
Glacial Outburst Floods

Outline

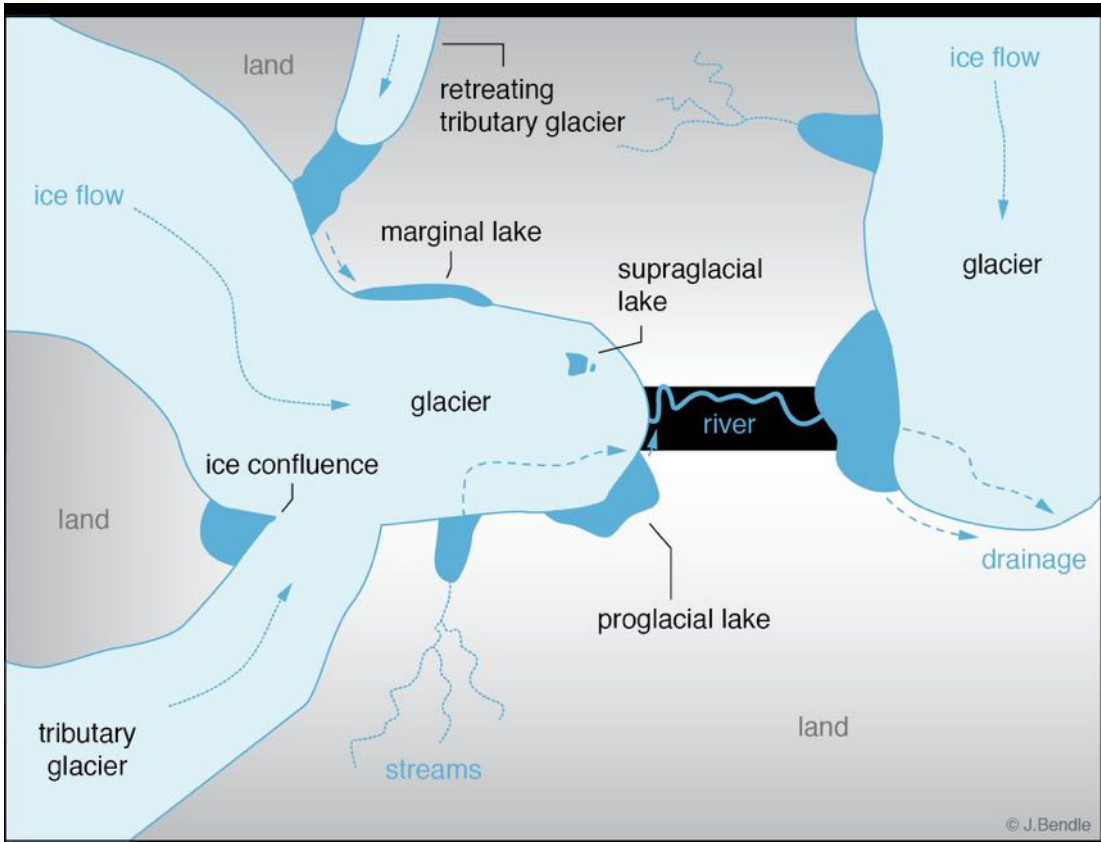
- Types of Glacial Lake Outburst Floods
  - Subglacial
  - Moraine Dammed
  - Ice Dammed
- Chamoli Landslide
- Downstream Impacts
- Megafloods

Types of Glacial Outburst Floods (GLOFs)

Subglacial Outburst Floods

Moraine Dammed Lakes

Ice Dammed Lakes (Marginal)

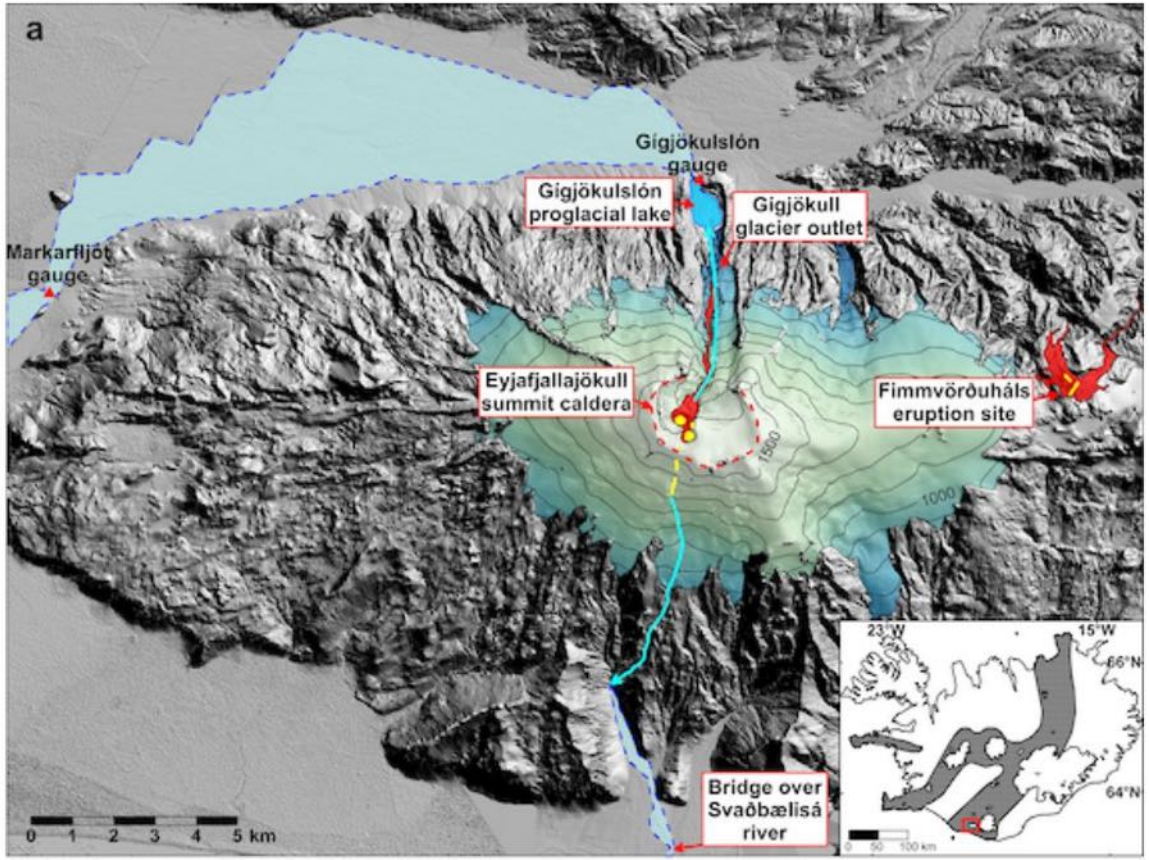


Subglacial Outburst Floods

Heating from volcanic eruption underneath glacier

Subglacial Outburst Floods

2010 Eyjafjallajökull Eruption

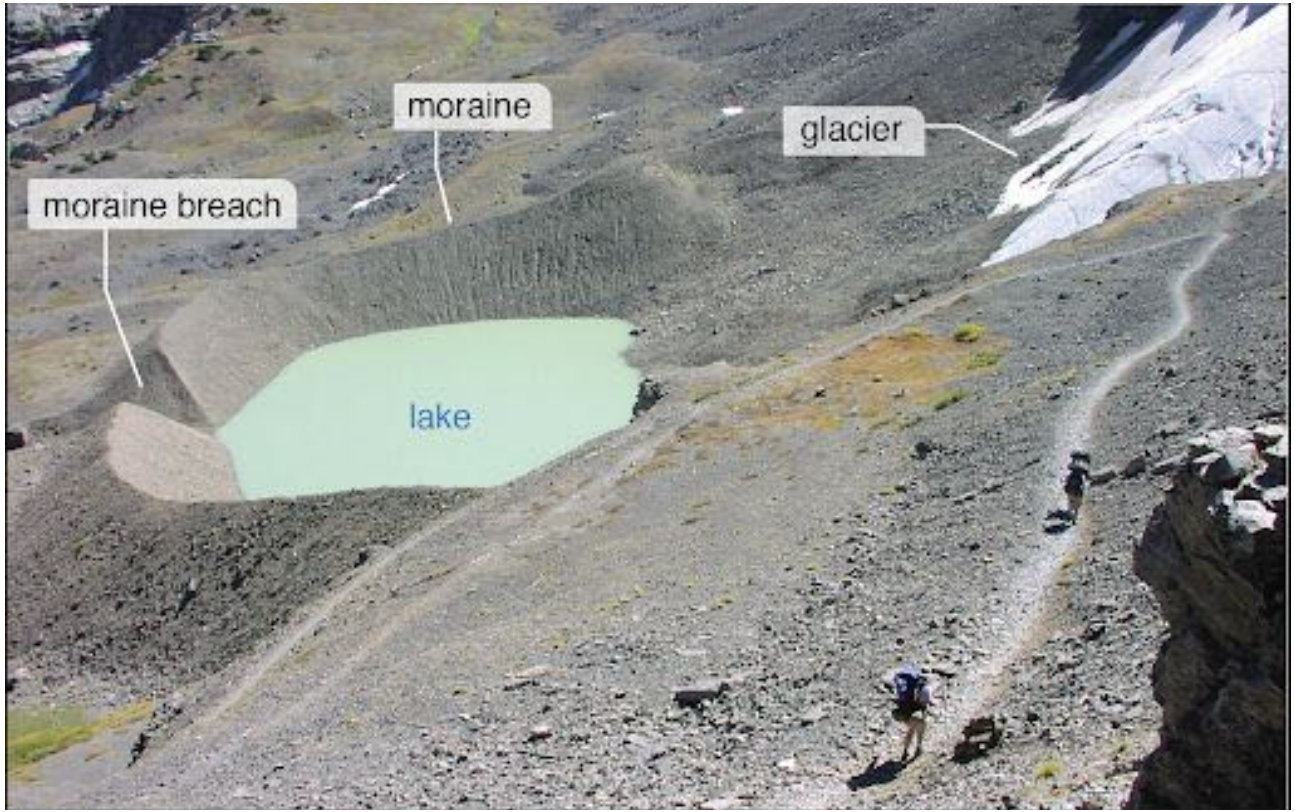


Subglacial Outburst Floods

- Peak discharge of 2640 $m^3\ s^{-1}$
- Sediment and and ash laden water
- Extensive flood area

Moraine Dammed Lakes

Moraine Dammed Lakes



Moraine Dammed Lakes

- Physical experiment with packed sand dam
- Analogous to moraine, landslide, or human manufactured sediment dam failure

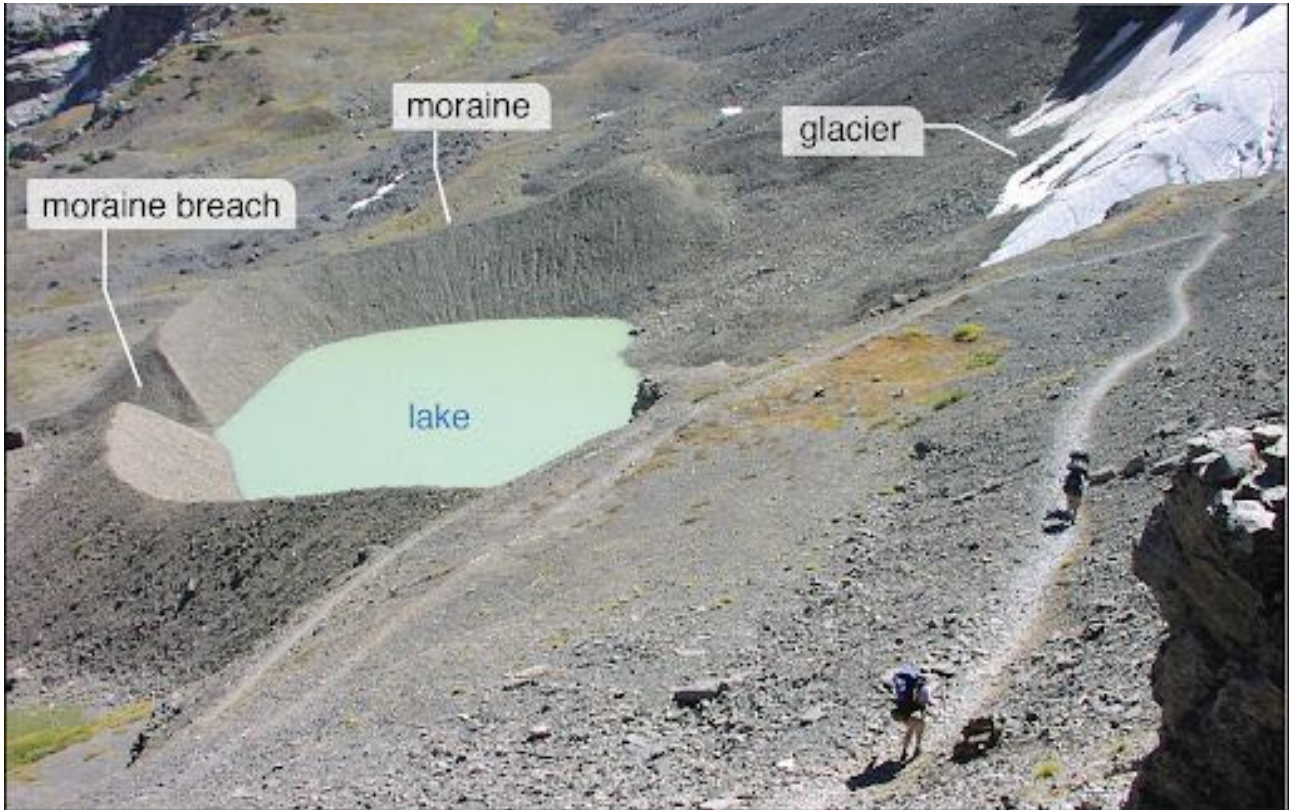
Moraine Dammed Lakes

Key Observations:

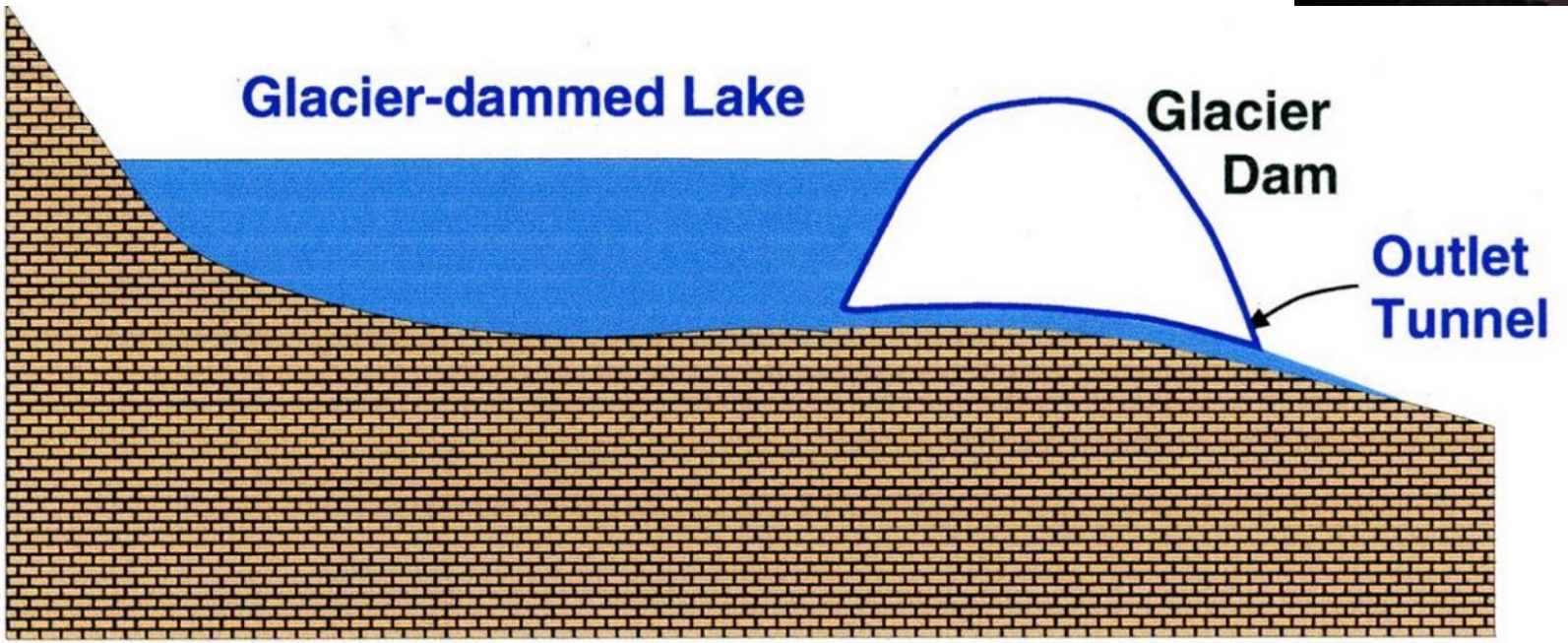
- Only small event needed to initiate breach
- Discharge first occurs slowly, then more quickly as a larger channel is incised
- Discharge is limited when
  - Lake level drops so that hydrostatic pressure is insufficient to erode a larger channel
  - Lake level drops to the new outlet height

Moraine Dam Mitigation

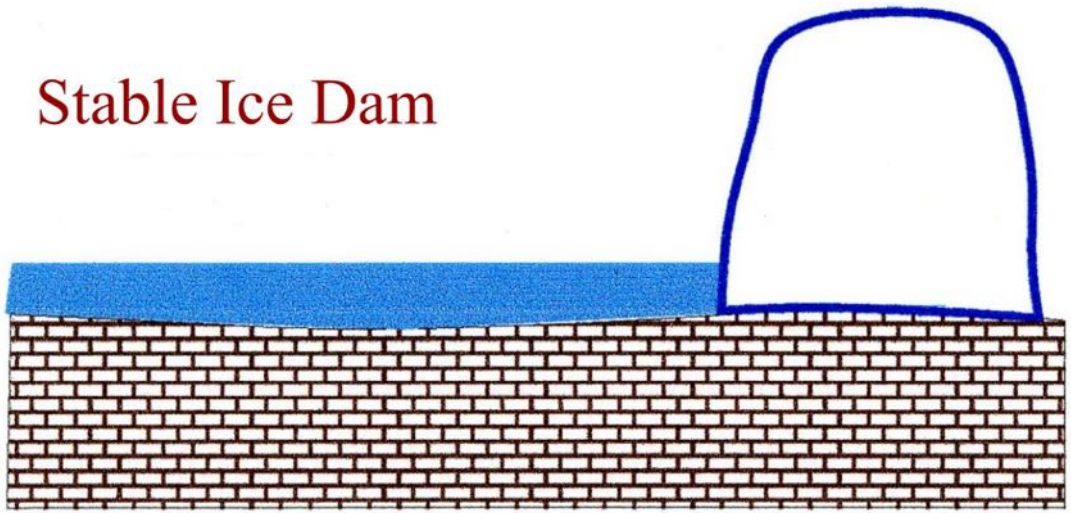
- Drain lake in a controlled manner
- Pre-cut channel to initiate earlier and smaller outburst flood
- Reinforce moraine with engineered materials



Ice Dammed Lakes

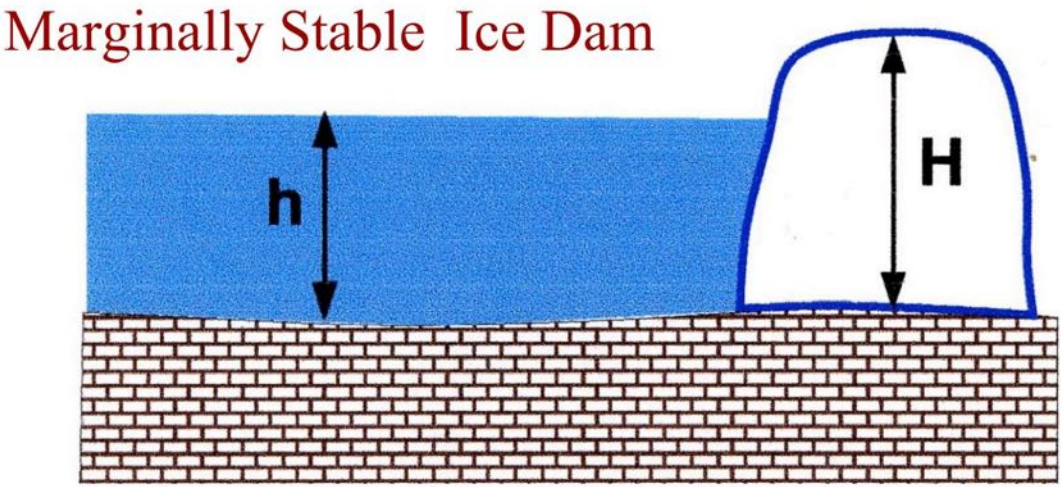


Ice Dammed Lakes



- Water pressure is low compared to ice pressure (weight of overlying ice).
- Ice pressure closes tunnels and cracks.
- System is self-sealing.

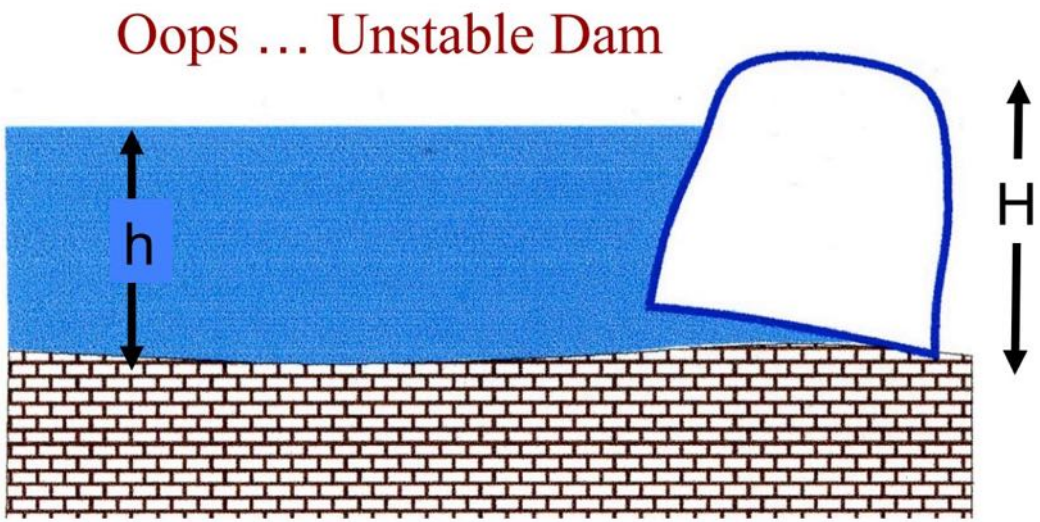
Ice Dammed Lakes



Ice density is 9/10 of water density.

- Ice can float when water depth h reaches 90% of ice depth H
- Water pressure = ice pressure at bedrock.
- Water pressure still cannot force open tunnels.
- But, if a tunnel exists, ice pressure cannot close it.

Ice Dammed Lakes



h > 0.9 H - dam can float!

- Water pressure exceeds ice pressure.
- Tunnels forced open by water pressure (like inflating balloons), and …
- Tunnels melted open by turbulent energy from water. Look out downstream!

2018 Bear Glacier GLOF

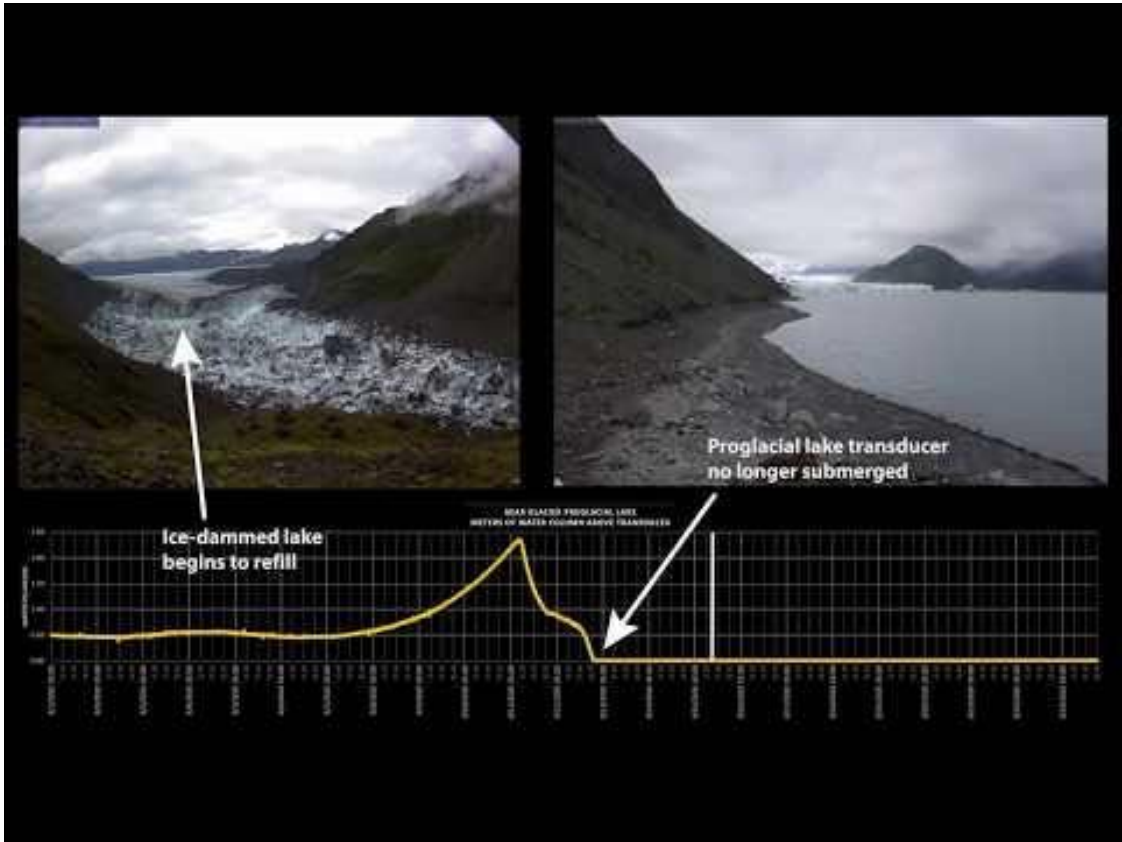
- Lake fills in late summer
- Remains steady through winter
- Dam breaches after snowmelt

NOTE:

- Glacier collapses with draining lake
- Lake immediately begins to refill

2018 Bear Glacier GLOF

Let’s watch the same event in more detail

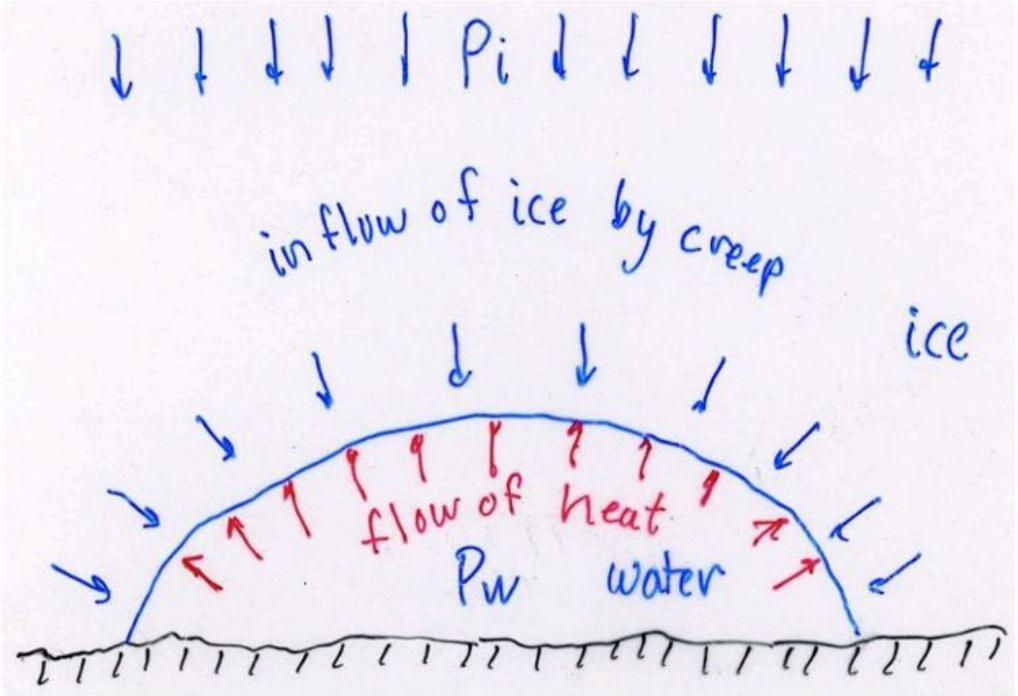


Subglacial Tunnels

A leak starts through a small tunnel...

- Energy from falling water is converted to turbulent energy.
- Turbulence heats water in tunnel.
- Warmed water melts and enlarges tunnel.
- More flow, more turbulence, more heating, more melting…

(Positive feedback loop!)



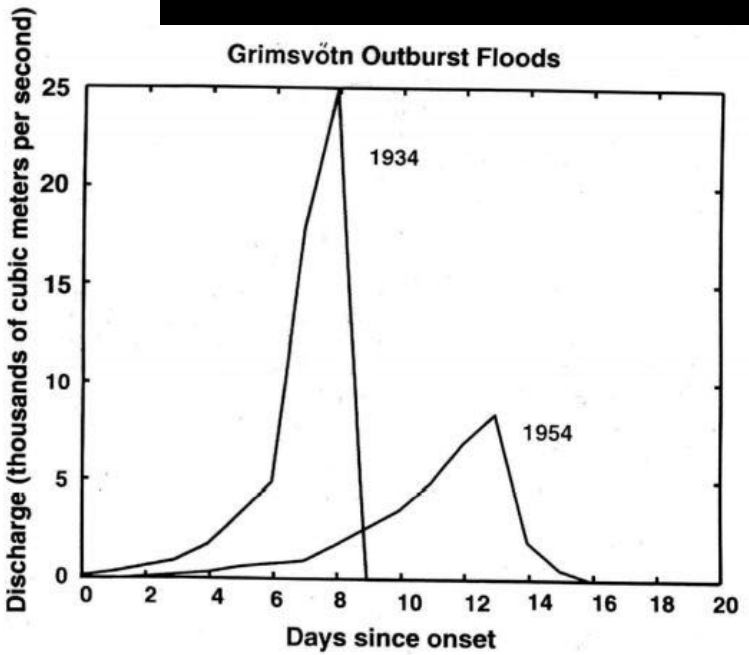
Subglacial Tunnels

Perito Moreno

Discharge Patterns

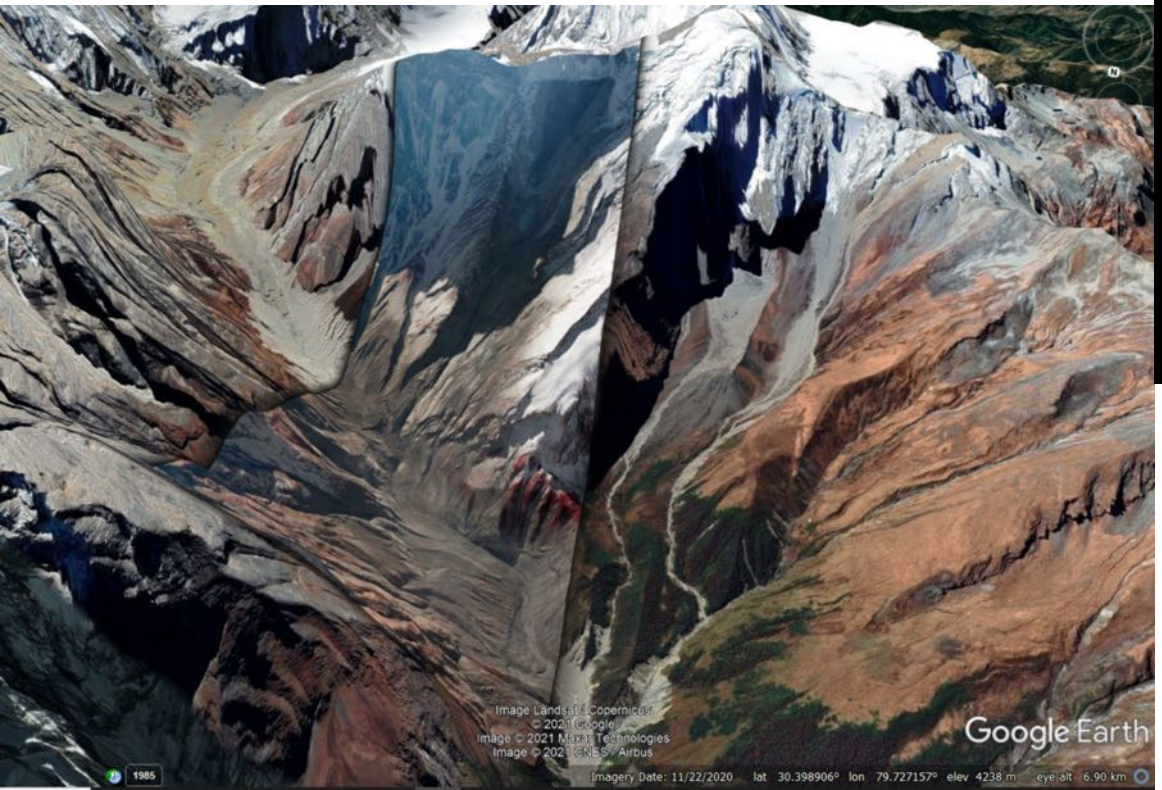
Recall that both moraine dam and ice dam outburst floods have mechanisms with positive feedback loop behavior.

What does this mean for discharge?



Chamoli Landslide

Feb 7, 2021



Chamoli Landslide

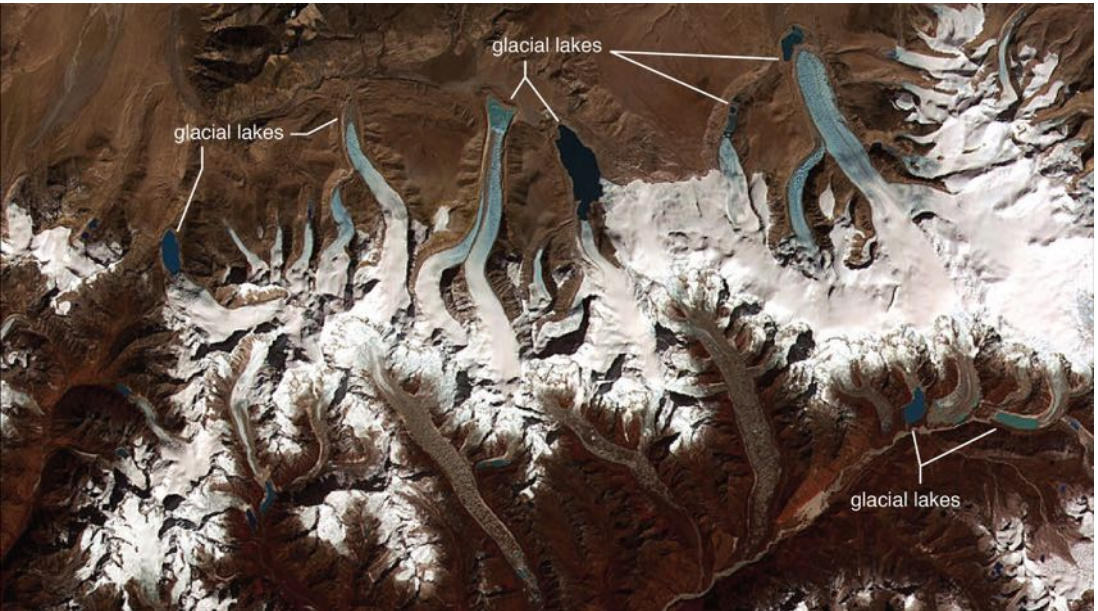
Chamoli Landslide

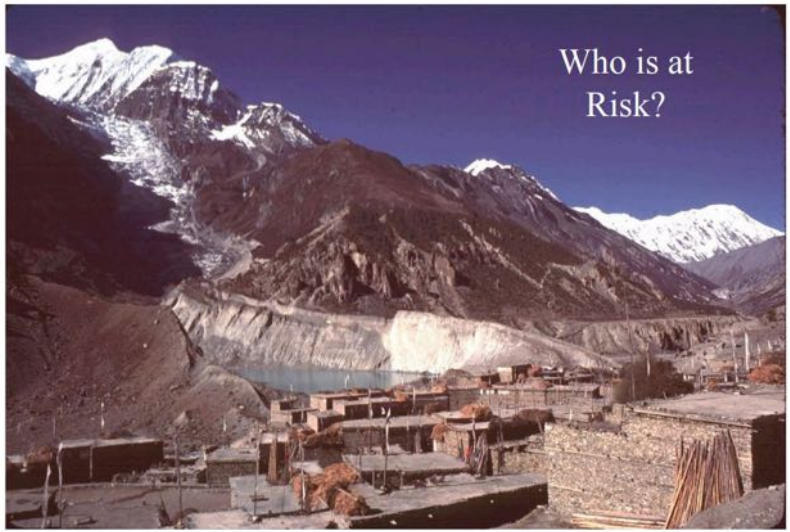
As of Feb 15th, 54 people are known to have lost their lives and 179 people are reported to be missing.

Downstream Impacts

Himalayas particularly prone. Why?

Are GLOFs an increasing hazard?





Downstream Impacts

Himalayas particularly prone. Why?

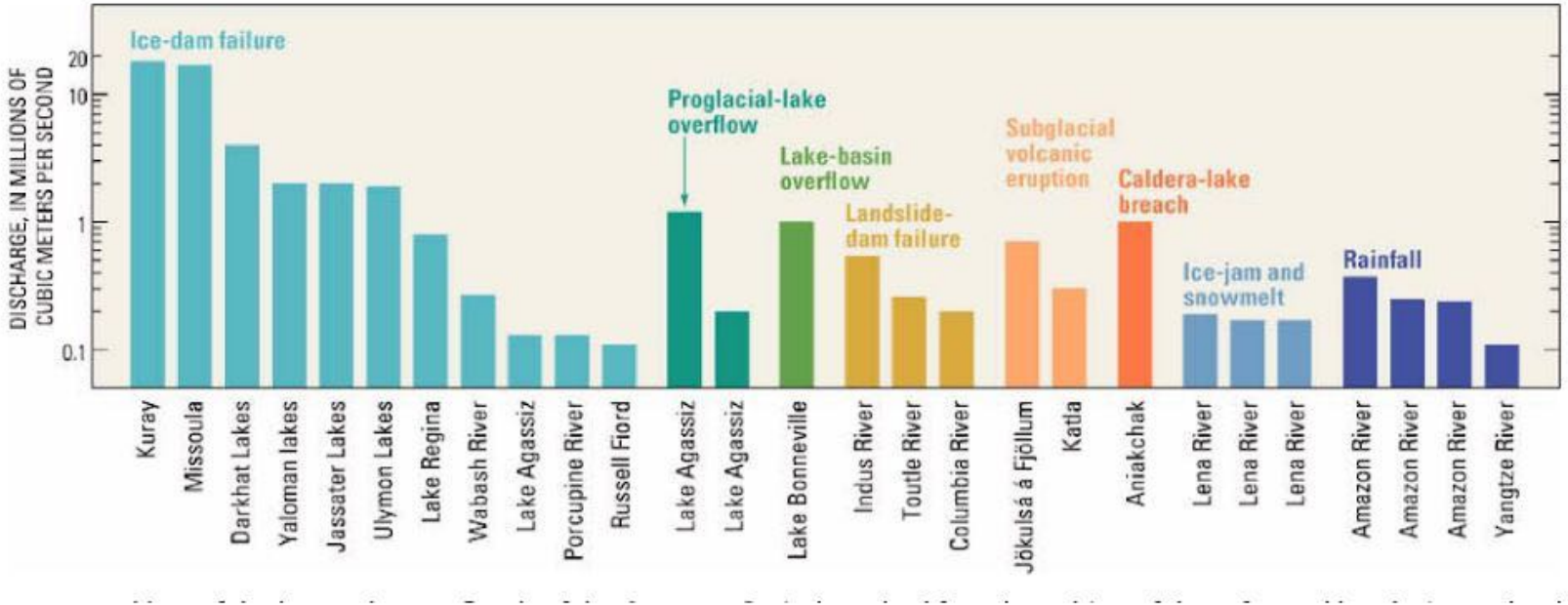
- Reliance on glacial lakes for water
- Tendency to build near rivers or near glacial lakes
- Steep terrain -> available land in flood zone

Are GLOFs an increasing hazard?

Yes!

- Global warming
  - Creation of new glacial lakes during recession
  - More water
- Increasing population in mountainous regions

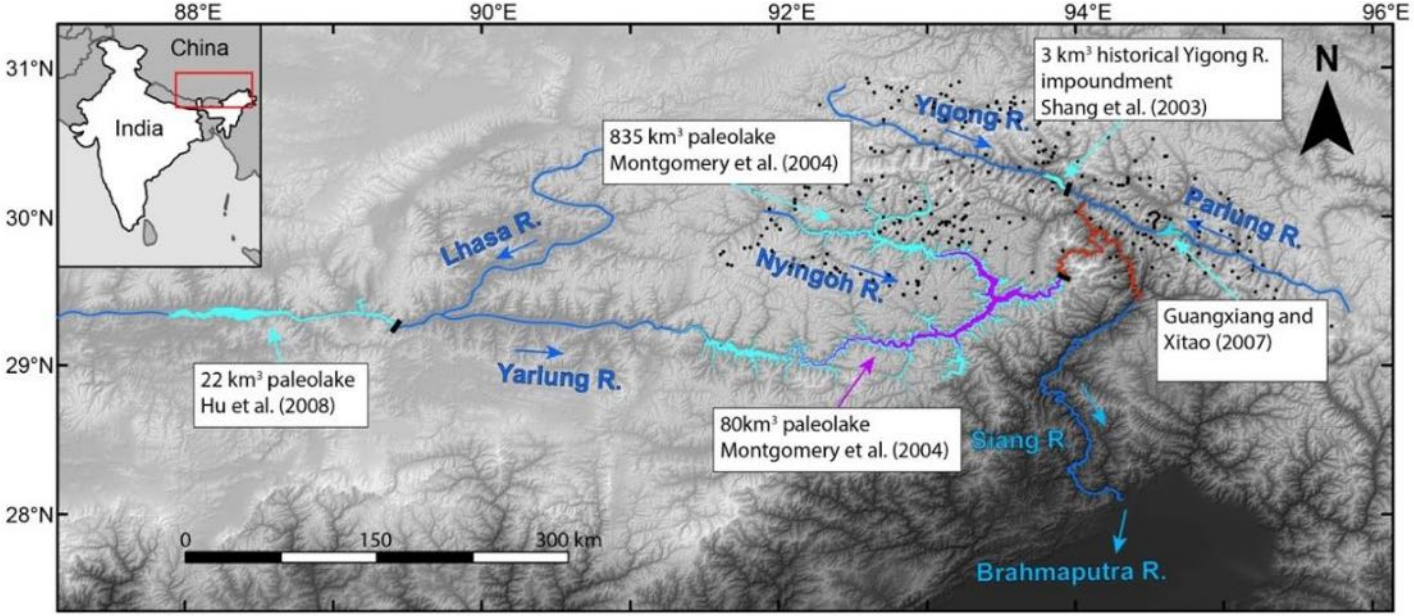
What if we had even bigger floods?



The world's largest floods from: O'Connor, Jim E., and John E. Costa. *The world's largest floods, past and present: their causes and magnitudes.* No. 1254. Geological Survey (USGS), 2004.

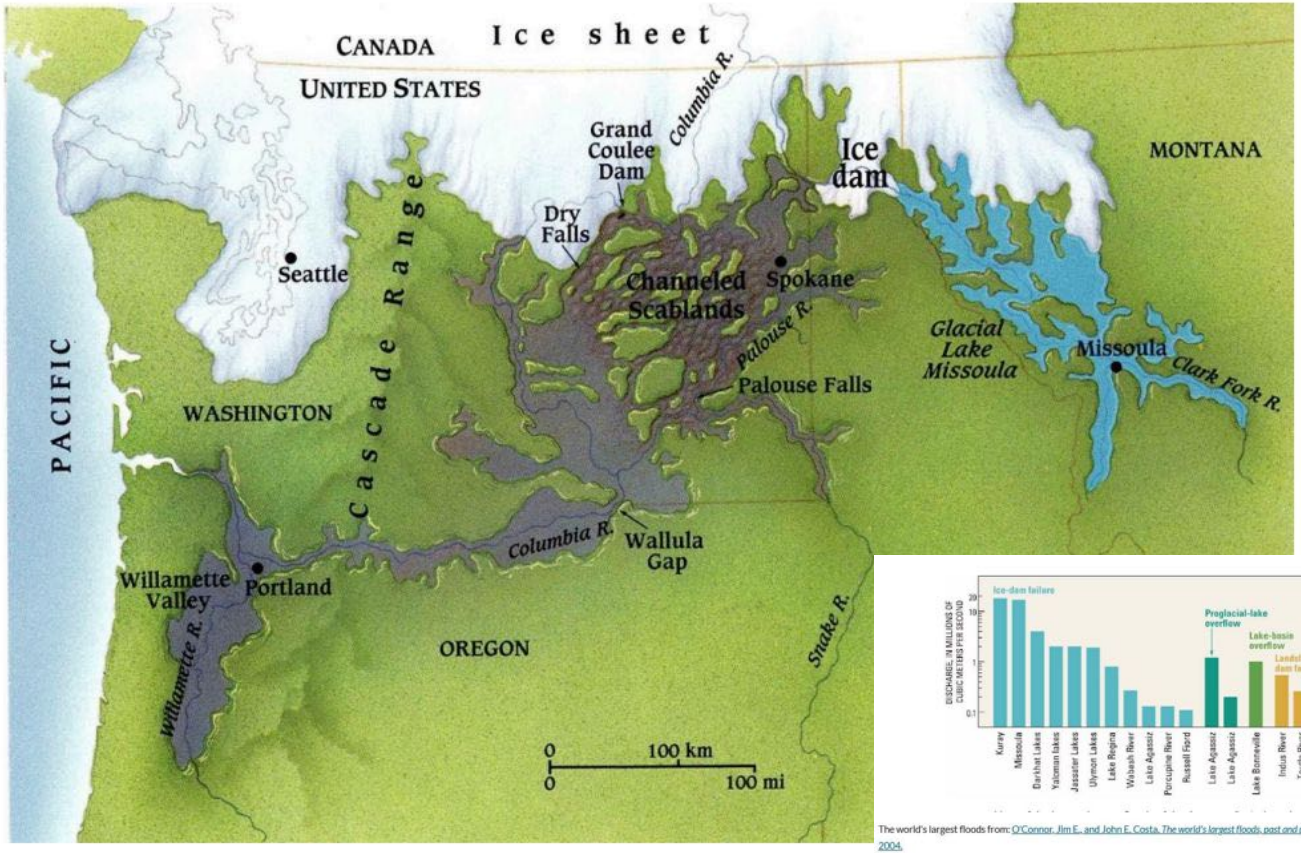
MEGAFLOODS

Himalayan Megafloods- Susannah Morey



https://sites.google.com/uw.edu/susannah-does-science/agu-2020

Glacial Lake Missoula- Channeled Scablands



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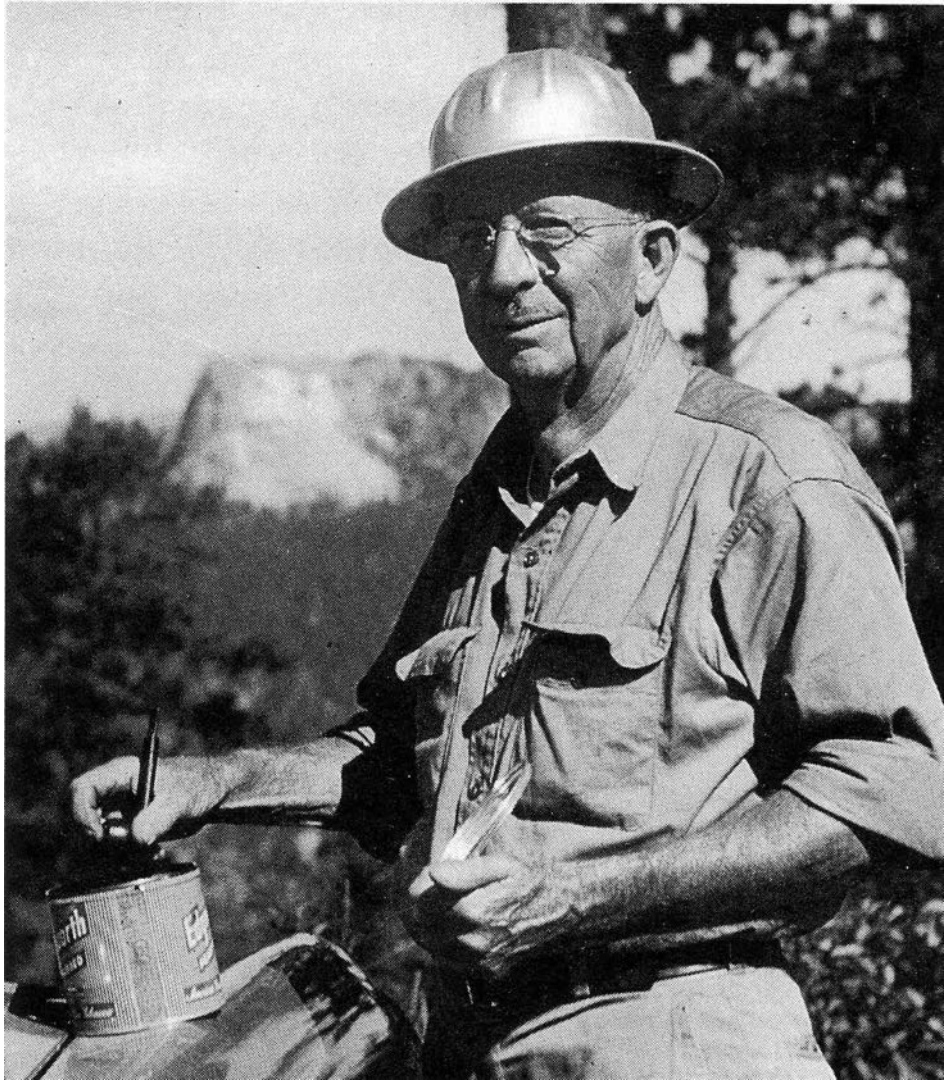
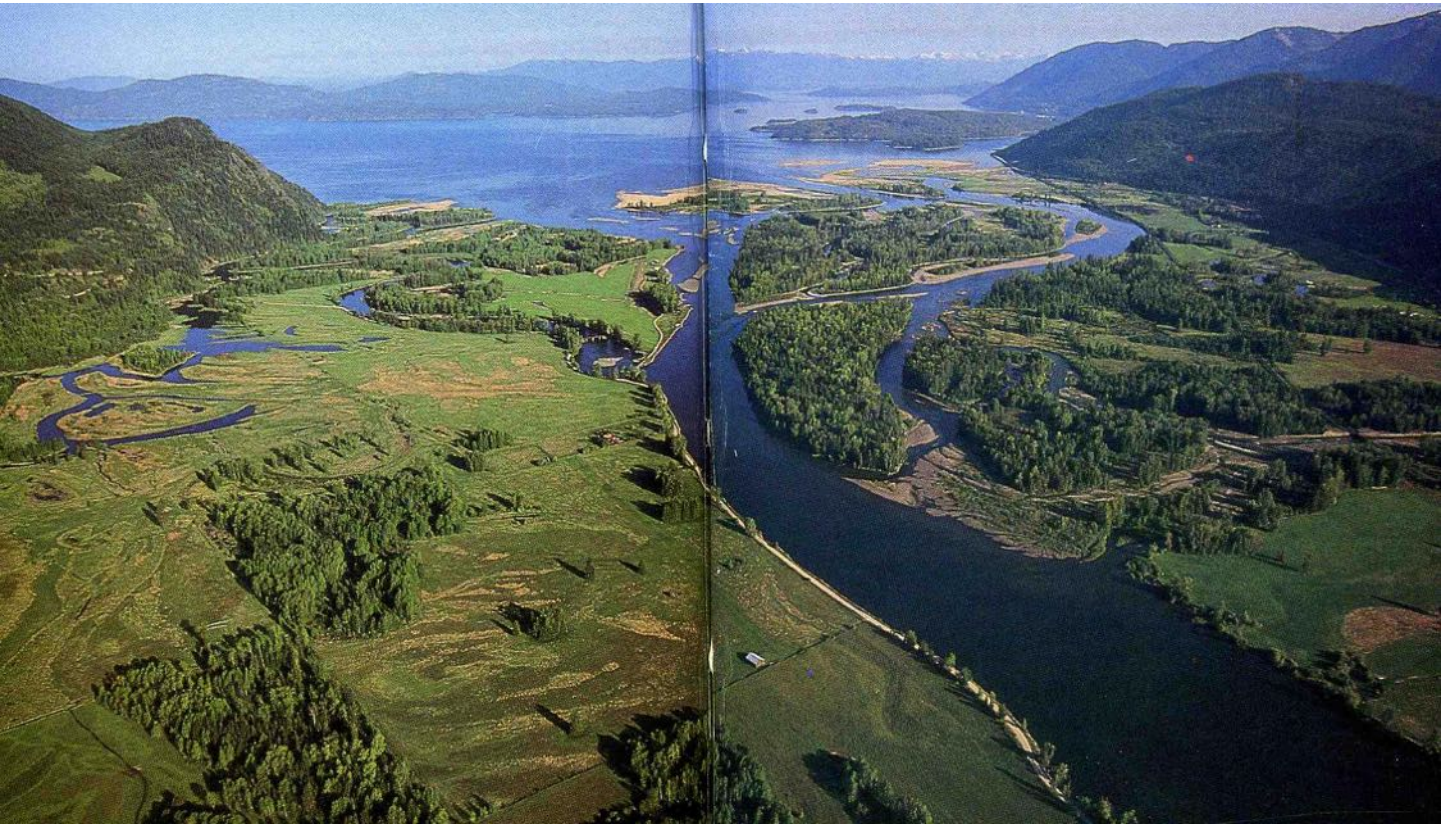
J. Harlen Bretz



M. Parfit 1995
Smithsonian 26(1) 48-59

Dam Location – Lake Pend Oreille



M. Parfit 1995 *Smithsonian* 26(1) 48-59

Missoula Bathtub Ring

M. Parfit 1995 *Smithsonian* 26(1) 48-59

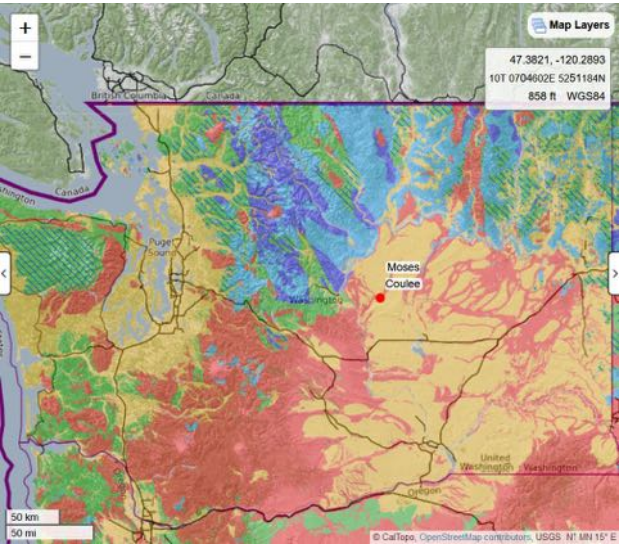

beautifulwashington.com

Quincy Basin Potholes

M. Parfit 1995 *Smithsonian* 26(1) 48-59

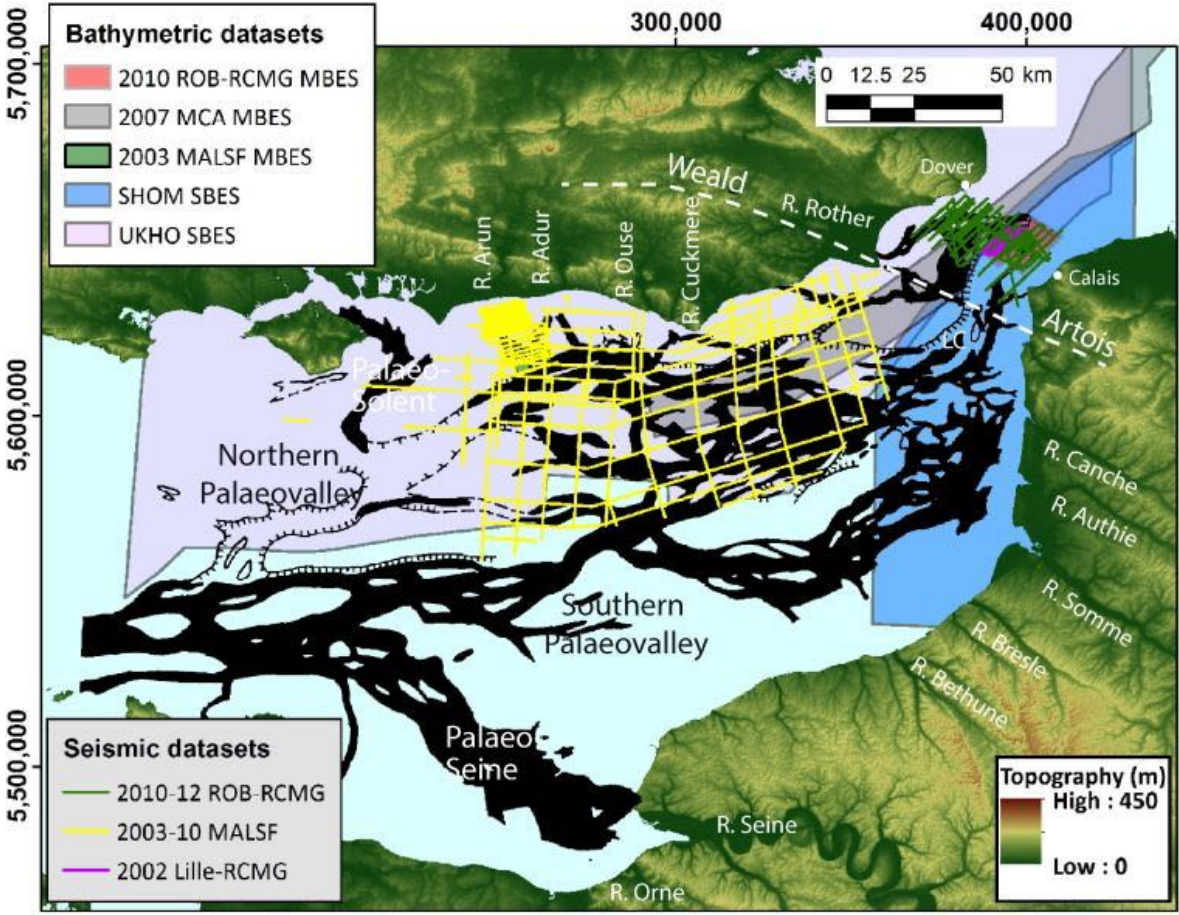
THE CHENEY–PALOUSE TRACT OF WASHINGTON'S CHANNELED SCABLANDS

Erratics! - Joel Gombiner



Nearest upstream granite is 50mi away

Small, seasonal stream. Incapable of transporting boulders of this size.


Bathymetric datasets
2010 ROB-RCMG MBES
2007 MCA MBES
2003 MALSF MBES
SHOM SBES
UKHO SBES
300,000
400,000
5,700,000
5,600,000
5,500,000
0 12.5 25 50 km
Weald
R. Rother
Dover
Calais
Artois
R. Arun
R. Adur
R. Ouse
R. Cuckmere
Palaeo-Solent
Northern Palaeovalley
Southern Palaeovalley
Palaeo-Seine
R. Canche
R. Authie
R. Somme
R. Bresle
R. Bethune
R. Seine
R. Orne
Seismic datasets
2010-12 ROB-RCMG
2003-10 MALSF
2002 Lille-RCMG
Topography (m)
High : 450
Low : 0