

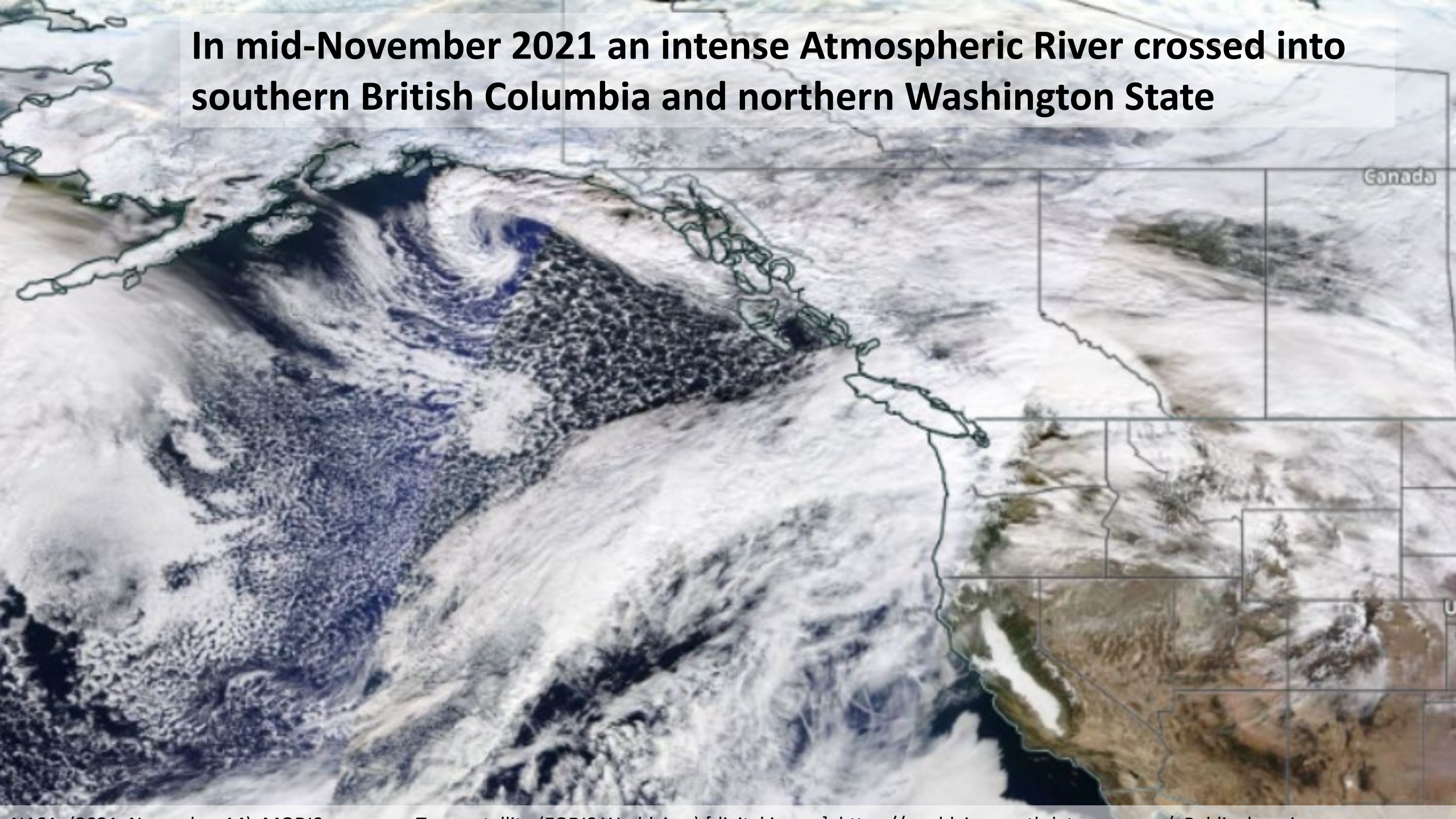


Atmospheric River: Rain, Flooding and Slope Failures

British Columbia and Washington, November 2021

This video has no sound track

In mid-November 2021 an intense Atmospheric River crossed into southern British Columbia and northern Washington State



Canada

An atmospheric river is a band of very moist air that typically moves from the ocean onto the land and brings a lot of rain over just a few days. In this region it's the same thing as a "Pineapple Express".



Very high rainfall was recorded in southwestern BC during November →

Much of that rain fell in just 3 days (November 13th to 15th)

Rainfall amounts, November 2021

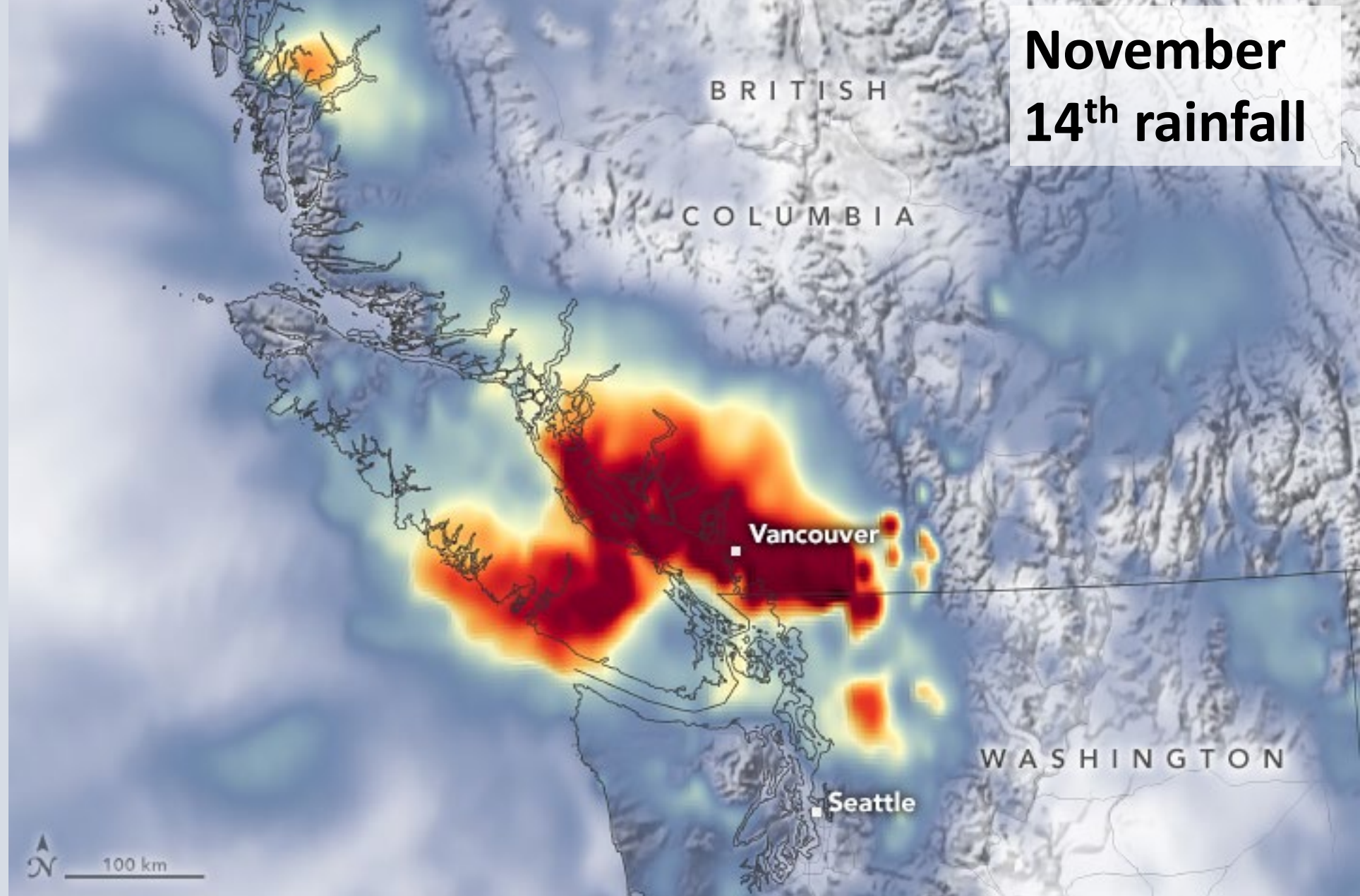
| Location | November 2021 | Average for Nov. |
|------------|---------------|------------------|
| Abbotsford | 541 mm | 245 mm |
| Vancouver | 312 mm | 189 mm |
| Victoria | 316 mm | 153 mm |
| Nanaimo | 359 mm | 197 mm |
| Hope | 730 mm | 344 mm |
| Chilliwack | 530 mm | 206 mm |

Rainfall amounts from Nov. 13th to 15th 2021 (in mm)



In some areas more than 100 mm of rain fell in just one day (Nov. 14th).

Many local rainfall records were broken.



**November
14th rainfall**

Total Rainfall (cm)



Earth Observatory. (2021, November 14). Severe Flooding in the Pacific Northwest [digital image]. <https://earthobservatory.nasa.gov/images/149100/severe-flooding-in-the-pacific-northwest>. Public domain

There was widespread flooding in the Fraser Valley area of BC and the Nooksack River area of Washington



Earth Observatory. (2021, November 14). Severe Flooding in the Pacific Northwest [digital image]. <https://earthobservatory.nasa.gov/images/149100/severe-flooding-in-the-pacific-northwest>. Public domain

Flooding around Highway 11 in the Fraser Valley



Flooding around Highway 1 in the Fraser Valley

VERY SLOW TRAFFIC
REDUCED SPEED AHEAD

Flooding in Merritt in the BC interior



Stepan_ (2021, November 17). Meritt BC Flooding November 2021.png [digital image]. Wikimedia Commons.
https://commons.wikimedia.org/wiki/File:Meritt_BC_Flooding_November_2021.png (Original source: (<https://www.youtube.com/watch?v=tBeWCU18TJ4>) YouTube (Time: 0:47). CC BY 3.0

Hundreds of homes and other buildings were damaged.

Farms were flooded and many thousands of animals died. Farm equipment was destroyed. Many farmers lost crops in the ground or fruit trees or bushes.

River flooding led to road damage in many areas because highways were not designed to withstand rainfalls of this magnitude.

Flood damage on Highway 19 on Vancouver Island



BC Ministry of Transportation and Infrastructure. (2021, November 17). BC Hwy 1 - A view from above of repairs underway on the Malahat [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51688211010/>; BC Ministry of Transportation and Infrastructure. (2021, November 15). Highway 1 Malahat - Closure Due to Flooding [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51682779433/> CC BY NC ND 2.0

Access roads destroyed by river flooding along Highway 5 north of Hope



BC Ministry of Transportation and Infrastructure. (2021, November 17). Highway 5 - Coquihalla - Caroline Mine Interchange 2 [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51687942384/>
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A bridge support undercut by river flooding on Highway 5 (Coquihalla)



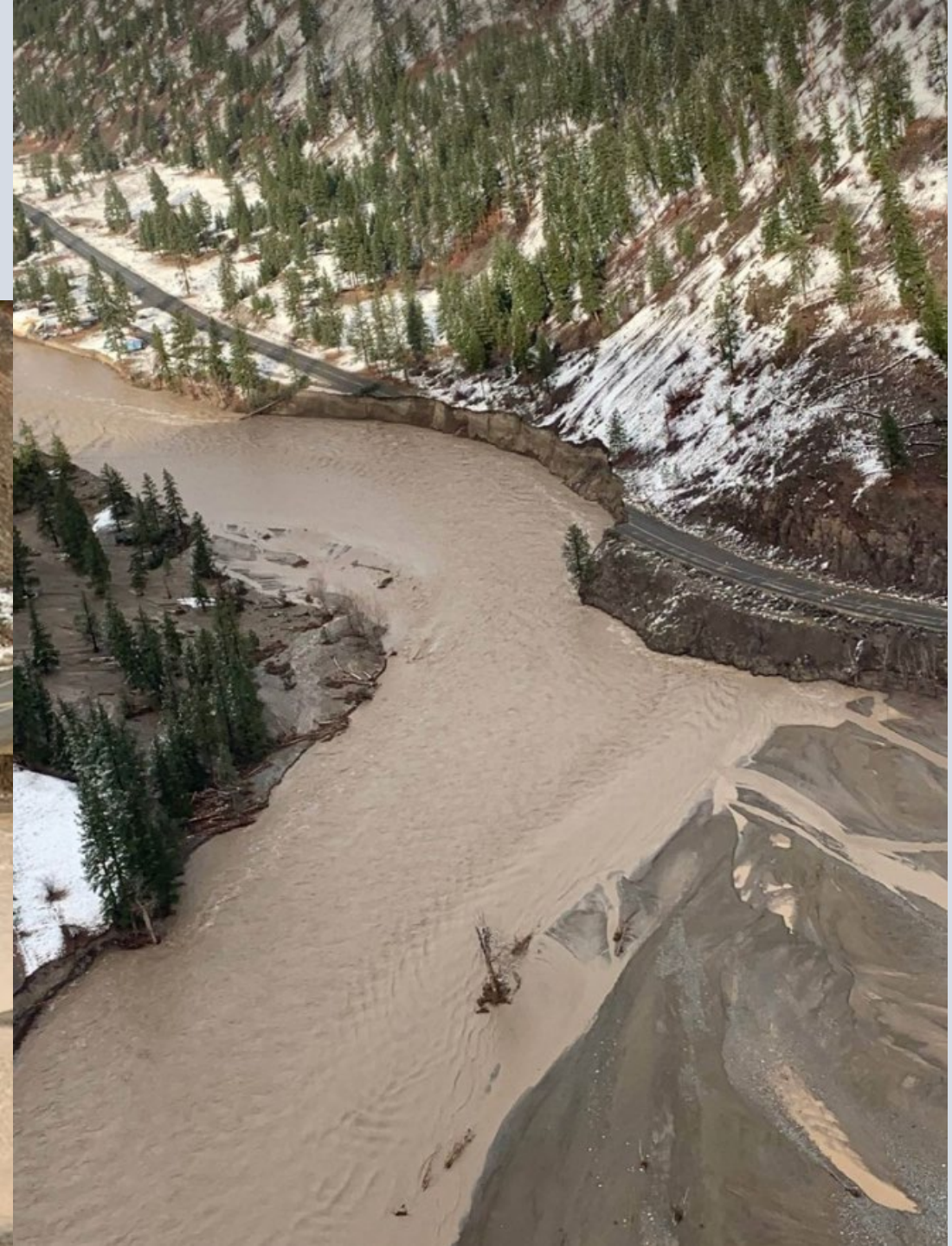
BC Ministry of Transportation and Infrastructure. (2021, November 17). BC Highway 5 - Coquihalla at Juliet [digital image]. Flickr.
<https://www.flickr.com/photos/tranbc/51687090478/> CC BY NC ND 2.0



A different bridge undercut on Highway 5

BC Ministry of Transportation and Infrastructure. (2021, November 17). Highway 5 - Coquihalla - Sowaqua [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51688161620/>

Roads destroyed by flooding along Highway 9 west of Merritt



BC Ministry of Transportation and Infrastructure. (2021, November 17). Highway 8 washout [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51687054763/>; BC Ministry of Transportation and Infrastructure. (2021, November 17). Highway 8 washout [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51687461559/>

The heavy rain and the consequent melting of snow destabilized slopes in many mountainous regions of southwestern BC. That led to debris flows on a scale that the existing highway infrastructure was not designed to withstand.

A debris flow on Highway 7 in the Fraser Valley



BC Ministry of Transportation and Infrastructure. (2021, November 17).
Highway 7 - Ruby Creek - November 15, 2021 [digital image]. Flickr.
<https://www.flickr.com/photos/tranbc/51684852986/>

A debris flow on Highway 5 at Ten Mile Creek.



BC Ministry of Transportation and Infrastructure. (2021, November 17). Debris on BC Highway 5 near Ten Mile [digital image]. Flickr. <https://www.flickr.com/photos/tranbc/51681605022/>

An aerial photograph showing a massive debris flow of grey rocks and sediment that has completely destroyed a section of Highway 1 and the adjacent railway tracks. The debris flow is a wide, chaotic path of destruction cutting through the landscape. To the right, a river with muddy, brown water flows. In the center, several workers in orange safety gear are visible near the wreckage of the infrastructure. The surrounding terrain is rugged and mountainous.

**Road and rail
infrastructure
destroyed by a
debris flow on
Highway 1 at
Tank Hill**

BC Ministry of Transportation
and Infrastructure. (2021,
November 17). Highway 1 -
Tank Hill Underpass [digital
image]. Flickr.
[https://www.flickr.com/photos/
/tranbc/51688335050/](https://www.flickr.com/photos/tranbc/51688335050/)



Highway 1 & railway at Tank Hill

The total cost of damages from the rain, flooding and slope failures in British Columbia in November 2021 is estimated at more than \$7.5 billion*, making it the costliest natural disaster in Canadian history.

The intensity of this event can be ascribed in part to warm Pacific Ocean sea-surface temperatures related to climate change.

*from R Kavcic, Bank of Montreal, as reported by Glacier Media

Thank you to
The BC Ministry of Transportation
and Infrastructure
for making many of these images available.

Text summary of video: Atmospheric River

In November 2021 a series of strong Pacific Ocean atmospheric rivers affected the southern part of British Columbia and northern Washington State. Record amounts of rain fell in just a few days. Significant areas were flooded, including the valley of the Skagit River in Washington, the Fraser Valley region of BC and the town of Merritt in south-central BC. Hundreds of homes and other buildings were damaged. Farms were flooded and many thousands of animals died. Farm equipment was destroyed. Many farmers lost crops in the ground.

River flooding also led to destruction of many roads and bridges, especially in the interior of BC, along Highway 5 (Coquihalla) and Highway 9. The heavy rain and melting snow destabilized slopes leading to major debris flows that also damaged roads, railways and bridges.

The video includes numerous images of infrastructure damaged by flooding and debris flows.

The total cost of damages from the flooding and slope failures in British Columbia in November 2021 is estimated at more than \$7.5 billion, making it the costliest natural disaster in Canadian history.

The intensity of this event can be ascribed in part to anomalously warm Pacific Ocean sea-surface temperatures related to climate change.