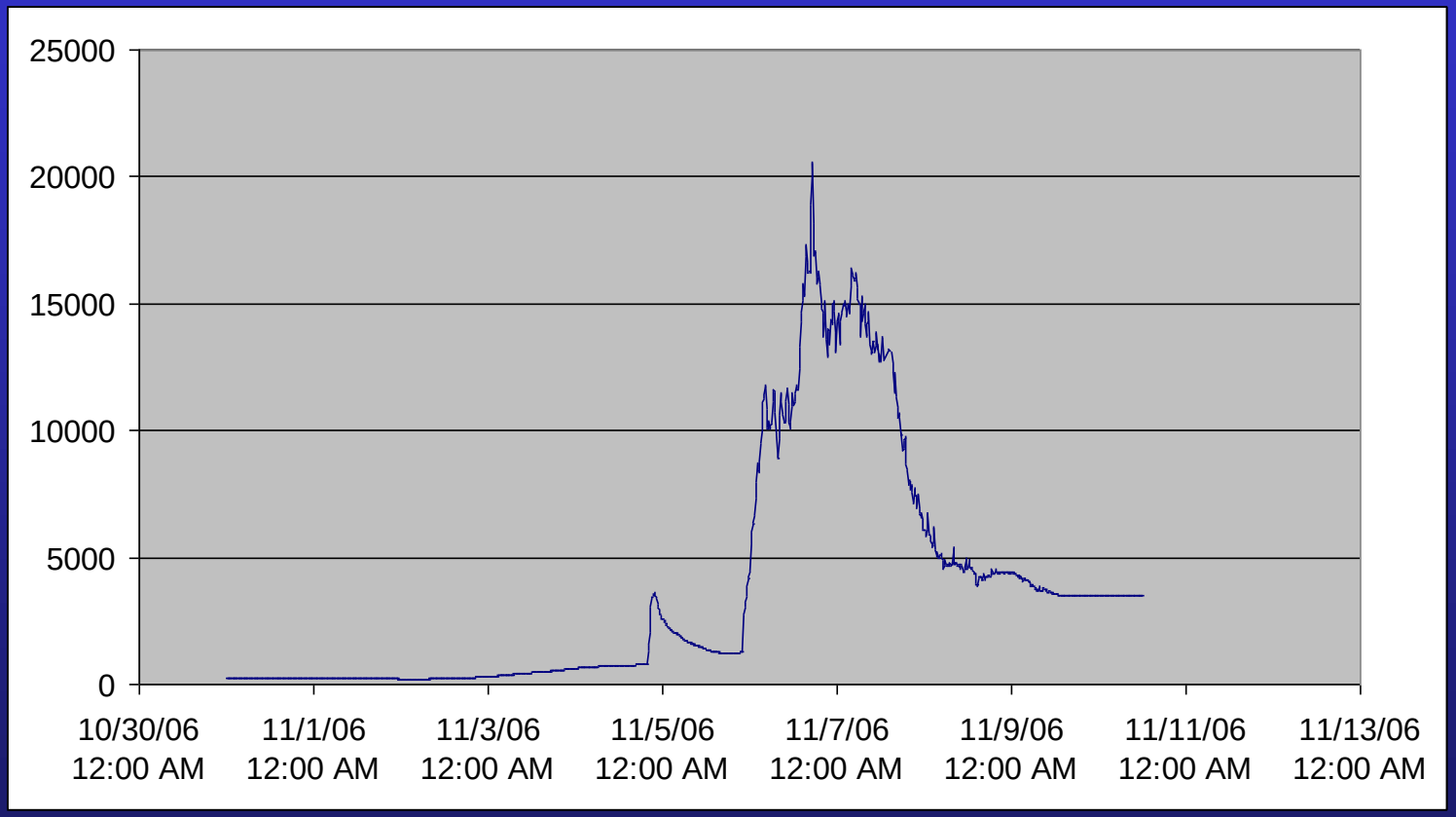
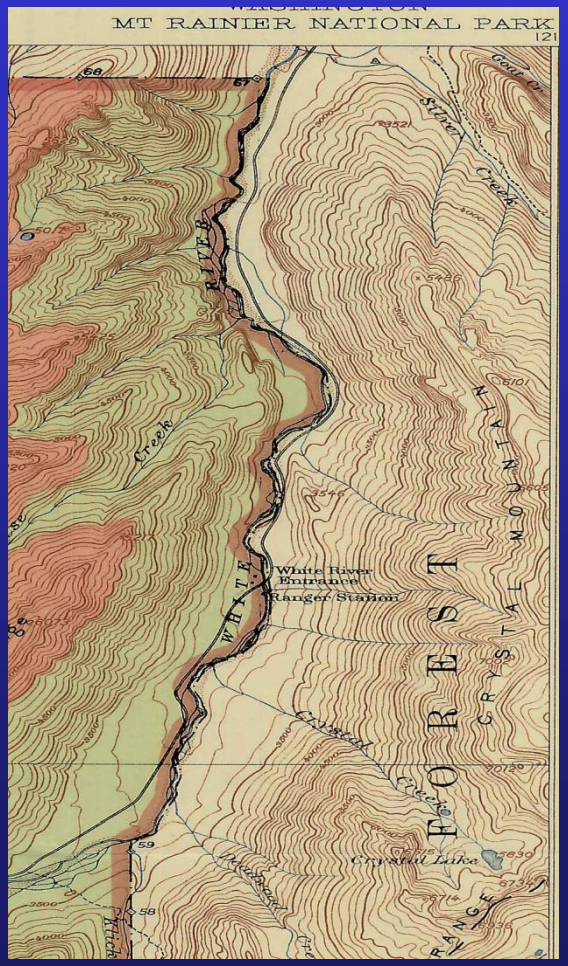
# Why was the Flood so bad?




Record rain and flood, but…

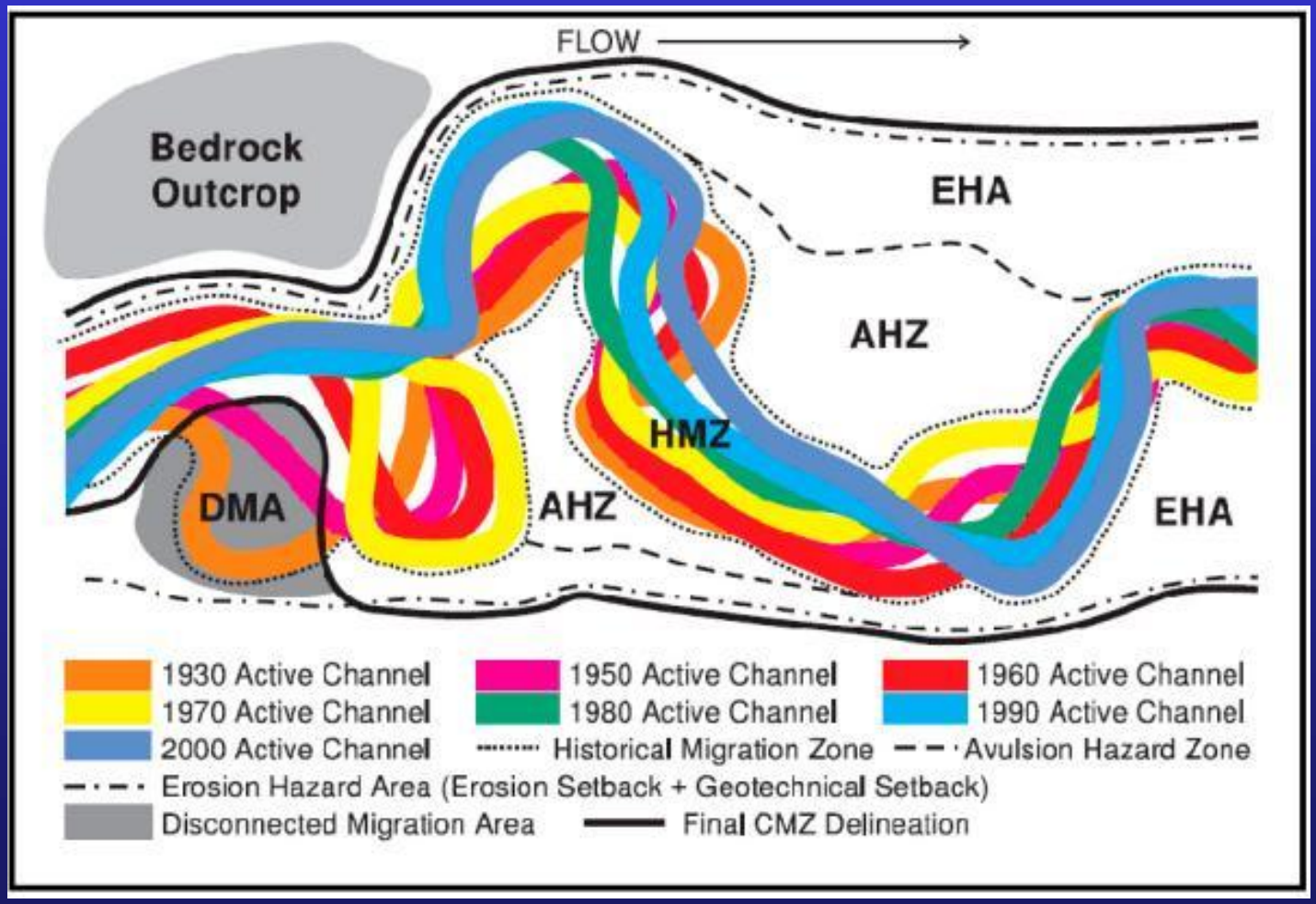
# That flood was exceptional — however, other, recent damage to the park was great in much smaller storms…

- Park dealt a "bad hand";
- The park inherited roads, which were often built in rivers….




Old Storbo Mine Road – 1915 map

# River Channel Migration Zones



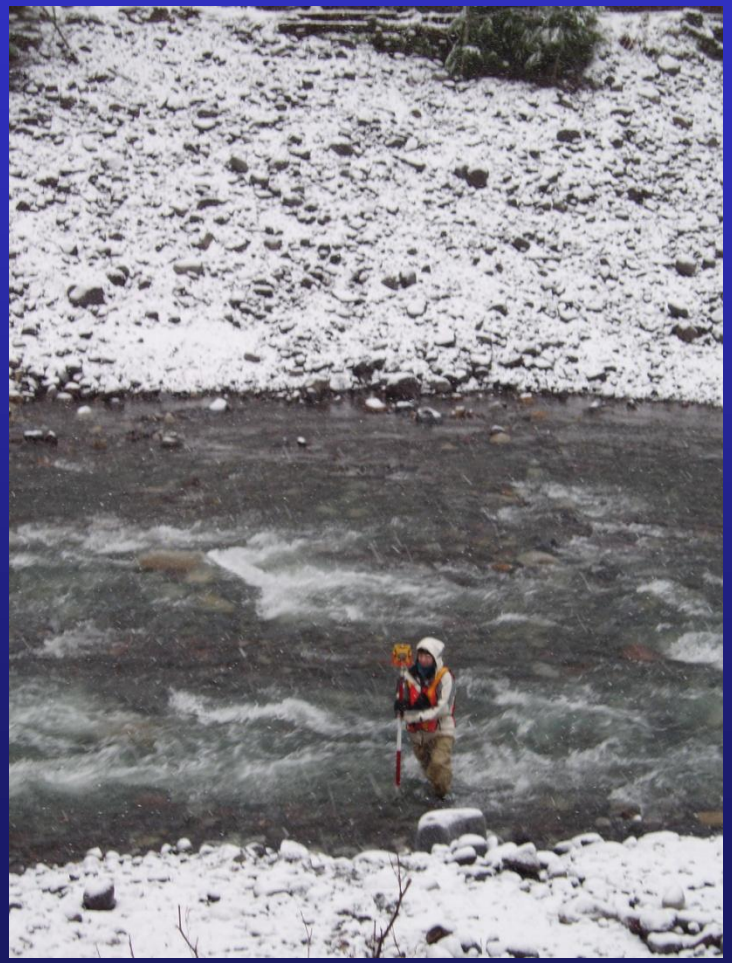

Rivers are dynamic, and move across valley bottom.

National Park Service
U.S. Department of the Interior

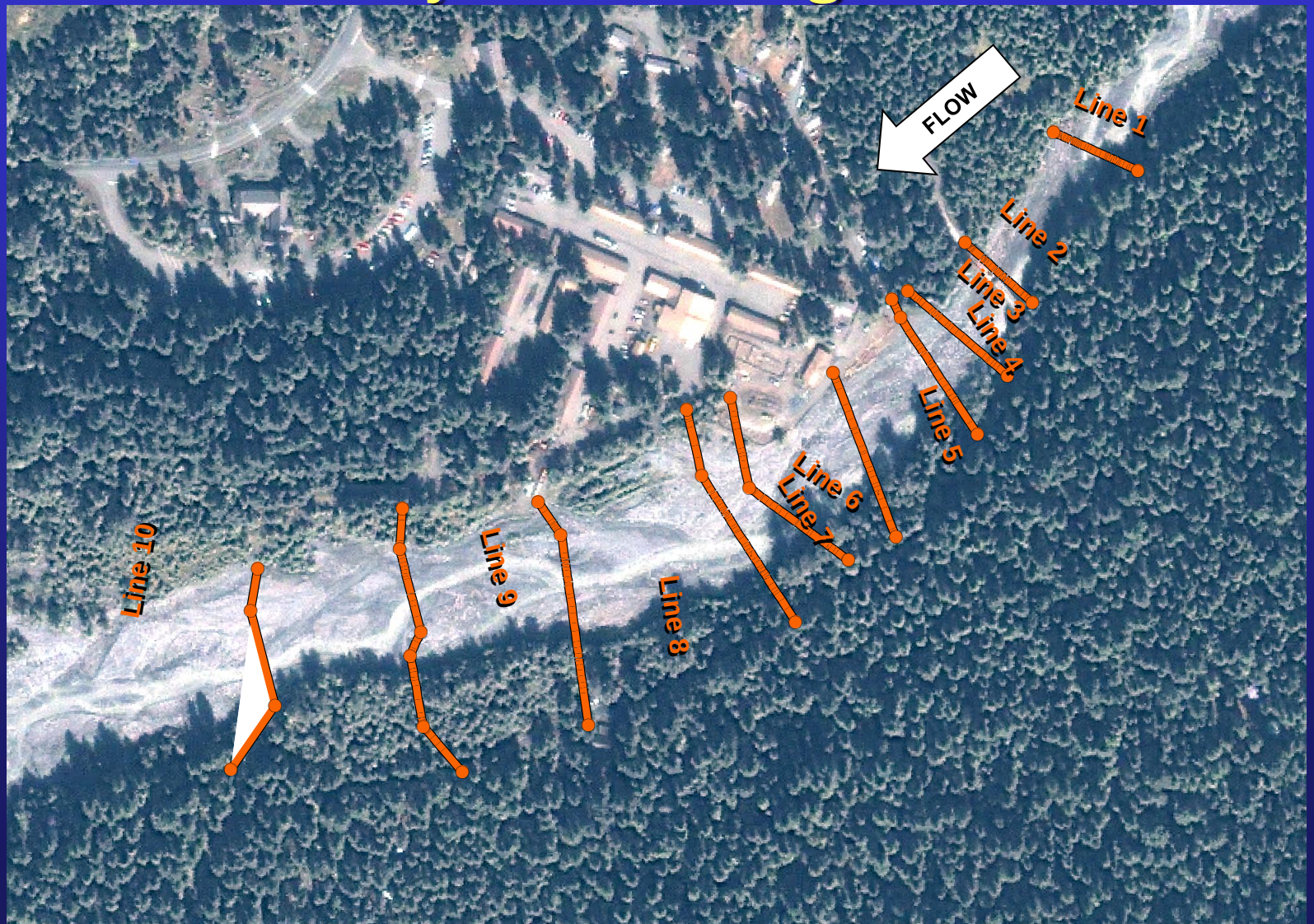
**Pacific West Region - Mount Rainier National Park**

# The Environmental Implications of Aggradation on Major Braided River Channels

# Team X-Stream (pre and post-flood cross sections)



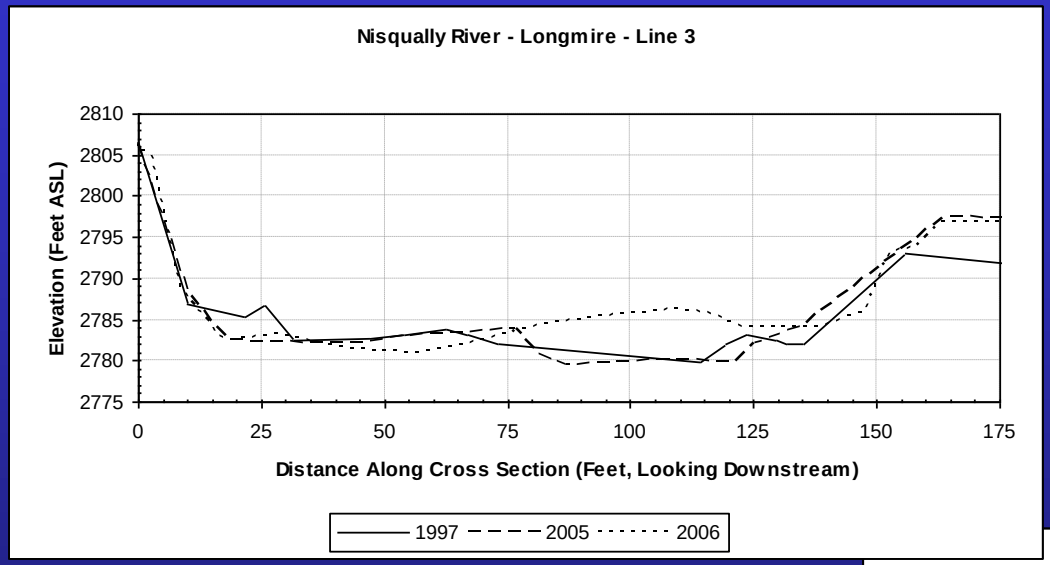
# Study Area - Longmire



# Methods

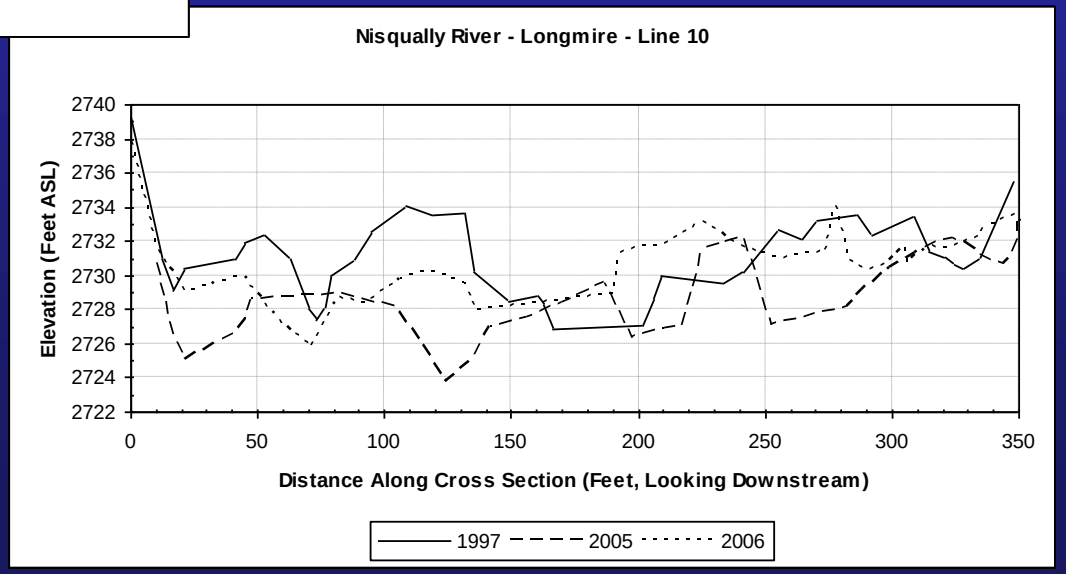
- Pentax Total Station surveying unit used to measure accurate positions along known cross sections;
- Data is  compared to earlier measurements;
- Information is displayed using Geographic Information Systems.

# XY graph of elevation, 1997-2006:




0.44 in•yr$^{-1}$

-0.88 in•yr$^{-1}$



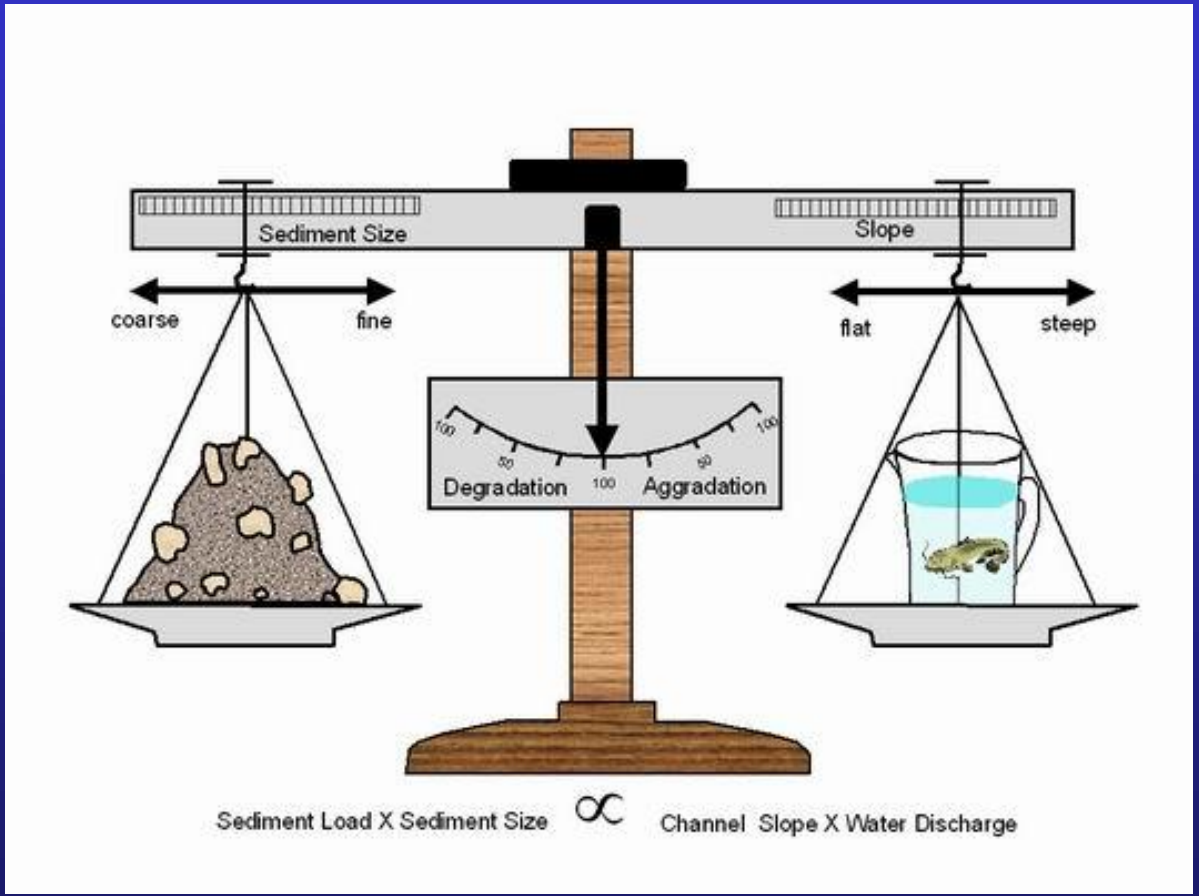
# Results – Longmire (Contd.)

- Determine the rate of change between years
- Determine (GIS) the area between lines (right)
- Area-weighted average change

# Park-wide Aggradation Trends

- **Historic Rate:** 2.3”/decade (last 230 years);
  - (1910-present): < 4”/decade;
- **Current rate** (last 10 years): 6-50+”/decade,
  - ~ 3 feet/decade average;
  - almost 10X historic rate
- **Debris flows**: 5.6 feet of material in 1 event;
- **2006 flooding**: ~ 1 foot in 1 event;
  - Floods *should* erode river channels…
- So…. **Why did we have river filling?**

# Geomorphology 101: Lane's Balance

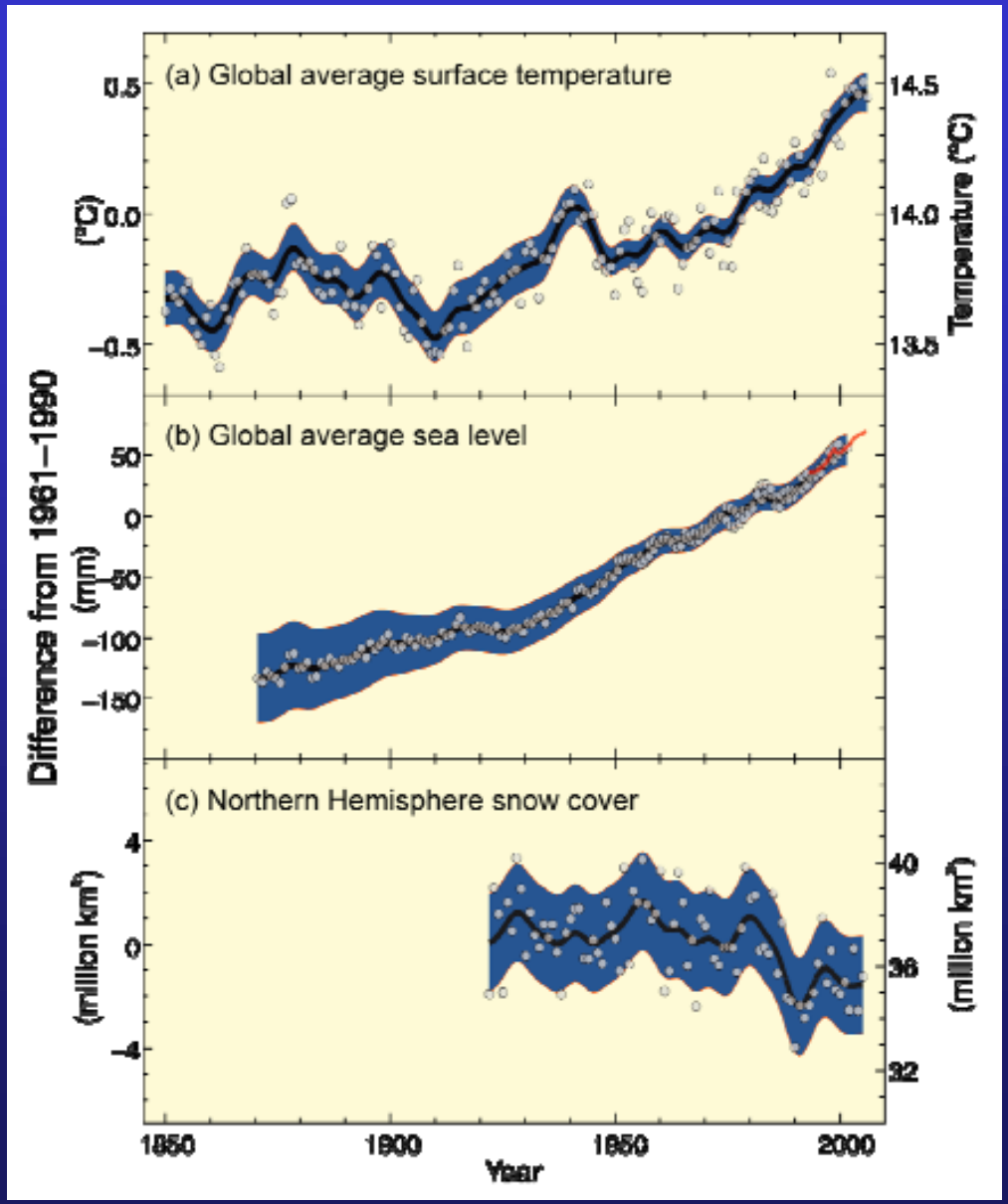



Now we look at how rivers respond to changes in *river flow* and *sediment* supply.

# Incision: Qc >> Qs

Normal channel response to increase in peak flows (Qc).

# Aggradation: Qc << Qs




# IPCC 2007:

The climate is warming.

Sea level is rising.

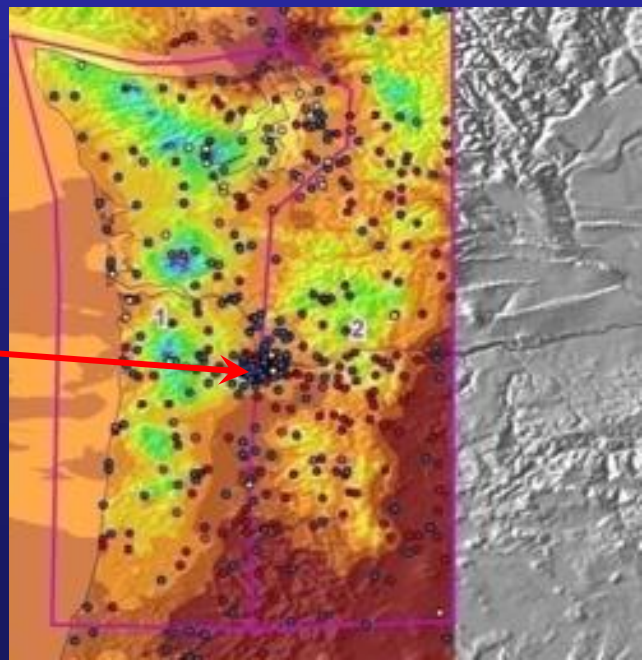
Glaciers are melting.

# Regional Storms

- Many extreme storms in the region have been studied since 1900. Parzybok (and others, 2009) found that **the 6 largest storms ever known in the Pacific Northwest have occurred in the last 25 years**.

- The December 2007 storm **produced the heaviest 12-hour precipitation** (at most area sizes) **ever analyzed** in the Pacific Northwest.

**Up to 28 inches of precipitation in 6 days.**



## Pacific West Region - Mount Rainier National Park

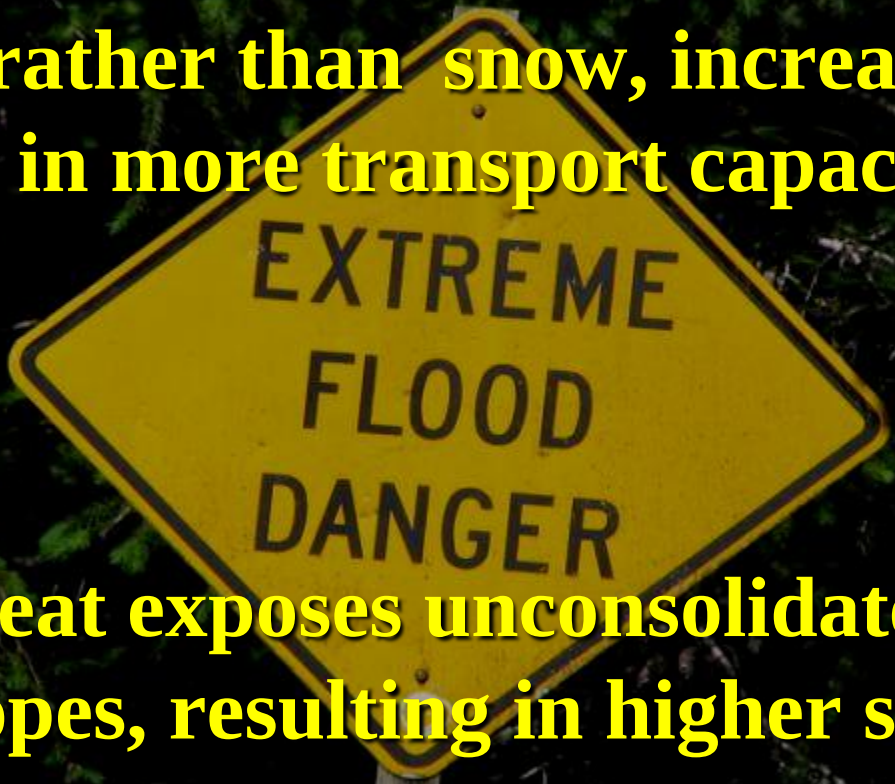

"Two years after **hurricane-force winds** and **rain** ravaged hundreds of miles of trail in **Mount Rainier National Park**, the true damage is finally becoming clear. **And what its telling scientists is alarming:** Bigger, more frequent-and more destructive-storms"

*from Backpacker magazine, January 2009*

After the storm, the Park, OSU, and ENTRIX became interested in run-off and sediment production from 2 perspectives: **climate**; and **geomorphic**.

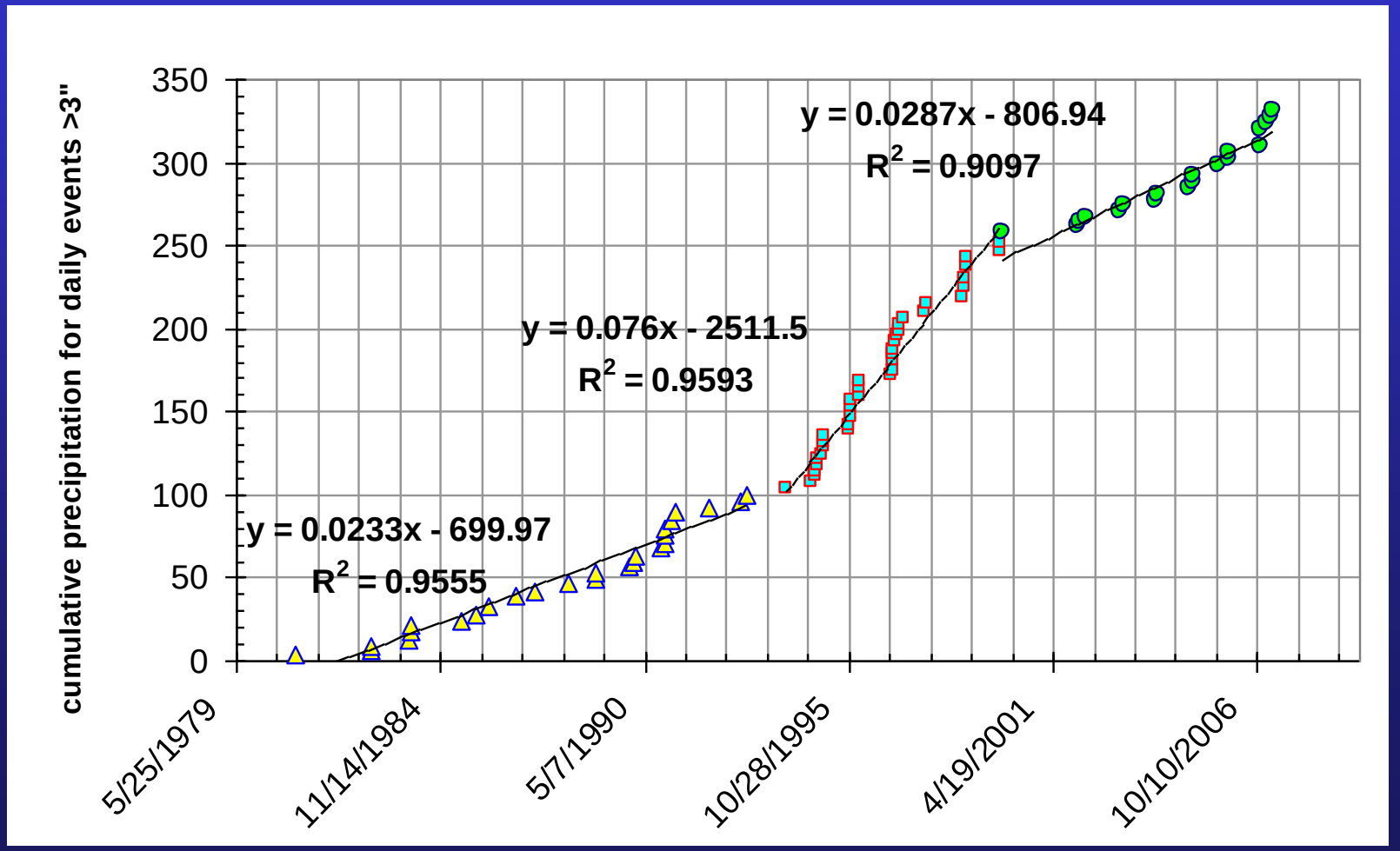
# So how can a warming climate change hydrologic and sediment conditions in glacial environments?

1) More rain rather than snow, increases runoff, resulting in more transport capacity, Qc.



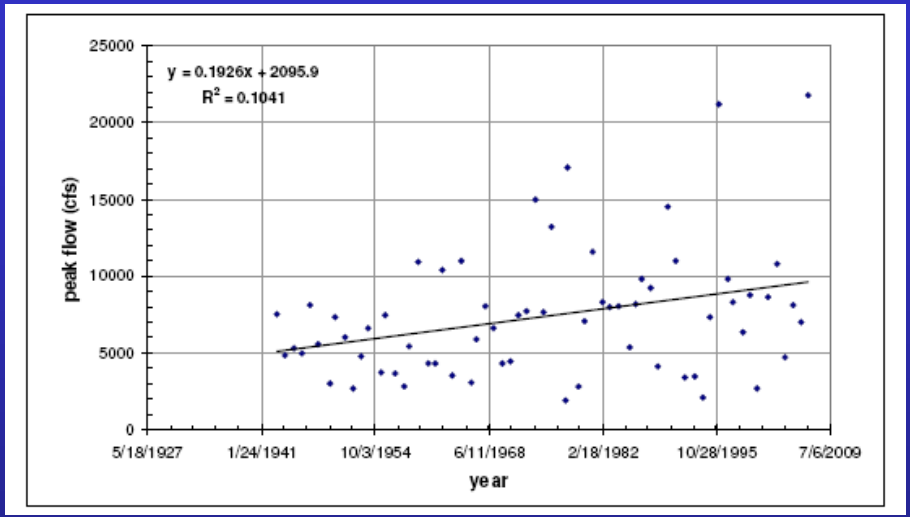

2) Glacier retreat exposes unconsolidated sediment on steep slopes, resulting in higher sediment supply, Qs.

# Cumulative daily precipitation of 3 inches or more – Paradise, Mt. Rainier

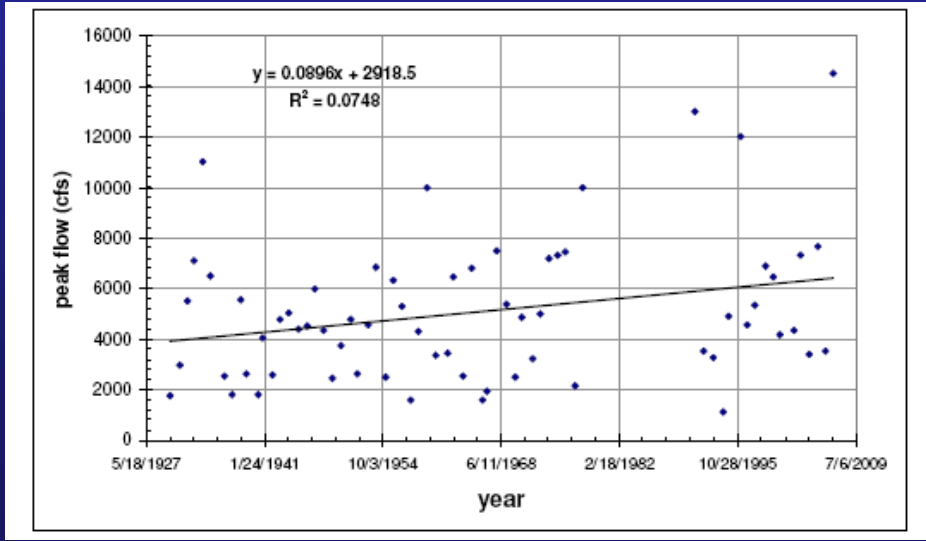


# Annual peak flow increases

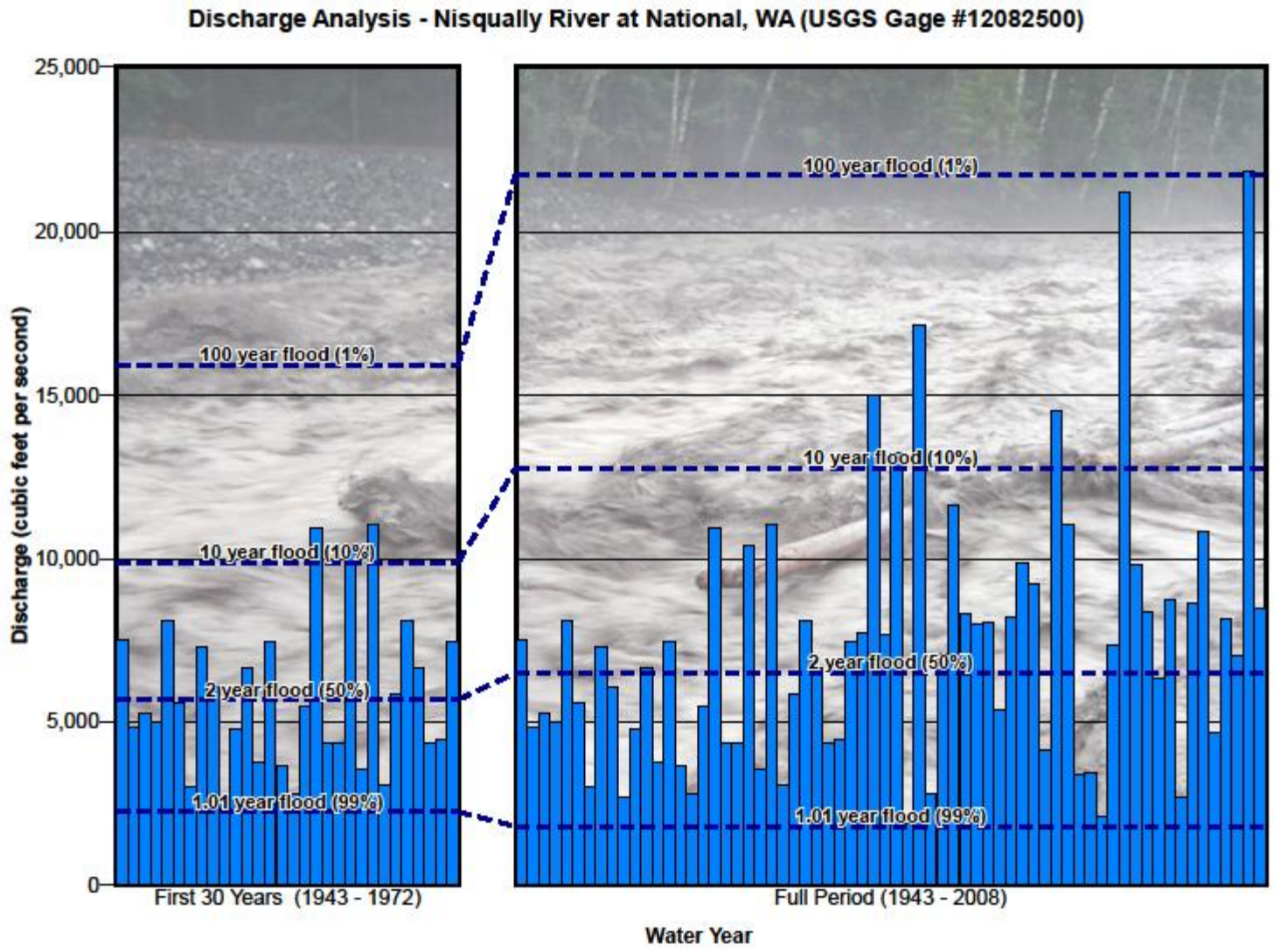
- Annual peak flows in upper **Nisqually** river, near National, WA;



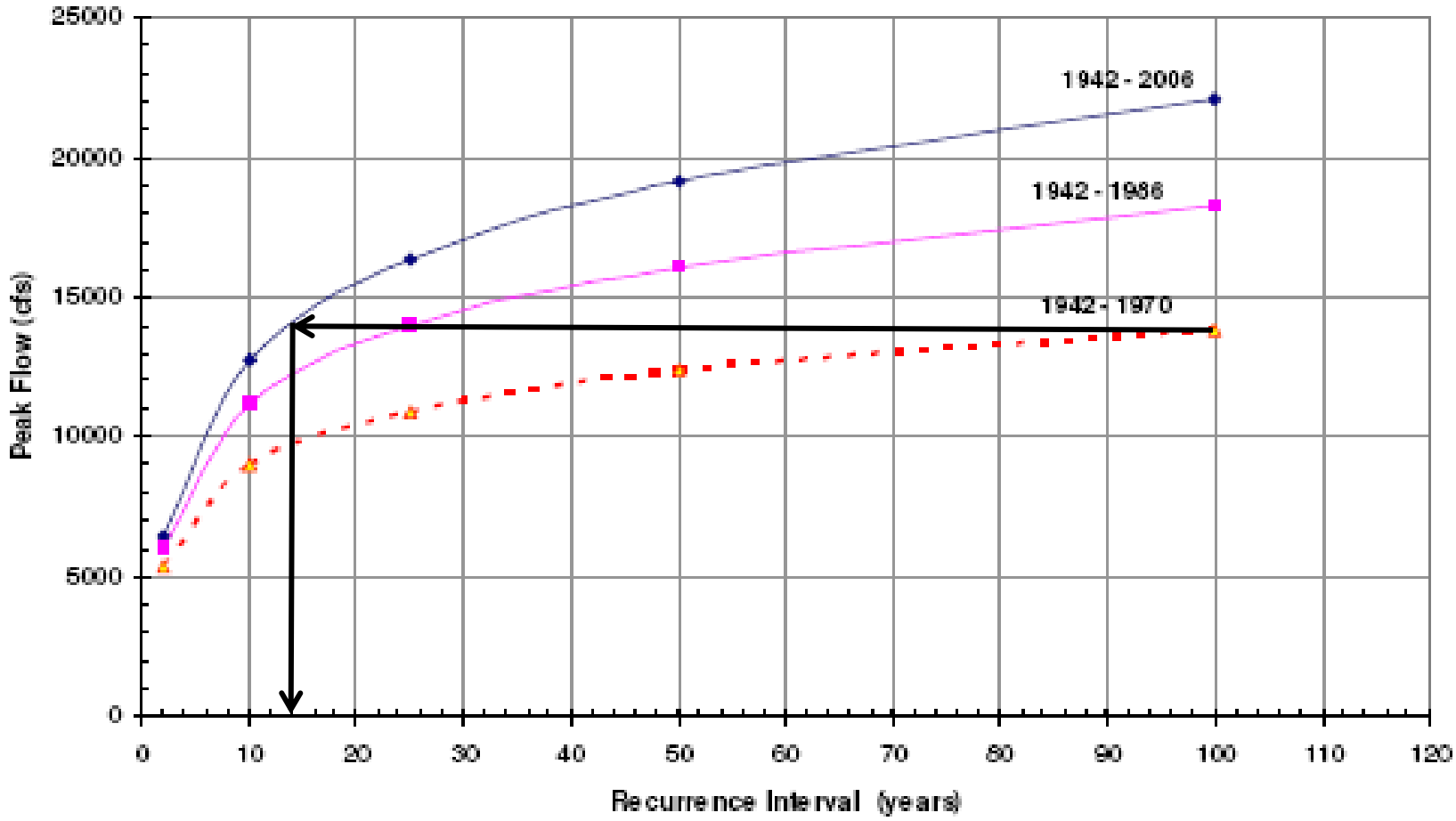

- Annual peak flows in upper **Carbon** river near Fairfax, WA.



# Pacific West Region - Mount Rainier National Park

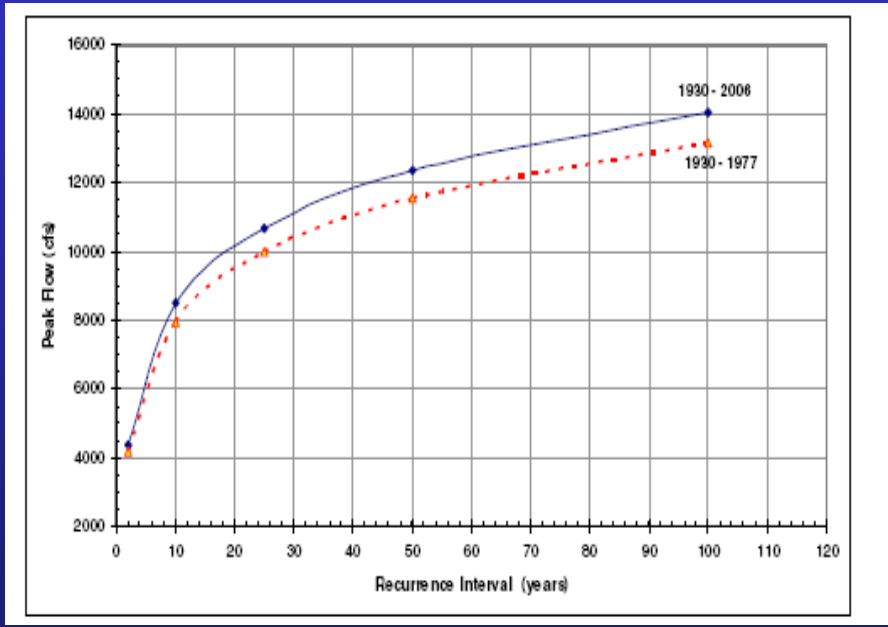


# Dramatic increase on Nisqually: Previous 100 year flood, now every 14 years

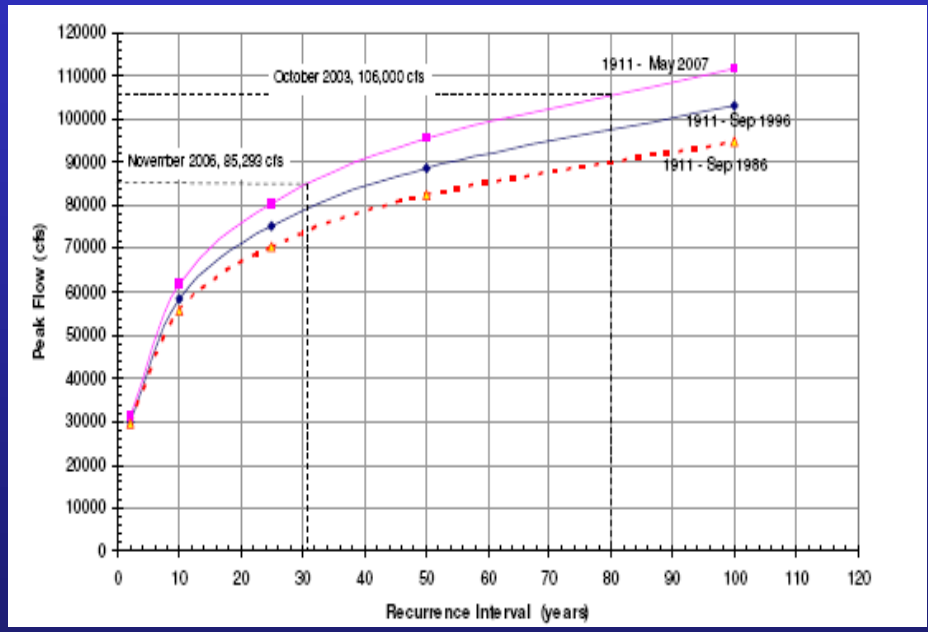


# Regional Trend

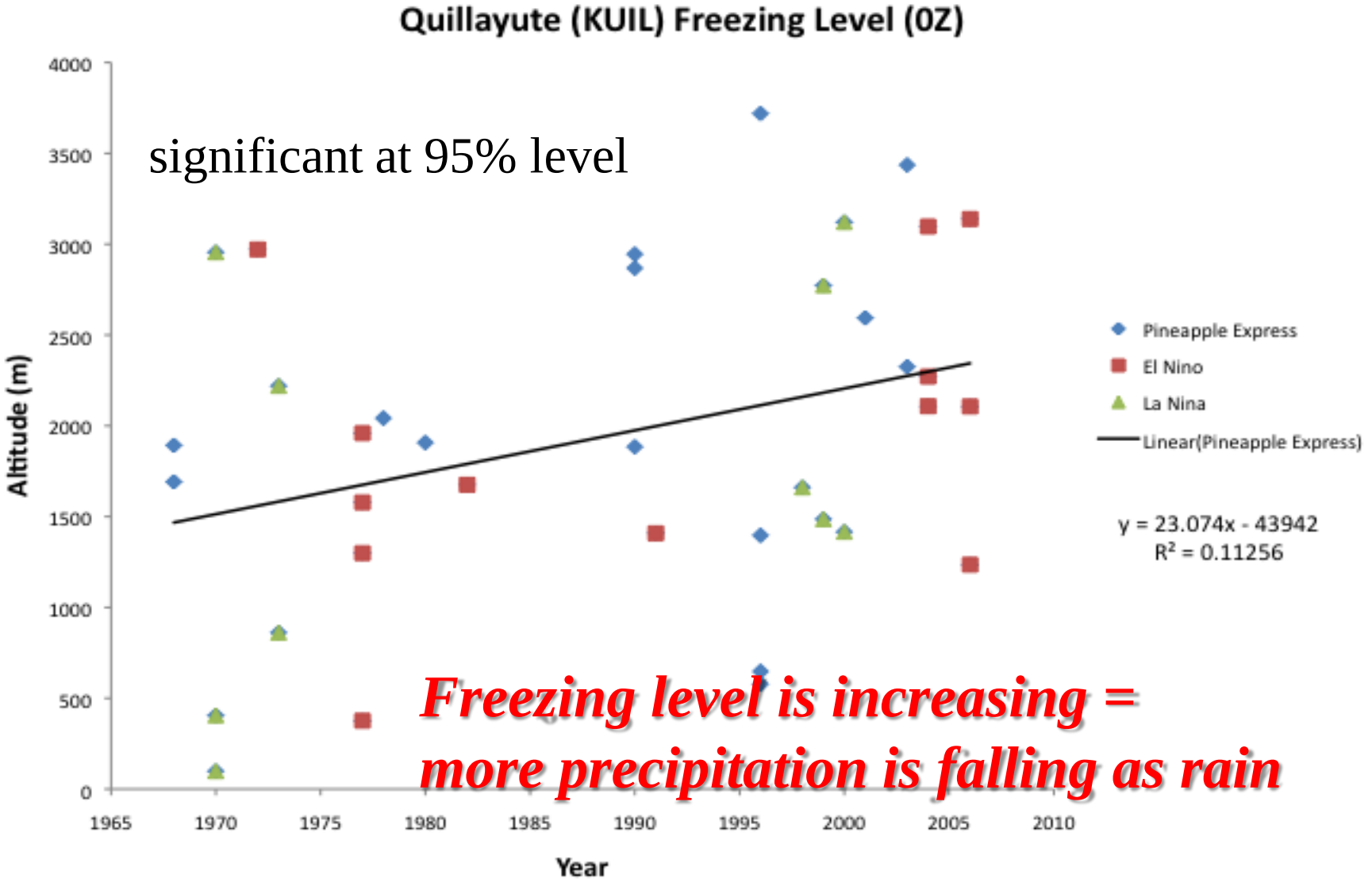
## Carbon




## Sauk




Similar results also seen on Hoh and NF Stillaguamish rivers, WA



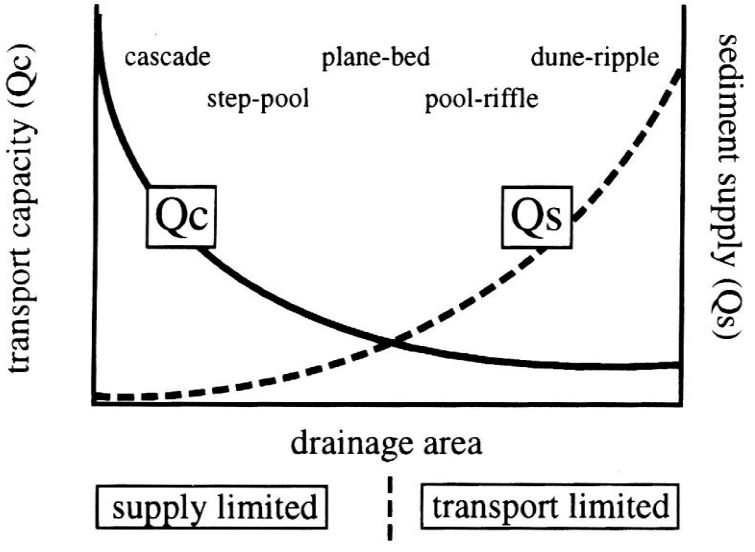

significant at 95% level

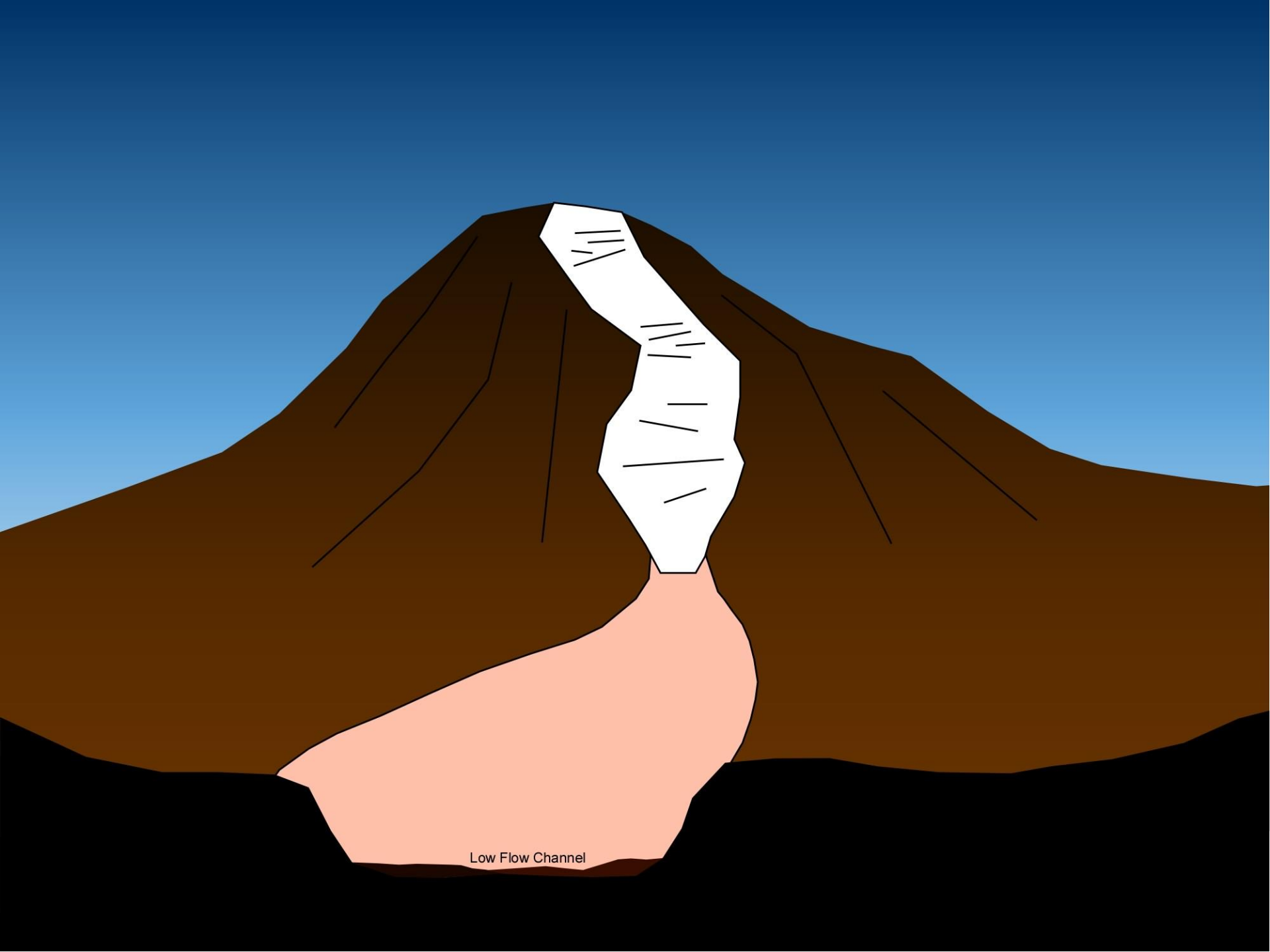
***Freezing level is increasing = more precipitation is falling as rain***

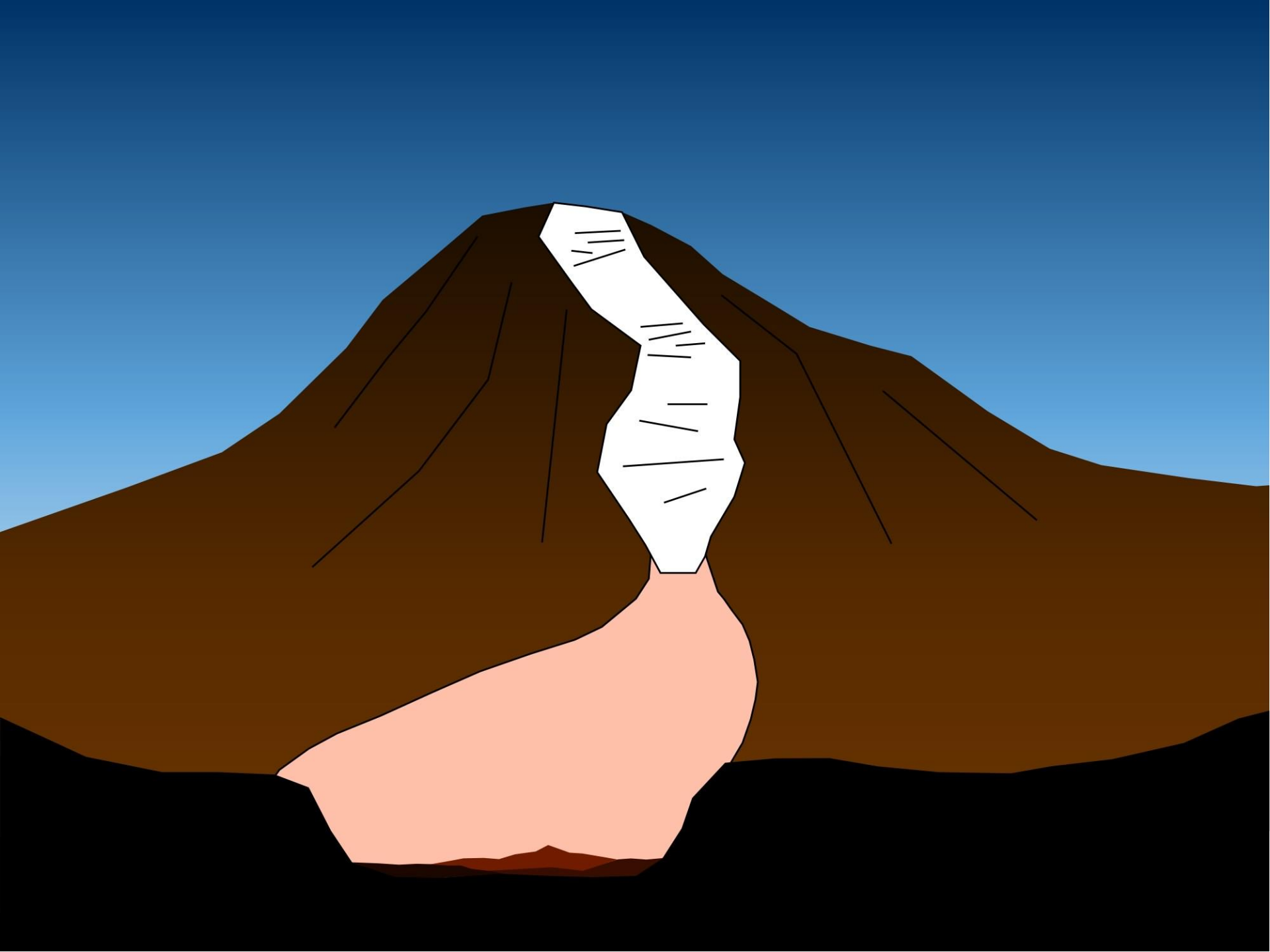
# River Valley Filling (or Aggradation)

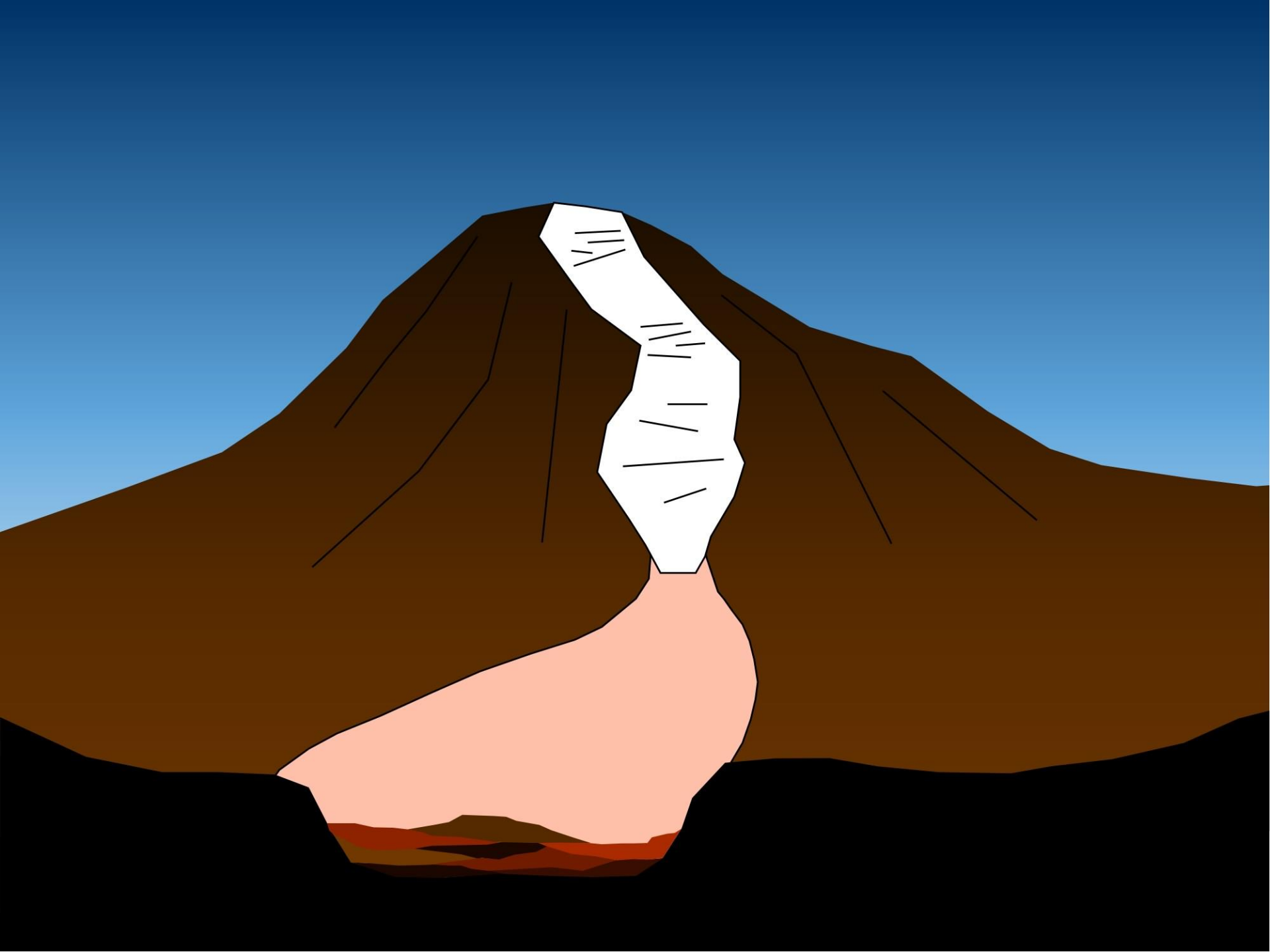

(Note exhumed snags in channel, above.)

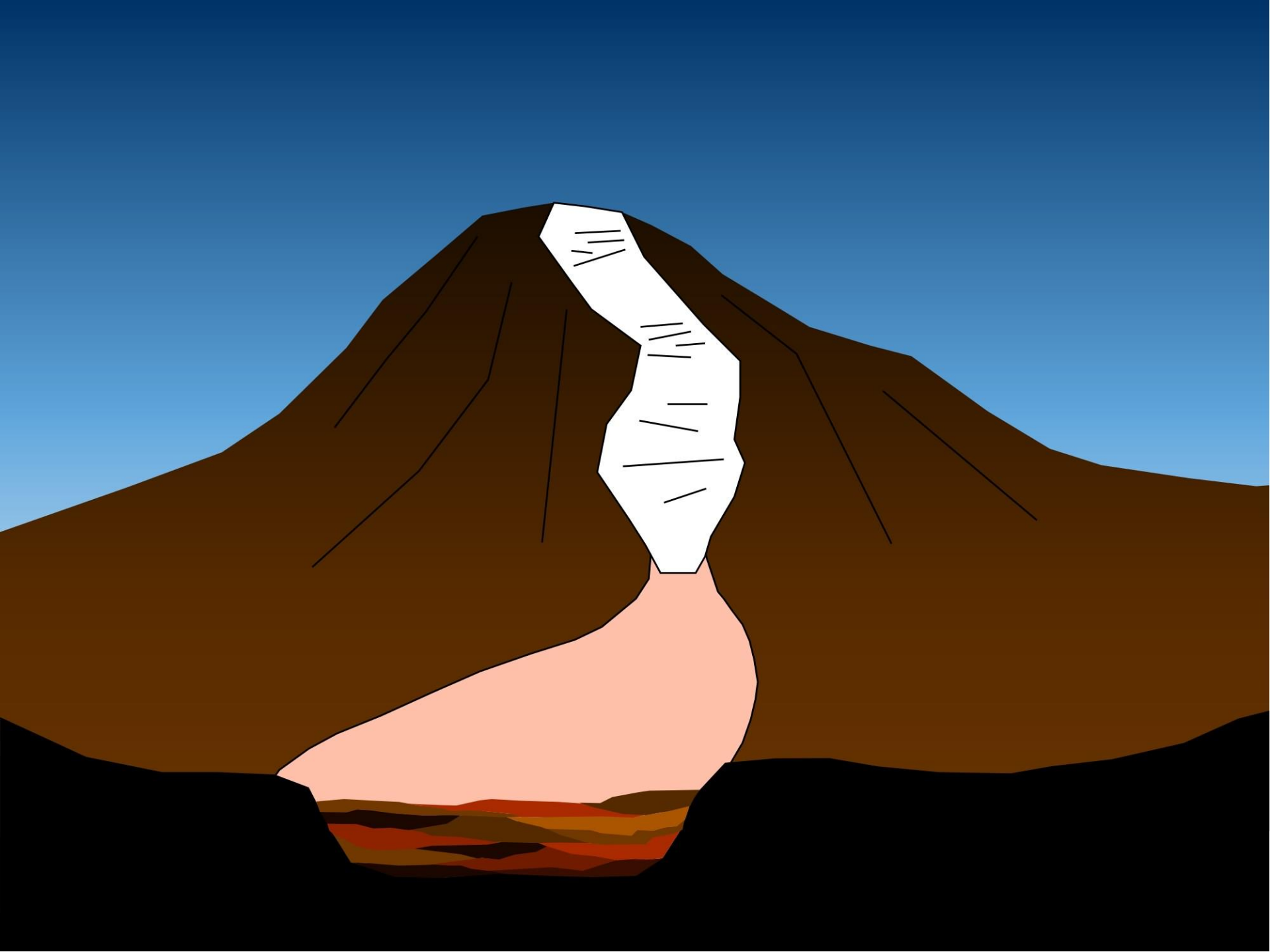
- The geologic driver.

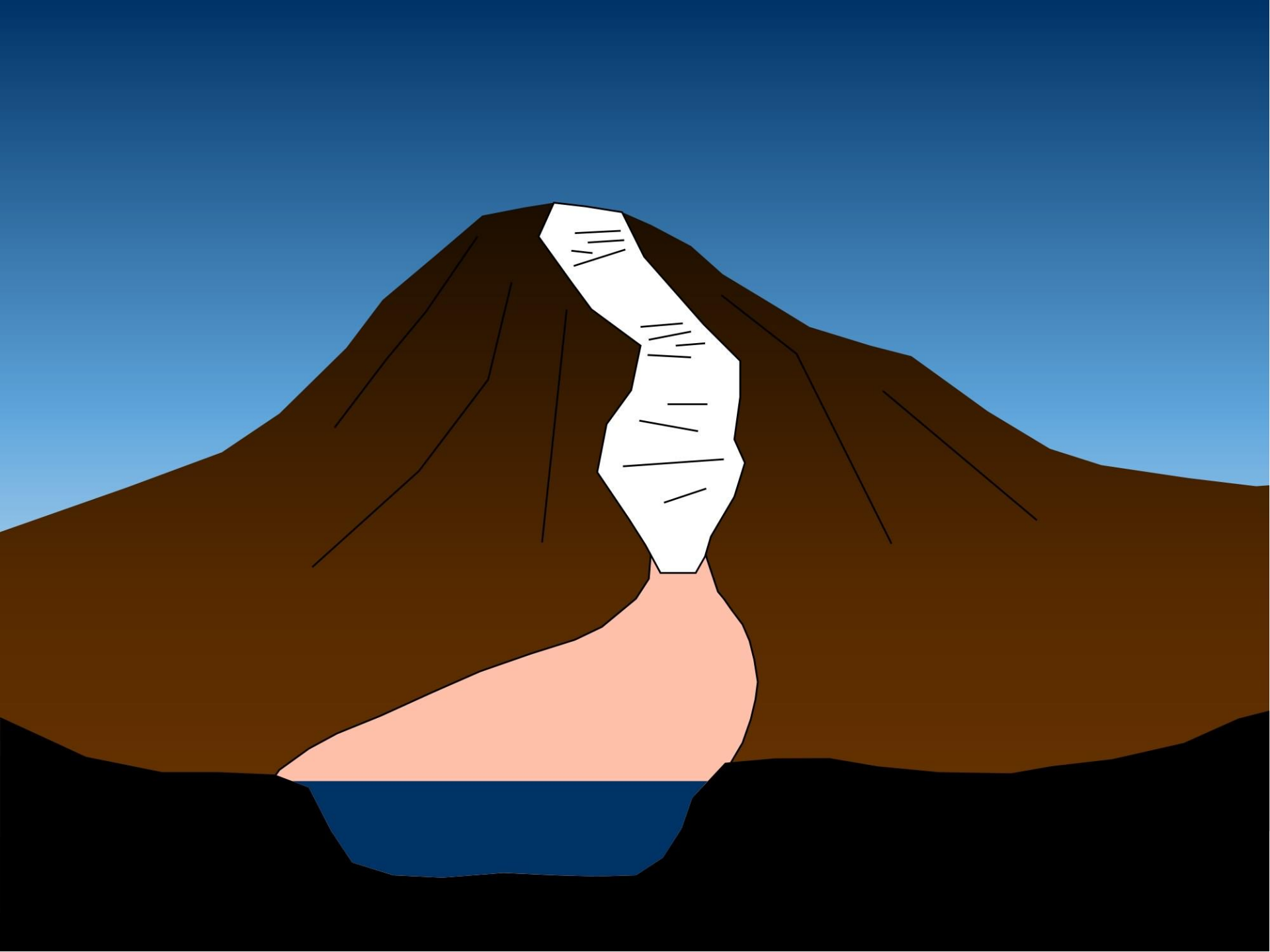


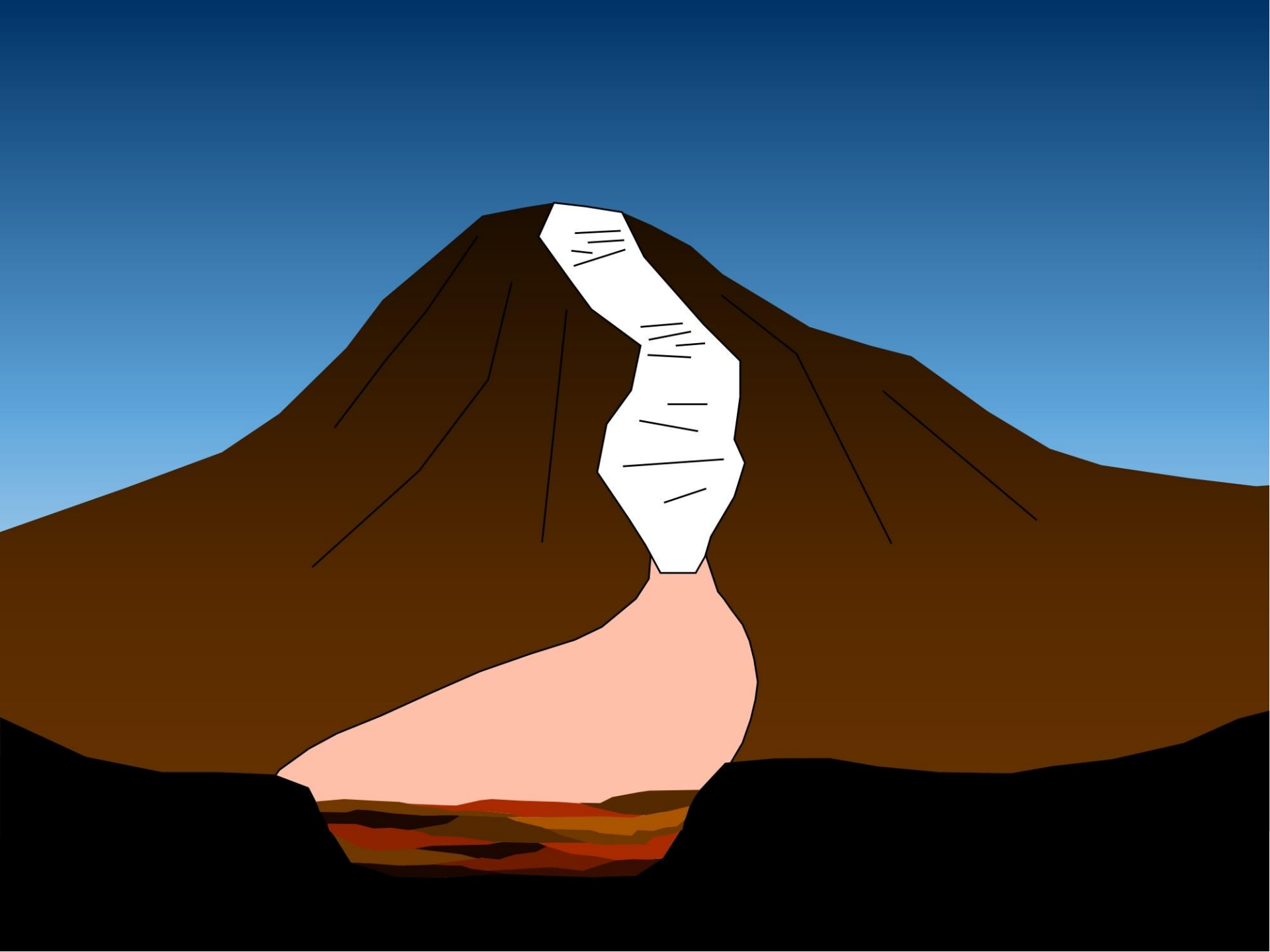

Low Flow Channel

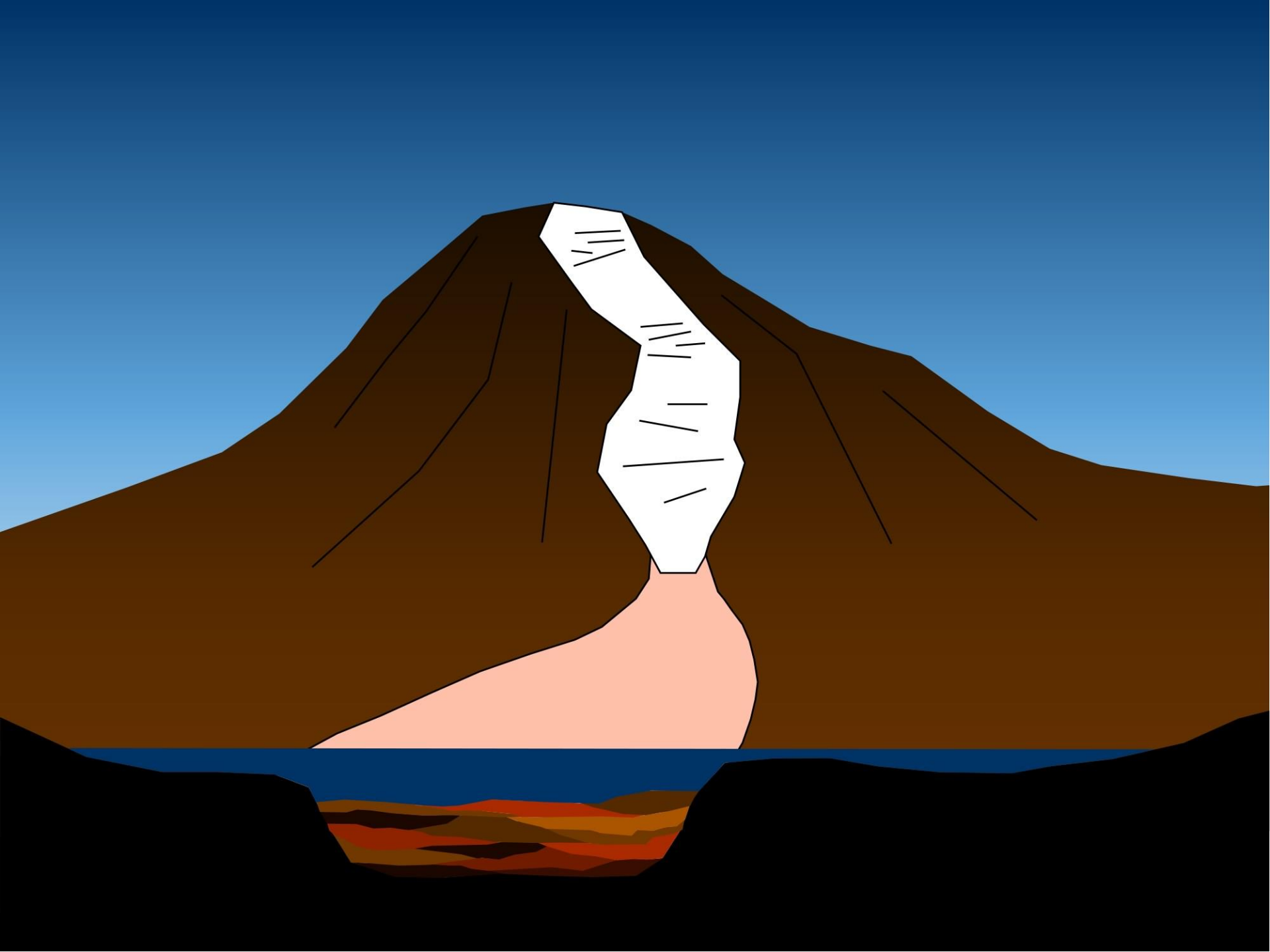












As the stream channel fills with sediment, ‘routine’ higher flows become floods.

# Van Trump Curve -- Debris Flow 2005

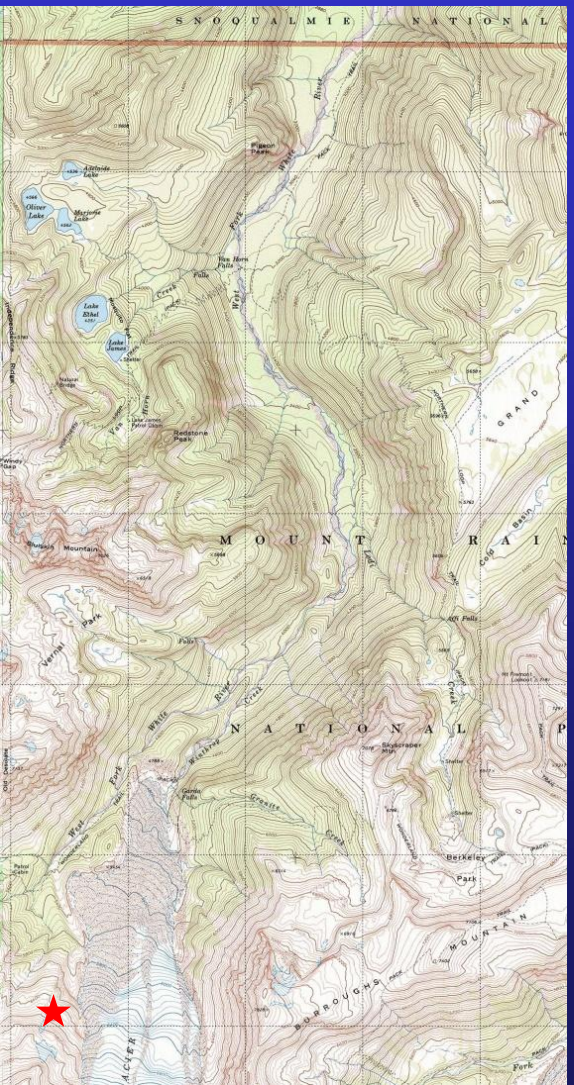
- Nisqually river aggraded over 5 feet in one year, across the 400+ foot wide floodplain, by Van Trump curve, after 1 debris flow.
- Area has aggraded ***38 feet*** since 1910….

# "IT'S ALL DOWNHILL FROM HERE…"

- Debris flows are a highly mobile, sediment-laden slurries that move downhill by gravity.
- Consist of rock, mud, and water (and trees, and anything else in its way….)

# Characteristics: Debris flows carry (and float) boulders….

# Debris flows “bulk up” as travel in steep, mountain channels (>10º), and travel long distances.



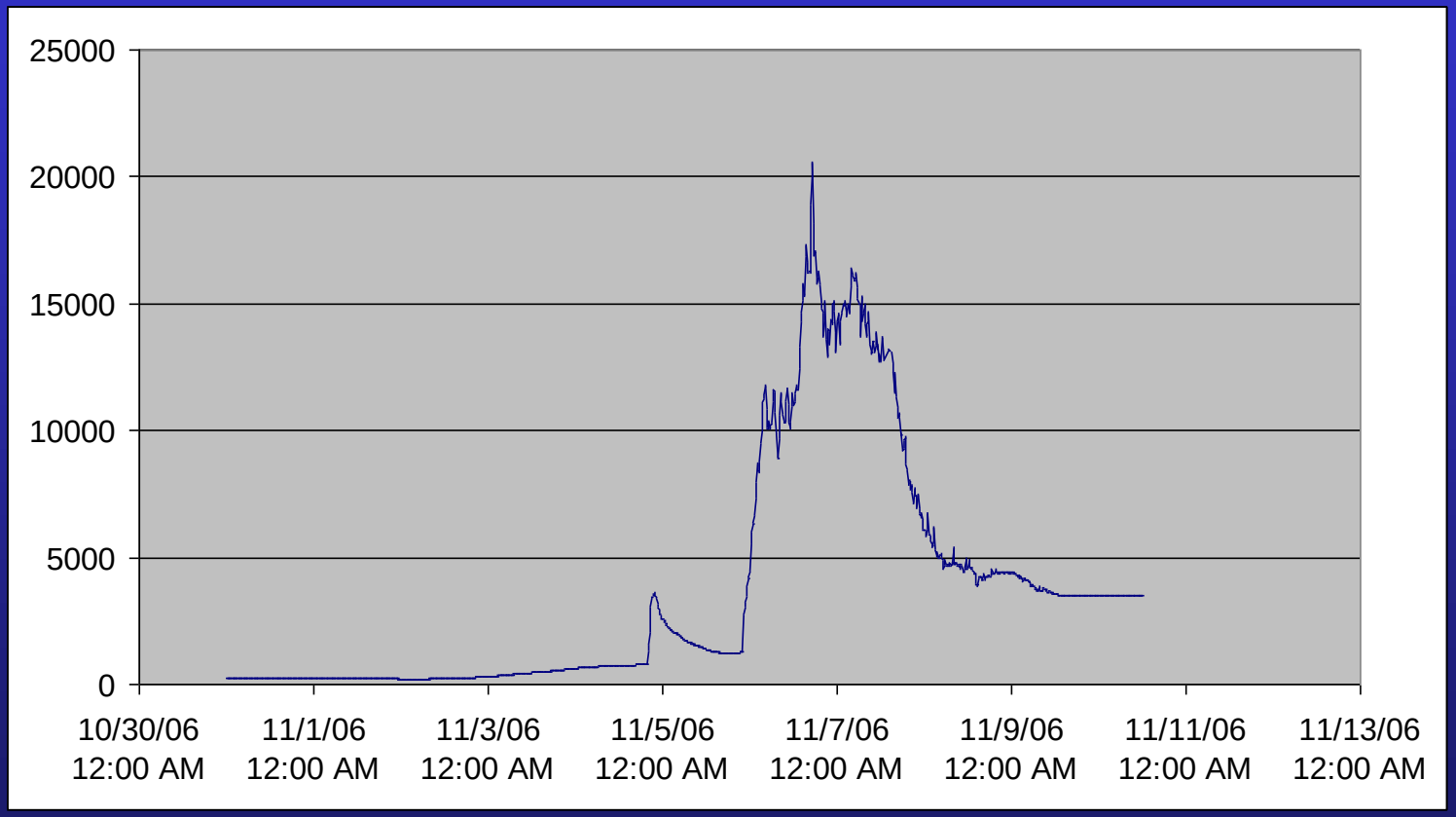

# Debris flows can travel very far from start…

# Debris flow breached lateral moraine

# Debris flows deposit, often far from where start, in flatter (<4º), wider valleys

# And Debris Flows contribute to flood damage…

# Why was the 2006 Flood so bad?



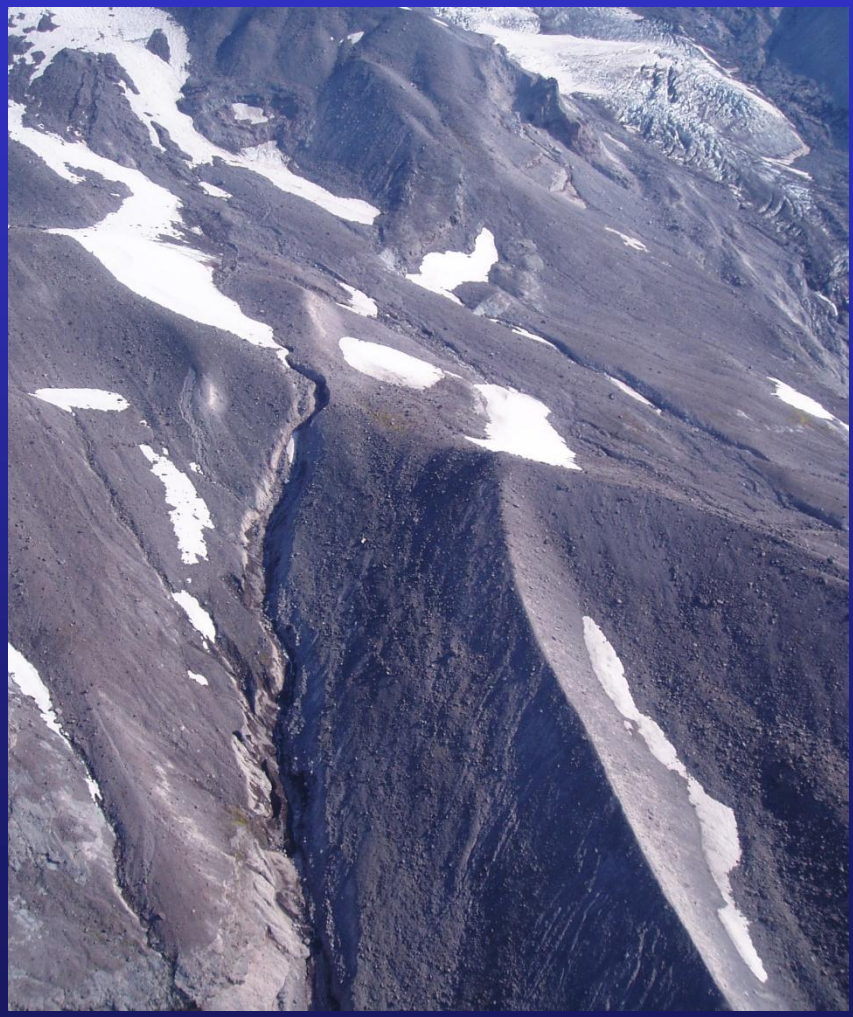

Debris flow spikes in the hydrograph, at gage outside of Ashford…


(1) Glacial sediment exposed on steep slopes
(2) Lateral moraine undercutting and failure

# Periglacial Debris Flows

FALL (warm storms):

- Catastrophic gullying below glaciers/perennial snow fields:
  - Rainfall intensity ≥5"/24 hr.;
  - Recently deglaciated; and
  - No seasonal snow.



# Recent debris flows from areas deglaciated since 1913

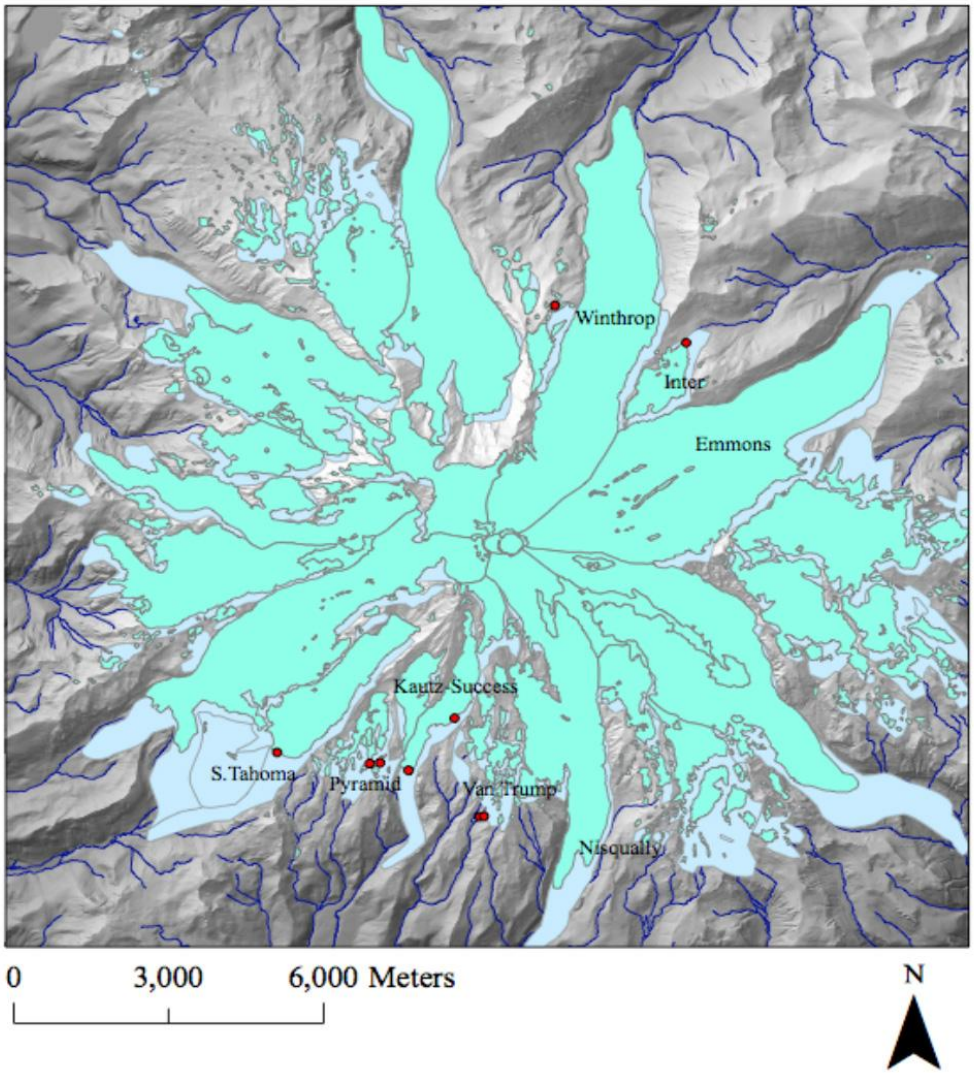
Map of 2001-2006 debris flow initiation sites.

Current glacier extent (blue) and 1913 glacier extent (light blue).

Since 2001, two new south-facing and one north-facing drainages have experienced debris flows:

(1) Van Trump Creek: 2001, 2003, 2006;
(2) Drainages of Pyramid Glacier: 2005, 2006;
(3) Inter Fork: 2006

From Copeland, 2009.



# Goats to Geoducks: Research Plan

## A Mount Rainier National Park, Oregon State University and United States Geological Survey Collaboration