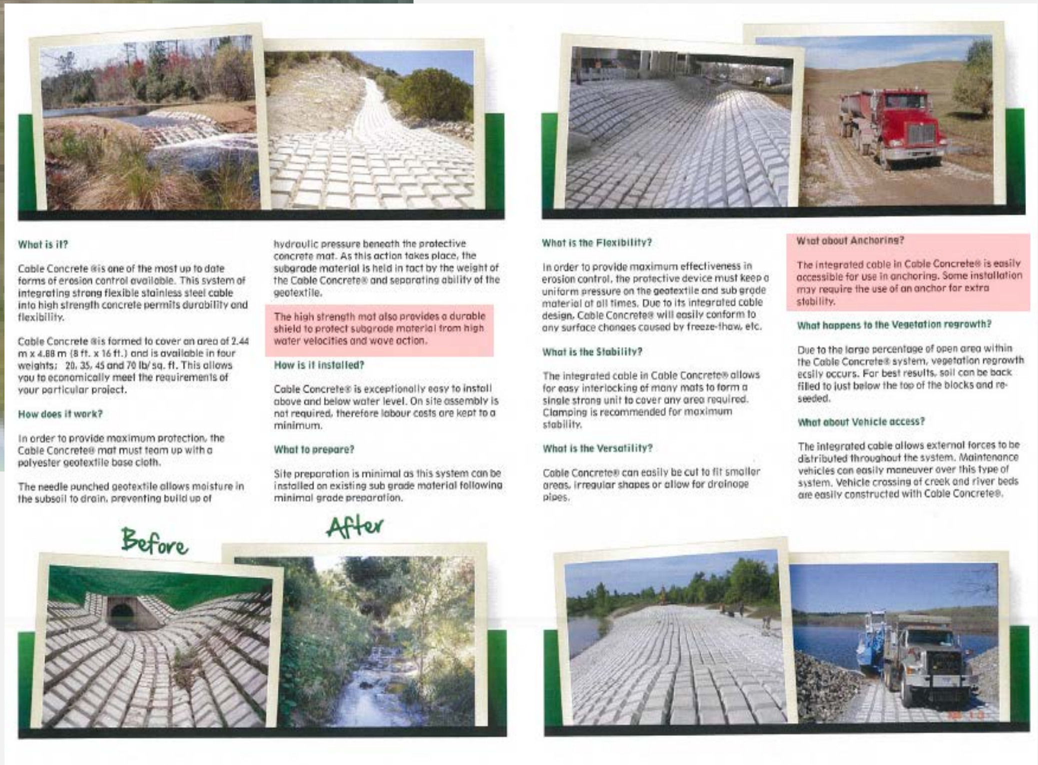
GeoStabilization to manage the risk

OVERTOPPING RISK MANAGED

GSI ANCHORING OF THE BERM BENCH

GEOSTABILIZATION FOR THE MIDDLE DAM

GEOSTABILIZATION FOR THE MIDDLE DAM



What is it?

Cable Concrete ®is one of the most up to date forms of erosion control available. This system of integrating strong flexible stainless steel cable into high strength concrete permits durability and flexibility.

Cable Concrete ®is formed to cover an area of 2.44 m x 4.88 m (8 ft. x 16 ft.) and is available in four weights: 20, 35, 45 and 70 lb/sq. ft. This allows you to economically meet the requirements of your particular project.

How does it work?

In order to provide maximum protection, the Cable Concrete® mat must team up with a polyester geotextile base cloth.

The needle punched geotextile allows moisture in the subsoil to drain, preventing build up of hydraulic pressure beneath the protective concrete mat. As this action takes place, the subgrade material is held in tact by the weight of the Cable Concrete® and separating ability of the geotextile.

The high strength mat also provides a durable shield to protect subgrade material from high water velocities and wave action.

How is it installed?

Cable Concrete® is exceptionally easy to install above and below water level. On site assembly is not required, therefore labour costs are kept to a minimum.

What to prepare?

Site preparation is minimal as this system can be installed on existing sub grade material following minimal grade preparation.

What is the Flexibility?

In order to provide maximum effectiveness in erosion control, the protective device must keep a uniform pressure on the geotextile and sub grade material at all times. Due to its integrated cable design, Cable Concrete® will easily conform to any surface changes caused by freeze-thaw, etc.

What is the Stability?

The integrated cable in Cable Concrete® allows for easy interlocking of many mats to form a single strong unit to cover any area required. Clamping is recommended for maximum stability.

What is the Versatility?

Cable Concrete® can easily be cut to fit smaller areas, irregular shapes or allow for drainage pipes.

What about Anchoring?

The integrated cable in Cable Concrete® is easily accessible for use in anchoring. Some installation may require the use of an anchor for extra stability.

What happens to the Vegetation regrowth?

Due to the large percentage of open area within the Cable Concrete® system, vegetation regrowth ecsily occurs. For best results, soil can be back filled to just below the top of the blocks and re-seeded.

What about Vehicle access?

The integrated cable allows external forces to be distributed throughout the system. Maintenance vehicles can easily maneuver over this type of system. Vehicle crossing of creek and river beds are easily constructed with Cable Concrete®.

Before

After

Addressing the overtopping failure

MIDDLE DAM AND DOWNSTREAM MITIGATION

Landslide Repair

Launched Soil Nail arrays can stop movement in shallow landslides—without excavation, drill cuttings or fluids, or significant site disturbance—and require only one lane of traffic closure during working hours. That translates to decreased environmental impact, a much reduced carbon footprint and significant project time and cost savings compared with more traditional repair techniques.
GSI® can typically provide design-build-warranty landslide repairs. That means that GSI® engineers or technicians will provide a no-cost no-obligation visit to any landslide.

After surveying the site and gathering data, a design and guaranteed fixed-cost proposal will be submitted to the client. In emergency situations, we routinely have crews installing nails three days or fewer after a failure and often have the road open to traffic within the week. With over 1000 landslides repaired to date, no other company has the experience, tools, rapid response time or guarantee of GSI®.

GSI® engineers use the most cutting edge limit equilibrium and finite element analysis programs to evaluate slope stability. The models are powerful tools, but only when coupled with proper input data and the experience and intuition to understand the results. At any given time our team is involved in several research projects sponsored by the company or by public entities. That translates into the newest methods and technologies going from concept to verification to implementation with no delays and with significant cost and time savings to our clients.

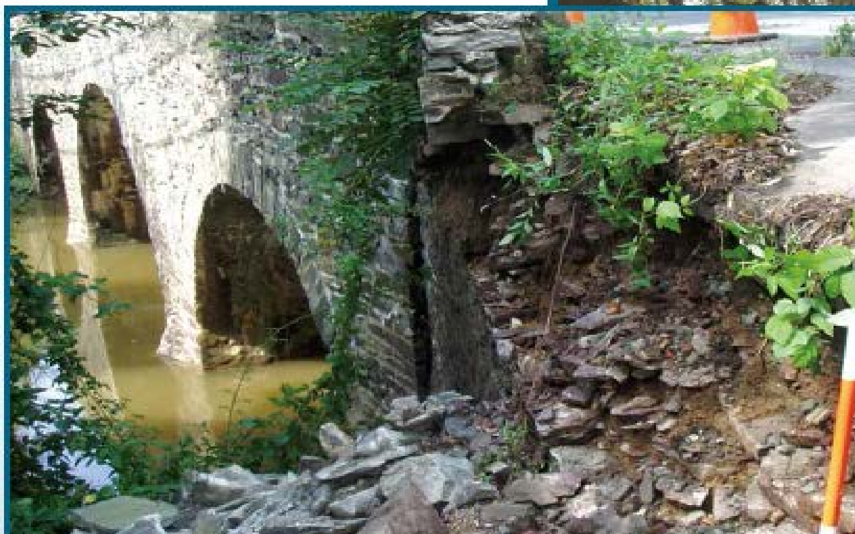
Complex Landslide Repair, WV

HISTORIC AND CULTURAL VALUES

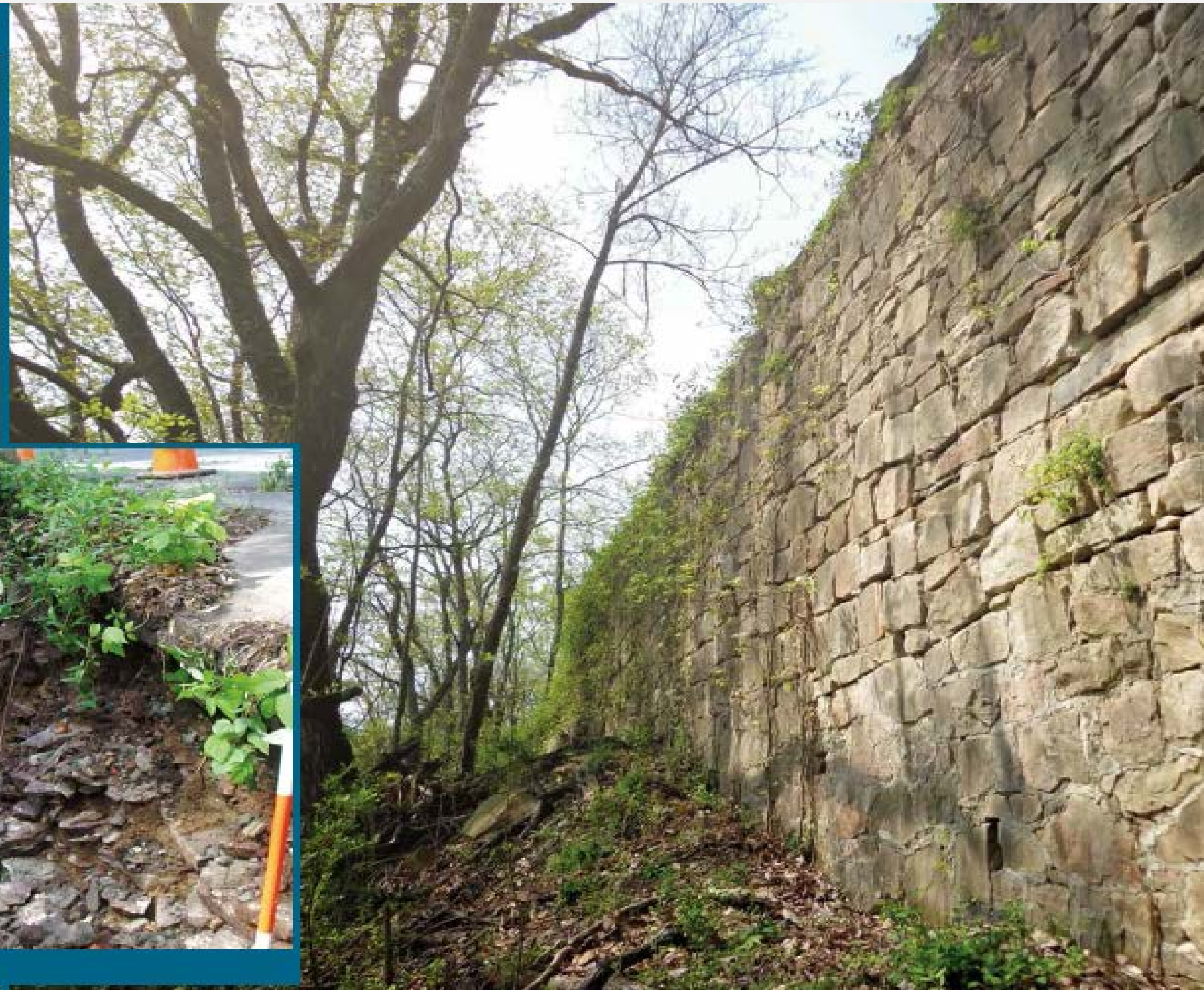
Historic Rock Wall Repair

GSI® has an impressive resume of historic rock wall preservation projects. Working in conjunction with roadway owners and local historical societies, our team of design engineers, operators and skilled masons can repair and restore even the most deteriorated of structures.

If the facing is mostly intact, an array of SuperNails® can provide reinforcement for the structure. If the wall has deteriorated badly, a combination of permanent stabilization and skilled re-stacking of the salvaged stone can return the wall to its original appearance.
GSI® employs masons who can emulate a wide variety of stacking patterns.



18th Century Rubble Wall Repair, Princeton, NJ



GSI financial proposal

Collieries Dam Overtopping Erosion Protection proposal
Based off all that we have been privy to and our extensive experience, our preliminary fee estimates indicate we can complete all the necessary works to protect

BOTH the Lower and the Middle dams from the catastrophic overtopping failure **for $3 Million or less.**
this fee would include:

- All engineering and sign off, based off the Golder flood flow calculations, and other engineering completed to date.
- Supply and installation of the matts, anchors and landscape works required to complete the works

This total project cost projection indicates a SAVINGS of:

- **$5.1+ Million savings,** as compared to the Proposed Spillway option, for Lower Dam only,
- **$4.2+ Million savings**, as compared to the Alternative Overtopping Option, for Lower Dam only.

As mentioned before, GSI fee estimates are an all inclusive cost for the project as a whole and due to extraordinary efficiencies found within our project delivery model this 50% cost saving are our norm and not unexpected.

If the City was to give us confirmation that they would entertain our proposal, we would be most pleased to:

- complete the final design and fee estimate; pro bono,
- Present the proposal to the City in a document format,
- and present our proposal in a live presentation meeting.

Thank you kindly for your consideration.
Sincerely,
Peter Bullock, P.Eng., M.Eng. Principal Engineer

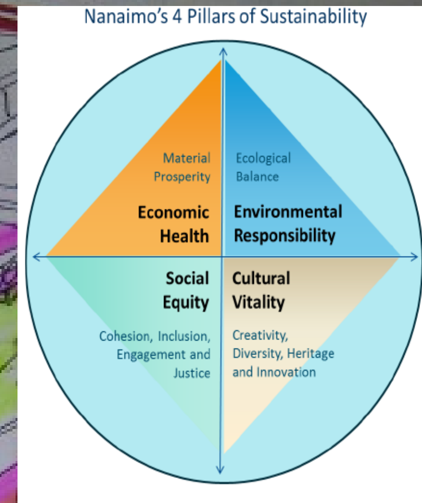
RISK, MANAGEMENT OF OVERTOPPING

ENVIRONMENT, LIMITED INSTREAM WORK

SOCIAL, PARK ENHANCEMENTS AND SAFETY

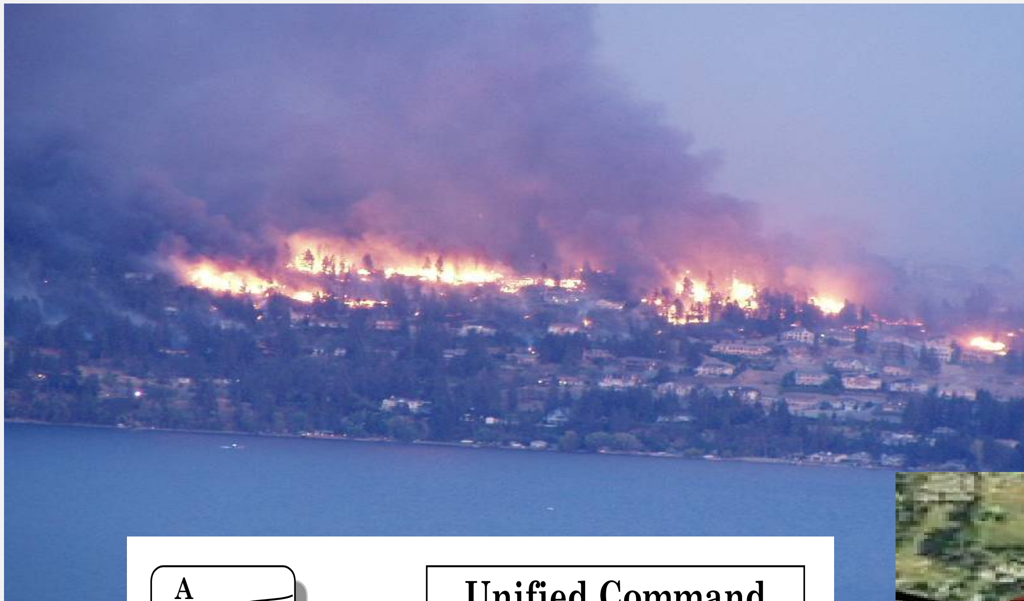
CULTURAL, HISTORIC VALUES PROTECTED

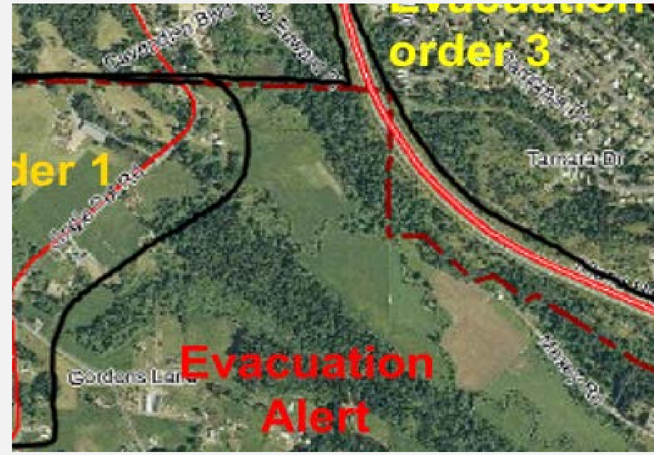
FINANCIAL, LEAST INTRUSIVE AND ECONOMICAL

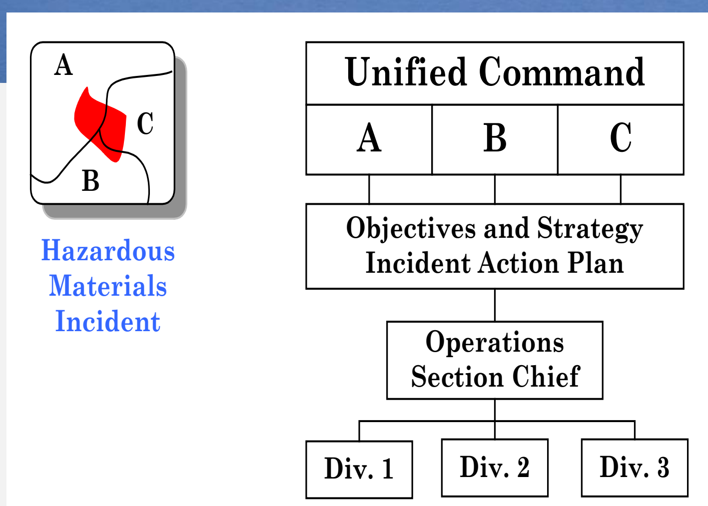


MEETING ALL OF OUR COMMUNITY PILLARS

Evacuation planning mapping, response and recovery







SIGNAGE AND NOTICES

MANAGE THE RISK

SAFETY FOR SOCIAL EVENTS

PROTECT THE HISTORY

Protect the Social Equity

Societal norms of acceptable risk

Table 6-1 CDA Dam Safety Guidelines 2007

Table 6-1: Suggested Design Flood and Earthquake Levels (for Use in Deterministic Assessments)

Dam class [note 1]	AEP	
	IDF [note 2]	EDGM [note 3]

PMF" or "2/3 between 1/1000 year and PMF" has no defined AEP.

Note 6. The EDGM value must be justified to demonstrate conformance to sócietal norms of acceptable risk. Justification can be provided with the help of failure modes analysis focused on the particular modes that can contribute to failure initiated by a seismic event. If the justification cannot be provided, the EDGM should be 1/10,000.

Note 3. AEP levels for EDGM are to be used for mean rather than median estimates of the hazard.

Note 4. Selected on the basis of incremental flood analysis, exposure, and consequences of failure.

Note 5. PMF has no associated AEP. The flood defined as "1/3 between 1/1000 year and PMF" or "2/3 between 1/1000 year and PMF" has no defined AEP.

Note 6. The EDGM value must be justified to demonstrate conformance to sócietal norms of acceptable risk. Justification can be provided with the help of failure modes analysis focused on the particular modes that can contribute to failure initiated by a seismic event. If the justification cannot be provided, the EDGM should be 1/10,000.

Societal norms of acceptable risk

The overall dam safety framework should ensure that no individuals or communities are unduly affected in the interest of the broader societal interests. On the other hand, society does not have infinite resources to spend on managing risks and often the resource spent inefficiently in one area is the same resource that is missing in another area where investment could be more beneficial. Effective application of the balanced equity-efficiency approach requires acknowledgment that both economic efficiency and social equity are legitimate goals that society wants to pursue.

- *Individual risk* relates to concerns of how individuals see the risk from a particular hazard affecting them and their property. It is usually defined as the risk to a hypothetical member of the public living in the zone that can be affected in the event that a hazard occurs. The criteria for individual risk depend on such factors as whether or not the exposure is voluntary, whether the individual derives benefit from accepting the risk, whether the individual has some control over the risk, and whether the risk engenders particular dread.
- *Societal risk* generally refers to hazards that, if realized, could impact society and thus cause socio-political response. Societal risk may be seen as a relationship between the frequency of a particular hazard and the number of casualties if the hazard is realized. In applications dealing with hazards from engineered installations where the predominant issue is life safety, societal risk is characterized by graphs showing frequency of events that could cause multiple fatalities.

An action to reduce the risk is clearly necessary if the risk is not acceptable. The ALARP principle is based on the duty to reduce risks to life to the point where further risk reduction is impracticable or requires action that is grossly disproportionate in time, trouble, and effort to the reduction of risk achieved.

ACCEPTABLE CONSEQUENCES

Table 6-1B: Flood and Earthquake Hazards, Standards-Based Assessments

2013 Revision

(Target Levels for Initial Consideration and Consultation between Owner and Regulator)

Dam Class [note 1]	Annual Exceedance Probability – Floods [note 2]	Annual Exceedance Probability - Earthquakes [note 3]
Low	1/100	1/100
Significant	Between 1/100 and 1/1000 [note 4]	Between 1/100 and 1/1000
High	1/3 between 1/1000 and PMF [note 5]	1/2475 [note 6]
Very High	2/3 between 1/1000 and PMF [note 5]	1/2 between 1/2475 [note 6] and 1/10,000 or MCE [note 5]
Extreme	PMF [note 5]	1/10,000 or MCE [note 5]

This table addresses two major natural hazards only, and does not consider the many other types of hazard that must be considered in dam safety assessments.

Acronyms: PMF, probable maximum flood; AEP, annual exceedance probability; MCE, maximum credible earthquake

Note 1. As defined in Table 2-1, Dam Classification (Section 2.5.4)

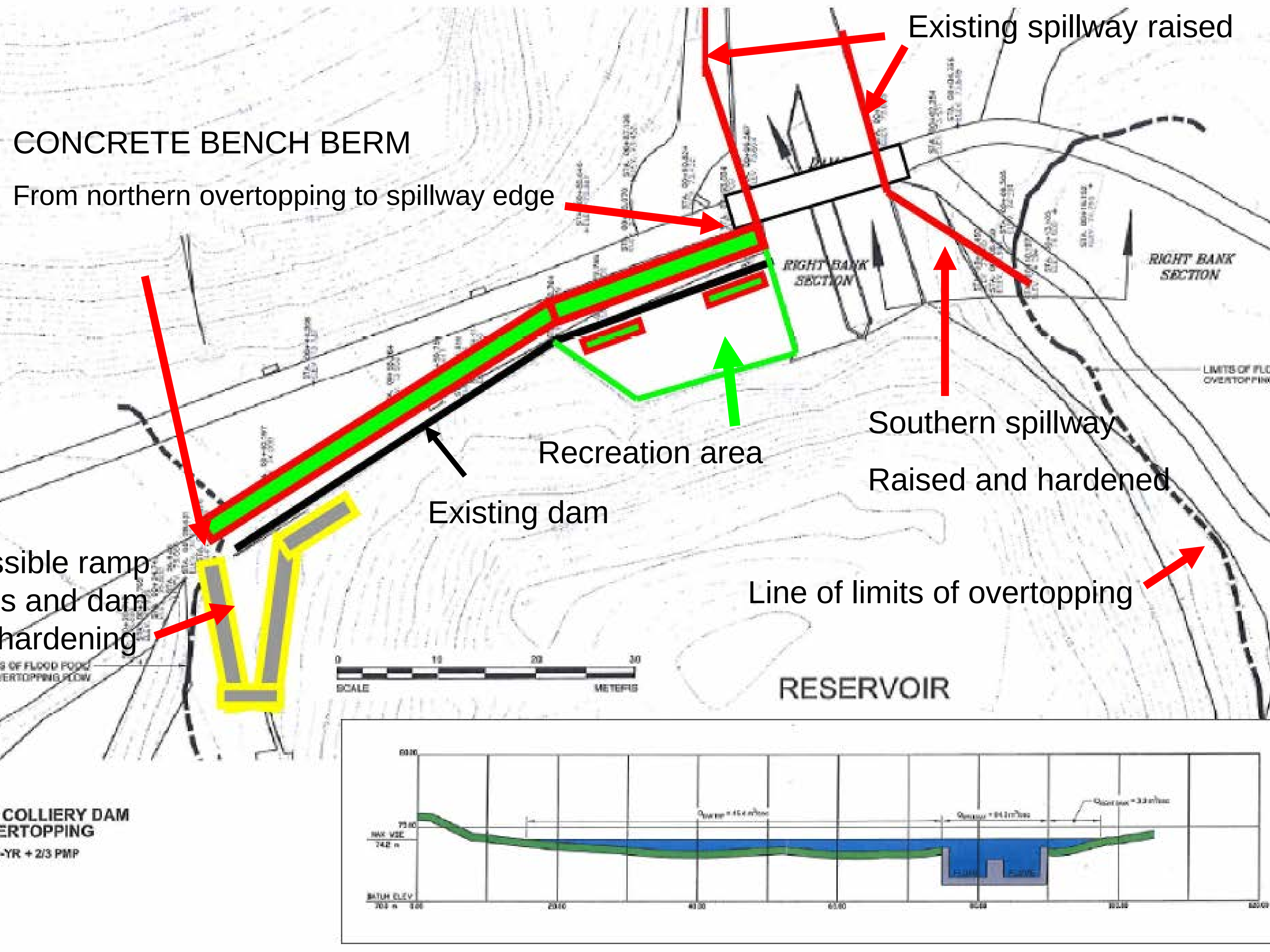
Note 2. Simple extrapolation of flood statistics beyond 10^{-3} AEP is not acceptable.

Note 3. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined in Table 6-1B is then input as the contributory earthquake(s) to develop the Earthquake Design Ground Motion (EDGM) parameters as described in Section 6.5 of these guidelines.

Note 4. Selected on basis of incremental flood analysis, exposure, and consequences of failure

Note 5. PMF and MCE have no associated AEP.

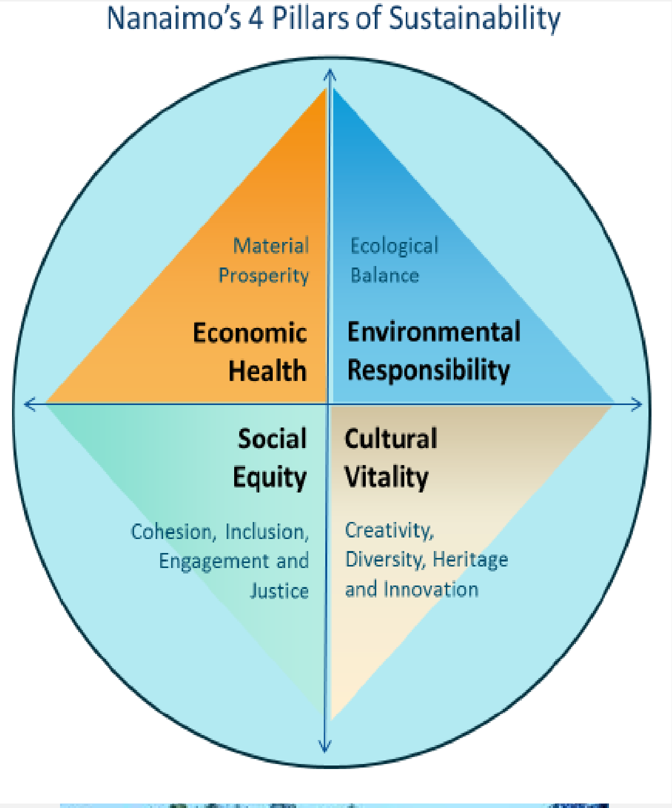
Note 6. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.



Existing spillway raised
CONCRETE BENCH BERM
From northern overtopping to spillway edge
RIGHT BANK SECTION
RIGHT BANK SECTION
Recreation area
Southern spillway
Raised and hardened
Existing dam
ssible ramp
s and dam
hardening
Line of limits of overtopping
SCALE
METERS
RESERVOIR
COLLIERY DAM
ERTOPPING
-YR + 2/3 PMP

Do the right thing – meet the greater needs

- ***Risk by management of overtopping***
- ***Environment concerns with limited in stream work***
- ***Social equity, park enhancements and public safety***
- ***Cultural, Historic values protected***
- ***Financially MOST economical AND***
- ***Least intrusive***



And You Know it's Bad Storm Coming When…….

Pleased to take any questions