Role of a sediment structure in stabilizing a mountain river after a volcanic eruption

Abstract

During eruption there is a lot of sediment that travels into the nearby mountain rivers and can create lahars. Along with widening the river channel and changing the sediment of the riverbed. An example of this would be what occurred at Mount St. Helens in 1980.After the eruption, there was 0.8 cubic miles of sediment that deposited into the North Fork Toutle River. This caused a massive disruption within the river, which led to the construction of the Sediment Retention Structure that began in 1989, finished in 1990. Thirty-two years later after construction, the SRS is still standing and the debris avalanche sediment is still travelling through the SRS and downstream, but is it healing? To answer this question I mapped and recorded data from Google Earth Pro and compared two other mountain eruptions that disturbed one of their nearby rivers and found a pattern. My results are that downstream the SRS is helping heal the vegetation and the riverbed as well, unlike upstream which is still facing a lot of problems that may take longer to fix. Portland District discussed a new long-term healing process, this plan began in 2012 and can continue for another 25 years. In conclusion, the SRS is healing the river downstream and has continued to heal through the years.

Introduction

The disruption caused by a volcanic eruption can lead to years of healing in nearby rivers and forests. During eruption there is a lot of sediment that travels into the nearby mountain rivers and creates lahars. An example of this would be what happened at Mount St. Helens in 1980. During the eruption of Mount St. Helens the North side of the mountain had a debris avalanche enter the North Fork Toutle River (NFTR), causing a massive sediment accumulation within the river leading to the loss of vegetation/forests around the river(Dunne, Thomas)(Figure 1), along with widening to the river channel (Figure 2). The debris avalanche began travelling downstream at a fast rate causing many floods within nearby towns and impacting I-5 bridges and traffic(Dunne, Thomas). Also, vegetation loss was at all time high. This problem led to the solution of constructing a Sediment Retention Structure (SRS) on the NFTR to slow the sediment transport going downstream, begin to heal the vegetation/forest loss and to decrease the width of the river channel. The SRS was built in 1990 and since then the healing process of the vegetation and forests downstream surrounding the NFTR have improved (Dunne, Thomas). However, upstream the river channel has expanded, breaking into a complicated series of braiding and severe widening. Along with more loss in vegetation and forests.

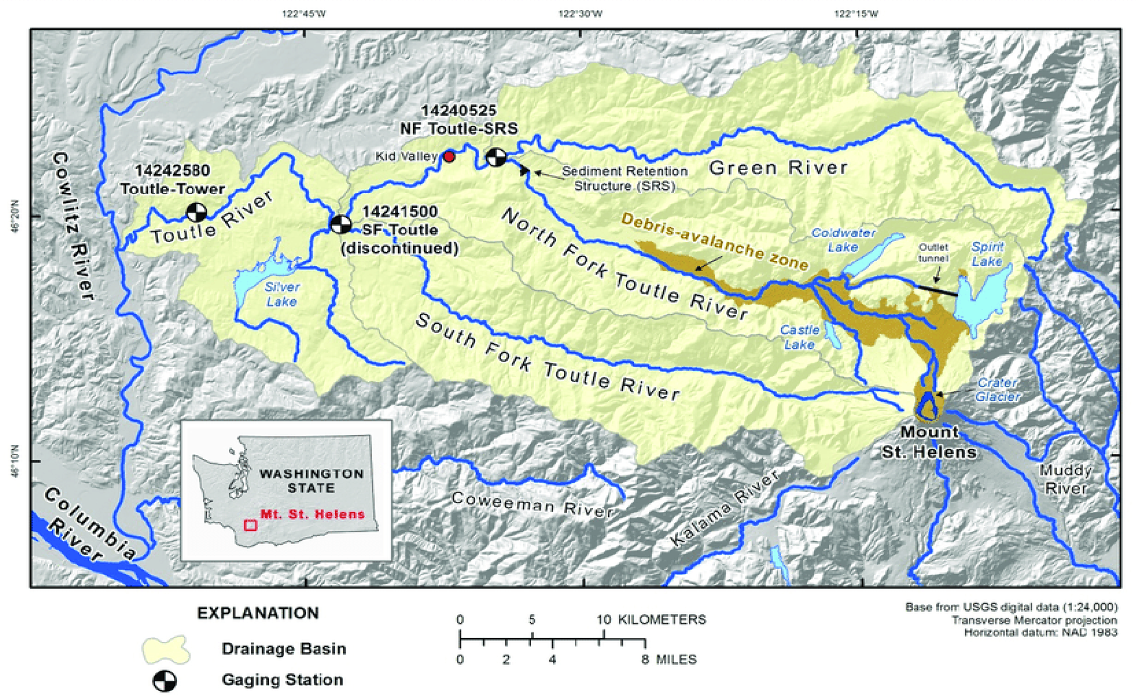

Figure 1- Location map of North Fork Toutle River. Marks the Sediment Retention Structure and shows the zone of how far the debris avalanche traveled.

Research Question

Since 1990, the SRS has been slowing the sediment transport, from the debris avalanche, travelling further downstream in the NFTR, along with beginning the healing process for the surrounding vegetation and forests. Thirty-two years later after construction, the SRS is still standing and the debris avalanche sediment is still travelling through the SRS and downstream. Has the SRS continued to trap the sediment from the debris avalanche and heal the vegetation and forests on the NFTR?

Background

Volcanic eruptions leave behind sediment that travels down into the nearby mountain rivers. Much like at Mount St Helens in the State of Washington, there was 0.8 cubic miles of sediment deposited into the nearby North Fork Toutle River (Dunne, Thomas)

➔ ***Field-site/ North Fork Toutle River-***
- ◆ On the North Flank of the Mountain a landslide was forming
- ◆ Followed by a debris avalanche filled with glacial ice, partially melted glacial ice, sediment, rocks etc.
- ◆ Debris avalanche damaged over 500 km² of forest that was North of the Mountain

Impact on NFTR

➔ Debris Avalanche deposited into the North Fork Toutle River causing the sediment bed to change from coarse cobblestone to a finer sand sediment

➔ NFTR began to experience high water levels than normal causing surrounding communities to become flooded.
- ◆ Part of I-5 became flooded causing transportation problems

Human Intervention (Dunne, Thomas)

➔ During 1985, Portland District of the US Army Corp of Engineers (USACE) began to develop a 50-year plan to help stop the sediment flow in the NFTR travelling further (shown in Fig 2-3)
- ◆ The main goal of the structure was to slow and trap the sediment travelling downstream of the NFTR

➔ In the 1990s,after construction, the trapping efficiency was between 70-80%
- ◆ Erosion was occuring on the structure, causing the USACE to rethink a new plan that would include further construction with new Compacted Concrete (Britton, J. Nygaard)

➔ The new plan included raising the spillway at the structure to open up slowly for more sediment to travel through
- ◆ After the construction with adding in compacted concrete the trapping efficiency was in-between 60-70% (and has continued to slowly increase as spillways increase)
- ◆ No eroding or fracture of rocks has occurred since construction
- ◆ First spillway raise was in 2012, increased the raise 2.1m (7ft.)

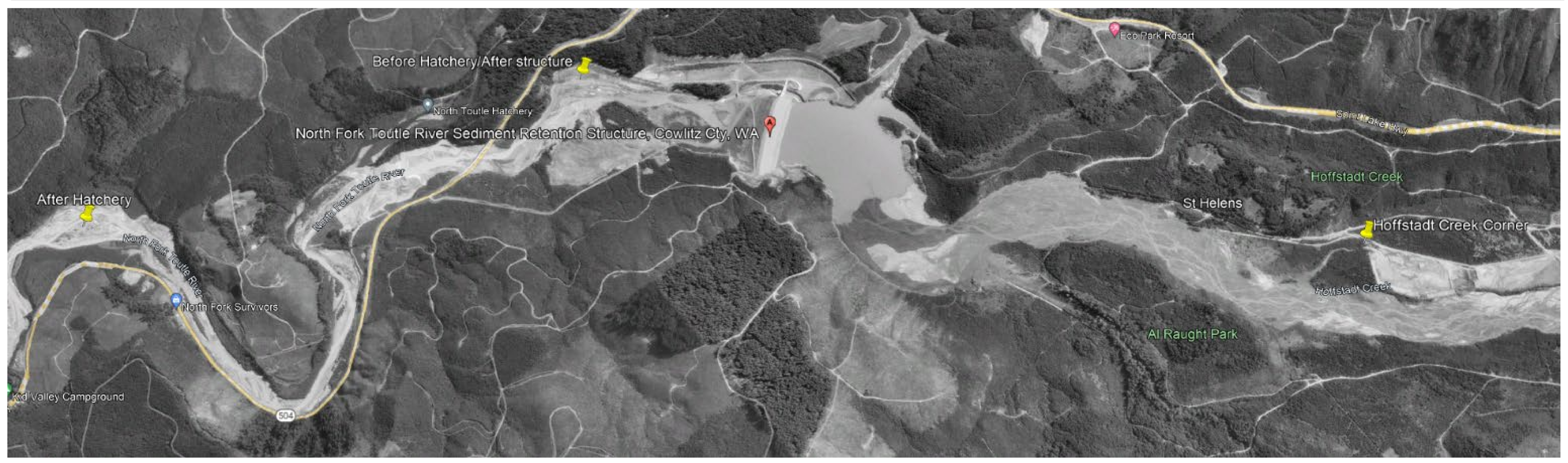

Figure 2- Google Earth Pro image of NFTR in 7/1990 right after the Sediment Retention Structure was built. The red A shows where the SRS is located on the river. The yellow pins show the location of where I mapped the vegetation and the width of the river channel.

Figure 3- Google Earth Pro image of NFTR in 6/2021, thirty-one years after the Sediment Retention Structure was built. Red A shows where the SRS is located on the river. The yellow points show the locations of where I mapped the vegetation and the width of the river channel.

Methods

➔ Mapped and recorded data from Google Earth Pro
- ◆ Mapped the Width of the river channel starting in 7/1990, 7/ 2006 and 6/2021, to show the change in kilometers post-construction of the SRS (Fig 2-3).
- ◆ Put data from mapping into bar graph (Fig. 5-6) to easier communicate that downstream is healing steadily, but upstream of SRS is still struggling.
- ◆ Mapped the Grass vegetation in acres to see how much healing has occurred since 7/1990
  - ● Used the years 7/1990, 7/2006, and 6/2021

➔ Researched and compared two other mountain eruptions that disturbed one of their nearby rivers and found a pattern (Figure 4)
- ◆ Mount Galunggung and Mount Pinatubo
- ◆ All 3 mountain eruptions have disturbed nearby rivers with a high volume in sediment deposits

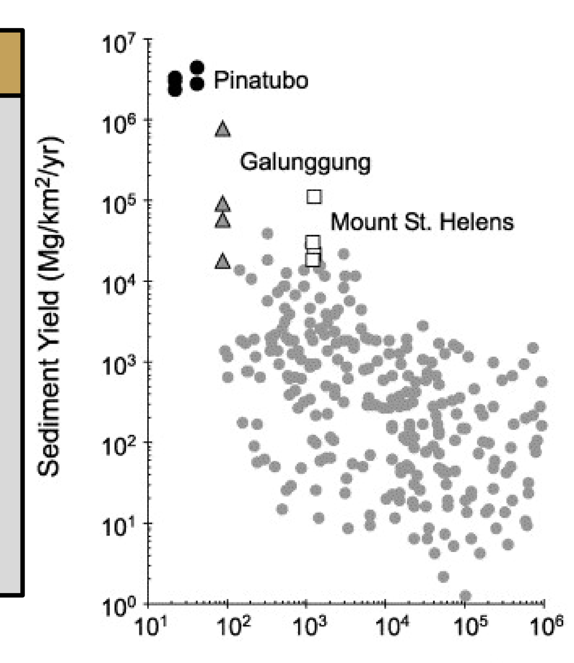

Figure 4- A graph showing the sediment yield of all three eruptions and the effect on the watershed area.

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Data/Results-

➔ The riverbed is no longer widening downstream of SRS, less braiding in river channel as well, showing that the river channel is healing gradually

➔ Grass Vegetation near mountainous rivers after eruption shows that the river is not as stable as it could be. With forests increasing this shows that the river is becoming more stable and healing gradually.

➔ Looking at the bar graphs (Fig 5-6) it is shown that the acres of grass have declined meaning that the forest line has increased.
- ◆ Confirms that vegetation loss is healing due to the SRS slowing of sediment

➔ In Figure 6 downstream of the SRS the riverbed width is decreasing while upstream is heavily increasing.
- ◆ Upstream is still dealing with all the sediment they are trying to slow downstream.
  - ● This is preventing the upstream vegetation and riverbed width from healing to its previous stage.
  - ● Upstream is also dealing with a heavily braided riverbed channel (Figure 3)
- ◆ Downstream is seen decreasing in width
  - ● Confirming that the SRS is trapping and slowing the rate of the sediment travelling downstream

➔ Overall, downstream the SRS is helping heal the vegetation and the riverbed as well. However, upstream is still facing a lot of problems that may take longer to fix.

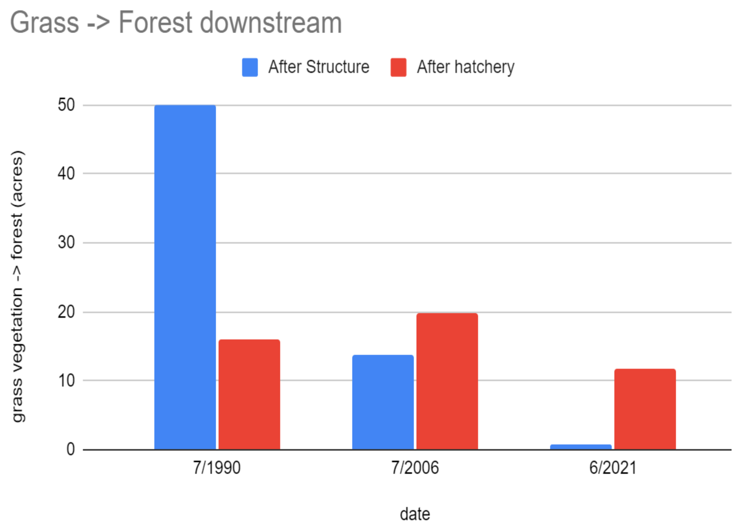

Figure 5- Grass to Forest area near the NFTR. Measured the areas of grass right before the forest line. Used the years 1990, 2006, and 2021.

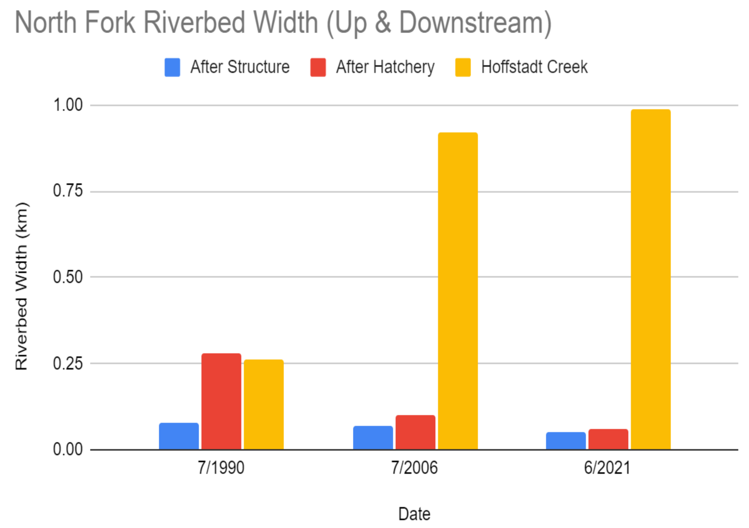

Figure 6- The North Fork riverbed width. Measured both up and downstream in the years of 1990, 2006, and 2021.

Discussion

➔ *Sediment Retention Structure (SRS)*
- ◆ Downstream is seeing improvement since construction of the SRS
- ◆ Upstream (Hoffstadt Creek) is not seeing improvement in forests or riverbed width
  - ● Sediment load stopped behind the SRS causing a back-up in sediment within the river

➔ *Where else has this happened?*

These two locations have similar disruptions to their nearby rivers after eruption. The difference is these locations do not have an SRS to help with sediment flow. These rivers are healing with minimal human intervention. This can help better understand how NFTR will heal after the SRS is gone.
- ◆ June of 1991, Mt Pinatubo, Philippines (Montgomery, David B.)
  - ● Following the eruption, many lahars caused damage to nearby towns and throughout the Pasig-Potrero River
    - ○ River saw an abrupt widening in the river channel and the riverbed changed from coarse gravel bed to a finer sand bed
    - ○ Since eruption, river is seeing a continuous increase in sediment yield within the river
- ◆ Mt Galunggung, Java, Indonesia. Eruption lasted for 9 months (1982-1983) (Gourgaud, Gerbe, MC)
  - ● Erupted during the rainy season → caused many lahars within the S. Cikunir River and deposited with the ash and silt around the mountain
    - ○ 250,000 people were in trouble and large areas of agricultural land due to these rain and sediment generated lahars.
    - ○ Fresh-water was scarce due to all the ash in the air
    - ○ Since eruption, surrounding communities and river are still healing, many lahars are still travelling down from the mountain.

➔ *New long-term plan introduced in 2012*
- ◆ New long term plan discussed at Portland District USACE → spillway raises
  - ● Small incremental spillway raises may take up 10 years to get to the level of trapping efficiency needed to continue healing the river.
  - ● Spillway raise focuses on migrating juvenile salmon in NFTR (Steelhead and Coho)
  - ● Small increase in trapping efficiency, highest number seen at 67% in 2014
- ◆ Slowly increasing spillway raises can take up to 25 years to complete healing process

Conclusion

In conclusion, the SRS is trapping sediment from the debris avalanche and is slowing the rate of sediment transport downstream. This is healing the surrounding forests and decreasing the width in the river channel. However, upstream is still facing loss in forests and the river channel is continuing to widen as well. With the new long term plan, the SRS will continue to have its spillways raised and continue to heal downstream of the NFTR.