Cheekeye River Fan Geohazards, risks and residential development

July 15, 2014, Squamish

DR. MATTHIAS JAKOB, P.GEO. AND DR. SCOTT MCDOUGALL, P.ENG.
BGC ENGINEERING INC.

Outline

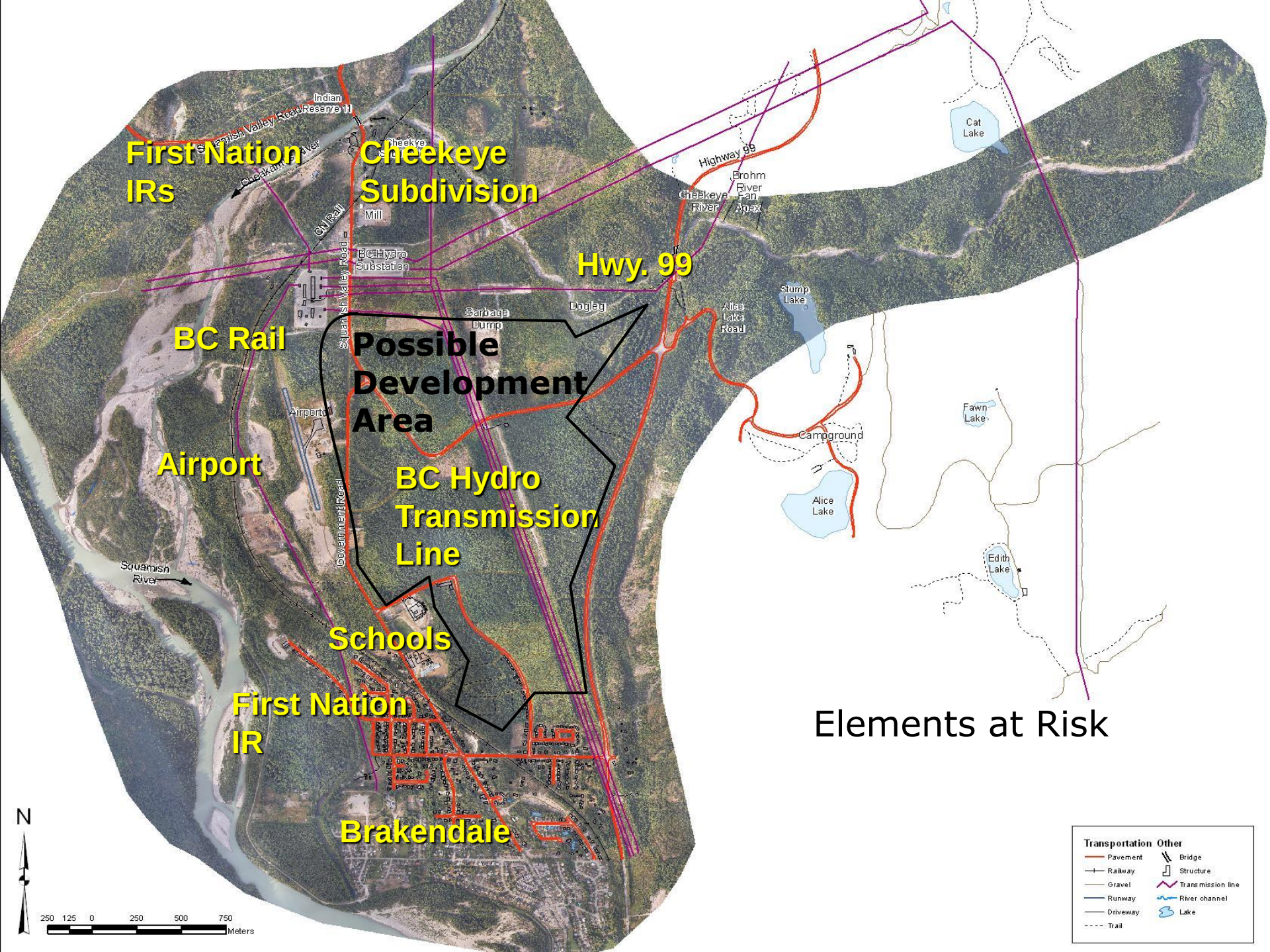
- Background and Process
- Objectives
- Glacial history and fan evolution
- Rock Avalanche Modeling
- Frequency – Magnitude Analysis
- Mitigation Concepts
- Summary

Objectives

- Establish a reliable frequency-magnitude relationship of debris flows
- Estimate/model the hazard intensity on the fan
- Estimate the existing risk for loss of life on the fan
- Can portions of the fan be safely occupied? If so, what type and scale of mitigation is needed?
- What can be done to improve current resident's safety and reduce hazard of future development to tolerable levels?
- In absence of legislated levels of risk tolerance, what levels are deemed tolerable by the DoS/the province?

Current Elements at Risk

First Nations Reserves
Don Ross Secondary School
Brackendale Elementary School
Brackendale Residential
Highway 99 Users
Cheekeye Bridge
BC Railway
Squamish Airport
DOS Infrastructure
BC Hydro Substation and Transmission Line
Ross Road
Saw Mill
Squamish Valley Road
Cheekeye Development

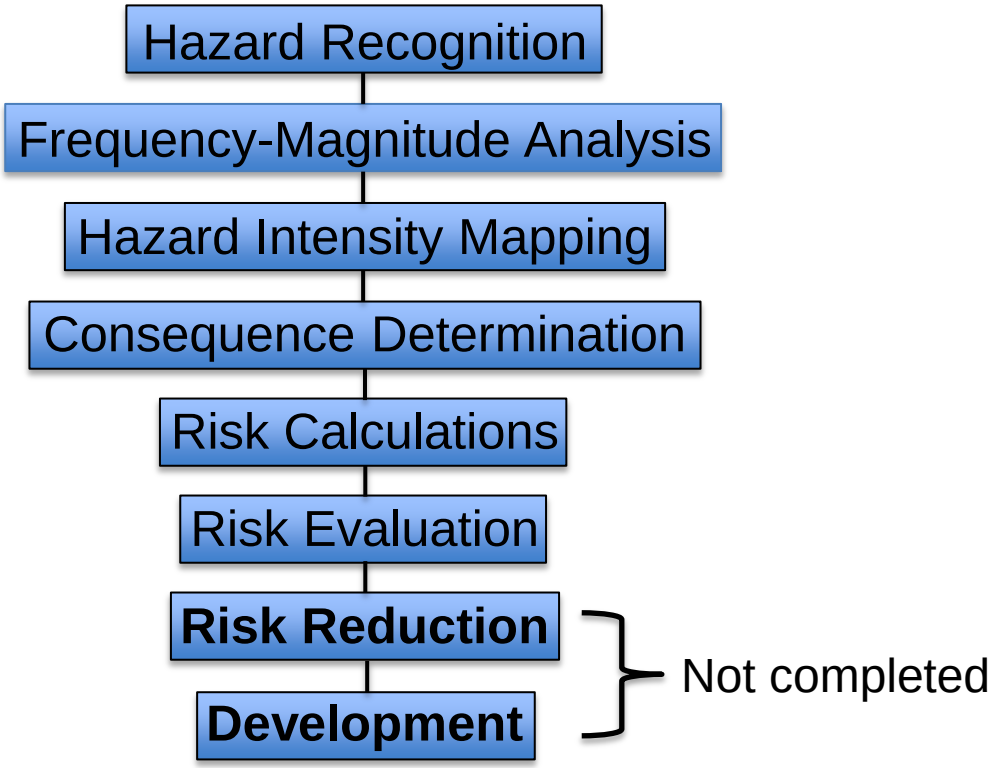

First Nation IRs
Cheekeye Subdivision
Hwy. 99
BC Rail
Possible Development Area
Airport
BC Hydro Transmission Line
Schools
First Nation IR
Brakendale
Elements at Risk
Indian Reserve 11
Squamish Valley Road
Cheekeye River
CN Rail
Mill
BC Hydro Substation
Garbage Dump
Dogleg
Highway 99
Brohm River Fan Apex
Cheekeye River
Cat Lake
Stump Lake
Alice Lake Road
Fawn Lake
Campground
Alice Lake
Edith Lake
Airport
Government Road
Squamish River
N
250 125 0 250 500 750
Meters
Transportation
Pavement
Railway
Gravel
Runway
Driveway
Trail
Other
Bridge
Structure
Transmission line
River channel
Lake


SQUAMISH
Lower fan
Upper fan
Cat Lake
Cheekeye Ridge Linears
Cheekeye River

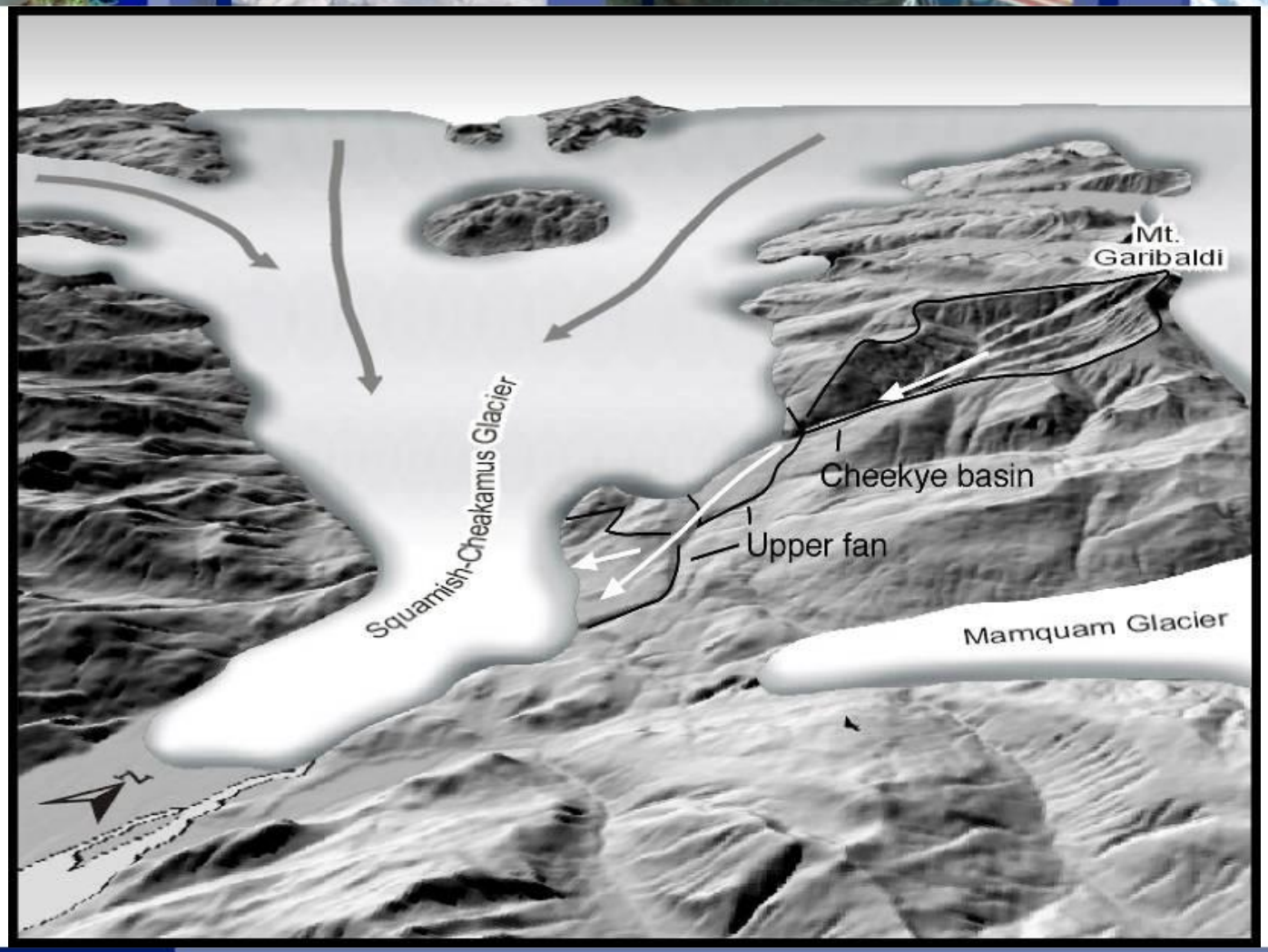

SQUAMISH
Squamish River
B R A C K E N D A L E
Approx. fan boundary
Primary School
Highschool

The Steps

Steps completed to date:

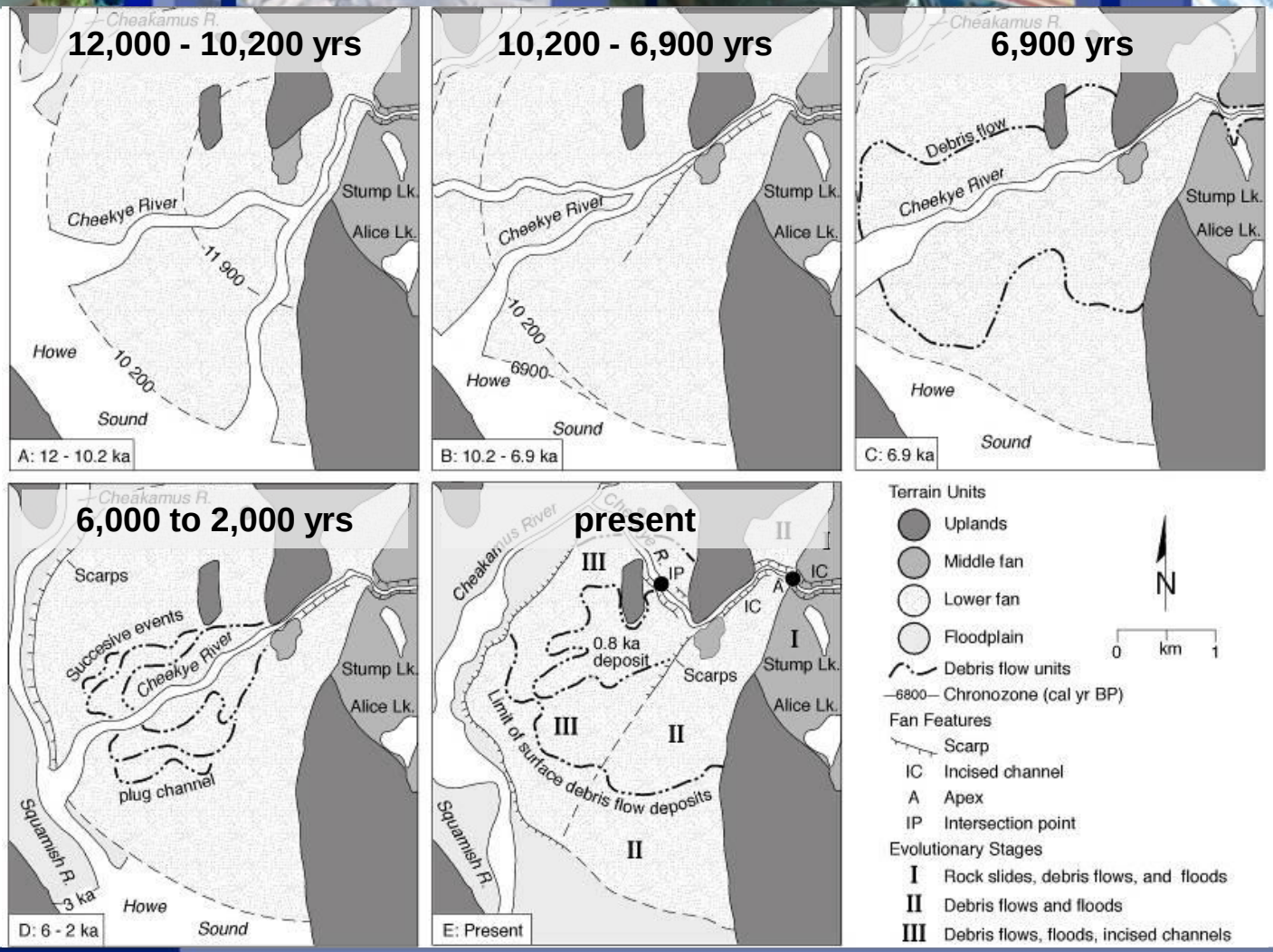


Glacial History

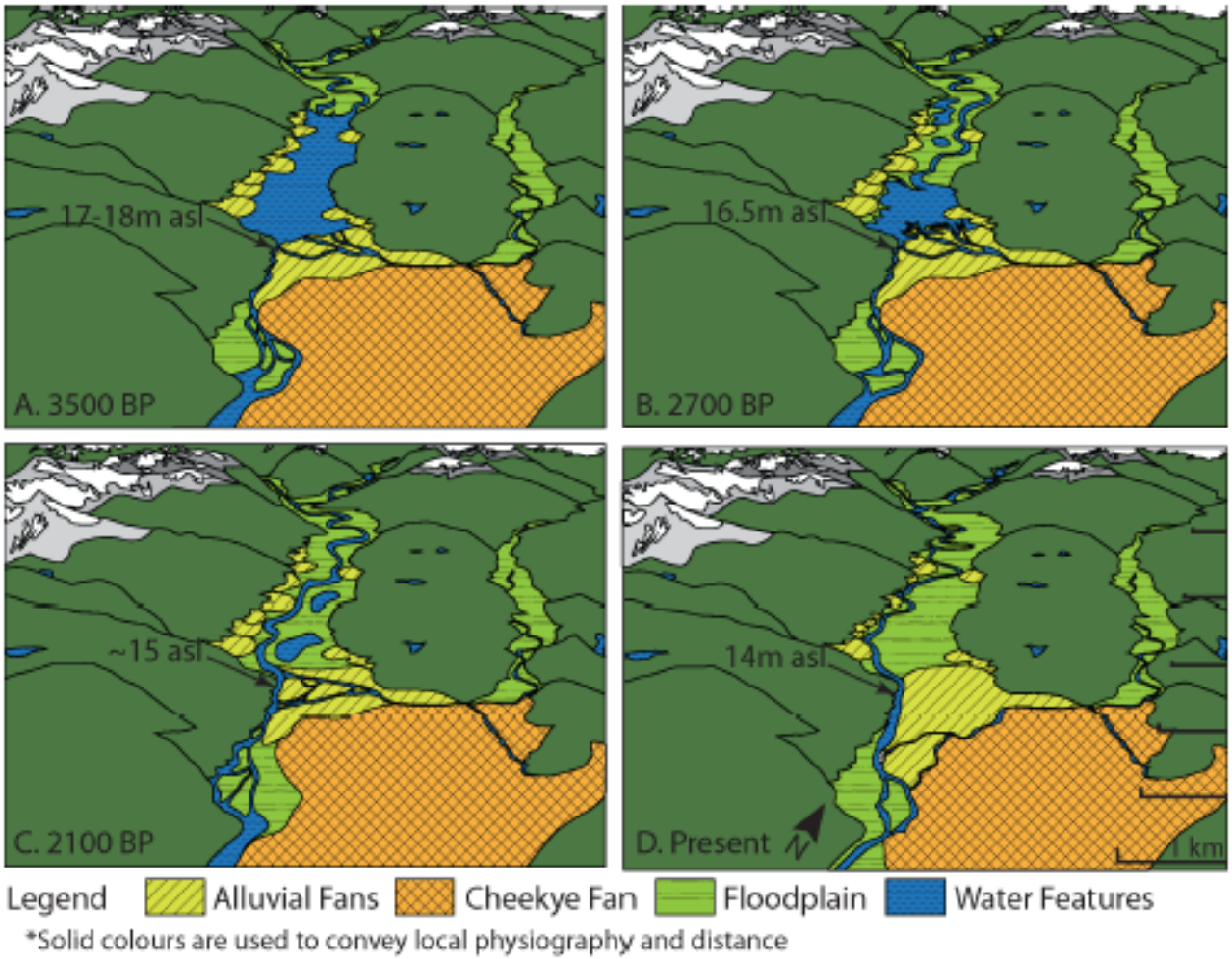


SOURCE: FRIELE

Fan Evolution



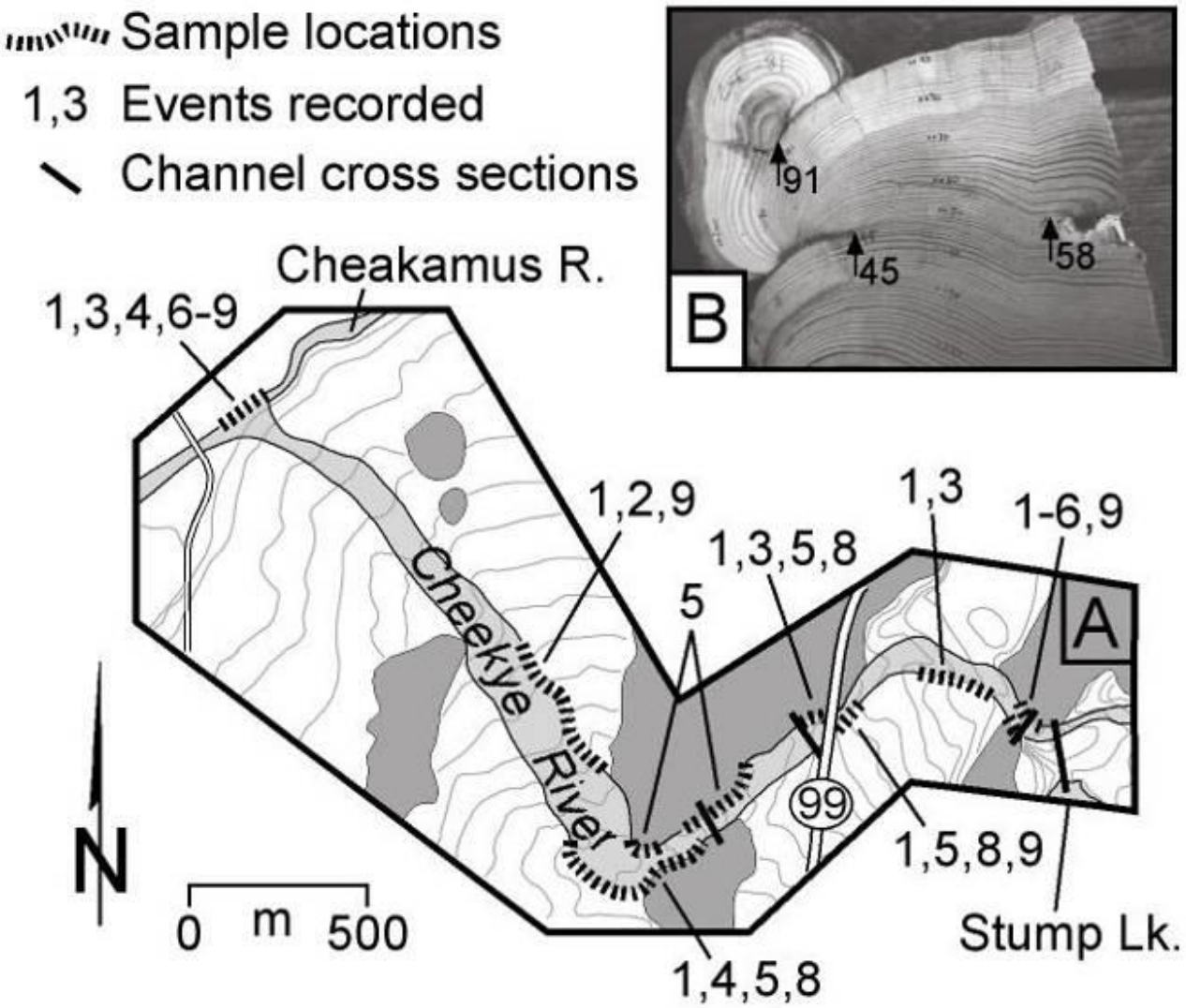
Squamish River and Cheakamus River damming potential



Fath, 2014

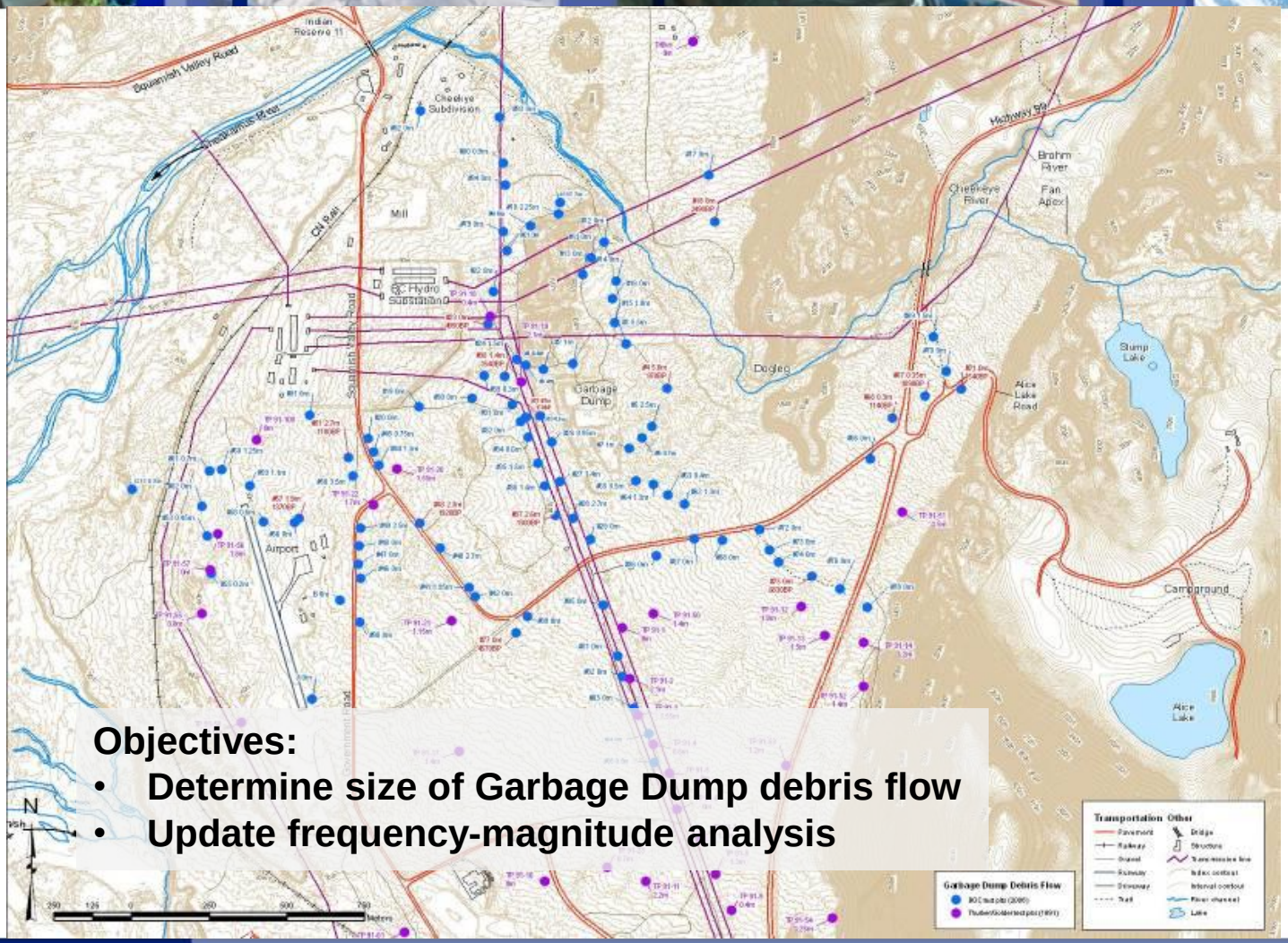
Dendrochronolgy

Dendrochronolgy



- ~60 wedges, cores, discs sampled along channel
- Cross-sections reconstituted along confined reaches
- Discharge back-calculated

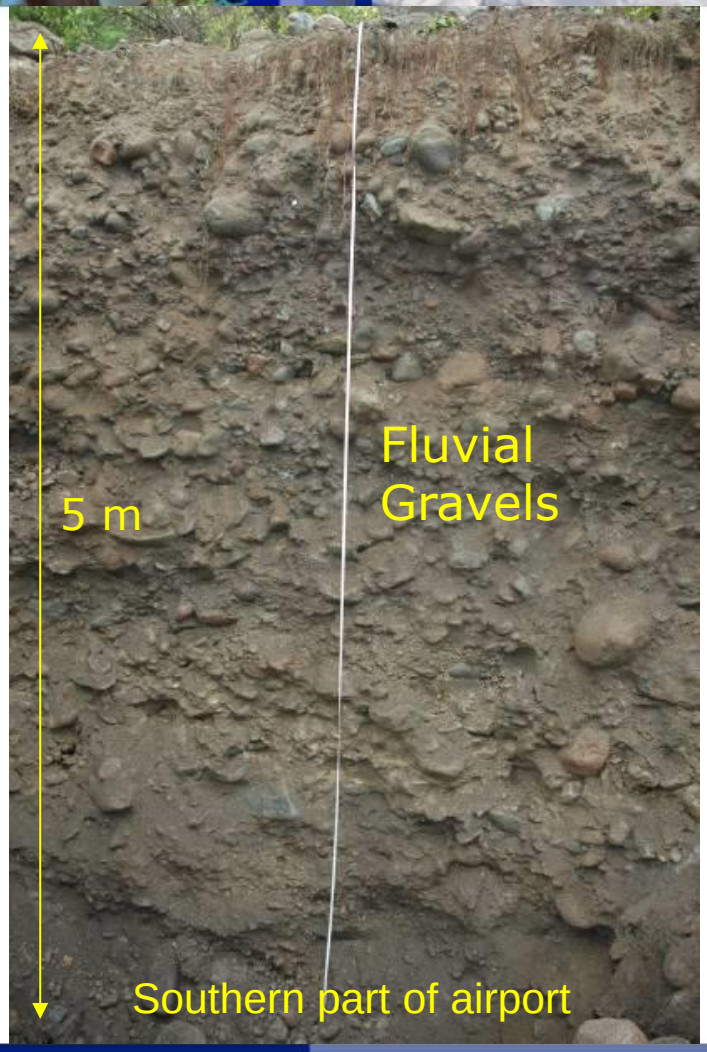
Test Trenching Program

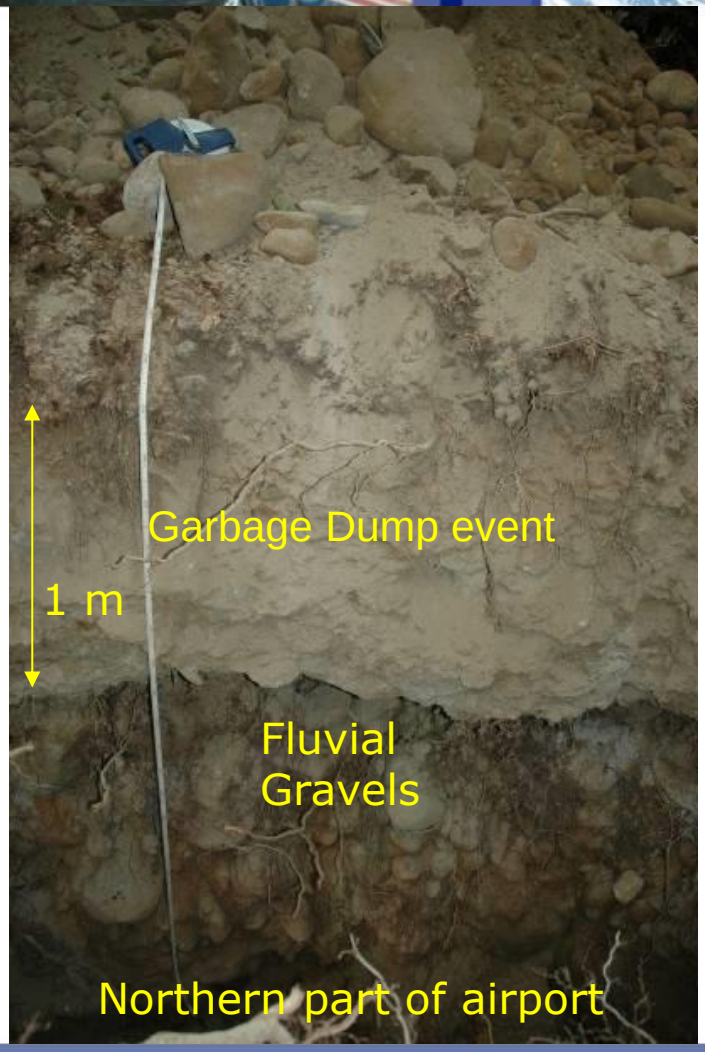


Objectives:

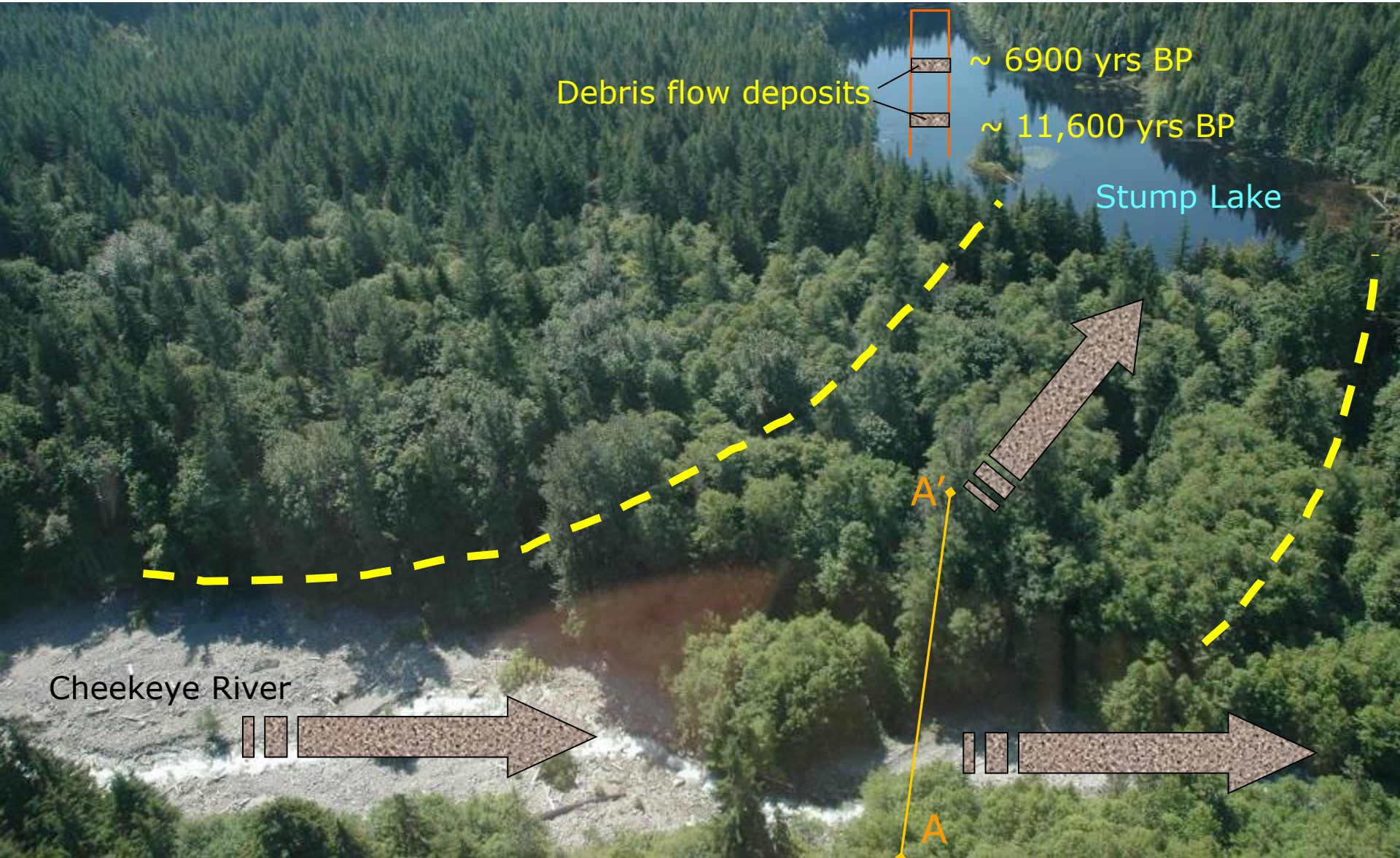
- **Determine size of Garbage Dump debris flow**
- **Update frequency-magnitude analysis**

Test Trenching Program

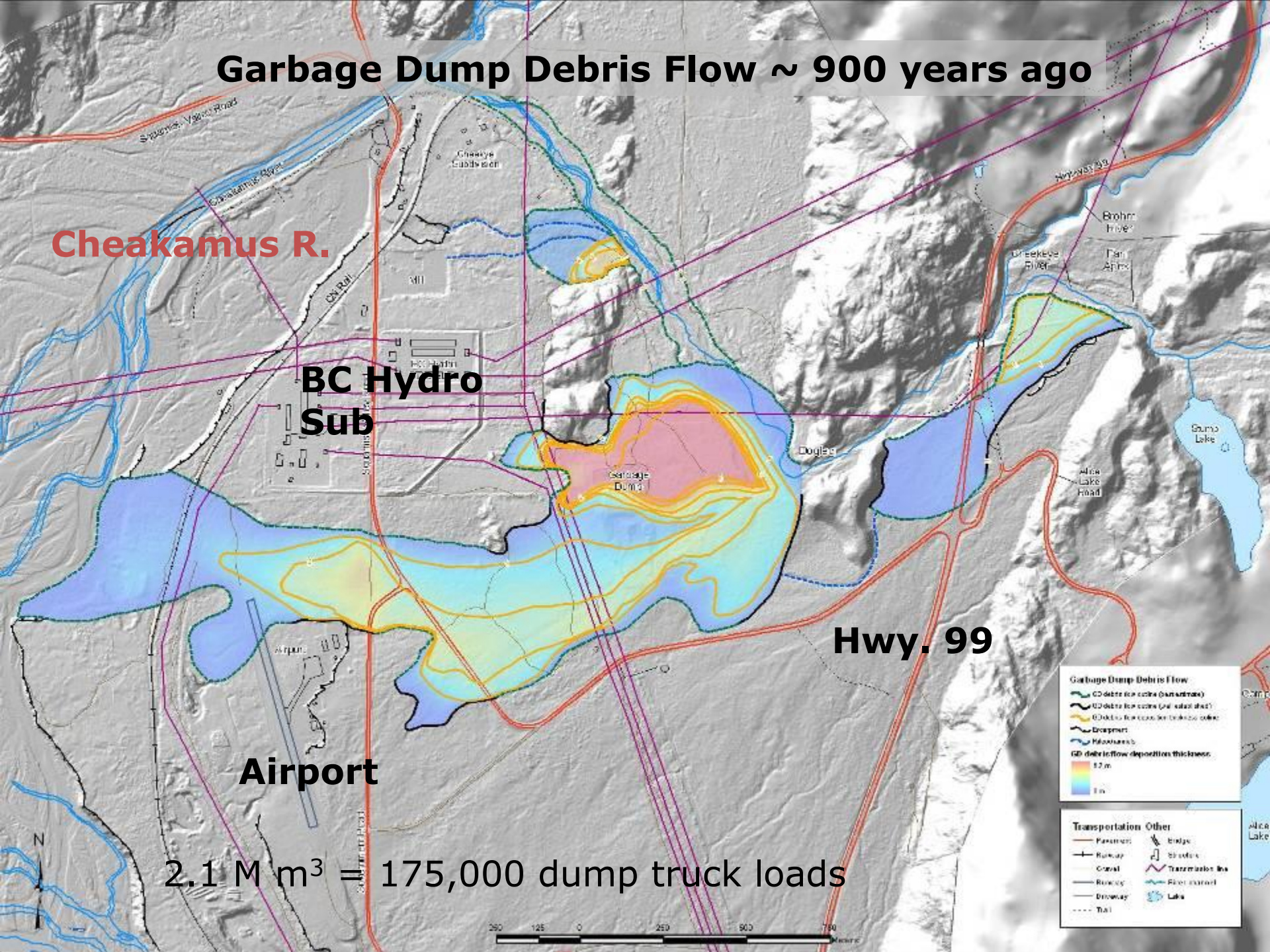




Stump Lake Sediment Coring

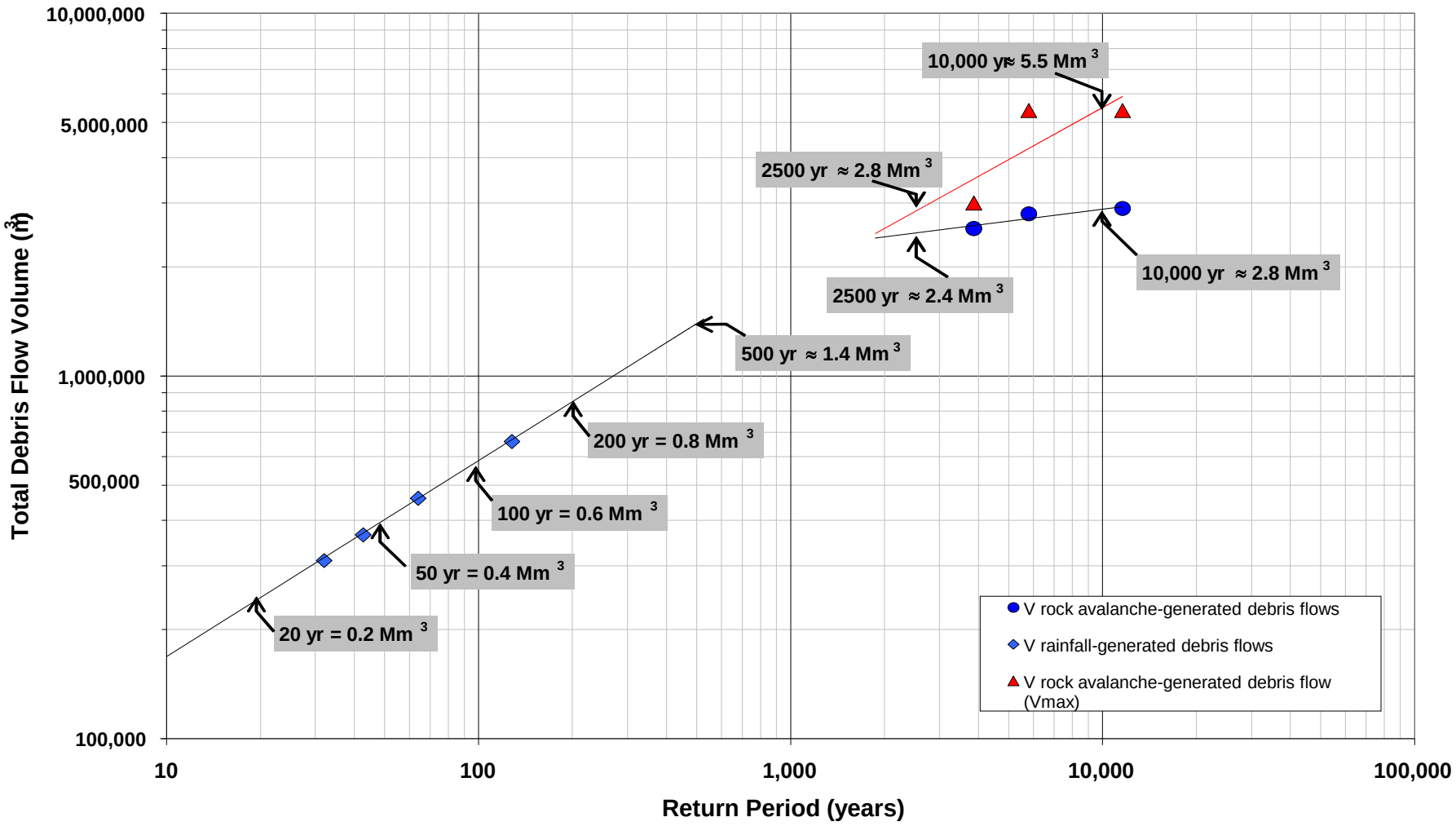


Garbage Dump Debris Flow ~ 900 years ago



2.1 M m^3 = 175,000 dump truck loads

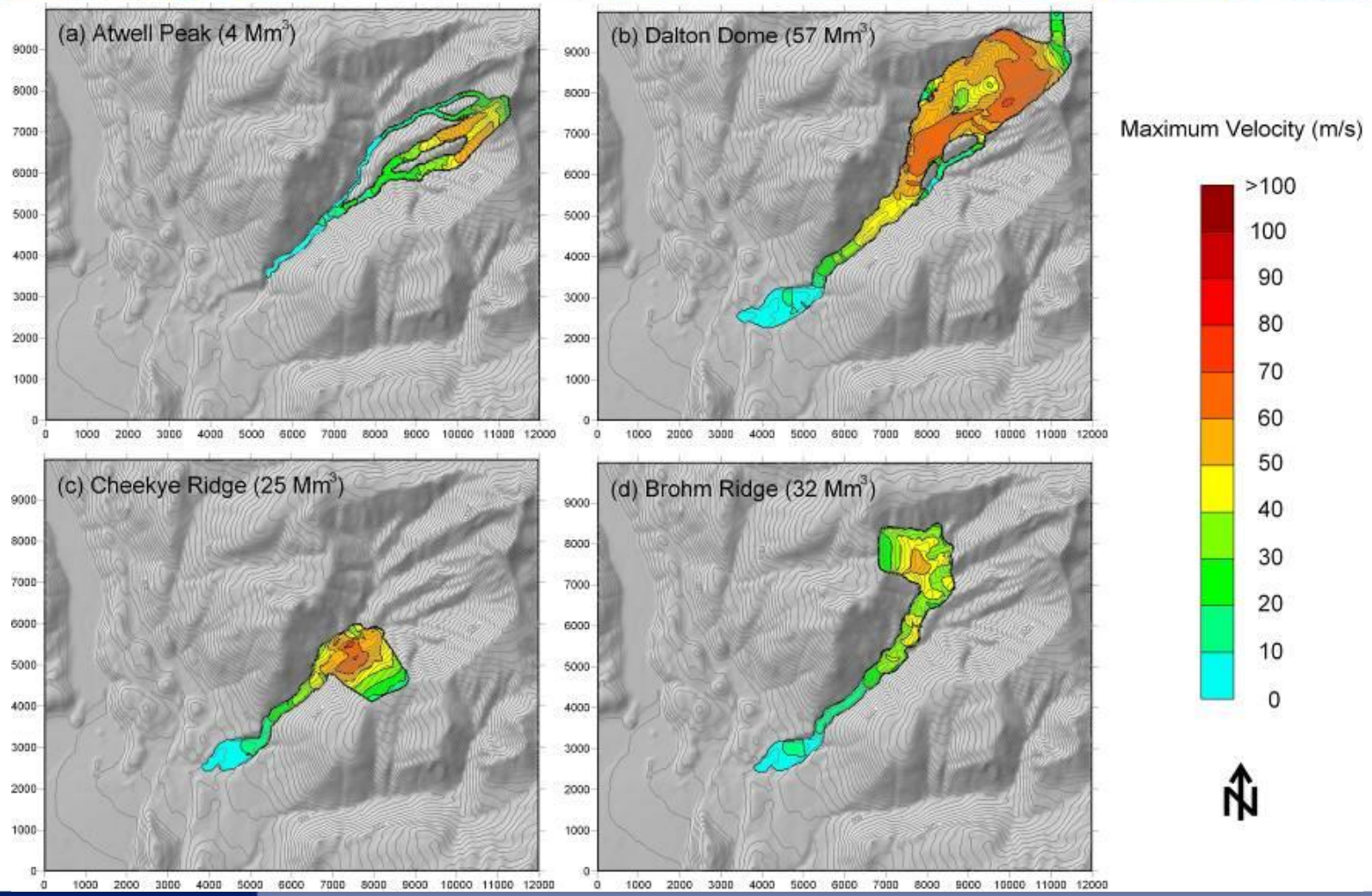
Debris Flow Volume



The July 2010 rock avalanche and debris flow at Capricorn Creek, Mount Meager

Photos: courtesy Prof. John Clague, SFU

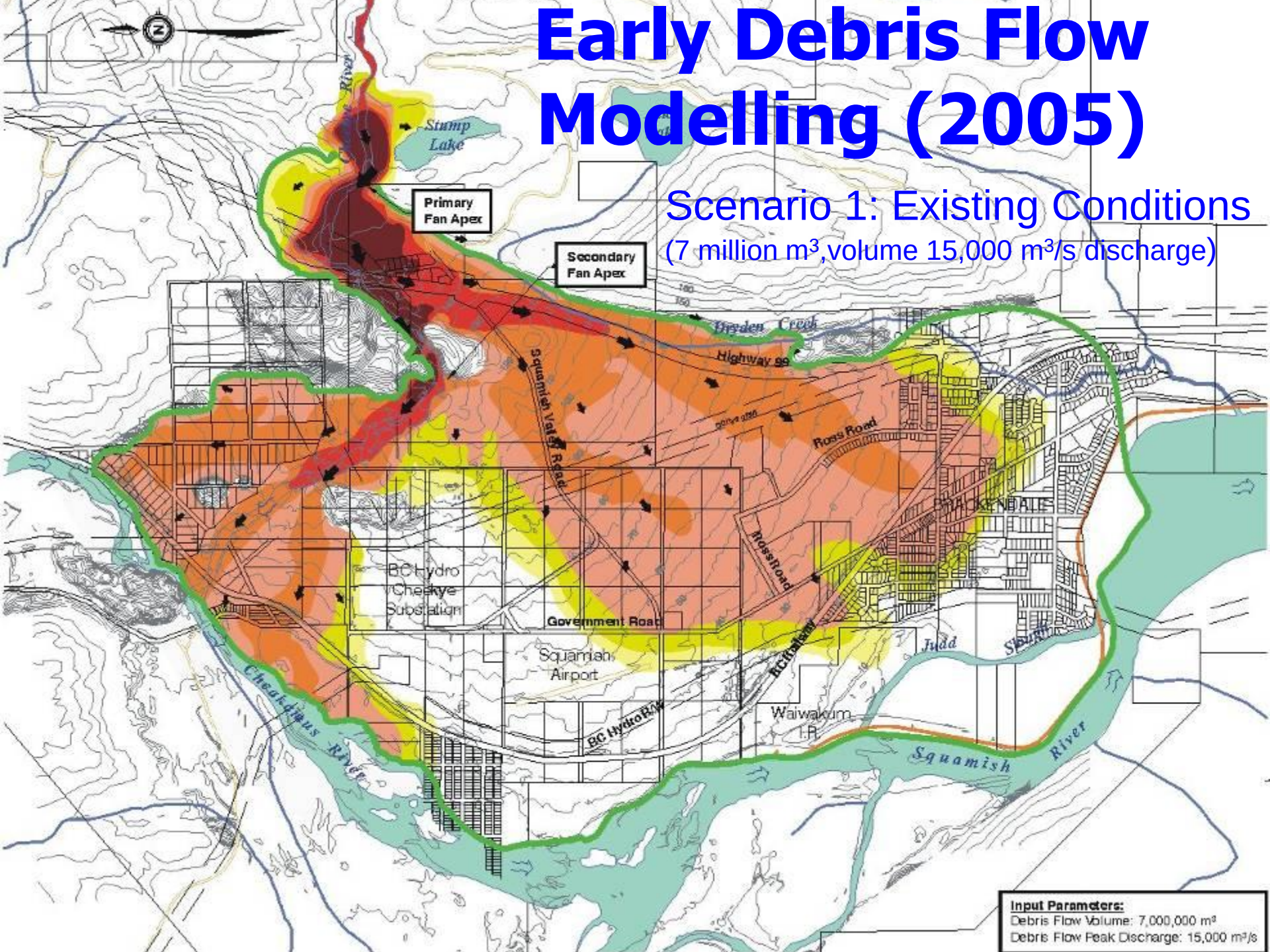
Rock Avalanche Modeling

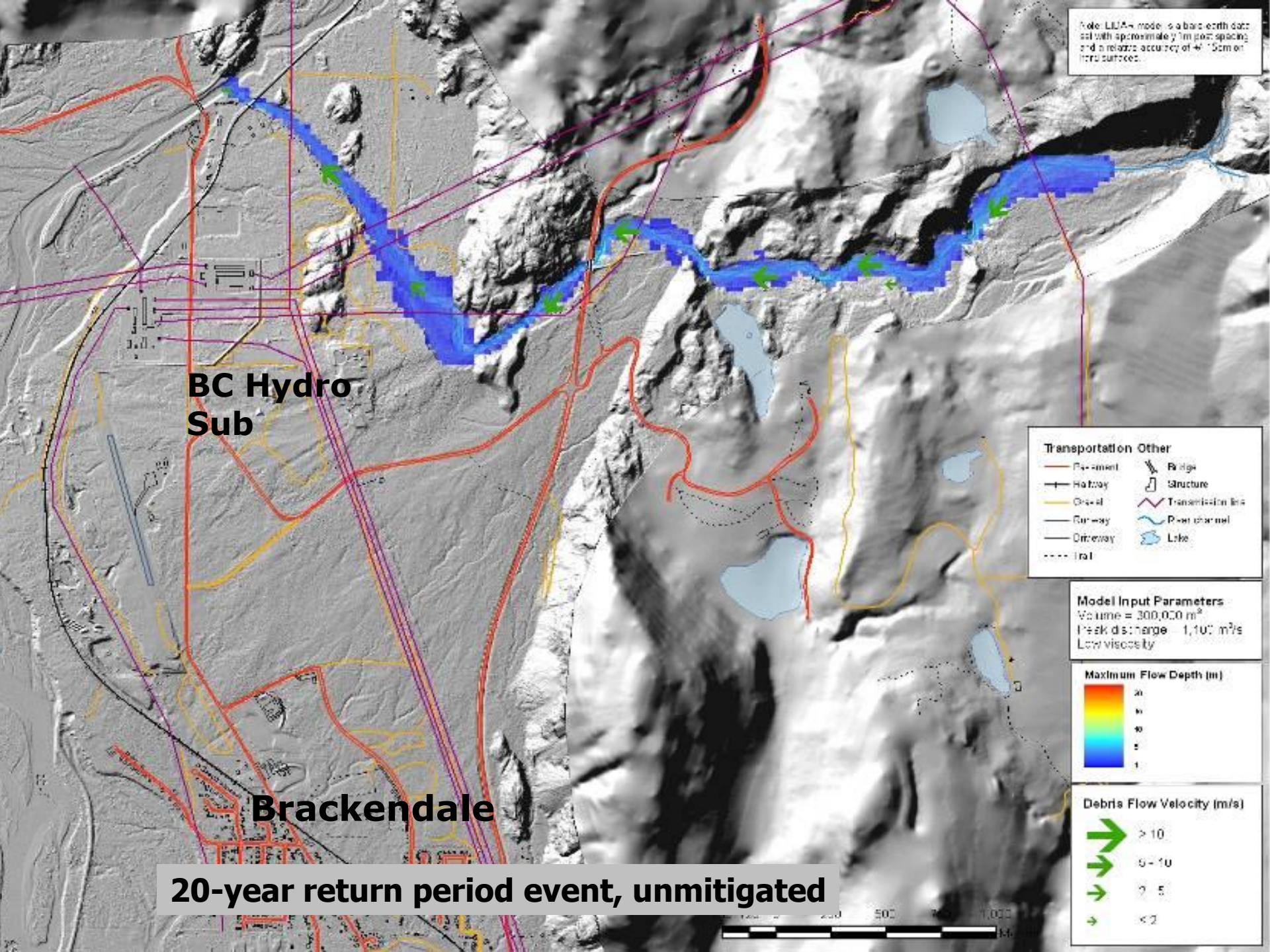


Early Debris Flow Modelling (2005)

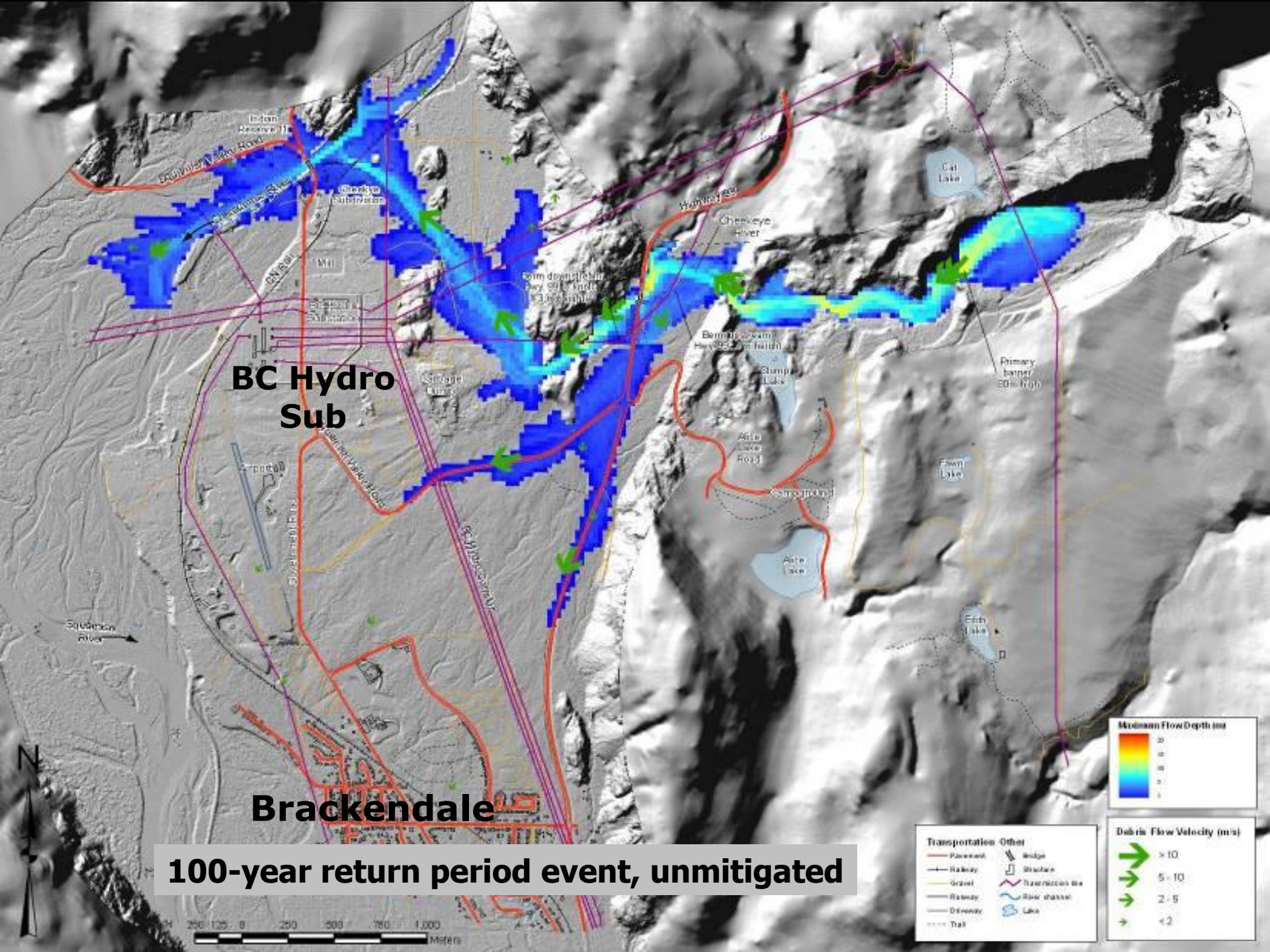
Scenario 1: Existing Conditions

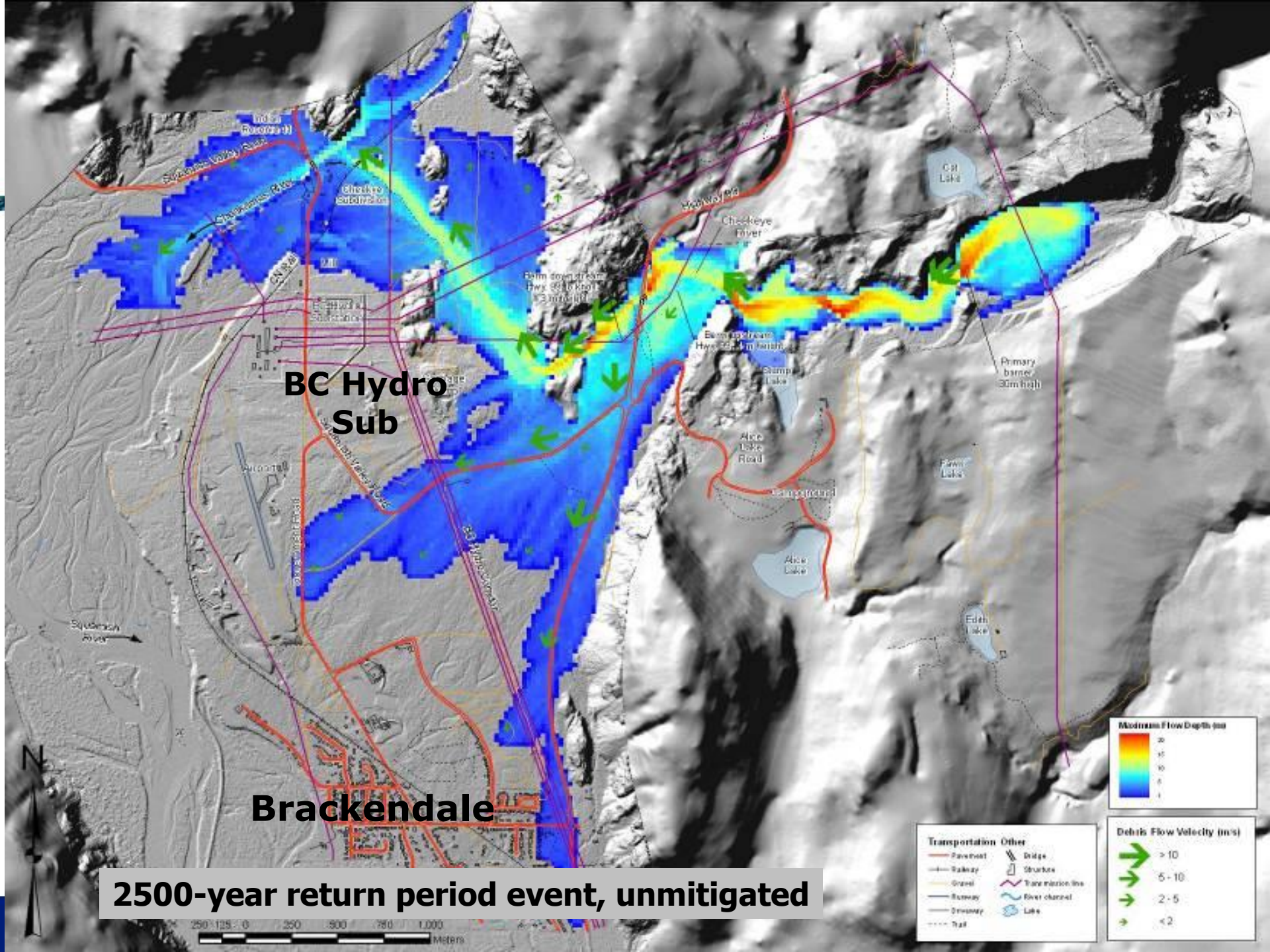
(7 million m³,volume 15,000 m³/s discharge)



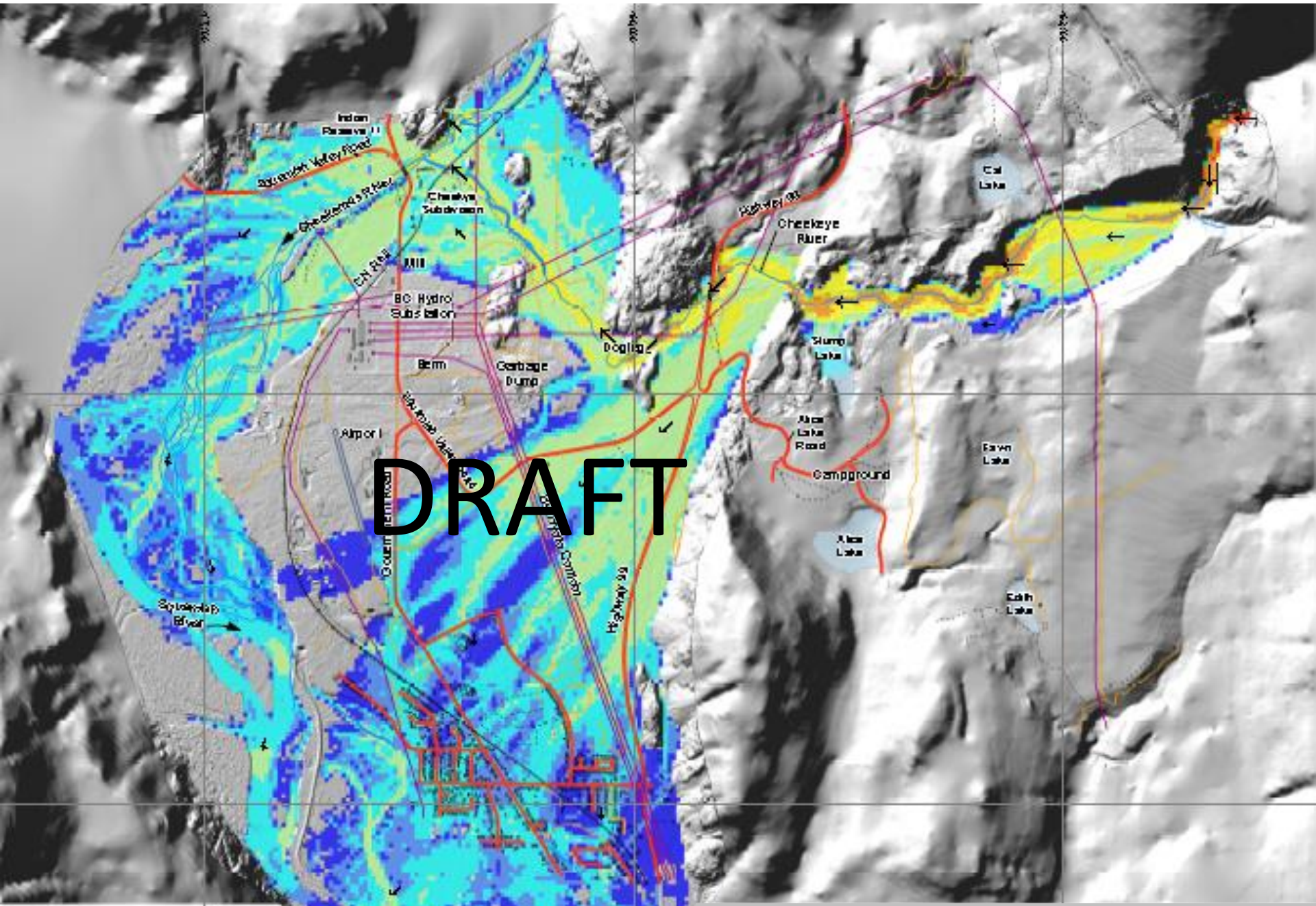


20-year return period event, unmitigated


BC Hydro Sub
Brackendale
100-year return period event, unmitigated
Cheekeye River
Cat Lake
Stump Lake
Alice Lake
Ewart Lake
Edith Lake
Squamish River
Primary berner 30m high
Maximum Flow Depth (m)
Debris Flow Velocity (m/s)
> 10
5 - 10
2 - 5
< 2
Transportation
Other
Pavement
Railway
Gravel
Roadway
Driveway
Trail
Bridge
Structure
Transmission line
River channel
Lake
250 125 0 250 500 750 1,000
Meters
N

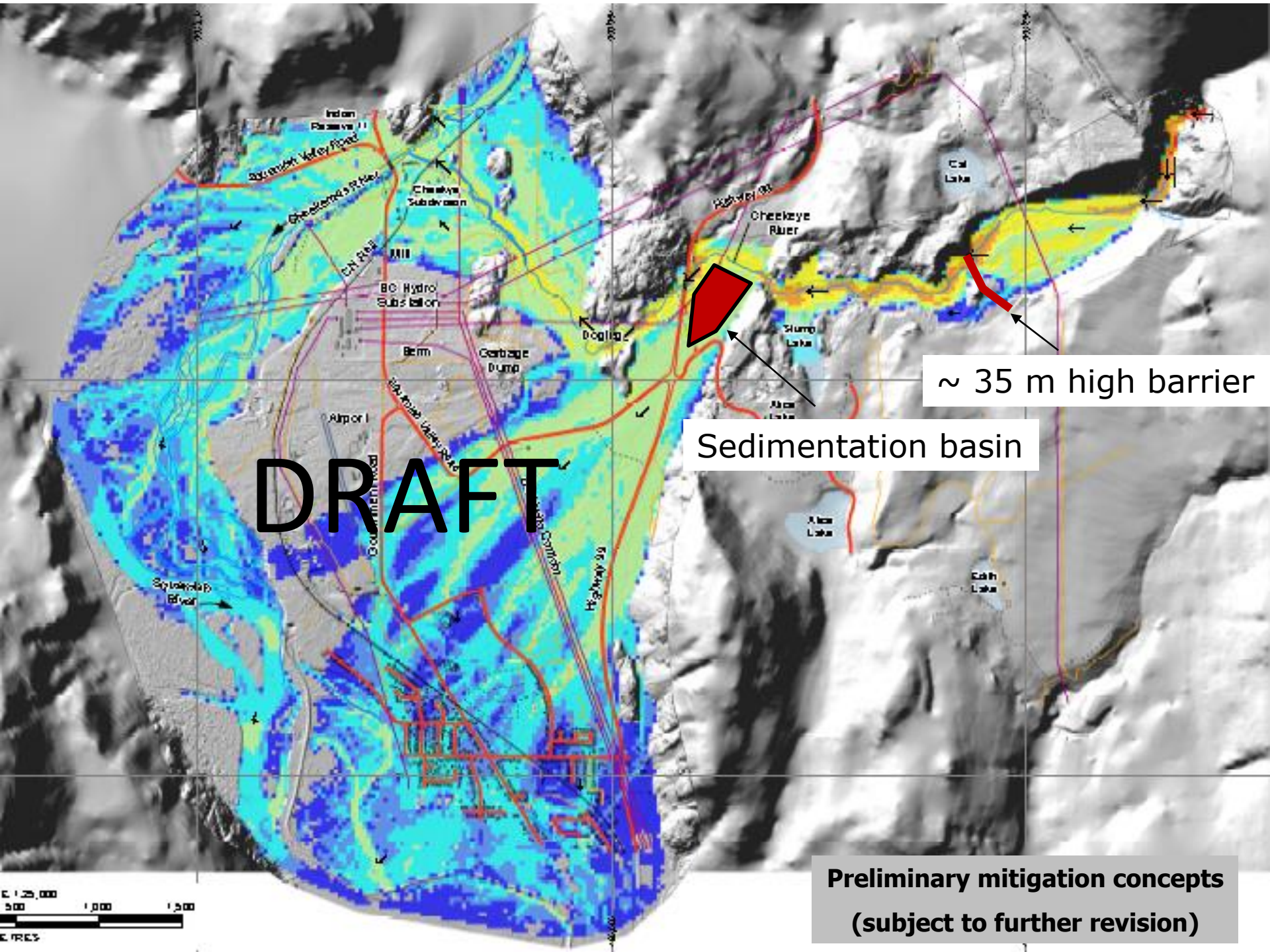


2500-year return period event, unmitigated



10,000-year return period event, unmitigated

(subject to further revision)

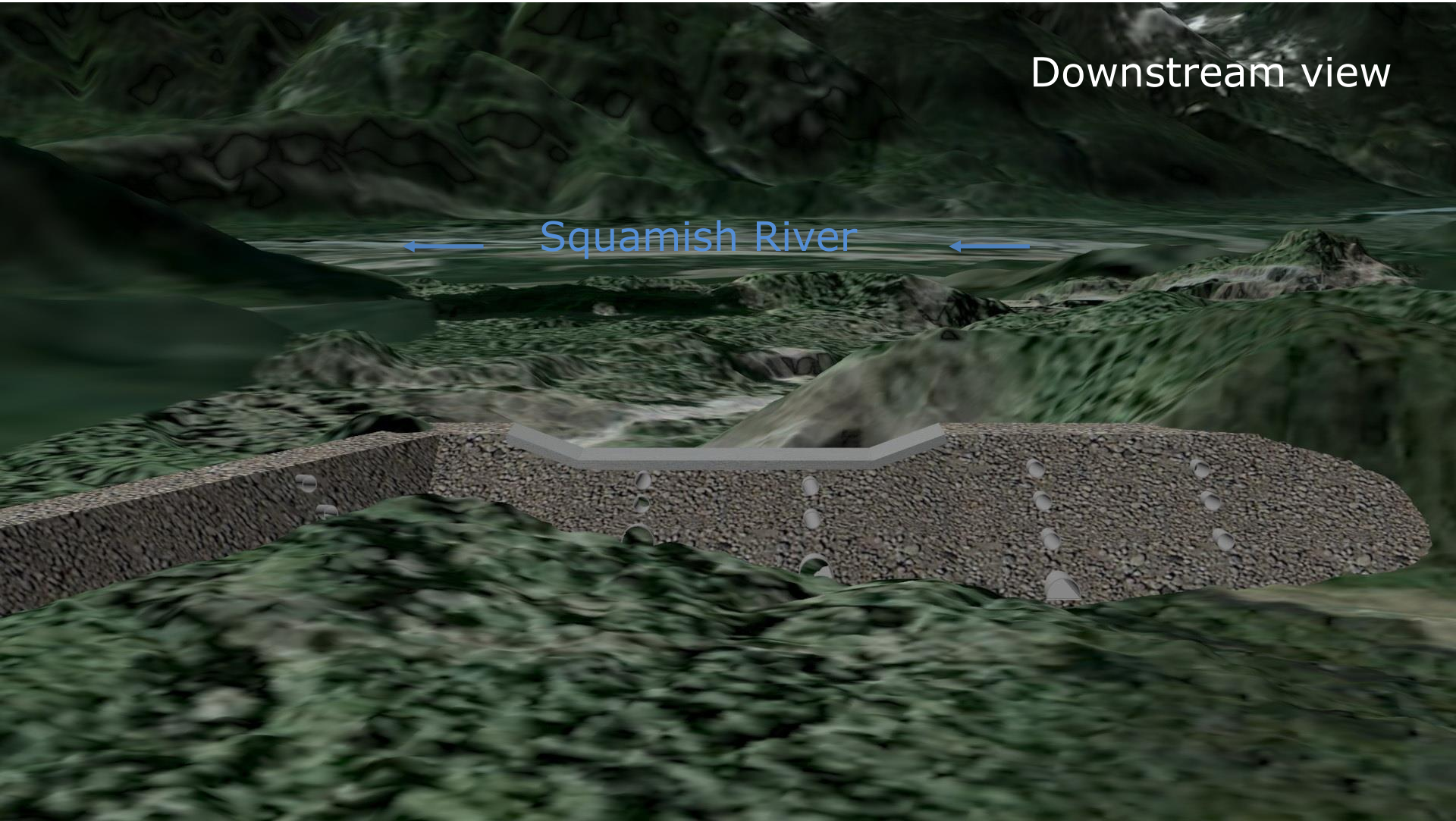

~ 35 m high barrier
Sedimentation basin
DRAFT
Preliminary mitigation concepts
(subject to further revision)

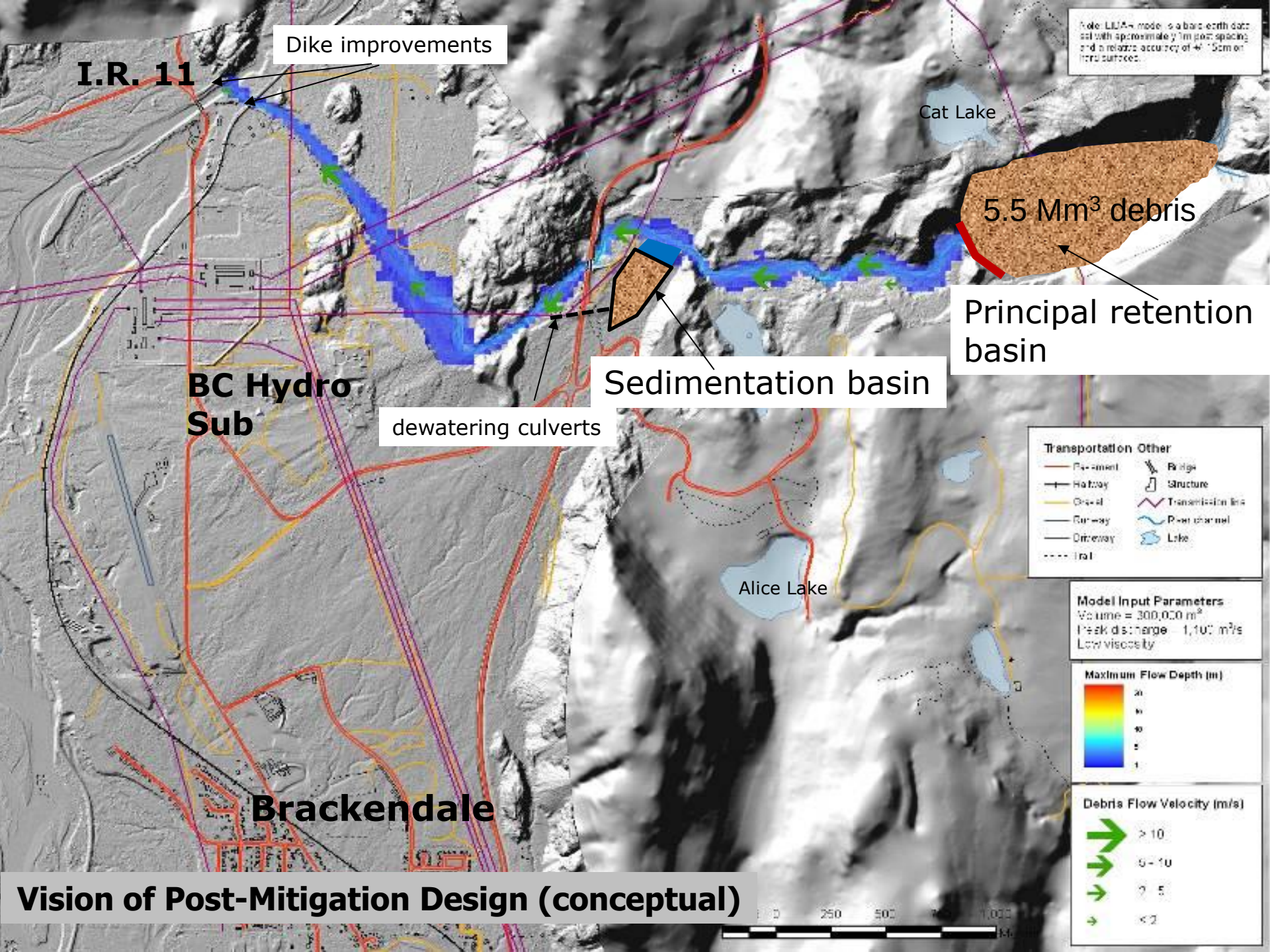
What does 5.5 M m^3 debris mean?

5.5 million cubic metres is roughly twice the volume of BC Place Stadium

Images from www.bcplacestadium.com

Main Barrier
(preliminary design concept)





Vision of Post-Mitigation Design (conceptual)

Conclusions

- Risk is currently deemed unacceptable as compared to standards, for example, used by DNV and requires mitigation irrespective of future developments
- Significant economic loss would result in case of moderate size and large debris flows
- The expert review panel suggested the structure(s) be designed for a 10,000-year return period event with a volume of 5.5 Mm^3
- The lay of the land lends itself well to mitigation works which would protect, amongst other elements at risk, the villages and people of the Squamish nation.
- Preliminary mitigation concept to provide two primary would be based on two structures with auxiliary risk reduction measures and monitoring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