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Restoration Design Evaluation of the East Branch of the Beaver River, Silver Bay, Minnesota: A Student-led Investigation Comparing Two Designs

Capstone Course for Stream Restoration Science & Engineering Graduate Program

360-4

Margaret Upton[1*], Elizabeth Brown[1], Nolan LaBonne[1], Stephen Labuz[2], Larissa Scott[2], Kate Sinner[3], Andrew Strasser[3], Ian Treat[1] , Thomas Voigt[1] , Karen Gran[1]
(1) Earth and Environmental Sciences, (2) Civil Engineering, (3) Water Resources Science, University of Minnesota Duluth, *upton040@d.umn.edu

Abstract

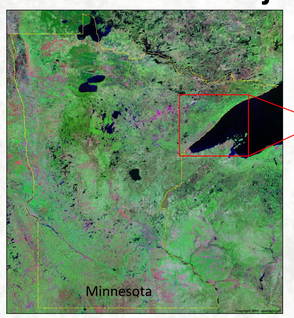
In 2016, the city of Silver Bay, MN, put out a request for proposals (RFP) to restore an area on the East Branch of the Beaver River adjacent to the Silver Bay Municipal Golf Course that sustained damage from a 500-year flood event in June 2012. The goals of the RFP were to **a) protect golf course infrastructure, b) restore river to a "stable state", and c) use "natural channel design" methods to accomplish the above objectives**. A stream restoration design class of advanced interdisciplinary STEM students at the University of Minnesota Duluth surveyed this site and evaluated two different design approaches with regards to the RFP.

The first plan involved a re-meander of the lower half of the existing reach and the second plan involved creating a steeper, lower sinuosity step-pool channel through the current floodplain. Each plan was based on existing proposals from the consulting firm undertaking the restoration project. Site surveys performed by the class in fall 2016 determined grain size distributions, vegetation composition, macroinvertebrate presence, and long profile and channel planform topography.

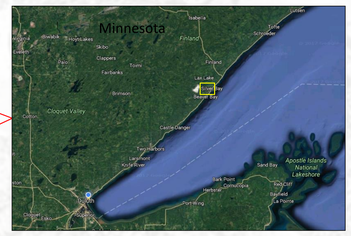
The following semester, two different restoration design plans were created and evaluated. The class analyzed hydraulics using HEC-RAS and CAD, executed a sediment analysis using BAGS and Monte Carlo simulations, created a re-vegetation plan, and proposed a post-construction monitoring plan. After both stream design plans were analyzed for suitability, the class concluded that the lower reach re-meander met the RFP goals in the least invasive manner and more effectively transported sediment within and just below the stream reach of interest. The class also concluded that the step-pool design was not ideal as it could create a net depositional environment below the study reach, inside the existing golf course channel.

The project stakeholders approved the step-pool plan, and it is scheduled to be constructed in summer 2018.

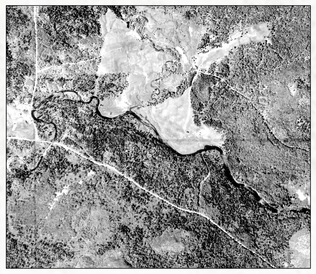
Project Location



The river cuts primarily through clay-rich glacial tills within the project site.



The East Branch of the Beaver River lies within the Beaver River Watershed. It starts 0.48 miles (0.78 km) upstream of its confluence with the main stem of the Beaver River and 2.25 miles (3.63 km) upstream of the Beaver River's outlet at Lake Superior. The total channel length of the construction site is 1,300 feet.



The establishment of the Silver Bay Gold Course has drastically modified the channel flow and form. The East Beaver River has been channelized within the golf course. A historic photo (right) is from 1939, showing a large floodplain with a meandering river.

One of the eroding till banks of concern to golf course and DNR.

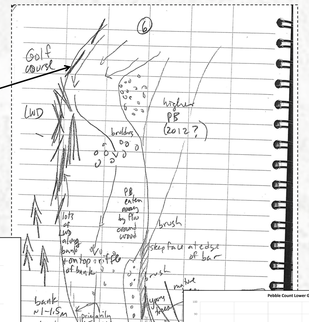
Project reach is depositional currently with large gravel bars.

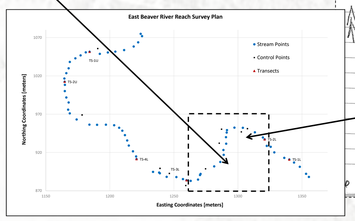
Site Investigation

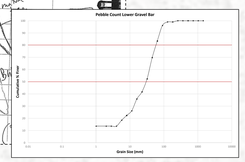
In Fall 2016, students collected data appropriate to develop a proposal for an active RFP including

1. Watershed-scale site assessment
2. Watershed hydrology via StreamStats and gage analyses
3. Site sketches and photographs
4. Stream long profile and cross-section surveys
5. Grain size distributions
6. Macroinvertebrate and vegetation sampling

Bluff eroding into golf course

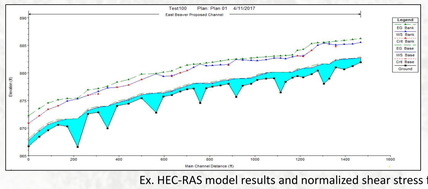


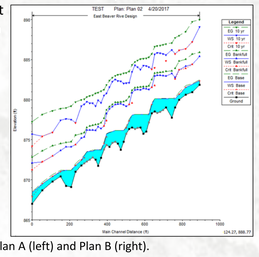




Project Design Methods

The class split into two groups to investigate two potential restoration designs (Plan A and Plan B on right). Due to the concerns regarding sediment transport and deposition in the reach or downstream, HEC-RAS models were developed for each plan to investigate flows from $Q_{1.5} - Q_{100}$. Sediment transport capacity was investigated upstream, downstream, and within the project reach to ensure transport capacity remained similar.





Ex. HEC-RAS model results and normalized shear stress for Plan A (left) and Plan B (right).

Vegetation plans were developed that utilized native vegetation appropriate to the soil and moisture conditions throughout the site (ex. shown below left).

FFn57*	FLOODPLAIN	
	COMMON NAME	SPECIES NAME
	COMMONLY INNUNDATED	
CANOPY	Silver maple	Acer saccharum
	Black ash	Fraxinus nigra
	Bur oak	Quercus macrocarpa
	American elm	Ulmus americana
UNDERSTORY	Silver Maple	Acer saccharinum
SHRUBS	Retrorse sedge	Carex retrorse
	Tuckerman's sedge	Carex tuckermanii
	Red osier dogwood	Cornus sericea

* *FFn57: Northern Terrace Forest (Black Ash – Silver Maple). Wet-mesic deciduous forests on silty or sandy alluvium on level, occasionally flooded sites along medium and large rivers in the northern half of Minnesota*

Care was taken to protect mature trees, and vegetation designs incorporated more mature trees to help improve survival.

Mature trees in paleochannel on terrace shown on right.

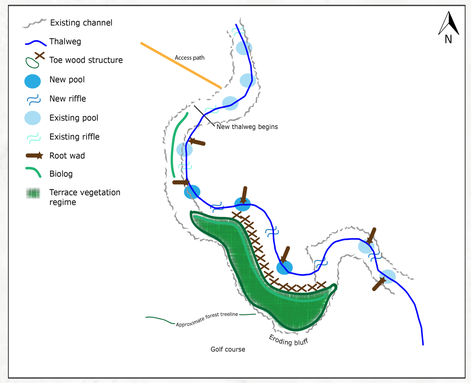
Conclusion

Both plans meet the RFP Goals. The re-meander minimizes impact to the riparian area, allowing for preservation of much of the area's mature vegetation. The step-pool planform (Plan B) may have issues with sediment transport capacity upon reaching the golf course, while the remeander (Plan A) allows for deposition to continue in the reach. The new step-pool channel will shortens the channel but provides additional wetland habitat.
The stakeholders opted for a step-pool channel design from Stantec Consulting, similar to Plan B, which is slated for construction in 2018.

Many Thanks To: University of Minnesota, Duluth; Stantec Consulting; Silver Bay Golf Course; Lake County SWCD

Plan A: Remeander

To preserve infrastructure and prevent further migration of the channel towards the golf course, this design will least impact the current pool habitat, riparian vegetation, and will result in minimal changes in channel length and slope.



Key features:

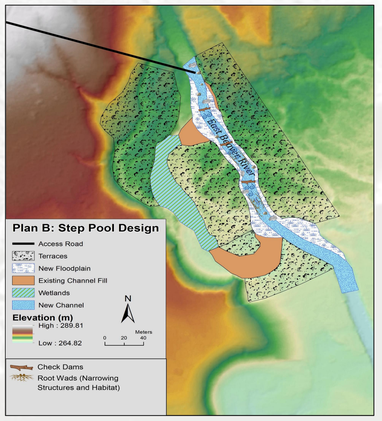
- New channel remains in same classification as existing channel
- Model results indicate new geometry to remain stable
- Increase in sediment transport capacity with new channel yet reach will still remain net depositional
- Focused on creation of pools, minimizing impact to riparian area, maximizing success of new vegetation
- Shift the channel alignment away from eroding bluffs
- Minimize the reduction in length of the reach as much as possible
- Paleochannels were used to reroute the lower portion of the reach away from an eroding bank

Channel geometry modifications :
Low-flow channel thalweg to increase depth during periods of critical low flow in the summer and winter months.

Channel materials:
Woody debris, rock pour overs, riffle boulder gardens and other features were incorporated into the design to increase channel roughness and provide shelter for aquatic organisms.

Plan B: Step-pool

A complete re-route of the current channel as a low sinuosity step-pool (type B) channel. This design introduces a stream channel of greater slope and roughness than the current channel with pool spacing every 3 bankfull widths.



Key features:

- Create a new step-pool channel using a paleochannel
- Create a wetland habitat that doubles as an overflow area
- Extra protection of golf course infrastructure long-term and in case of large flooding events
- Sinuosity and slope similar to upstream reaches (1.8% through project reach; low for step-pool planform)
- Higher shear stresses than existing reach during high flows
- Models indicate there will be sediment deposited downstream of the design

Channel materials:
Materials will be boulders and cobbles placed as a series of "steps" and pools ranging from irregular spacing to 3 – 5 bankfull widths. The bed and bank material of B channels are considered stable and contribute only small quantities of sediment during bankfull or storm events. Large woody debris is incorporated into the channel as it is an important component for fisheries habitat. Sinuosity should be around 1-2 but in this case it is 1.