Assessing Bank Erosion Affected by Bridges on Goldstream and O'Connor Creek, Alaska

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Introduction

Goldstream and O'Connor Creeks are important for the wildlife that relies on them as well as the people who use them for recreation. Last spring I did an evening float trip on Goldstream creek. I had noticed how eroded the bank was where we put in below the bridge, and was fascinated by how high the water level was and how close it was to the bridge. This sparked my interest as to whether the bridges had something to do with this erosion, and how they might be impacting the stream morphology. For this research I used GLOBE protocols for looking at turbidity as well as the Bank Erosion Hazard Index (BEHI) for measurements to analyze how the bank is eroding. Typically without bridges, "Stream channels are shaped during heavy storm events that produce high flows. In a healthy stream channel, the energy of those high flows is dissipated when the stream spills out into the flood plain" (Aquatic Epidemiology Conservation). Bridges can funnel water through them creating forces, especially in high water which can then cause erosion and scouring above and below the stream. [1] Sometimes the road around the bridge can act like a dam, so when the water backs up and spills over into the floodplains there is more water on the upstream side of the bridge than the downstream side of the bridge. [4]

Question

How do bridges impact stream morphology on local creeks in Fairbanks?

Methods

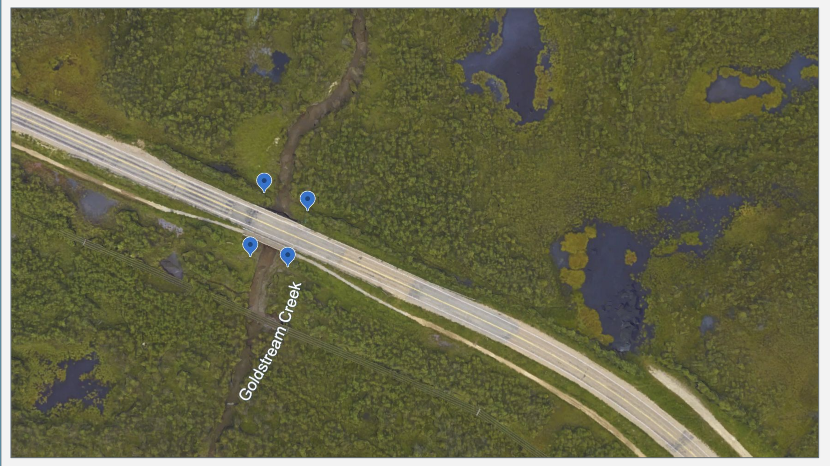


Fig. 1. Overhead view of Goldstream Creek

Fig. 2. Overhead view of O'Connor Creek

- Two bridges were selected for this assessment. One bridge was the Goldstream Creek Bridge (built 1975), on Ballaine Road, and the other was the O'Connor Creek Bridge (rebuilt in 2013) on Goldstream Road.[6]
- Using the Bank Erosion Hazard Index[4] along with proper GLOBE protocols[5], measurements were taken in four places around each bridge. The measurements were taken on river right and left, upstream and downstream starting at the bottom of each bridge.
- At each site eight measurements were taken; bank length (m), study bank height (m), bankfull height (m), root density (%), bank angles (degrees), surface protection (%), bank material adjustment, and transparency tube (cm). GLOBE Landcover observations were also posted for each of these sites.
- I visited each site a total of three times on three different days. Each site had all of the measurements repeated each time with an exception of the transparency tube due to ice. All measurements were taken once each visit, aside from transparency tube and bank angle which were repeated three times each for GLOBE protocol.[5]
- Data was organized into a summary table to show the study observations. To illustrate how my data compared to Alaska Department of Environmental Conservation's turbidity data I converted their data from NTU to Secchi Depth using equation from USGS. [2]

Fig. 3. Goldstream creek, looking upstream towards Ballaine Road and the bridge for Goldstream Creek

Fig. 4. O'Connor Creek, looking upstream towards Goldstream road and the Bridge for O'Connor Creek

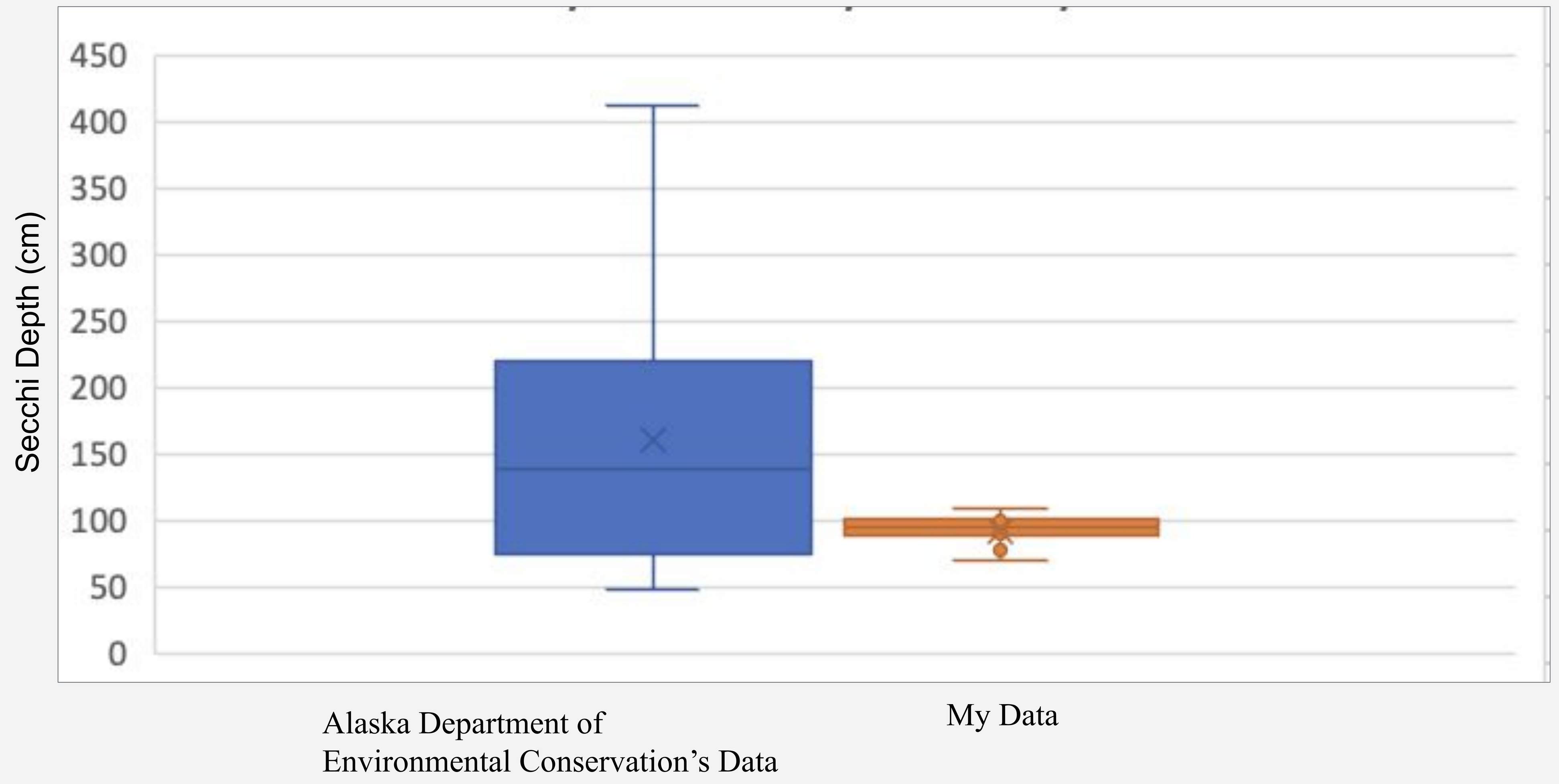
Results

Table 1. Bank Erosion Hazard Index (BEHI) Summary

Site of Measurements	Goldstream Creek Upstream River Right (at Ballaine Road Bridge)	Goldstream Creek Upstream River Left (at Ballaine Road Bridge)	Goldstream Creek Downstream River Right (at Ballaine Road Bridge)	Goldstream Creek Downstream River Left (at Ballaine Road Bridge)	O'Connor Creek Upstream River Right (at Goldstream Road Bridge)	O'Connor Creek Upstream River Left (at Goldstream Road Bridge)	O'Connor Creek Downstream River Right (at Goldstream Road Bridge)	O'Connor Creek Downstream River Left (at Goldstream Road Bridge)
Mean Bank Length (m)	12.7	28.5	21.2	23.4	20.41	20.7	27.4	12.1
Mean Study Bank Height (m)	1.17	1.21	1.03	1.13	0.68	0.43	0.65	0.63
Mean Bankfull Height (m)	1.54	1.65	1.46	1.48	2.31	2.28	2.47	1.93
Root Density (%)	15	15	10	10	15	15	23	20
Mean Bank Angles (degrees)	95	94	98	96	111	118.5	110	107.6
Surface Protection (%)	60	60	55	60	55	65	75	80
Bank Material Adjustment	Silt	Silt	Silt	Silt	Silt	Silt	Silt	Silt
Mean Transparency Tube (cm)	75.43	94.86	85.23	83	91.8	96.4	100.3	103.06

Table 2.

Alaska Department of Environmental Conservation Turbidity Data for Goldstream Creek in 2017 vs. my transparency tube data for Goldstream Creek 2023



- The results show that there is very steep bank angles around the bridges on all sites around both of the bridges
- Bank height for Goldstream Creek was was 1.8 times higher on average than the bank height for O'Conner Creek
- O'Connor Creek had a higher bankfull height than Goldstream creek on average.
- Both of these sites had silt as their bank material adjustment
- Most of the Data from the Transparency tube fell into an acceptable range according to a table from Penn State. [3]

Discussion

- The overall observations from this study show erosion happening both up and down stream from both O'Connor Creek and Goldstream Creek.
- In both Creeks the BEHI Summary shows steep bank angles, both up and down stream from the bridges.
- Goldstream Creek had significantly more water in wetlands on the upstream side of the bridge than the downstream side. This suggests that bridge is acting like a dam during breakup and causing the water to backup and spill over into it's floodplains in high water conditions. (this can be somewhat observed in figure 2)
- O'Connor Creek and Goldstream Creek's bridges were both constructed and worked on about 38 years apart which would likely have an impact on how much they have been able to show signs of erosion and scouring.[6] With Goldstream Creek having more prominent signs of erosion and changes in stream morphology due to its older age.

Fig. 5. This image shows the eroding bank on Goldstream Creek looking downstream towards the bridge on Ballaine Road.

Conclusion

Using the data collected we can conclude that Goldstream and O'Connor Creek are facing problems with erosion. This study does not have enough information to conclude whether this erosion is occurring because of the bridges, or if it is happening due to other factors that may cause watershed degradation. More research would need to be done taking measurements further up and downstream as well as new variables being included into the study. The significant age difference in both the bridges likely impacts the results shown as well as different activities that have taken place upstream from these bridges such as mining. The comparison of my transparency tube data vs. the Department of Environmental Conservations turbidity data likely has a big difference due to the timeframe of when each data set was collected, since their data was collected over a span of several months while mine was collected within a few weeks.

Fig. 6. O'Connor Creek, downstream from the bridge where the multi use trail crosses in the winter when frozen

Fig. 7. Upstream from the Bridge on O'Connor Creek, frozen before below the bridge

Fig. 8. A small vole that peeped out off the trail by Goldstream Creek

Citations

[1] Aquatic Epidemiology Conservation. (n.d.). Effects of Bridges and Culverts. http://www.aeclab.org/modules/info/print.php?tac=Effects_of_Bridges_and_Culverts

[2] *Estimation of secchi depth from turbidity data in the Willamette River at Portland, OR (14211720)*. Estimation of Secchi Depth from Turbidity Data in the Willamette River at Portland, OR. (2016, December 15). https://or.water.usgs.gov/will_morrison/secchi_depth_model.html

[3] Fetter, J., & Kristen Koch. (2022, August 20). *Understanding transparency tube measurements*. Penn State Extension. https://extension.psu.edu/understanding-transparency-tube-measurements

[4] Frankenberger, J., & Esman, L. (2012). *Indiana's fluvial erosion hazard program*. Indiana's Fluvial Erosion Hazard Program. https://feh.iupui.edu/tools/bank-assessments/behi/

[5] GLOBE . (n.d.). *Water transparency protocol* . The GLOBE Program. https://www.globe.gov/documents/11865/354449/Water+Transparency+Protocol/6384d688-d6bc-4d35-bf5d-cf3b1292a9b3

[6] Pyun, Y. (n.d.). *Ballaine Road over Goldstream Creek fairbanks north star borough, alaska bridge inspection report*. Indianapolis Star. https://data.indystar.com/bridge/alaska/fairbanks-north-star/ballaine-road-over-goldstream-creek/02-1009/

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