Ipswich River
Coastal Bank Stabilization Pilot Project
Ipswich, MA

Task 2 Report
December 27, 2016

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Contents

1. Introduction

The Town of Ipswich is concerned about erosion occurring at various locations along the northern side of the Ipswich River between the EBSCO campus and the boat ramp at the Ipswich Boat Club on Water Street. This erosion may be exacerbated in the future by sea level rise and climate change impacts on rainfall events and intensity. The Town secured a Coastal Resilience grant from the MA Office of Coastal Zone Management to assess these erosion areas of concern, and develop options for stabilizing them using green infrastructure and living shoreline techniques to the extent possible. The causes of the erosion include a combination of poorly managed stormwater runoff from upland areas, pedestrian foot traffic as people try to access the river, informal storage of small boats along the banks, and erosive forces from the flows in the River, exacerbated in some cases by human constructs such as retaining walls, headwalls, stormwater outfalls, bridges and the like.

The Town contracted with the Horsley Witten Group (HW) to assess the sites and provide options for stabilizing the banks. This work is presented in this draft report. Concurrently, the Town contracted with Conoco Engineers to assess the sites where stormwater runoff is potentially contributing to the erosion problem, and provide recommendations to address the stormwater runoff to prevent future erosion. Conoco's work is not presented in this report. Through a Steering Committee discussion of HW's and Conoco's initial assessment and recommendations, the Committee will identify up to two sites for which HW and Conoco will develop conceptual designs and then permit-ready designs for bank stabilization projects.

2. Methods

The Steering Committee, HW staff, and Conoco Engineers staff walked the Ipswich River on September 27, 2016, and observed the areas of concern for erosion, as identified along the way by Alicia Geilen, Ipswich Conservation Commission. The group discussed each site, including insights about the likely cause of the erosion at each site, the current pedestrian access and use at each site, any historical knowledge of the area, the existence of public utility infrastructure near each site or at risk at each site, and possible bank stabilization techniques. HW used tablet computers and mobile GIS-based site assessment software to record observations, delineation project limits, and record geo-referenced photographs of each site. These raw data forms are provided in Appendix A for reference. Section 3 of this report provides a summary of the site assessments.

HW then developed a list of appropriate potential shoreline stabilization techniques applicable for the riverbank conditions found along this stretch of the Ipswich River. These techniques are described in Section 4 of this report.

HW then used that menu of techniques to make recommendations about which techniques were most appropriate for each of the AOCs. These are presented in Section 5.

HW provided a draft of this report to the Steering Committee and discussed the draft with the Steering Committee at their meeting on November 30, 2016. Additional comments were

incorporated in this draft, including comments solicited from the Ipswich Water Access Committee.

HW will work with the project Steering Committee to evaluate each site and its respective solution, and to prioritize the sites for restoration efforts in the next phase of the project.

3. Ipswich River Areas of Concern

Map of sites

The Town of Ipswich identified a set of nine Areas of Concern (AOCs) along the northern bank of the Ipswich River where bank erosion was occurring. These sites are identified on Figure 1, presented in Table 1 and described in more detail below. The site assessment forms completed in the field using iPads with GIS capability are presented in Appendix A.

Figure 1. Areas of Concern for Bank Erosion

Area 1. *Water Street*. River bank along Water Street. Undercutting and damage from existing stormwater runoff, particularly at 1C. Boat storage and foot traffic at 1A and 1B.

Area 2. *Green Street*. River bank just south of Green Street. Significant erosion of the bank into the river, just south (upstream) of the old structural retaining wall.

Area 3. *Water Access*. Water access from the path, defined by existing exposed tree roots on either edge.

Area 4. *County Road Outfall*. The existing drainage outfall is rusted out, causing severe undercutting and erosion in the bank.

Area 5. *Exposed Sewer.* Exposed sewer along northern river bank and where siphon crosses the river from south to north. 5A is the siphon crossing the river, and 5B is the sewer line on north streambank.

Area 6. Farley Brook Outfall and Bank. The riverbank is undercut in the area downstream of the Riverwalk and parking lot at the EBSCO property and extending approximately 200 feet along the back of the parking areas serving the Market Street businesses.

Table 1. Assessment of Areas of Concern (AOCs) for Bank Erosion Along the Northern Bank of the Ipswich River, Ipswich, MA

Area of Concern	Site Description	Likely Cause of Observed Erosion	Threat to Town Infrastructure?	Threat to Ipswich River Water Quality?	Possibility for public access as part of erosion solution?	Other Notes
1A	This site is located just west of the boat docks and boat ramp. The bank is eroding, likely due to a combination of some unmanaged stormwater but mainly pedestrian and non-motorized boater access to the river. The bank from the edge of the road is a steep drop of approximately 1-3 feet, down to a riparian marsh along the river.	Pedestrian access to the river and transport and storage of small boats (canoes/kayaks), which is trampling the bank. Uncontrolled stormwater draining off Water Street into the River.	The pavement along the southern edge (river side) of Water Street is eroding due to unmanaged stormwater. There are overhead utilities located along the bank that could be threatened over the long term.	The loss of salt marsh habitat and upland vegetation, and the erosion of the bank are potentially increasing sedimentation into the river.	Possible limited public access for foot traffic and launching of kayaks and canoes may be allowed at this site, given that it is already occurring and habits are difficult to break. Storage of small boats on the bank and wetland resource areas should be prohibited.	
1B	This site is located on Water Street across the street from Summer Street. At the site is a stormwater outfall with a headwall and duckbill check valve installed to prevent backflow into the system. The headwall is failing, and the bank around the headwall, particularly to the west, is heavily eroded, compromising the headwall integrity. The area west of the headwall has been heavily trampled and the existing salt marsh has been degraded. A large mud flat extends into the river in this area.	Pedestrian access to the river and transport and storage of small boats (canoes/kayaks), which is trampling the bank. The toe of the bank is being undercut by the river flow. Stormwater draining off Water Street into the River instead of being captured by the existing underground stormwater collection and treatment (catch basins and Stormceptor). The runoff from the road appears to bypass the drainage infrastructure and flow over the bank into the river.	The existing stormwater outfall structure and adjacent pavement on Water Street are heavily eroding due to stormwater runoff, foot traffic and boat storage at the site. This will continue to worsen if it is not addressed. There are overhead utilities located along the bank that could be threatened over the long term.	The stormwater that bypasses the drainage system and the Stormceptor is receiving no treatment prior to reaching the river. The loss of salt marsh habitat and upland vegetation, and the erosion of the bank are potentially increasing sedimentation into the river.	Possible limited public access for foot traffic and launching of kayaks and canoes may be allowed at this site, given that it is already occurring and habits are difficult to break. However, storage of small boats on the bank and wetland resource areas should be prohibited.	Entire length of bank along Water Street between AOC 1A and 1C. The bank is eroding and unstable in various locations. The bank is steeper and taller at the AOC 1C end and gets continually lower and less steep toward AOC 1A. The bank between AOCs 1B and 1C includes boulders that have begun to shift and fall out of the bank. The bank between AOCs 1A and 1B is much shallower and includes sections of salt marsh extending up to the paved road.
1C	This site is located on Water Street just downstream of the Green St. bridge. The bank in this location is taller and steeper than further downstream, because of the bridge abutment and associated embankment. Erosion in this area appears to be occurring at various locations where road runoff flows unmanaged over the bank. Some undercutting erosion is occurring at the toe of the bank as well.	Stormwater draining off Water Street into the River instead of being captured by the existing underground stormwater collection and treatment (catch basins and Stormceptor). The runoff from the road appears to bypass the drainage infrastructure and flow over the bank into the river.	The pavement along the southern edge (river side) of Water Street is eroding due to unmanaged stormwater. There are overhead utilities located along the bank that could be threatened over the long term.	The stormwater that bypasses the drainage system and the Stormceptor is receiving no treatment prior to reaching the river.	No public access is appropriate at this site due to the steep tall banks. No public access appears to be taking place under current conditions.	

Area of Concern	Site Description	Likely Cause of Observed Erosion	Threat to Town Infrastructure?	Threat to Ipswich River Water Quality?	Possibility for public access as part of erosion solution?	Other Notes
2	This site is just upstream from the Green St. bridge and just upstream from an old bridge abutment constructed of granite blocks that still stands over 10 feet tall. Approximately 35-40 feet of the bank has eroded into the river, depositing sediment and boulders into the riverbed just in front of the site. The bank is quiet unstable and drops down vertically by 2-3 feet from the walking path. This appears to be a high traffic area for pedestrians accessing the river, but it is unclear if people are using this site as a put in for non-motorized boats.	Erosion at this site appears to be caused by a combination of factors: Heavy use by pedestrians accessing the river has damaged the embankment. Flow in the river appears to be causing erosion at this location, and is likely exacerbated by the adjacent manmade structures. The downstream edge is defined by a tall remnant bridge abutment wall and the upstream edge is defined by large boulder revetment that was installed sometime in the last century, possibly related to the sewer installation in the 1960s.	There is a notable threat to the sewer infrastructure at this site. The sewer trunk line is underground within the walking path and likely very close to the eroding edge of the bank.	There is a significant threat to the sewer infrastructure at this site. The sewer trunk line in this area is old, based on the 1956 design plans, and any failure could result in a direct discharge of sewage to the river.	This site was favored for public access for canoe/kayak launch, wading, dog access, and viewing during discussions at the site walk, because of the proximity to public parking and the relatively large site (30-40 feet long) that is being addressed. The river is also somewhat shallow at this location because of all of the material that has eroded from the bank into the river channel. However, a put-in just upstream of a large bridge structure can pose some safety hazards, especially when the river flows are normal or heavier than normal.	The area that is eroding was originally constructed and filled for the purpose of cover and bank stabilization for the installation of the sewer line. The sewer line was actually installed within the river and the river was filled and narrowed.
3	This site is about halfway between Green St and County Rd. It is clearly used as an access point to the river, and has been heavily altered by pedestrian access. A clear path extends from the walking path down to the river, lined on both sides by exposed tree roots around which the sediment has been long eroded away. This site is the inside of a curve in the river, and there is a significant amount of deposition occurring in front of this area, creating a large shallow mud flat feature in the river.	Erosion at this site appears to be caused almost entirely by pedestrian access to the river, which is quite shallow in this area. It is not readily clear if people bring non-motorized boats to this location to put in. There may be some limited stormwater runoff from the ball fields behind Town Hall that is contributing to the bank erosion at this location and in the surrounding areas.	There is a sewer trunk line within the adjacent walking path along the Ipswich River in this area, but the erosion at this site does not appear to pose any imminent threat to that line due to the separation distance from that line.	There does not appear to be a significant threat to water quality.	This site would be a potential candidate for public access for wading, dog access, fishing, and viewing, in particular because the bank slope is relatively shallow at this point and the river itself is quite shallow due to significant deposition in front of the site.	
4			This site threatens the stability of the bank that contains the rusted out stormwater drain pipe. The drain pipe needs to be replaced.	The stormwater pipe is causing significant erosion and incising of the bank, which is delivering excess sediment into the channel. It is unclear if the stormwater is being pretreated prior to discharge, but this site may present an opportunity to retrofit the stormwater infrastructure for treatment	Public access to the water is not appropriate at this site because of the high steep slope.	

Area of Concern	Site Description	Likely Cause of Observed Erosion	Threat to Town Infrastructure?	Threat to Ipswich River Water Quality?	Possibility for public access as part of erosion solution?	Other Notes
5A	A sewer siphon that crosses the Ipswich River downstream of the S. Main St. bridge is now exposed in the riverbed. The soil cover that once protected the siphon has been washed away.	Erosion is likely caused by high velocity flows, either during large storm events or in combination with long-term exposure to higher flows, potentially exacerbated by increased development in the watershed or increasing frequency of high-intensity storm events.	There is a significant threat to the sewer infrastructure at this site. The pipes that were observed are old and likely in need to repair or replacement.	The water quality threat at this site originates from the threat of the sewer infrastructure failing, which would cause a wastewater discharge into the river.	Public access for canoe/kayak put-in is not appropriate at this site.	This exposed siphon was observed during the site visits related to this project during a long period of severe drought and very low flow conditions. The level of stabilization, protection, evaluation, and restoration of the sewer infrastructure likely makes this project significantly broader than the scope of the CZM grant, and likely more significant in cost.
5B	A sewer trunk line that runs parallel to the river on the north side of the river in the vicinity of and underneath the S. Main St. bridge is fully exposed. It appears that portions of it were originally installed under soil cover for protection, while other portions were purposefully installed above the riverbank. The protective soil cover along the downstream segment of this pipe has been eroded away, exposing the sewer to the river environment.	Erosion is likely caused by high velocity flows, either during large storm events or in combination with long-term exposure to higher flows, potentially exacerbated by increased development in the watershed or increasing frequency of high-intensity storm events.	There is a significant threat to the sewer infrastructure at this site. The pipes that were observed are old and likely in need to repair or replacement.	The water quality threat at this site originates from the threat of the sewer infrastructure failing, which would cause a wastewater discharge into the river.	Public access for canoe/kayak is not appropriate at this site.	The level of stabilization, protection, evaluation, and restoration of the sewer infrastructure likely makes this project significantly broader than the scope of the CZM grant, and likely more significant in cost.
6	The riverbank is undercut at the back edge of the parking lots serving the Market Street businesses, beginning at the Riverwalk at the EBSCO property and extending approximately 200 feet downstream toward the Choate Bridge. The Farley Brook outfall also discharges in this area.	Flow in the river appears to be causing erosion at this location, which is the outer edge of a significant bend in the river. It is likely exacerbated by flows passing the EBSCO parking lot and the Riverwalk located just upstream of this site.	The parking areas serving the Market Street businesses are located at the top of the bank. Further erosion could eventually threaten the back edge of the parking lot. In addition, the Farley Brook outfall structure could be compromised by additional erosion.	There does not appear to be a significant threat to water quality.	Public access down to the river for canoe/kayak put-in or wading/fishing is not appropriate near the Farley Brook outfall pipe. The Riverwalk is currently located upstream of this site.	

Sources: VA DCR, 2004. NRCS, 1996. MA CZM, 2016. FEMA, 2014.

Area of Concern 1A

Bank erosion appears to be caused by unmanaged runoff from Water Street as well as foot traffic and storage of kayaks and small boats on the bank.

Area of Concern 1B

Similar to site 1A, stormwater runoff from the adjacent street and trampling by pedestrians are contributing to the erosion, but the bank is also being undercut by the river, likely due to elevated flow velocity.

Area of Concern 1C


The bank at this location just downstream of the Green Street bridge is being undercut by the flow in the river. In addition, stormwater runoff from both Green Street and Water Street is flowing uncontrolled off the pavement and down the bank next to the tree in the picture on the right above.

Area of Concern 2

Scour from existing bridge abutment is contributing to the bank eroding down into the river, leaving a large sediment deposit in the river and exposing roots of trees along the bank. This site is also being used as an access point to the river by pedestrians for viewing the river. No visible evidence of boat access at this time, but the Town is interested in exploring potential canoe/kayak access at this location.

Area of Concern 3

The observed erosion at this site appears to be cause by a combination of stormwater runoff from the adjacent upland area, and pedestrian traffic down to the river and mud flat area that has formed on this shore of the river.

Area of Concern 4

The outlet end of an old corrugated metal stormwater pipe from County Road has disintegrated, allowing water to drain directly out of the bottom of the last several feet of the pipe. As a result, the bank is severely undercut under the pipe and the edge of the cut is receding.

Area of Concern 5A

The sewer siphon has been exposed within the riverbed where it was originally buried. It crosses from the southern side of the river to the northern side, where it connects to the main sewer trunk line at a manhole in a residential back yard on the north side of the river.

Area of Concern 5B

Transition from where exposed sewer pipe travels underground, losing ground cover between bank and top of pipe.

Area of Concern 6

Photo credits: Kevin McHugh, CONECO Engineers, 2016.

The eroded riverbank extends approximately 200 feet downstream from the Riverwalk at the EBSCO property, along the back side of the parking areas serving the Market Street businesses. The photos above show the erosion at low tide, looking downstream from the Riverwalk toward the Farley Brook outfall (top photo) and upstream toward the Farley Brook outfall (bottom photo).

4. Potential Shoreline Stabilization Techniques

There are essentially five shoreline stabilization techniques that are appropriate for the type of erosion we observed at the Areas of Concern on the Ipswich River in Ipswich and that rely on "green infrastructure" design principles. These include coconut coir logs, brush mattress and live stakes, revetments (including boulder, log, rootwad, and tree), boulder sills, and live crib walls. We also describe living shorelines as a combination of the techniques listed above. These techniques are summarized in Table 2 below, and are described in more detail following the table. These techniques were identified as natural green infrastructure techniques that use a living shoreline element to create a shoreline that is naturally adaptable to the changing conditions in the bank that can be anticipated in the face of climate change as well as the ongoing development in the contributing watershed. As described above, the climate change conditions that are contemplated here include the slow long-term rise of sea level and potentially more frequent erosion from flood-inducing rain events.

Table 2. Bank Stabilization Techniques for Consideration at Ipswich River AOCs in Ipswich, MA

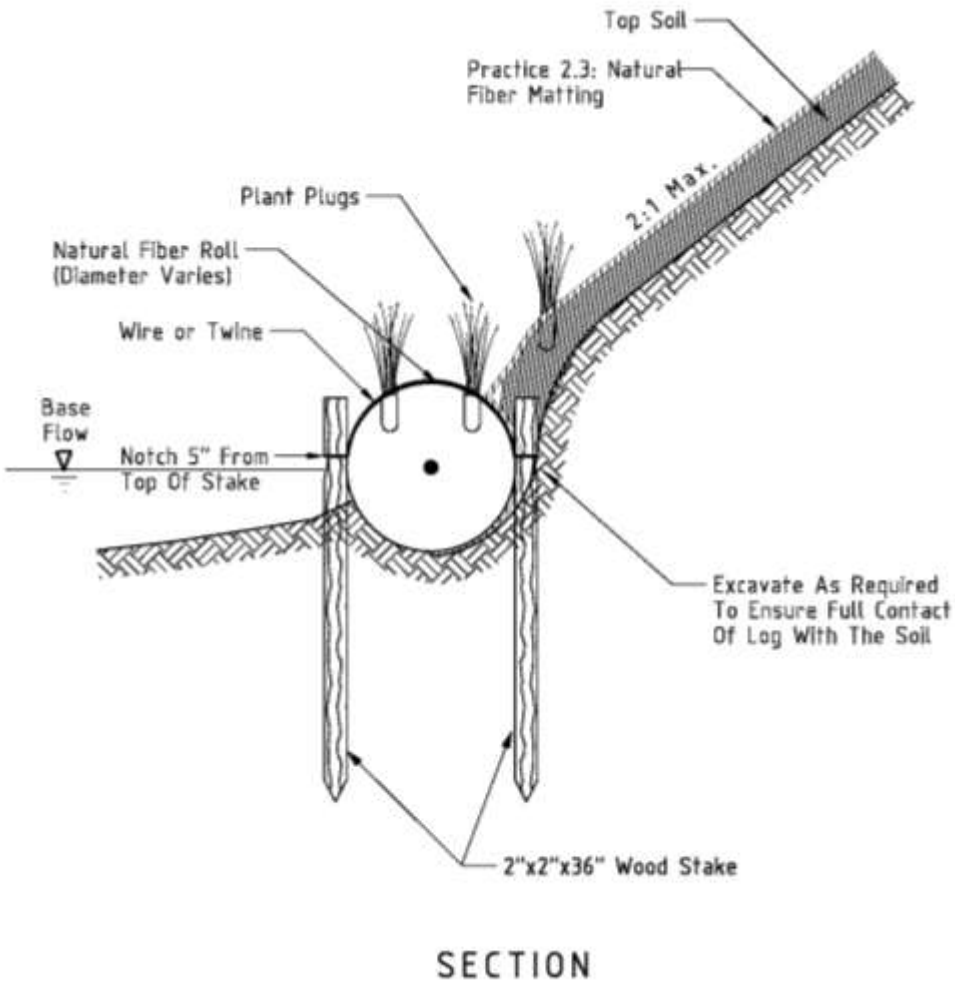
Bank Stabilization Technique	Description	Appropriate Sites for this Technique	Advantages	Limitations	Construction Notes	Approximate Planning Level Construction Cost	Maintenance Notes
Coconut Coir Logs	100% biodegradable and easily installed. Provides a natural material to stabilize hills, banks and shorelines.	Use where the bank is being undercut at Ordinary High Water. Can be used to increase elevation at certain points to establish living shoreline.	Natural material that will become part of shoreline as it biodegrades. Flexible material that can be molded.	Does not provide significant protection during larger storms. Effective life of 6 to 10 years.	Use of 2" x 2" stakes is required to hold in place. Vegetation may be used as the environment will allow.	$30 / LF (will include plants and stakes)	Coir logs may need to be maintained during the several months after installation, by either replacing logs or securing anchors.
Brush Mattress and Live Stakes	Covering and stabilizing shoreline banks. Mainly used on faster flowing riverine sections. Able to capture sediment during flood events.	Application to steeper slopes. Effective in areas with fluctuating water levels. Stakes will continue to grow.	Slows flow and prevents erosion where practice is applied. Filters waters through the growing brush.	Brush Mattresses and Live Stakes will take time to establish roots in existing slope; limited to above high-tide applications.	Use a mix of live and dead stakes. Layer in between filter fabric and connect to existing slope.	$12/ SF	Live stakes could be damaged in larger storms.
Revetment (Boulders, Logs, Rootwads, Trees)	Take a more dense object and anchoring it to the earth	Applied to areas with a lot of wave action.	Resistant to high velocity/wave action, provides long-term resiliency.	Not effective near bridges and may require maintenance, depending on the type of revetment.	Trees must be 12 inches or larger in diameter. Base of revetment must be below current scour depth.	Boulder - $90/ CY Tree - $25/ LF Rootwad- $500/ EA (All costs will vary depending on availability)	Logs could rot and may need to be replaced in time.
Boulder Sills	Boulders that are spaced periodically to form a type of vane that will prevent scour and reduce flow.	Combines with Coir Log at certain areas to protect the establishment of the coir log.	Can use existing material. Will be less expensive.	During larger storms and flooding, boulders may move slightly due to increased velocities	Boulders will be spaced about 2-3 feet apart. Bury the boulder 1 foot into the ground to prevent scour.	$10/ SF (cost of labor)	Areas around boulders may need to be cleared of debris
Live Crib Walls	A live crib wall is a rigid structure that will be comprised of layers of untreated logs or timbers with live stakes extending into the adjacent slope.	Useful in areas with steep slopes must be maintained due to site constraints.	Provides very good habitat for fish and insects that provide food for fish.	Complex to build and will require specific materials which can become expensive.	Use of rot resistant timber is very importance.	$30 / SF	Debris on the face of the wall may need to be cleaned to allow for free flowing water
Living Shoreline	Very broad term that will combine multiple methods presented above together with salt or fresh water marsh restoration.	Areas that have a receding shoreline and salt marsh, undercut banks, and/or mudflats near the shoreline.	Over time will become stronger and a more effective method as plant roots are established. Enhances intertidal habitats.	Takes time to see results from establishment of vegetation.	This practice will be included with another BMP to be able to install. After toe is protected, native plugs will be planted.	$15 / SF (Includes any plantings)	Maintenance will be required as living shoreline is established, particularly after any storms greater than 5-year event.

Sources: VA DCR, 2004. NRCS, 1996. FEMA, 2014.

Coconut Coir Log

"A toe and lower bank protection technique using fiber rolls made from coir(coconut) fiber and netting. The natural fiber roll stabilizes the toe of the bank in areas of low stress. The natural fiber rolls promote trapping of sediment and provide a medium for the establishment of vegetation." These logs are appropriate for toe stabilization on banks with generally stable beds (i.e., not in deep muck/peat locations). They are also appropriate for areas where aesthetics are of concern because they degrade over a period of 4-6 years, generally, and the trapped sediments and plant materials take precedence and stabilize the bank. Figure 2 below presents a basic detail drawing of the installation of the coconut coir log practice, also called natural fiber rolls. (VA Department of Conservation and Recreation, Division of Soil and Water Conservation, 2004)

Figure 2. Standard Detail for Coir Log Installation (VA DCR, 2004)



Brush Mattress and Live Stakes

Brush mattresses are a combination of branch cuttings and live fascines, sometimes bound together before installation, and staked to the shoreline bank to cover and stabilize the bank against erosion. This mat is secured to the bank by live stakes and partially covered with topsoil. Live stakes are dormant woody cuttings that are prepared by removing small branches and carving a strong point at one end, and which area driven through the brush to hold it in place. The goal is for the stakes to also root, grow, and create additional vegetative cover to stabilize the streambank. Brush mattresses are appropriate in areas where the goal is to fully cover the slope above the high tide line with vegetation, and where the slope of the bank is less than 2:1 (horizontal: vertical) and the slope length is less than about 10 feet. The brush mattress should be installed above the stream-forming flow, or high tide line in this case, and requires a stable toe below the mattress, which can be provided by the installation of coir fiber logs, boulders, or other means. Live stakes used in this practice are likely to be most successful where the stakes will have some contact with a seasonally high water table. Figure 3 below presents a basic detail drawing of the installation of the brush mattresses, with stakes that can be exchanged with live stakes. (VA DCR, 2004) Figure 4 presents a variation on this technique (NRCS, 1996).

Figure 3. Standard Detail for Brush Mattress and Stakes (Live or Dead) (VA DCR, 2004)

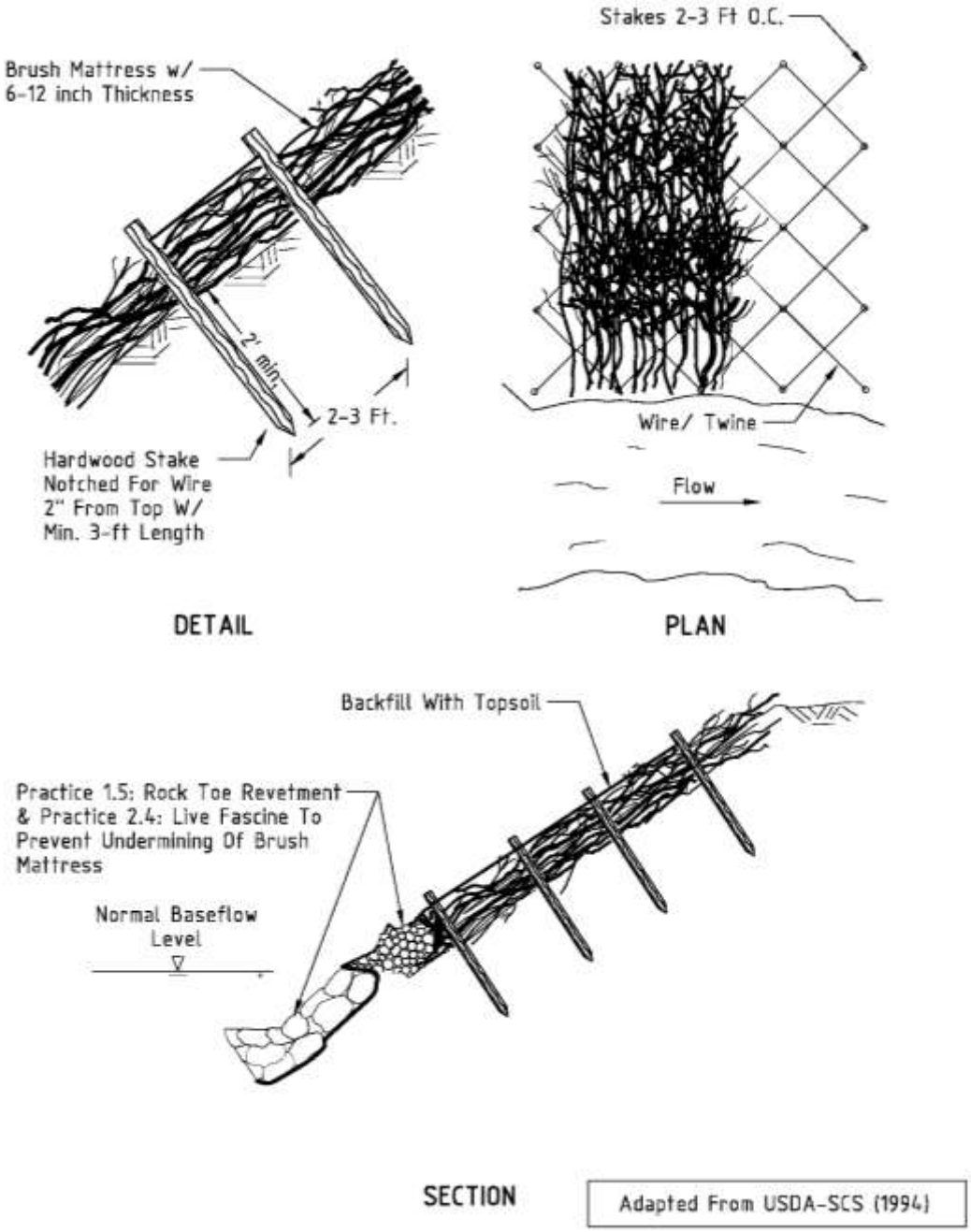
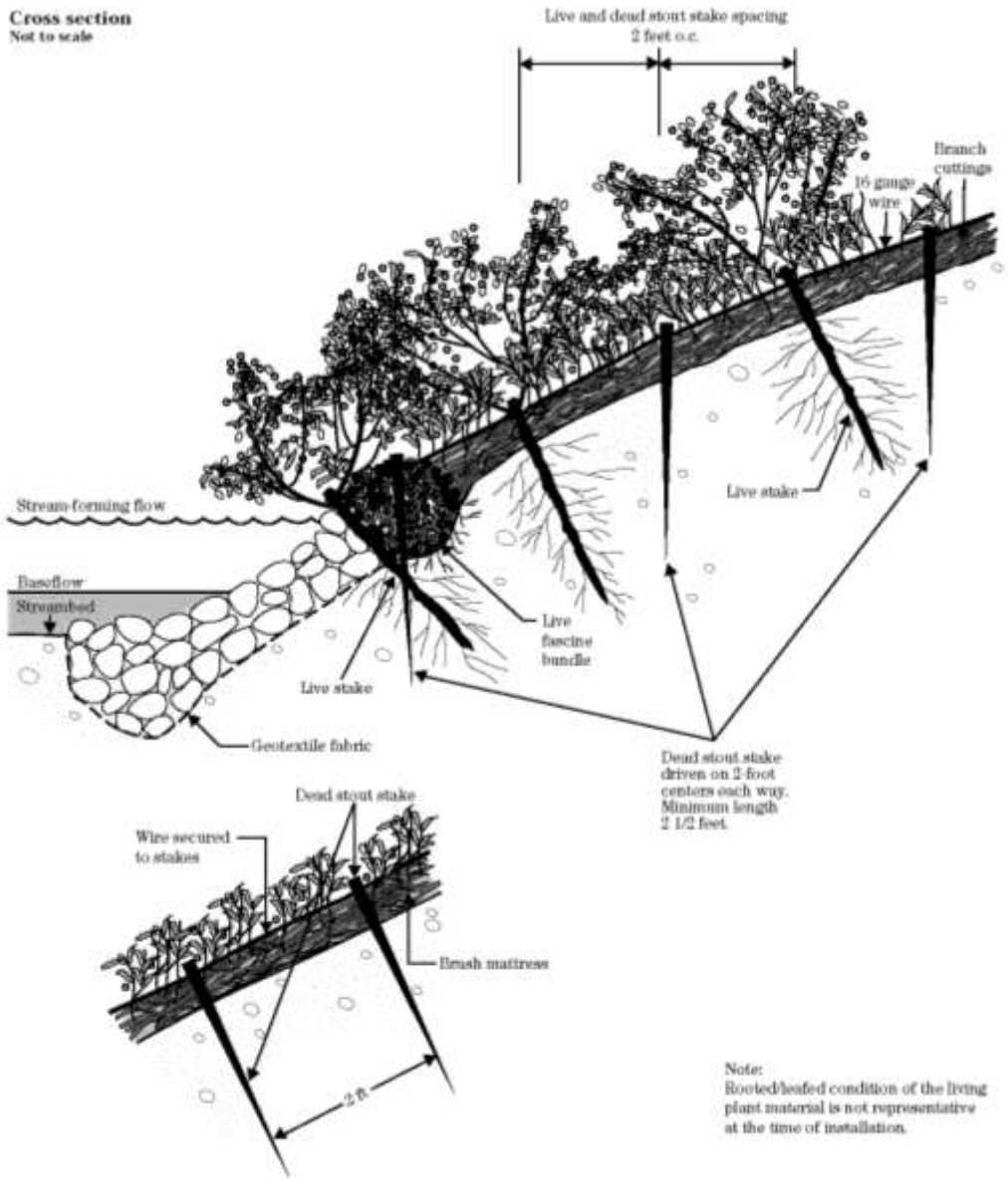


Figure 4. Brush Mattress with Live Stakes Detail (NRCS, 1996)



Revetment (Boulders, Logs, Rootwads, Trees)

The term revetment simply refers to the stabilization of a bank by armoring with erosion-resistant material. Revetments are often used as one element of a bank stabilization solution. Living shoreline and green approaches to shoreline stabilization include the use of a combination of materials in revetments to armor the streambank with a living materials that will eventually provide a living armor to stabilize the bank. The combination logs, rootwads and boulder revetment is presented in Figure 5 below, as excerpted from the NRCS Environmental Field Handbook (NRCS, 1996). This type of application is appropriate for areas where fish habitat deficiencies occur and there is a goal to create a

more diverse fish rearing and spawning habitat. These structures will tolerate high boundary sheer stress if the root wads and logs are well anchored to the bank. (NRCS, 1996)

A simple boulder revetment can be used at the base of a slope to provide stability below a bioengineered slope. Figure 6 presents an example detail from VA DCR, 2004.

A tree revetment is an alternative revetment system that provides enhanced habitat value, and evolves over time as additional vegetation becomes established around it. A tree revetment is constructed using whole trees that are cabled together and anchored to the earth along the slope, extending below and above the stream-forming flow (high-tide) elevation. Siting of a tree revetment should consider downstream structures that could be damaged in the event that a tree dislodges during a flood. Figure 7 presents an example tree revetment details from NRCS, 1996.

Figure 5. Log, Rootwad, and Boulder Revetment details (NRCS, 1996)

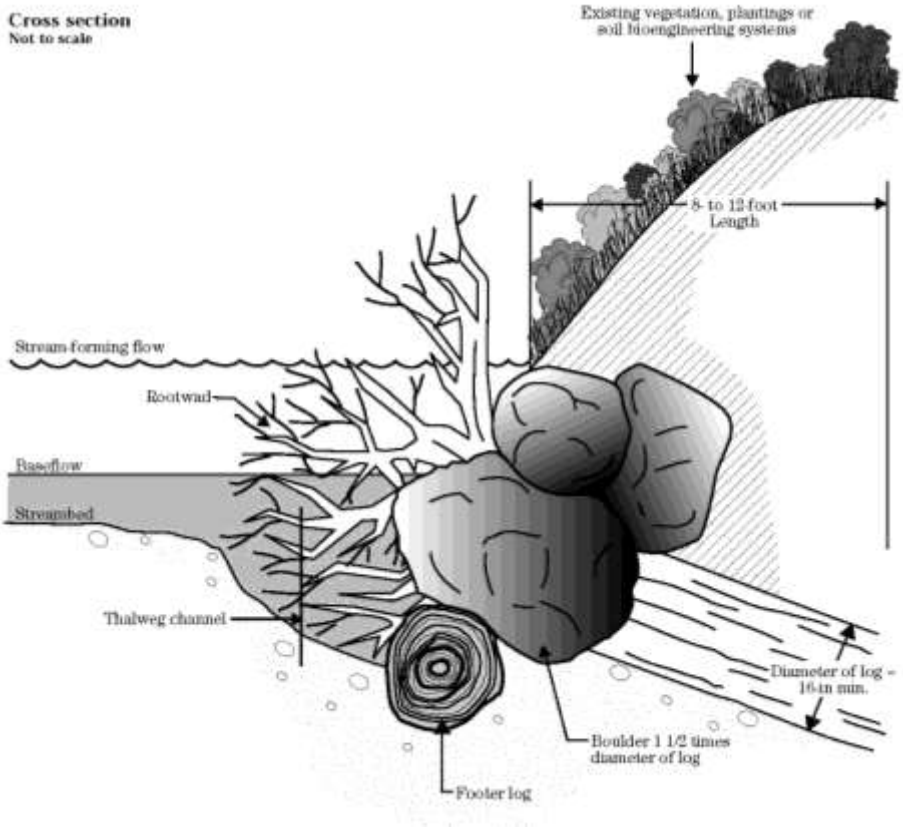


Figure 6. Boulder Revetment Detail (VA DCR, 2004)

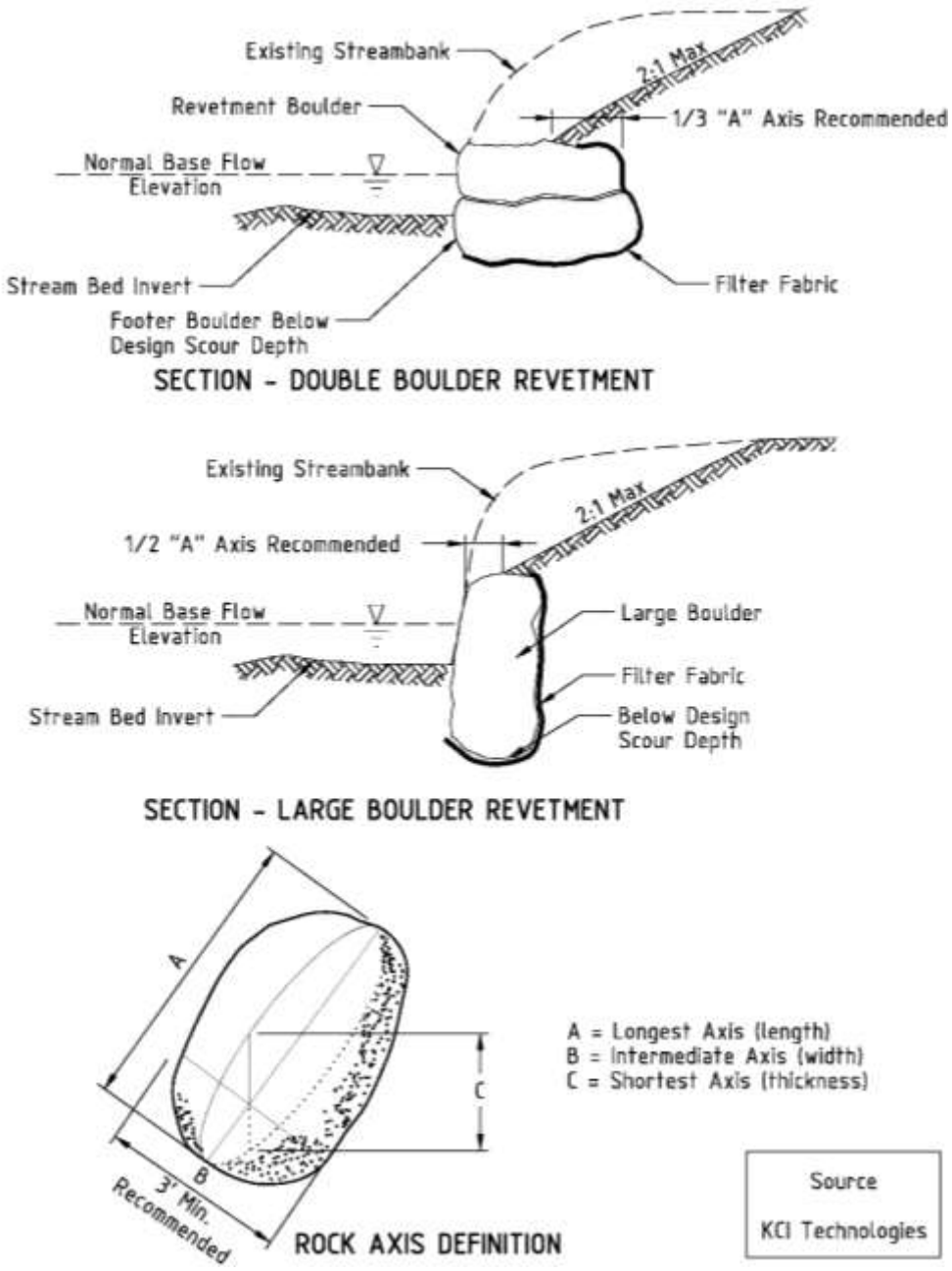
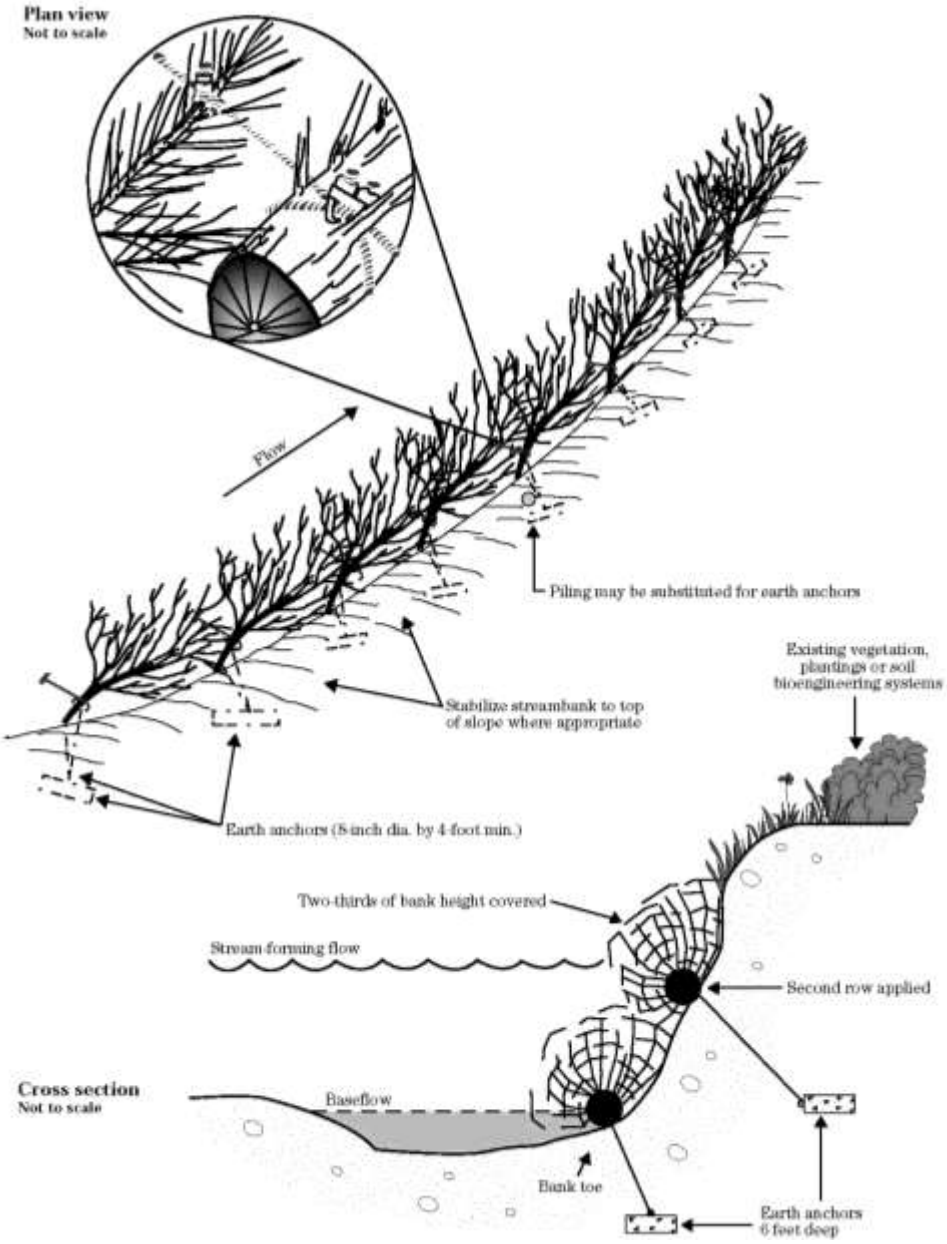


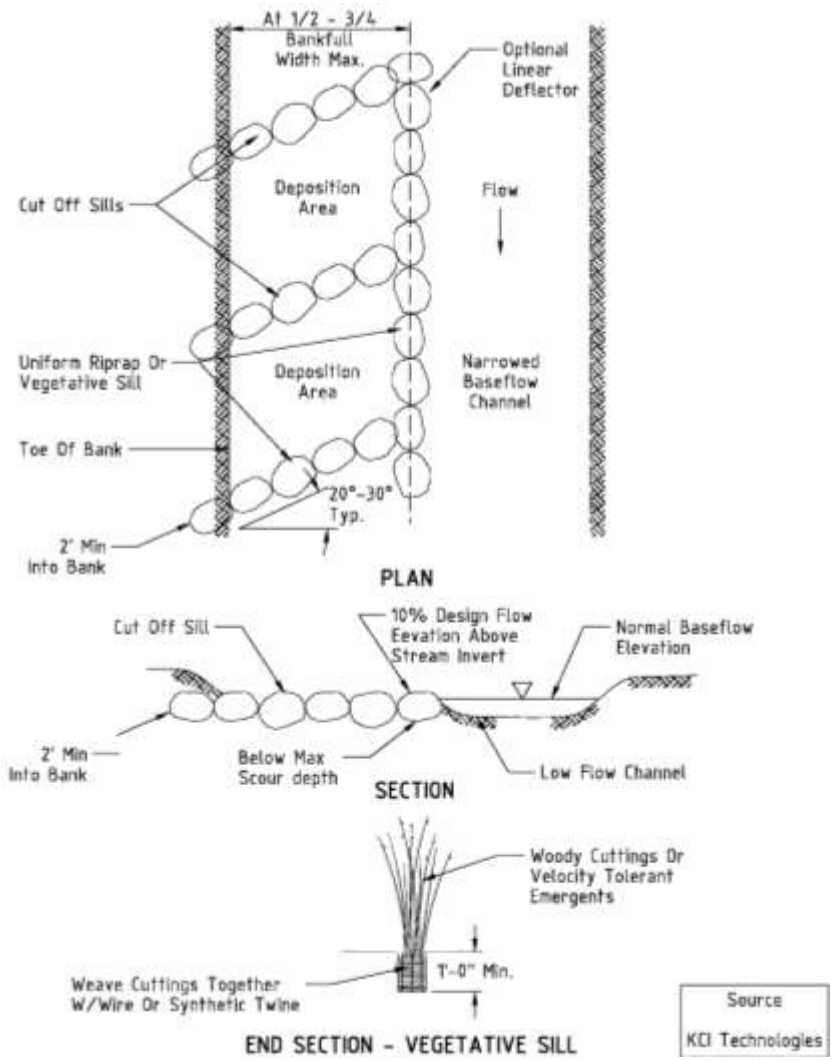
Figure 7. Tree Revetment Details (NRCS, 1996)



Boulder Sills

Boulder sills are structures that extend out at 20 to 30 degree angle from the bank into the river, upstream, with the goal of concentrating low flows and accumulating sediment behind them. They are designed to build up over time as a result of the sedimentation. Sills are useful in areas of streams and rivers that have been overly widened and no longer present a defined baseflow channel. The bed material should be predominantly cobble/gravel bed, rather than bedrock channels. Because the practice depends on sedimentation behind the sills, it should be used in systems with sufficient sediment load. The greater the flow velocity at the restoration site, the smaller the angle of deflection should be. Figure 8 presents a basic detail for a boulder sill structure. (VA DCR, 2004)

Figure 8. Details of a Boulder Sill Structure (VA DCR, 2004)



Living Shoreline

A living shoreline, in the context of this project, is considered to be a combination of practices that includes as a primary component a vegetated shoreline, comprised of fresh water or salt water marsh vegetation. The marsh system is created behind a staked coir log, which is lined on the water side by large boulders to help secure it in place (See Figure 9 below). Over time the marsh system regenerates and expands, stabilizing behind the coir log as the coir log biodegrades. In other applications, as in the photo in Figure 10 below, the edge of the marsh system is defined and stabilized by a sill or small berm of boulders that can be overtopped by the changing elevations of water in the tidal section of the river. This type of system can be constructed in terraces along the river's edge, with plantings and soils selected appropriate for the level of inundation and flow expected at each terrace.

Figure 9. Detail of a Living Shoreline Marsh

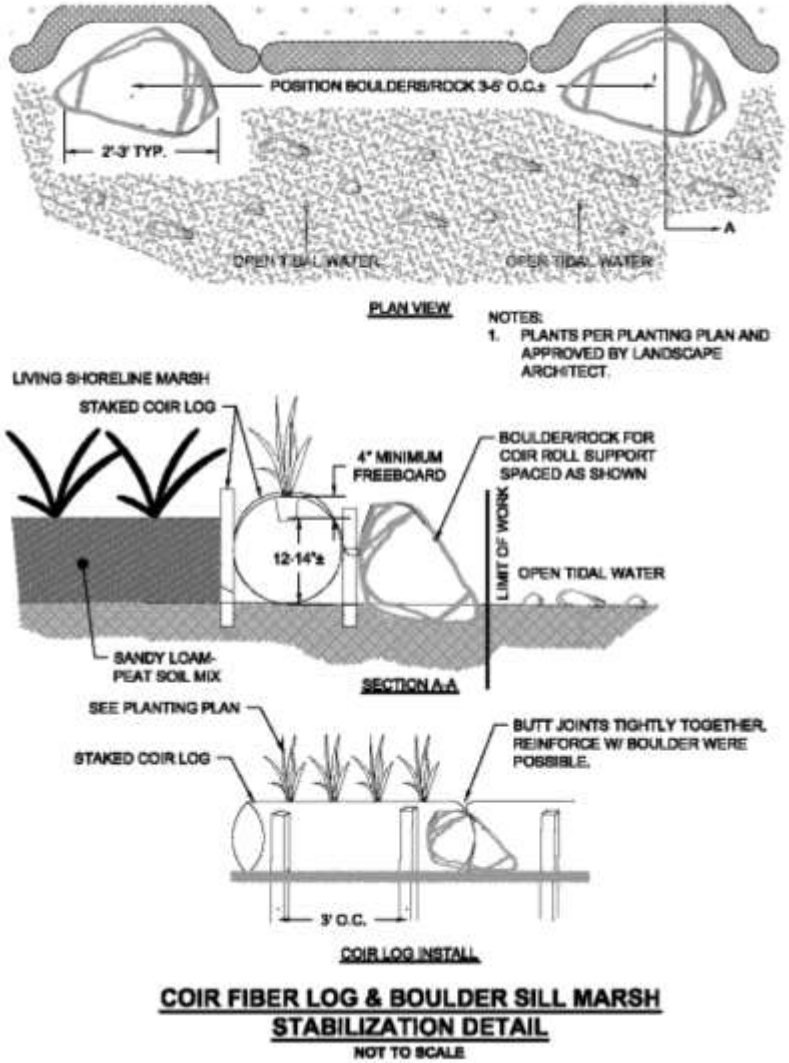
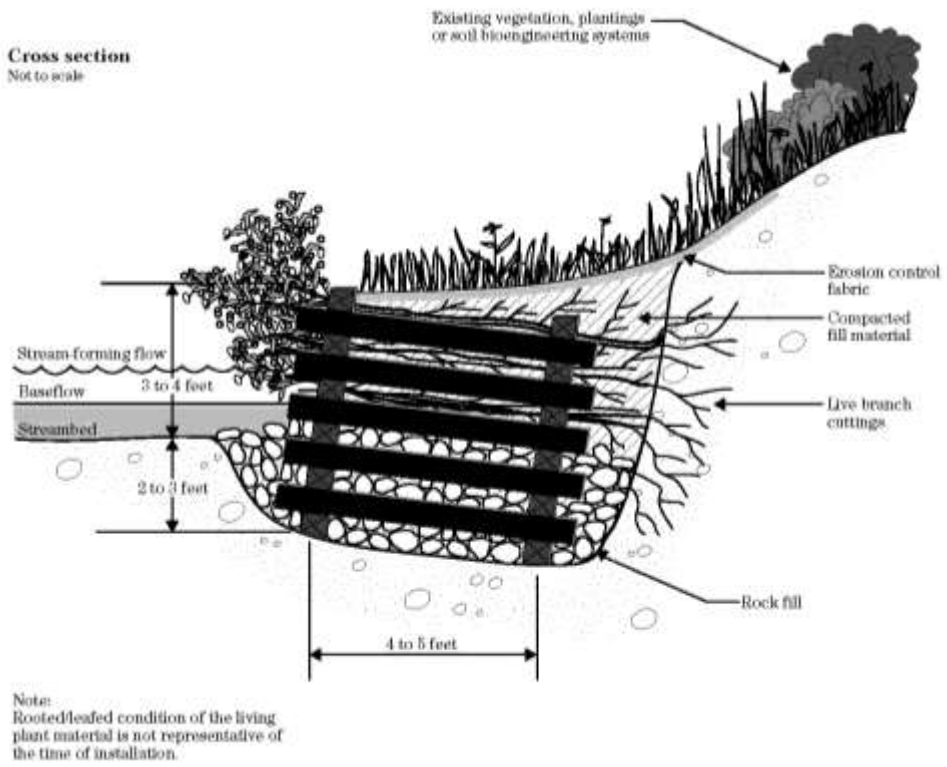


Figure 10. Photograph of a living shoreline installed in a tidal river environment (SOURCE?)

Live Crib Wall

A live cribwall is a box like structure of untreated logs and timbers that is filled with backfill materials and live branch cuttings that extend out into the slope of the streambank. Over time, the live cuttings will become established and live vegetation will take over the structural functions of the cribwall logs and timbers. A cribwall is appropriate at the base of a slope where a low wall may be needed to reduce the slope of the bank, where space is limited and more vertical wall is required. It can be installed below and/or above the water levels, and is effective in high velocity areas. This practice can also provide excellent habitat benefits. It can be expensive because of materials and installation requirements. A detail is provided in Figure 11 below. (NRCS, 1996). Trees/shrubs would be planted above the high-tide line (designated at the “stream forming flow” in the figure.

Figure 11. Live cribwall details (NRCS, 1996)



5. Recommended Options for Each Area of Concern

HW developed recommendations for specific bank stabilization techniques at each of the Areas of Concern identified in this project. We also incorporated input from the Ipswich Steering Committee November 30, 2016 meeting and from the Ipswich Water Access Committee (via email, Dec 21, 2016) about how each Area of Concern is currently used by the public (provided as a result of the November 30, 2016 Steering Committee discussion). These recommendations are presented in Table 3 below. In addition, HW made recommendations about which sites should be prioritized over others, based on our assessment of the severity and stability of the current condition at the site, the cost of implementing the recommended bank stabilization technique, and the potential benefit served by the project. The purpose of these recommendations is to provide a basis for discussion and decision making among the full project Steering Committee about which projects to pursue, and in what priority order.

Table 3. Recommended Bank Stabilization Techniques for each Area of Concern

Area of Concern	Recommended Bank Stabilization Technique	HW Recommendations for Public Access	Ipswich Water Access Committee Comments	Notes
1A	• Coconut Coir Logs • Living Shoreline, Marsh • Boulder Sill	This site is a potential location for public access, particularly for local neighborhood residents, but public parking is difficult. We note that there was some discussion of opening talks with the adjacent local boat club with regard to public access and upland boat storage and parking.	Current uses: • Mooring access • Dinghy tie-up Recommendations: • See Area of Concern 1B	The areas of concern along Water Street (A1-A3) will all be similar in nature and will require similar materials. However, each individual site will require specific design for the placement of materials and extent of stabilization required. At this site, the coconut coir log will be used to protect the receding salt marsh. This will also help bring the grade up to be able to establish a living shoreline behind the coir logs. The living shoreline will then transition into the existing salt marsh.
1B	• Coconut Coir Logs • Living Shoreline, Marsh • Boulder Sill	This site is a potential location for public access, particularly for local neighborhood residents, but public parking is difficult. We note that there was some discussion of opening talks with the adjacent local boat club with regard to public access and upland boat storage and parking.	Current uses: • Mooring access • Dinghy tie-up • Non-motorize boat launch/haul • Boat passenger drop off • Swimming/wading • Dog swimming • Fishing access Recommendations: • Combine all uses for 1 A,B,C into one defined area in the location of 1B • Use permits to control dinghy tie up, consolidate to 1B location	The areas of concern along Water Street (A1-A3) will all be similar in nature and will require similar materials. However, each individual site will require specific design for the placement of materials and extent of stabilization required. At this site, the coconut coir log will be used to protect the receding salt marsh. This will also help bring the grade up to be able to establish a living shoreline behind the coir logs. The living shoreline will then transition into the existing salt marsh. We will work around any retrofit to the existing stormwater outfall and headwall.
1C	• Coconut Coir Logs • Living Shoreline, Marsh	This is not an area that is recommended to have public access. The existing slope will be too steep to have any safe way to access the coastal bank.	Current uses: • Boat passenger drop off • Swimming/Wading Recommendations: • See Area of Concern 1B	In this area, the coir log will be used to fill in and stabilize the undercutting at the toe of the bank at the high water elevation.
2	• Coconut Coir Logs • Revetment (Boulder, Log, Rootwad, Tree) • Boulder Sill • Living Shoreline, Marsh	This area is not recommended to have public access. This area is of such concern to stabilize and to possibly incorporate a living shoreline that to provide access to the public may interfere with the proposed methods. However, we note that public parking is very convenient to this location, making it an attractive option.	Current uses: • Limited dog swimming • Not much other use due to condition of the bank	This is an area that will need to be addressed with a stabilization technique. It is experiencing significant scour, likely as the incoming tide passes the existing retaining wall/old bridge abutment wall that extends upstream from the Green Street bridge. Boulder sills will reduce the scour by decreasing the force on the riverbank.
3	• Coconut Coir Logs • Brush Mattress and Live Stakes	We recommended this site for continued public access. This site clearly has an established use as a public access, and could be adapted to provide small-boat put-in access.	Current uses: • Dog Swimming • Wading • Fishing	This is a small area that would not require significant effort to manage, if the coir logs are installed correctly and remain in place.

Area of Concern	Recommended Bank Stabilization Technique	HW Recommendations for Public Access	Ipswich Water Access Committee Comments	Notes
4	• Coconut Coir Logs • Living Shoreline • Brush Mattress and Live Stakes	This area is not recommended to have public access.	Current uses: • Dog swimming • Wading • Fishing	
5A	• Revetment (Boulders, Logs, Rootwads, Trees)	This area is not recommended to have public access.	Current uses: • Dog Swimming	Due to the age of the sewer line, this site might require replacement of the sewer infrastructure, making this a much larger undertaking than is anticipated from this grant.
5B	• Revetment (Boulders, Logs, Rootwads, Trees)	This area is not recommended to have public access.	Current uses: • No activity noted	Due to the age of the sewer line, this site might require replacement of the sewer infrastructure, making this a much larger undertaking than is anticipated from this grant.
6	• Coconut Coir Logs • Boulder Sill • Living Shoreline • Brush Mattress and Live Stakes	This area is not recommended to have public access to the water. Any contemplated extension of the Riverwalk should be above the top of bank.	This site was not discussed.	

6. Resources

Federal Emergency Management Agency (FEMA). Year? Engineering with Nature: Alternative Techniques to Riprap Bank Stabilization.
Weblink:https://www.fema.gov/pdf/about/regions/regionx/Engineering_With_Nature_Web.pdf

Massachusetts Coastal Zone Management (MA CZM). 2016. StormSmart Properties Comparison Chart – Relative Costs of Shoreline Stabilization Techniques. Web link: http://www.mass.gov/eea/docs/czm/stormsmart/properties/cost-comparison-chart.pdf

Massachusetts Coastal Zone Management (MA CZM). 2016. StormSmart Properties Fact Sheets About Stabilization Techniques. Web link: http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/stormsmart-properties/

National Oceanic and Atmospheric Administration (NOAA). 2015. Guidance for Considering the Use of Living Shorelines. Web link: http://www.habitat.noaa.gov/pdf/noaa_guidance_for_considering_the_use_of_living_shorelines_2015.pdf

Natural Resources Conservation Service (NRCS). 1996. Environmental Field Handbook, Chapter 16. Streambank and Shoreline Protection. Part 650. 210-vi-EFH. Web link: http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17553.wba

Reston Association. 2006. Shoreline Stabilization Guidelines. Web link: https://www.reston.org/portals/3/Parks-Recreation-Events/Nature/Publications/PDF/ShorelineStabilization.pdf

Virginia Department of Conservation and Recreation (VA DCR). 2004. The Virginia Stream Restoration & Stabilization Best Management Practices Guide. Web link: http://www.deq.virginia.gov/Portals/0/DEQ/Water/Publications/BMPGuide.pdf

Appendix A. Field Assessments Data Collected by HW (Steering Committee Site Walk, September 27, 2016)