PURDUE UNIVERSITY | Agricultural and Biological Engineering

CAPSTONE/SENIOR DESIGN EXPERIENCE 2020

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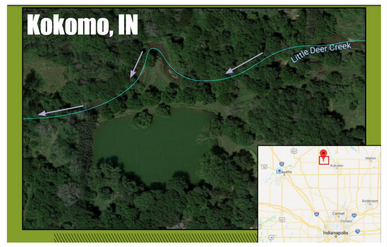
Title: NC-1 Nature Conservancy Pond-Stream Rehabilitation Project

Problem Statement

The landowners, the Cotners', and The Nature Conservancy need a solution to reduce the erosion occurring on the bank between the Cotners' pond and the adjacent stream in Kokomo, IN.



Important Factors

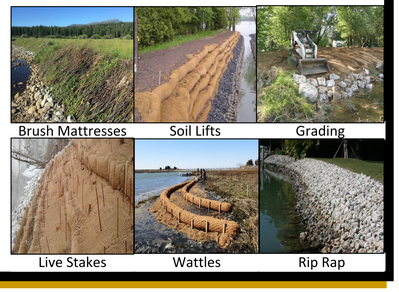
Factors	Importance
Public Health	Safety of homeowners
Global	Demonstration Project
Social	Beneficial for neighbors
Cultural	Environmental Stewardship
Economic	Retention of property value
Environmental	Erosion control, reduced sediment transport

Constraints and Criteria

Constraints	Criteria
Must not depend on large construction equipment	Reduce amount of erosion: change in stream classification factors
Prefer an ecologically-based engineering solution	Resilient and long-lasting
Must stay within permits and standards	Utilization of bioengineering/environmental systems
$10,000 budget	Cost of $10,000 or less
	Able to be implemented in a reasonable amount of time

Alternative Solutions

- Brush Mattresses & Livestaking/Vegetation
- Brush Mattresses & Grading
- Brush Mattresses & Wattles
- Livestaking/Vegetation & Grading
- Livestaking/Vegetation & Soil Lifts
- Soil Lifts & Brush Mattresses
- Rip Rap & Grading



Final Solution

Two areas of concern were identified. Both of these areas were selected because of the banks' steep slopes, minimal vegetation for bank coverage, and susceptibility to higher velocity waters

Area 1

Area 1 is the main area of concern because the stream at this point meanders very close to the pond, endangering the stability of the levee between the stream and pond

Solution: Vegetated Riprap

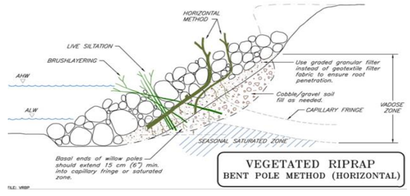
Area 2

Area 2 is being targeted to help reduce flow downstream to Area 1 during large storm events

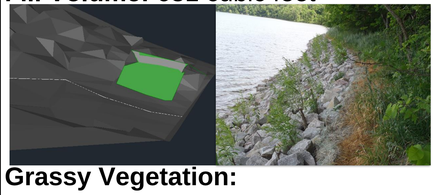
Solution: Two-Stage Floodplain Reconnection

Design of Solution

Area 1



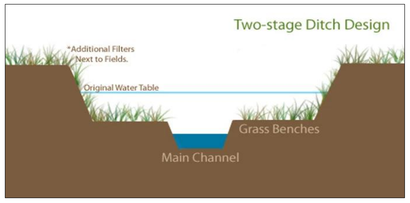
Riprap Classification: Revetment
Riprap Sizing: D_{50} = 8 inches
Riprap Thickness: 18 inches
Riprap Volume: 496 cubic feet
Filter Volume: 496 cubic feet
Fill Volume: 631 cubic feet



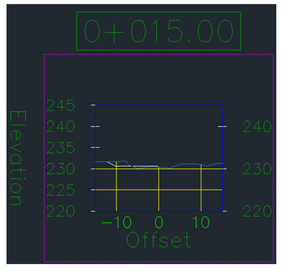
Grassy Vegetation:
- Sideflowering Aster
- Gray Sedge
- Common Wood Sedge
- Fowl Manna Grass

Woody Vegetation:
- Salix Discolor (Pussy Willow)
- Prairie Willow
- Sandbar Willow

Area 2



Only Applied to Left Bank (facing downstream)
Grass Bench Elevation: 757 feet
Grass Bench Width: 21.5 feet
Upper Channel Bank Slope: 1V:2H
Cut Volume: 1977 cubic feet
Vegetation:
- Sideflowering Aster
- Gray Sedge
- Common Wood Sedge
- Fowl Manna Grass



Impact and Analysis

HEC-RAS:
Program modeled stream flow with various design storms to assess shear stress from flow on the stream banks. Table below shows the reduction of shear stress on Area 1 banks when vegetated riprap is added to the current bare banks.

Shear Stresses of Modified Cross-Sections (lb/ft^2)			
Cross Section	Current Conditions	Added Vegetation	Added Rip-Rap
1.1	0.34	0.18	0.12
1.2	0.17	0.11	0.07
1.3	0.15	0.10	0.07
1.4	0.11	0.06	0.05

Bank Erosion Hazard Index (BEHI):
Scoring system used to evaluate a streambank's susceptibility to erosion. The original banks and estimate for modified banks for Area 1 and Area 2 scores listed in table below. These scores show that the minimal soil protection and shear slopes were large contributors to erosion susceptibility.

	Original Area 1		Design Est. Area 1		Original Area 2		Design Est. Area 2	
		BEHI Score		BEHI Score		BEHI Score		BEHI Score
Ratio Root Depth : Bank Height	35%	4.95	90%	1.45	15%	6.95	60%	2.95
Root Density	10%	8.5	75%	2.95	15%	6.95	60%	2.95
Surface Protection	10%	8.5	100%	1.45	15%	6.95	40%	4.95
Bank Angle	87°	6.95	27°	2.95	82°	6.95	82°	6.95
TOTAL SCORE		28.9		8.8		27.8		17.8
BEHI Category	Very High		Low		High		Moderate	

Economic Analysis

Project Budget

Category	Unit	Quantity	Price ($/unit)	Cost ($)
Area 1 Riprap Stone	ton	46	50.00	2300.00
Area 1 Filter Material	ton	46	19.00	874.00
Area 1 on-site fill	cubic yard	15	4.44	66.60
Area 2 Excavation	cubic yard	75	3.92	294.00
Loader	hour	35	120.00	4200.00
Area 1 Operator	hour	35	50.00	1750.00
Backhoe & Area 2 Operator	hour	5	100.00	500.00
Total Labor	hour	30	40.00	1200.00
Total Cost ($)				**11184.60**

Project Implementation

All design notes will be handed off to The Nature Conservancy. They have accepted the responsibility of finding contractors to bring in and operate the equipment needed to excavate Area 2 and fill Area 1. They will manage the workers that will hand-place the riprap stones into the bank of Area 1. The Nature Conservancy also has a nursery that will be supplying the grass seed needed, as well as starting the woody species. The livestaking of the woody species will need to be layered into the riprap as it is laid. The team recommends that after construction is complete and the vegetation has established itself that The Nature Conservancy returns to the site to conduct another BEHI assessment to properly gauge the impact that the designs have on the streambanks.

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