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**“Alternative Techniques
to Riprap Bank Stabilization”**

Engineering With Nature

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Engineering With Nature

Alternative Techniques to Riprap Bank Stabilization



FEMA

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Contents

Introduction	7
Hamakami Strawberry Farm	11
Riverview Road	13
Eatonville Logjams	15
Burley Creek Brush Mattress	18
Everson Overflow	20
Hiddendale	22
Old Tarboo Road Bridge	24
Black Lake Drainage Ditch	27
Little Washougal Creek	29
Schneider Creek	31
Conclusion	34
Acknowledgements	

Introduction

We have always endeavored to harness and manipulate our environment. Efforts to shape or restrict nature often involve mechanically or artificially forcing our surroundings to bend to our will. Sadly, many of these activities have serious effects. Clear cutting forests, pollution, endangering entire species or simply driving them to extinction are just some of the major impacts. As we grow and develop technologically and as a society, we often overlook just what we are doing to the land around us, frequently until it is too late.

Over the past century, the Pacific Northwest has seen a significant amount of development in the areas of agriculture, housing, urbanization and population. The 12 counties spanning the area of Puget Sound in Washington State alone have seen growth in numbers of up to 4 million people since the 1950s. This continuing expansion has put increased pressure on the multitude of rivers, streams and other bodies of water that festoon the region, and growing presence is having a marked impact on those waters.

The more development this area undergoes, the more we are forced to restrict and inhibit the environment, in particular the varying and numerous waterways that surround us. While land erosion, stream migration and even flooding are natural processes, they can cause havoc when occurring near human populations. This has led to the creation of a number of measures to control or eliminate such hazards. Unfortunately, while many of these techniques solve the immediate problem, they are not always the safest or most environmentally conscious choice for the long-term.

Riprap, or hard armoring, is the traditional response to controlling and minimizing erosion along shorelines or riverbanks. As demonstrated by past multiple disasters in Washington State, the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) has provided funding assistance for the repair to these riprap facilities.*¹ The very nature of having to repair these facilities counters the popular engineering belief that riprap is the best solution for mitigating stream bank erosion.

^{1*} Funding is contingent upon eligibility criteria established under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended

Riprap

Put simply, riprap is the layering of rocks (angular rocks generally being preferred,) along a threatened area to counteract the constant wearing away of land brought about by repetitive hydrologic activity. Whenever waves or moving waters meet unprotected soil, there will always be erosion. Covering exposed soil with rock helps protect it from being washed away, securing an embankment against further erosion.

Problems arise because the effects of riprap do not stop at the point of installation. When positioned along a section of riverbank, for example, riprap has a number of negative impacts on the surrounding environment. Riprap tends to increase the speed of water flow along an armored reach, as the water has no points of friction to come up against and nothing to slow it down. This additional strength of flow presents issues further downstream from a riprap protected bank, as water is deflected off the riprap and directed at other points of riverbank. The increased strength and speed of the water only increases erosion suffered at these new locations, the typical result of which is the necessity of installing additional armoring, which merely moves the problem further down the stream.

Riprap impedes the natural functions of a riverbank or shoreline, as it interrupts the establishment of the riparian zone, or the point of interface between land and flowing water. A properly functioning riparian zone is important for a number of reasons; it can reduce stream energy and minimize erosion; filter pollutants from surface runoff via biofiltration; trap and hold sediments and woody debris, which assists in replenishing soils and actually rebuilding banks and shorelines; and it provides habitat diversity and an important source of aquatic nutrients. Not to mention, a naturally functioning riparian zone simply looks better.

Another aspect of riprap is its considerable effect on wildlife, specifically fish that live in and utilize streams and rivers where eroding banks have undergone armoring. While erosion can cause potential problems for fish, especially in high-silt locations, the installation of riprap leads to other, more significant, issues. When riprap is the primary or only form of riverbank stabilization measure, the end result is typically a uniform, smooth channel, with no complexity. This means that there are no areas of vegetation either in or overhanging the water, leaving fish at risk from predation. In addition, a lack of riverbank diversity denies fish a place to seek refuge during periods of high-water, which often results in their being washed out of a fast moving system during flooding.

Riprap causes other, albeit less significant, problems as well. In areas of low vegetation, when exposed to direct sunlight, the rocks that comprise riprap can reflect light into



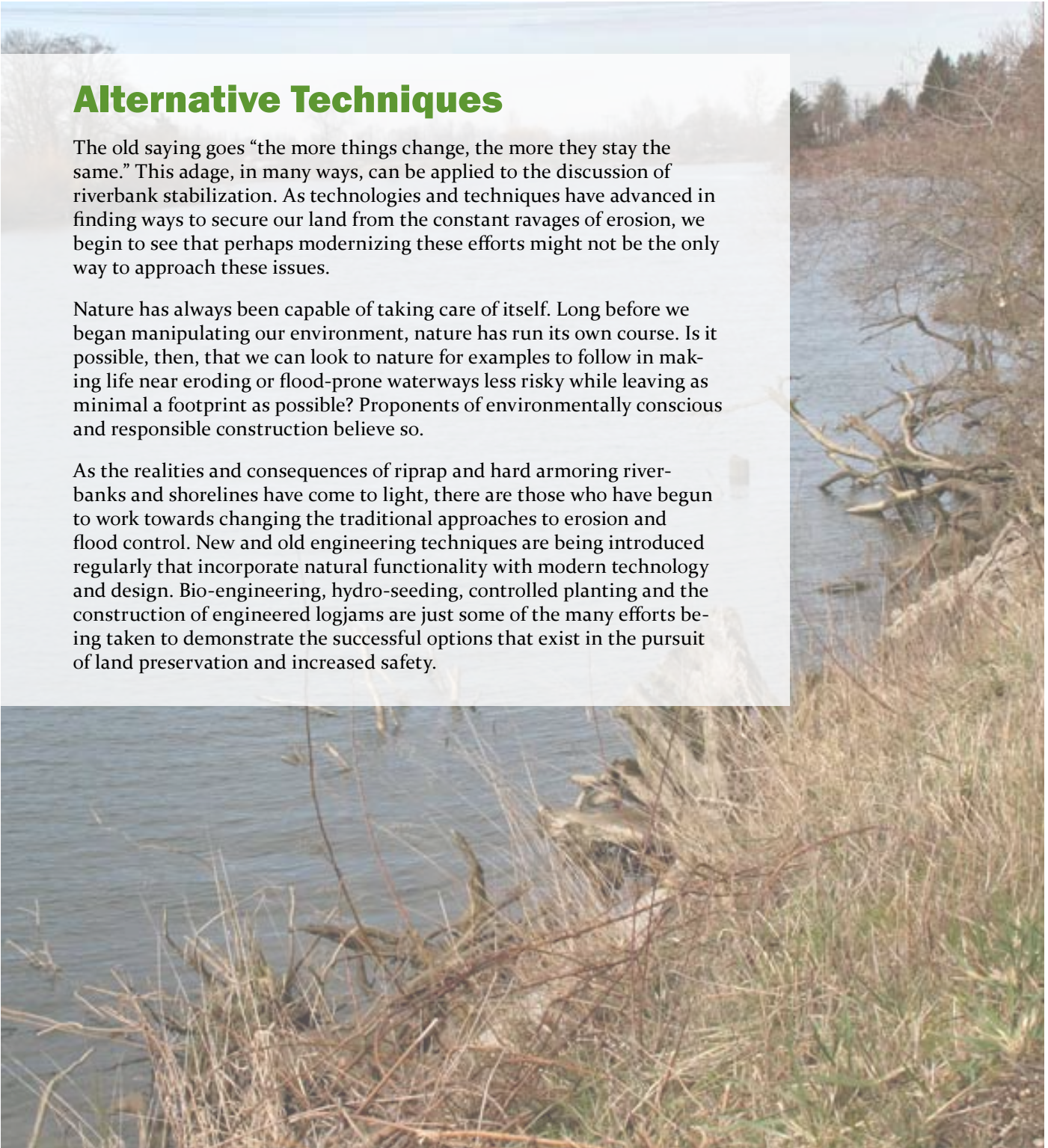
the water, which increases water temperatures to an unhealthy degree for fish. Riprap also tends to suffer from structural integrity issues during and after high-water events. Losing rocks to high water or fast flows, a riprap structure will soon begin to fail in its purpose. Once the soil that the riprap is designed to protect is exposed, the damage continues as before its installation. This possibility requires constant monitoring and maintenance, which ultimately becomes expensive and problematic.

Alternative Techniques

The old saying goes “the more things change, the more they stay the same.” This adage, in many ways, can be applied to the discussion of riverbank stabilization. As technologies and techniques have advanced in finding ways to secure our land from the constant ravages of erosion, we begin to see that perhaps modernizing these efforts might not be the only way to approach these issues.

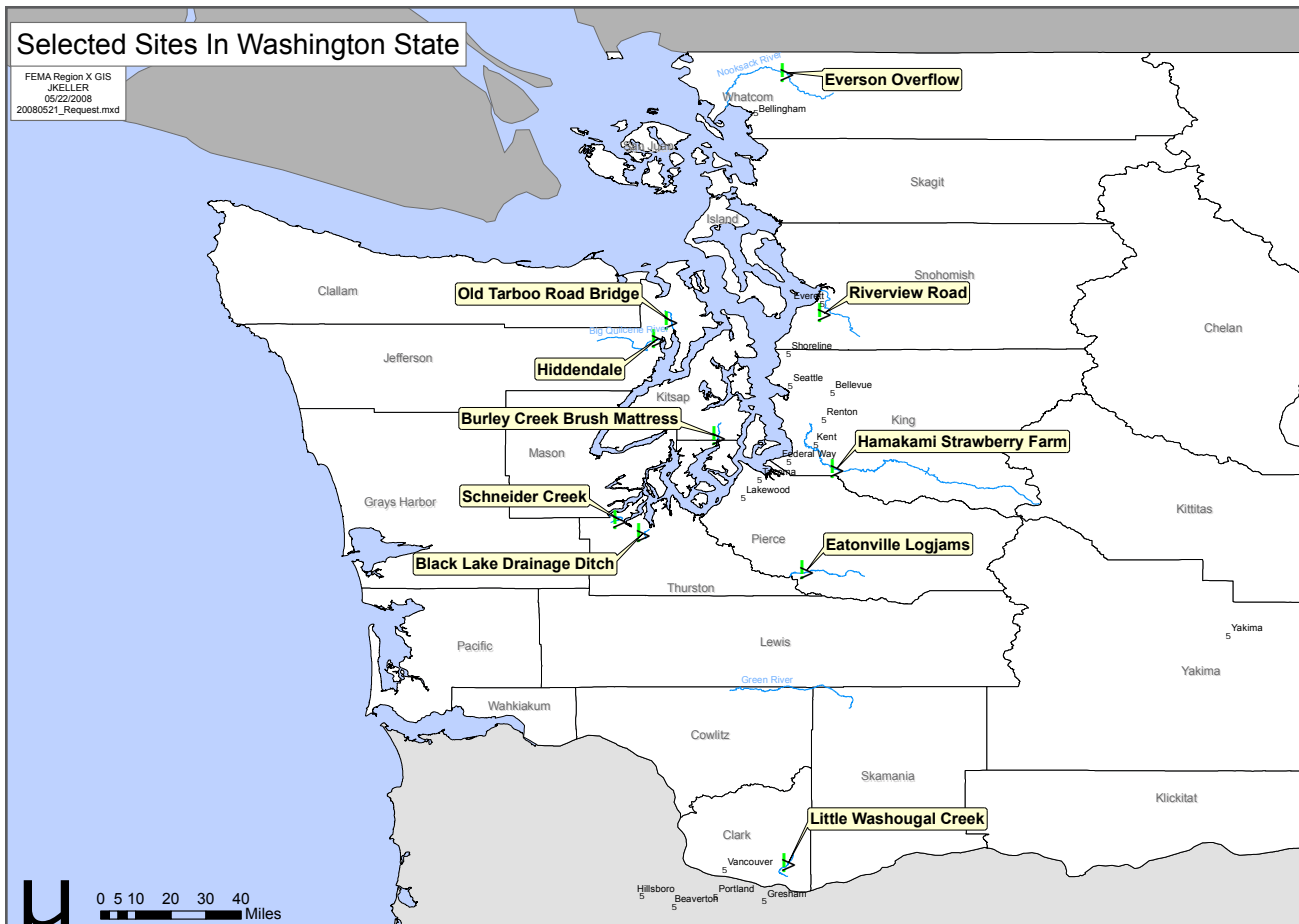
Nature has always been capable of taking care of itself. Long before we began manipulating our environment, nature has run its own course. Is it possible, then, that we can look to nature for examples to follow in making life near eroding or flood-prone waterways less risky while leaving as minimal a footprint as possible? Proponents of environmentally conscious and responsible construction believe so.

As the realities and consequences of riprap and hard armoring riverbanks and shorelines have come to light, there are those who have begun to work towards changing the traditional approaches to erosion and flood control. New and old engineering techniques are being introduced regularly that incorporate natural functionality with modern technology and design. Bio-engineering, hydro-seeding, controlled planting and the construction of engineered logjams are just some of the many efforts being taken to demonstrate the successful options that exist in the pursuit of land preservation and increased safety.



Purpose

Standard engineering calls for hard armoring an eroding bank. Lately, the tide has turned on the accepted practice of hard armoring due to public conscience of the eroding environment we live in. The 10 stories in this booklet represent a handful of successful alternatives to riverbank stabilization that have been taken throughout Western Washington. While this collection is in no way complete, it offers a comprehensive look at some of the varied techniques that are available for consideration. These best practices illustrate the fact that we can manipulate streams and rivers without completely overriding nature's design, that indeed, it is possible to work hand in hand with nature to make living by the water not only viable, but much safer and secure in the long run.



Hamakami Strawberry Farm: Adding Roughness to River Keeps Farm Running Smoothly

In 1994, King County built a bioengineered bank stabilization project on the Middle Green River at the site of John Hamakami's Strawberry Farm. The site was designed at a time when the Washington State Department of Fish and Wildlife, the Muckleshoot tribal fisheries groups, and King County ecologists were realizing that the continued placement and replacement of riprap was harming fish and their habitat. Hamakami Strawberry Farm became a demonstration site for the positive effects of using natural elements, particularly wood and vegetation, as opposed to hard armoring in a high energy river environment.

"We started looking at how river hydraulics were interacting with wood," said Andy Levesque, a King County senior engineer, who works in the River and Floodplain Management Unit. "We wanted to see how wood could be used constructively without destabilizing banks, while actually helping to direct the river flow to make the banks more stable if possible. The actual design and construction work was overseen by Jeanne Stypula, one of our engineers, working with a consulting biologist, Alan Johnson."

"We wanted to see how wood could be used constructively without destabilizing banks." - Andy Levesque



Numerous logs are placed along the toe of the riverbank.

In 1990, the Middle Green River created a whole new quarter mile meander bend in just over one day. In the process, the river demolished 150 feet of rock lined levee, a dozen maple trees and a couple acres of the Hamakami Strawberry farm. Historically on the Green River, rock riprap was used to prevent embankment scour. On such an alluvial floodplain as the Hamakami property, with an abundance of silt and sand, however, slumping is the primary cause of bank failure. Fine grained materials do not provide bank resistance, so in a high energy event, like the one that occurred at the Hamakami site in 1990, the Green River was able to move laterally at a very rapid pace.



During flooding additional woody debris is recruited by the original logs.



Recruited vegetation lends cohesion to the riverbanks.

The 1990 flood event left a steep 10 to 15-foot high raw embankment along the Hamakami Strawberry Farm. As a result, over the following years, the farm lost a significant amount of land to the river meander that was moving rapidly through the property. In fact, strawberries from the farm were literally falling into the river channel.

In 1994, King County stabilized 500 feet of the rapidly eroding riverbank using bioengineering measures. Over 60 logs were placed along the river's toe and secured to the bank with coir fabric, soil wraps and vegetation. The logs were placed in groups of three every 20-25 feet and buried into the embankment. As a demonstration project, the idea was to show that installing natural elements added roughness to the channel, which increased flow resistance and slowed the river down.

“Now we’ve got 100-fold the habitat edge, variety, complexity, structure, interaction, and process that we did right after the flood event.” - Andy Levesque



“We used wood and vegetation to slow the river processes down,” said Levesque. “When the wood that showed up in the next flood landed, it started forming a jam. The jam evolved and recruited sediment, and the sediment recruited vegetation. That slowed the water down enough to deposit the gravels upstream, which caused the river to cut multiple channels across the bar that it had previously built. Now we’ve got 100-fold the habitat edge, variety, complexity, structure, interaction, and process that we did right after the flood event. We counted fish at the site, before our installation, and there were four of them. Now there are five different species at ten different times of year.”

The Hamakami site exemplifies that if a bank stabilization design can jump-start channel processes, ecological rehabilitation will occur. The logs placed by the county now have wood, debris, sediment, and vegetation surrounding them. As a result of the project, several side channels have been created which distribute the system’s energy, allowing sediments to disperse and vegetation to thrive. In total, the site’s ecological productivity is greatly improved.

“This type of technique is what I would advocate even in a high energy environment,” said Levesque. “It can be done with wood. It can be done with vegetation. There are some precautions that have to be taken depending on the landscape. If the river meander has basically cut itself to the edge of where it’s going to go, just respect that meander belt and add some structure back into it. Get things jump-started. You get your process back. You get things reshaped and you get environmental benefits.”

Riverview Road: Several Steps to Safety in Snohomish County

Riverview Road in Snohomish County, Washington runs beside a section of the Snohomish River. The road was built by landowners in the late 1800s and then expanded and improved in the early 1900s. It primarily serves the local farming communities as both a thoroughfare and as the base of a flood control levee system. At the time of its construction, these levees were created with drag lines which pulled soil from the river bottom and deposited it on the top of the riverbank. The material was then flattened for use. The pulled river soil is described as alluvial sediment and is composed of fine grained, porous material.

Problems arise when such material is subject to inundation. Over the years, as the County developed, modern surfacing was laid over the old roadway originally built from the river alluvium. During periods of high water resulting from floods on the Snohomish River, the road embankment becomes saturated. When the water recedes, the material tends to compact, and the saturated soils begin to slide down towards the river. This process often compromises the stability of the riverbank, undermining the integrity of the road itself.

“This is happening at a number of places where there are levees on the lower Snohomish River,” said Jeffrey Jones, an Engineering Geologist for Snohomish County’s Public Works Department. “Every time the water comes up and goes back down, we find new problem sites.”

The Riverview Road area of the Snohomish River is a migration corridor for Chinook salmon and Bull trout, both listed under the Endangered Species Act (ESA). The increase of sedimentation from the collapsing embankment into the river was regarded as potentially harmful to fish, as sedimentation can negatively impact oxygen levels, suffocate salmon eggs and decrease visibility for feeding. Because rip-rap reduces cover, increases temperature and eliminates access to spawning areas, it can have a negative impact on habitat. Based on these potential effects the team sought out other alternatives.

Jones, working with Dave Lucas, a River Engineer for the Snohomish County Surface Water Management Department, designed a system of embankment stabilization. This environmentally-friendly design incorporated wood and vegetative plantings. The design was successful because it kept the road from collapsing and avoided placing major amounts of rock into the river.

Since the embankment along Riverview Road is so steep, typical stabilization techniques were impractical. Jones and his team of Snohomish County Road Maintenance workers built a structural earth wall (SEW) composed of a number of soil wraps placed in a step-like fashion starting from the waterline and climbing to the top of the embankment. Each step is created by laying down a 13-foot wide roll of polypropylene or polyethylene geo-grid fabric. The grids are



The offsetting of the soil wraps comprising the structural earth wall (SEW) give it its step-like appearance. The logs anchored to the toe of the embankment protect the structure from fast flowing woody debris and provide habitat for migrating fish during high water.



Dave Lucas and Jeff Jones standing atop their structural earth wall on Riverview Road.



The willow cuttings planted throughout the embankment lend root cohesion and stability to the structural earth wall.

weighted down by layers of compacted gravel-borrow taken from a local quarry. The geo-grid is folded over, and another layer of gravel is used to weigh it down further. As each wrap is completed, the following one is offset by at least one foot, creating the step-like appearance. The outer face of the wall is covered with a layer of heavy coir fabric, and topsoil which is then hydro-seeded. This allows the geo-grid to lock in place and secure the embankment without threat of degradation from exposure to ultraviolet light. Finally, the entire embankment is planted with live willow cuttings which ultimately take root. As the trees grow, their root structures add to the stability of the embankment.

According to Lucas, Snohomish County utilizes a native plant program to assist in habitat restoration projects such as the Riverview Road effort. Not only are they able to determine which plants and trees are appropriate for a particular location, they also incorporate a holding facility that grows the plants to be used. With advance notice of upcoming projects, the holding facility personnel can have the plants ready and perform the recommended planting.

“In the toe of the embankment we anchored a continuous row of logs,” said Jones. “They’re about 20 or 30 feet long, with the root wads still attached. We use “Manta Ray” type anchors, vertical anchors and horizontal anchors to hold them in place.”

The Snohomish River at this location is tidally influenced, which means the logs are not in the water at all times. During high tide the logs provide necessary shelter for migrating fish. They also act as a shield, preventing larger woody debris from puncturing the base of the soil wraps during periods of high water or flooding. Over time, additional woody debris is recruited by the logs and absorbed into the shoreline, further enhancing the establishment of habitat.

The first stage of the Riverview Road stabilization project was completed over four years ago, just down the road from the most recent construction. At this point in its progression, the first area has assumed a completely natural appearance. The planted vegetation has grown and continues to develop a functioning root system that further strengthens the embankment. The logs on the waterline have recruited additional woody debris, incorporating them into the habitat, and the surface of the project is overgrown by the hydro-seeded grass and planted vegetation. The geo-grids holding the embankment in place are now completely invisible.

When speaking about the success of the project, Lucas was confident in its long-term value.

“Overall, this type of design will require less ongoing maintenance than riprap,” said Lucas. “It secures the riverbank against erosion, and it helps to meet our commitment towards maintaining salmon habitat, a stated goal of Snohomish County. When we can add those elements together and stabilize a County road in a habitat friendly manner, I think the project speaks for itself.”



Eventually the coir fabric and the structural earth wall itself will be completely overgrown with hydro-seeded grass and other vegetation.



The completed project, a short distance down the road, is now fully vegetated and looks entirely natural.

Eatonville Logjams: Engineered Logjams Protect Banks on Mashel River



Four of the engineered logjams designed by Herrera Environmental Consultants on the Mashel River outside of Eatonville, WA.

On the Mashel River, just outside of the town of Eatonville, Washington, Smallwood Park contains a pond utilized by the town's residents for their annual fishing derby. Every few years the Mashel River is subject to flooding and the park, along with the pond, becomes inundated with floodwaters. The river embankment by this pond has begun to erode, and with each new flood event, the park, and the County road nearby, are potentially threatened with damage.

Following a major flood in 1996, the Army Corps of Engineers funded the installation of a riprap structure on the threatened riverbank. That area of the river happened to be a straight channel providing no complexity to slow the river's flow, or for fish habitat. As is often the case with riprap, the speed of the river in that reach accelerated, and increased the threat of erosion on banks further downstream. In addition, the riprap itself ultimately began to fail, with the rocks that comprised the bank protection falling into the river.

To address the problem, a private company, Herrera Environmental Consultants was contracted to install several engineered logjams along a number of reaches in the river along the Smallwood Park bank. The intent was for the logjams to slow down water flow,

while providing long-missing habitat for fish that utilized the Mashel for spawning and migration.

"One of the main limiting factors of that area of the river was that it had been very simplified by prior human activity," said Jose Carrasquero, a Fisheries Biologist and Project Manager for Herrera. "Logging and removal of wood had negative effects on the riparian areas, and left no complexity to the stream. There were very few pools for juvenile salmon to utilize for rearing, or off-channel habitat for much-needed protection during high flows. Spawning habitat for returning adult salmon was also lacking. The area had also been cut off from its floodplain, and therefore, it conveyed water during high flows very fast, which was effectively flushing the fish out of the system."

Another important consideration was that the riprap installed by the Corps was having an impact on the levee on the opposite bank of the river where erosion had also started to occur. Behind the levee was another pond that sat beside an old mill site. There was concern that the water from this other pond was contaminated by pollutants left over from the mill, and that, if the bank collapsed and the levee was breached during a flood, those pollutants would be released into the water.

Funding for the installation of the logjams was provided by the Salmon Recovery Funding Board (SRFB), which gives money to a number of different organizations throughout Washington State for the restoration of salmon fish habitat. The South Puget Sound Salmon Enhancement Group, one of the groups that received money from the SRFB, then contracted with Herrera to have the logjams installed in 2005.

The initial funding provided by the Salmon Enhancement Group allowed for the removal of the riprap along that section of the river and the construction of 11 logjams. The logjams were modeled in detail at the Herrera offices, and then meticulously constructed on site.

“We needed to figure out what we could do to help fix the riverbank and change the flow characteristics of the river without accelerating flow through the reach,” said Ian Mostrenko, a Civil and Environmental Engineer for Herrera. “We looked at potential hydraulic effects, calculated potential scouring, and determined how big the structures needed to be to accomplish our goal. Typically, natural logjams are stabilized by very large pieces of wood. We couldn’t get natural 36-inch diameter, 120-foot long logs to the site, so we had to simulate that stability in other ways. In this case, we used a combination of vertical log pile structures and gravity structures. We put in vertical log piles for lateral stability, and then we built what are called gravity structures, which hold the structures in place through their height and weight.”

The logs comprising the base of the logjam structures are driven deep into the riverbank, some as much as 15-30 feet in depth. A criss-crossed pattern of logs forms the core, which is likened to that of an eleva-

tor shaft. The logs interlock in place underground, lending the entire structure strength. The outer face of the jams extend into the river approximately 10-15 feet, creating the roughness elements necessary to not only slow the river flow down, but preserve the river banks from erosion, and form the pools that establish vital fish habitat.

While vegetation was not included in the original budget for the logjam construction, the Salmon Enhancement Group chose to address that issue on its own. In collaboration with the town of Eatonville, as well as the Nisqually Indian Tribe (who are involved with the project as stakeholders and eager participants,) they utilized volunteers and initiated a vegetation planting program on the logjam sites.

“We propose planting as an important component to the process,” said Carrasquero. “You want that root cohesion to be a structural element of the logjam as well as the river banks. It’s not ornamental. It will also provide habitat. From the restoration perspective, and the structural perspective, we see that as a critical element of the stability of the structures.”

During the November 2006 flood (which was listed as a 25-year event) the sites suffered no damage, and no logjams were lost to high water. Additionally, the jams performed their intended function of providing protection, and no evidence of erosion was reported on either bank of the river.

“We needed to figure out what we could do to help fix the riverbank and change the flow characteristics of the river without accelerating flow through the reach.” - Ian Mostrenko



The complexity added by the logjams is important for slowing down water flow on the river.



The pools established behind each jam provide much needed habitat and refuge for migrating fish.

The installation of the original 11 logjams, which covered three reaches of the river, totaled approximately \$400,000. The logjams have proven so successful that the Salmon Enhancement Group contracted with Herrera for the construction of two additional jams, bringing the number of Herrera-designed structures on the Mashel to 13.

In the year since the logjams have been in place, a three-fold increase in salmon numbers has been observed. The South Puget Sound Salmon Enhancement Group has performed snorkeling surveys to monitor fish utilization of the river. Data from these tests demonstrates that there is considerably less usage by fish in riprapped sections of the river, compared to banks that have been treated with wood.

“Obviously, development is going to continue,” said Carrasquero, “but it can be done in a way that’s restorative of habitat functions so that it can be sustainable. I think this type of technique is demonstrative of that. In a situation where you have constraints; infrastructure to be protected, a major transportation thoroughfare to consider, a recreational area that has to be maintained, you have to come up with concepts that will meet all those expectations. I think, so far, that riprapp has demonstrated that it can’t do all that. We live in a time in society where people have really started to care more about the environment. Right now, our water is one of our most important resources, and we need to protect it. I think this type of natural approach is more protective of that important resource.”



Herrera Environmental Consultant employees Leonard Ballek, Jose Carrasquero, Ian Mostrenko and Chris Brummer stand firmly behind (and on) their design.

Burley Creek Brush Mattress: Natural Armor Protects Bank in Mason County

In October of 2006, a property owner along Burley Creek contacted the Kitsap County Conservation District for assistance. The landowner was dealing with a stream that was eroding his backyard. When the embankment adjacent to his shed began to fail, the landowner sought outside help.

Upon evaluation of the site, Rich Geiger, District Engineer for Mason Conservation District, identified the site's significant problem areas. Although Burley Creek is a small system, its alluvial soils easily erode, making it a significant cause for concern.

"There were two issues," said Geiger. "First was the severity of the bend. Second was the ease at which these soils were being eroded. They had no internal strength."

Because coho salmon utilize this section of Burley Creek for spawning, choosing an embankment stabilization method was a complex matter. In addition, the site required immediate management. However, the embankment failure occurred in the Fall, which is spawning season for coho salmon. At that time of year, it is almost impossible to install stabilization measures without negatively affecting fish habitat.

Geiger's solution was to design a brush mattress along 77 feet of the creek. The mattress was built by tying 6-foot long Douglas fir and Grand fir tree tops to 4-foot long, 2-inch by 2-inch cedar stakes, driven in a 1-foot by 2-foot pattern into the stream bank. The tree tops are placed with the butt upstream, with each piece tied to at least three separate stakes, and shingled so the upstream tree overlaps two-thirds



Rich Geiger standing by the brush mattress as it develops.

of the downstream tree. After placement, additional living tree stakes are driven through the brush mattress to promote root growth for soil retention. In this case, a natural fiber geotextile was placed against the bare soils, and the stakes were driven through the fabric for additional soil retention. As the structure is composed entirely of natural materials, it is much more expedient to pass through the permitting process than a hard-armoring embankment stabilization project.

"It was during a period when the Fish and Wildlife Department would normally not allow you to do any kind of work in this stream," said Geiger. "However, these types of structures can be installed with just about zero sedimentation. This qualified us for the streamlined Hydraulic Project Approval, which takes a much shorter time to permit, and eliminates the



The eroding property prior to the start of the project.



Construction of the brush mattress underway.

requirement to get local permits. Since the structure is 100-percent wood, the Corp of Engineers does not consider it fill and therefore they don't require a permit. If we had used more traditional techniques, we would have had to wait for permitting."

Geiger explained that the brush mattress technique can be adapted to the specific water velocities at alternate sites.

"You can vary the strength of this based on the length and diameter of the stakes and the tensile strength of the rope used to tie down the trees," said Geiger. "You then determine how much shear stress this installation will be able to resist based on those parameters."

"This is a very easy armor to install, and in short order you can have an area protected." -Rich Geiger

Four months after it was installed, the brush mattress structure at Burley Creek withstood the February 2007 100-year-flood, suffering minimal damage in the event.

In sensitive ecosystems, when emergency management is needed for stream bank erosion control, brush mattresses can inhibit erosion without threatening habitat and requiring costly mitigation measures at a later time. Installing the brush mattress does not significantly disturb fish spawning habitat and once installed, the structure provides complex habitat for fish and other aquatic species.



Cedar stakes driven into the creek bank provide additional soil retention.



The added vegetation to the creek provides habitat and cover for fish.

"The reason that we are allowed to do this work is that Washington State Fish and Wildlife considers it an enhancement to the stream," said Geiger. "It simulates a heavily vegetated stream bank. Fish just love it. We've actually seen fish using it as we are installing it. They get right in there and use it for cover and so forth. It was pretty surprising."

The average longevity for brush mattresses is yet to be determined. Even though the Kitsap County Conservation District originally installed these structures as a temporary measure, many of the original structures installed over four years ago are still functioning today. The key to the brush mattress' long term success is to plant through the stakes with vegetation.

Characteristic of bioengineering techniques that work with nature, the brush mattress will completely biodegrade and integrate into its surroundings. The planted vegetation strengthens the bank's soils after the mattress decomposes and provides the root system and brush necessary for future stabilization. Root mass, soil strengthening properties, hydraulic drag, and compatibility with the natural environment are all characteristics to consider when choosing vegetation to incorporate into a brush mattress installation.

"If you need to do something right away and you don't want to be facing a heavy mitigation requirement after the project is installed, then this is a good technique," said Geiger. "This is a very easy armor to install, and in short order you can have an area protected."

Everson Overflow: Keeping Floodwaters in Check on the Nooksack River



One of the scour holes being stabilized by the Overflow project. Woody debris has begun to collect and will be incorporated into the riverbank.

The Everson Overflow, located outside the town of Everson in Whatcom County, Washington, has wide-reaching affects during high water events. The overflow is a high ground divide situated between the Nooksack River Basin and the Fraser River Basin. During significant flood events at this site, water tends to overtop the right bank of the Nooksack River and spill into the Everson Overflow. It can then surge into the Johnson Creek floodplain, flowing north, and ultimately reaching the Fraser River Basin in British Columbia, Canada. In the aftermath of one such occurrence in 1990, the Trans-Canada highway was closed for several days and millions of dollars of damage occurred. To address this trans-boundary flooding issue, an international taskforce assembled consisting of a number of agencies and technical experts from both Canada and the U.S.

Recently, several flood events occurred in Whatcom County that necessitated emergency management measures along the Everson Overflow. To forestall another disaster, the County, from 2003 to 2006, implemented four temporary rock riprap projects stabilizing two large scour holes within the project reach. In 2006, the County was permitted to construct a permanent bank stabilization design. In accordance with the Lower Nooksack River Flood Hazard Management Plan, which recommends protocols for flood management problems pertinent to the Everson Overflow, the County's objective was to sustain the Nooksack River's current bank elevations along the Everson Overflow.

“Our management approach now is to maintain the existing geometry,” said James Lee an engineer with Whatcom County's Public Works Department. “We do not want to increase or decrease water flow over the bank, we just want to make the banks as stable as possible. By lowering or raising this bank elevation you alter how much flow leaves the Nooksack River Basin and heads north, ultimately reaching the Fraser River Basin in British Columbia during a significant flood event. By maintaining the existing bank elevations we are not changing this dynamic, known as the Everson Overflow.”

Whatcom County's engineers designed a bank stabilization project with the intent of halting the chronic failure occurring along 1400 feet of the lower main stem Nooksack's right bank. The project was initially funded through the Whatcom Flood Control Zone District and the local Sumas-Nooksack-Everson River Subzone. Additional grant funding was later made available through the Federal Emergency Management Agency's (FEMA) public assistance program.

The project involved a combination of hard and soft armoring measures focused on halting further erosion of the scour holes, securing the embankment's toe, and stabilizing the slope. Providing for fish habitat was integral to both the design and the permitting process.

“The lower main stem Nooksack is an important river for a number of species,” said Lee. “It is a migratory reach for Chinook and coho salmon, as well as steelhead trout. Bull trout, which are listed under the



The timber piling structures capture woody debris, which provides roughness to the river, and ultimately establishes additional habitat.

Endangered Species Act (ESA), can also be using it anytime of year in their different life stages, and it is used by Pink salmon in odd number years.”

The county placed timber piling structures in the outside edge of the pools created by the two main scour holes. The decision to keep the two large scour holes along the embankment’s edge is a primary benefit for fish. The scallop-shaped holes interrupt the linearity of the bank, creating irregularities perfect for fish habitat.

“The fisheries biologists don’t want to see a straight smooth bank,” said Lee. “Those irregularities are areas of slack-water back currents where the fish can go to get out of the main current.”

The piling structures further enhance the habitat complexity which shelters the fish and stabilizes the river channel during large flows. In addition, the pilings recruit debris flowing through the channel during high water events.

“In terms of the bank stabilization project, the timber pilings are a stand-alone component,” said Lee. “This means that if some of the timber piling structures are damaged, the integrity of the entire bank stabilization design is not compromised. At the same time, there are bank stability benefits provided by these structures. They provide an incredible amount of roughness along the portions of the riverbank where they are located. This slows the water along the bank behind them, promoting deposition and the establishment of vegetation, which helps to further stabilize these areas.”

Along the linear portions of the embankment, the county laid large limestone rock up to the ordinary high water mark. Seventy-five pieces of large woody debris were then placed along the project length with



Coir fabric covers the upper bank.

their root wads facing outward toward the flow. The debris provides asymmetry to the otherwise straight-edged sections of the channel, and the root wads create scour that diverts energy away from the toe, thus decreasing the likelihood that the rock toe will fail.

The County reconstructed the slope of the upper bank with coir fabric, soil lifts, and live willow cuttings.

“The fisheries biologists don’t want to see a straight smooth bank. Those irregularities are areas of slack water back currents where the fish can go to get out of the main current.” - James Lee

“Using three-quarter-inch plywood that was eight feet long and 12 inches high, we built forms to aid in the construction of over a couple miles of soil lifts,” said Lee. “Basically, we laid down the coir fabric, planted the willow cuttings, and placed the dirt. The wooden form provided something for the dirt to push up against as you ran over it with the walk-behind compactor. Otherwise, if you just simply had coir fabric holding back the soil when you put the compactor on it, the fabric would bulge out and likely rupture. The forms allowed us to build the soil lifts in a uniform manner. As the crews got proficient, we started to make excellent production numbers per day. It really worked well.”

Because the coir fabric eventually decays, the live stakes are the source of long-term stability for the slope. For the Everson Overflow project, the Whatcom County Public Works Department planted 10,000 thriving willow cuttings. In addition, a twenty-foot wide buffer was designated along the top length of the project. The buffer is planted with a mix of native tree species such as cedar, fir and alder, providing a great improvement to this section of the bank which had previously been overgrown with an invasive, non-native blackberry species.

“Engineers would be well-served to come out and look at some of these projects,” said Lee. “I’ve stood out here at flood flows and seen the ferocity of the flows and the amount of water and the debris that comes down the system. When the water recedes and you see that the project has held up well, it is solid evidence that these techniques can work if designed and built properly. People need to keep their minds open. It does what we need from the flood hazard perspective, but it also goes further to benefit the salmon recovery effort.”

Hiddendale: Combining Wood and Rock to Protect Property

In Quilcene, Washington, the small community of Hiddendale sits beside the Big Quilcene River. Development of Hiddendale began in the 1960s, and to protect the houses under construction, the developer built a dike several hundred yards long using material from the river. Immediately, problems began when flooding occurred because the material used to create the dike was not strong enough to form an effective barrier against rising water. Within a short time, the dike had begun to erode.

In 1996, engineers from Agua Tierra Environmental Engineering were looking for an area to conduct a riparian demonstration project utilizing bio-engineering. The community of Hiddendale was chosen, as the dike had reached a critical point of potential failure. Portions of it had actually disappeared due to chronic erosion from periodic high water on the Big Quilcene, and several homes were threatened.

“The first step was to pull the dike back about 40 feet and make a little more room for the river to occupy,” said Al Latham, District Manager for the Jefferson County Conservation District. “They then installed three rock groins into the river along a 200-foot section of the Hiddendale riverbank, the outer edges of which were approximately at the edge of the prior levee’s location. Then the entire area was heavily planted with willows and other vegetation.”



Downed trees claimed by the Forest Service provide the skeleton for the rock groin structure.

The rock groins were carefully designed with several considerations in mind. Calculations were taken into account for such factors as the river’s width, water flow during average and flood stages, as well as impact of the structures to the overall area.

The first step in installing the groins involved temporarily blocking the river from entering the construction site. Since the project was undertaken while the river was at a seasonally reduced level, only a small area had to be coffered off with sandbags. Once the construction site was secured, three trenches extending 25 feet back into the bank were dug, and tapered down into the river channel. Multi-sized rocks similar to that used in riprap design were then carefully layered into the trenches.



Planted willows, dogwoods, conifers and other trees will create a mat of roots to help stabilize the riverbank.



Al Latham stands on top of one the groins extended into the river.

The National Forest Service donated almost forty 25 to 30-foot long logs, several with root wads still attached, which the Forest Service retrieved from areas of blow-down during previous storms. The logs were laid within the trenches, several logs to a trench, with the root wads sticking out into the river. To lock the structures in place, the logs were integrated with the rocks. Additional rocks were then piled on top of the logs, giving the structures strength and stability.

Hundreds of branch cuttings from several different species of local trees were laid within the trenches before they were filled in with the final layer of rocks, and then topped with soil. The intertwining of the various root systems provided by the cuttings as they grow plays an integral part in the success of the project.

“We planted a lot of willow in there,” said Latham. “Along with red ochre dogwood, alder, some conifers, as well as Douglas firs and cedars. By the time the logs decay, which is a long way off, there will be such a mat of roots from the vegetation that it’s going to make the banks really stable.”

By the time the logs decay, which is a long way off, there will be such a mat of roots from the vegetation that it’s going to make the banks really stable.”

- Al Latham

The Big Quilcene River serves as migration reach and spawning ground for several species of fish, including coho, Chinook and King salmon, as well as steelhead and cutthroat trout. Prior to the setback of the dike and the introduction of the rock groins to the river, the channel was essentially a straight passage with a minimal amount of woody debris, offering limited

habitat diversity for migrating fish. With the rock groins installed, root wads extended into the river and the vegetation established throughout the area, the habitat provided for the fish is far more extensive than ever before.

The Hiddendale bank stabilization project was funded through a \$50,000 grant from Washington State’s Flood Control Assistance Account Program, which provides money for a number of different flood control activities throughout the state. Additional assistance was made available by the Department of Natural Resource’s Jobs for the Environment program, which provides funding to hire displaced logging professionals to perform restoration activities.

Since the introduction of the rock groins to the Hiddendale area 13 years ago, the Big Quilcene River has been subjected to several high water flood events. According to Latham, the groins have withstood the floods, sustaining no damage and no significant impact to their stability. They have also provided invaluable protection for migrating fish and, best of all, the properties once threatened by the river have remained completely safe.

“The typical approach before we did this would have been to line the banks with riprap, using the same size material we used in the groins,” said Latham. “The thing is, when you go that way, currents accelerate along riprap, and you’re just sending the problem downstream. You don’t get any improved habitat or channel diversity. It’s just a rock wall. With these three small groins, it didn’t establish a big footprint, but it’s really kept the thalweg, or the main part of the river, well out beyond the bank, preventing any further erosion. It also created all this habitat in between each groin. Now the bank has been stabilized as well or better than riprap ever could do it.”



In the background stands one of the Hiddendale properties protected by the project.

Old Tarboo Road Bridge: New Bridge Design Eliminates Flooding

Old Tarboo Road in Jefferson County, Washington crosses Tarboo Creek, which is a small, steady stream running from its spring-fed headwaters in the hills east of the Olympic Mountains down to Tarboo Bay. The stream is used for migration and spawning by coho and fall chum salmon, as well as steelhead, sea run and resident cutthroat trout. Juvenile summer chum salmon and Chinook salmon rear in the estuary of Tarboo-Dabob Bay about two miles downstream. Three of these species; steelhead trout, summer chum and Chinook salmon are listed as threatened under the Endangered Species Act (ESA).

The county road was originally built in the 1890s, and numerous forms of crossings have been utilized over the years, including wooden bridges and various forms of culverts. In the 1970s, a six-foot wide, 40-foot long culvert was installed under the road. During especially high water events, such as the flood of 1996, water would back up and overtop the creek banks and cover the road. Directly downstream of the culvert, the creek flowed into a straight ditch approximately eight-feet deep with steep banks. Over the years, this led to problems of bank erosion and flooding as well as impeding travel of some of the weaker species of fish that could not traverse the culvert.

“There was riprap on either end of the culvert, as well as some downstream where the channel had eroded the banks,” said Peter Bahls, an aquatic ecologist, fish biologist and Director of the Northwest Water-

shed Institute. “When a large amount of water goes through a culvert, it acts as a fire hose, and it can cause a lot of impacts further downstream as well.”

In 2004 the Northwest Watershed Institute, in partnership with Jefferson County, pulled the culvert from under the road and built a bridge over Old Tarboo Creek. Removing the culvert opened up passage for the creek, significantly reducing the threat of ongoing erosion while also reestablishing a migration route for fish that had been cut-off from traditional spawning waters for over 20 years. An added benefit of the project was the reconnection of the creek to the local floodplain.

During construction of the bridge, the designers took the opportunity to lower the gradient of the creek, reducing it to less than one-half a percent under the bridge for a length of approximately 100 feet. This had the effect of slowing water flow throughout the reach, further reducing erosion and making it easier for migrating fish to traverse.

“When a large amount of water goes through a culvert, it acts as a fire hose, and it can cause a lot of impacts further downstream as well.” -Peter Bahls



Wood positioned downstream of the bridge slows water flow and provides habitat for fish and other wildlife.



Coir matting and planted vegetation stabilize the creek banks under the bridge.

The bridge was installed with the use of concrete pilings driven approximately 20 feet into the ground, removing the threat of instability due to possible undercutting. Though the channel width was only 13 feet at its maximum, they designed the bridge to span over 40 feet in length.



The extra wide design of the bridge ensures adequate room for water flow during flood conditions.

“The main mistake in bridge construction, and the reason you often have problems with bridges and flooding is because the span is not long enough,” said Bahls. “They don’t leave enough room for flood and scour flow. We made sure our bridge was long enough to handle the flow spreading out under the bridge, without causing scour along the banks.”

Bahls also stated that, as a rough rule of thumb, the width of the floodplain under the bridge (including the stream channel,) should be at least twice the bankfull channel width of the stream from bank to bank. At the Old Tarboo Bridge, the bankfull channel is approximately 12 feet wide and the total floodplain width was designed to be approximately 20 feet. With the addition of sloping banks up to the bridge this required a 40-foot long bridge.

A floodplain bench was built under the bridge on each side of the creek and extending 30 feet up and downstream, starting with large, rounded river rock laid in a single row along each stream bank. Soil was then infilled behind the rock for the floodplain bench. The rock was laid atop a layer of heavy coir fabric which was then pulled over the rock, wrapping around it and securing it to the bank. The coir creates a layer of strengthening material to hold the bank together and prevent further erosion.

“The rock is holding down the coir, and providing stabilization from below,” said Bahls. “And now you

can’t even see the rock because the floodplain is actually acting the way it’s supposed to, and has started to accumulate sediment.”

Another portion of the bank stabilization and habitat complexity involved the addition of wood in the creek immediately past the bridge, as well as further downstream. The wood establishes important habitat for fish traversing the stream, and causes flow to slow down considerably during periods of high water, further adding to the protection against erosion.

“All the wood is put in naturally, with natural log placements,” said Bahls. “Along with specifically placing it, we bury the wood from one-half to two-thirds of its length into the banks. A lot of the wood that is seen in this area is actually buried way back into the earth. We use different sizes, different types of wood and different positioning to secure the logs.”

Planting of native vegetation also comprises an important part of the bank stabilization, as active and healthy root systems lend strength to the creek banks.

“We’re starting to get some alder and willow growth in the riparian area,” said Bahls. “This will get more shaded as the trees grow in, and we’re hoping that they’ll take over and shade out some of the non-native, invasive species of vegetation that often move into any new restoration site.”

Interestingly, the land around Old Tarboo Road had been purchased for conservation use by famed ecologist Aldo Leopold’s granddaughter, Susan, and her husband, Scott Freeman. According to Bahls, the Freemans worked with Jefferson County vigorously to reestablish the area ecologically.



Many of the logs are actually buried in the banks.

“They’ve been great, active participants in the restoration,” said Bahls. “They do a lot of the planting and cutting back of invasive plants, and they’ve worked with us the entire time of the project.”

The entire area is now covered by a conservation easement held by the Jefferson Land Trust, which protects the land from any form of development or use other than as an ecological preserve.

In addition to funding from Jefferson County and the Northwest Watershed Institute, money for the project was also provided by the National Fish & Wildlife Foundation, the National Oceanic and Atmospheric Administration (NOAA) and the Community-based Restoration Program. The cost of the installation of the bridge totaled approximately \$150,000, while the downstream re-meander came to an additional \$100,000, bringing the total cost of the Old Tar-boo Road Bridge and stream restoration project to \$250,000.

When speaking about the advantages of utilizing more naturalistic techniques than riprap and hard armoring, Bahls was definitive in his preference.

“It can be done,” he said. “If you design the bridge right, holistically in context of the stream reach, get the gradient of the stream correct, and make the

bridge span long enough, you don’t need to worry about slapping a bunch of riprap on. In fact, riprap is counter-productive because not only does it not protect the banks over a long period, but it will ultimately fall into the creek and cause problems behind it. The riprap also constricts your channel, so you end up with less floodway under the bridge for the water to flow through. If you can take pressure off your banks by leaving more floodway and reducing the gradient under the bridge a little, adding wood downstream and stabilizing the banks with planting, that’s better for your stream in the long run. We’ve had some major floods here in the past three years, and because of this design, we’ve had no bank erosion near the bridge, and the flood flows have stayed safely under the bridge instead of flowing over the road.”



Peter Bahls, director of the Northwest Watershed Institute.



The entire area is protected as an ecological preserve.

Black Lake Drainage Ditch: Live Crib Wall Increases Options for City of Olympia

In 2004, Craig Tosomeen, an engineer with the City of Olympia, faced the challenge of stabilizing eroding stream embankments on Percival Creek at the Black Lake Drainage Ditch on RW Johnson Drive. The culvert running under the road was rated as the number one fish barrier in Thurston County. A four-foot drop in stream grade prevented Endangered Species Act (ESA) listed fish, such as Chinook and coho salmon, as well as other protected species like cutthroat trout, from migrating through the ditch. The decision was made to replace the original culvert with a bottomless arch culvert similar to a bridge. Tosomeen was tasked with designing a fish-friendly plan for controlling erosion on the vertical earthen bank, both up and downstream of the removed culvert.

Black Lake Drainage Ditch is a human-made channel characterized by steep embankments and high stream velocities. Because of this, the option of setting the bank back to lower the slope gradient was not available. To meet the recommended 2:1 to 3:1 ratio for bank setback, the 20-foot vertical embankment on RW Johnson Drive would have to be



Craig Tosomeen beside the Black Lake Drainage Ditch.

moved back 40 to 60 feet. Not only would this action have caused difficult “right of way” issues, but it would have also required the removal of a large stand of Douglas fir trees.

“There was no point making the culvert for fish passage if that habitat doesn’t remain,” Tosomeen commented.

Preserving the riparian shading provided by the Douglas firs benefited fish habitat, and was key to facilitating fish passage.

Tosomeen considered several techniques to halt embankment erosion, including sheet pile weirs, a concrete wall, and a live crib wall. Experience, however, had taught Tosomeen that streams can erode concrete structures.

“I’ve seen a lot of concrete-lined ditch failures,” said Tosomeen. “Once the water starts to get underneath the structure, concrete has nothing it can do but break and become a further obstruction, diverting more water into where it shouldn’t be going.”

Unlike the other options considered, live crib walls meet Washington State Department of Fish and Wildlife’s fish habitat criteria. They also provide structural support to sheer embankments, and with maturation they ecologically integrate into their surroundings. Live crib walls are constructed with interlocking, untreated logs and live stems. The logs are anchored into the slope, forming the wall, and vegetation is initially used to tie the logs together.



Long-term stability to the slope is further developed with the vegetation's root growth. With time, the logs naturally degrade and the vegetation becomes the structure itself.

Dogwood and willows were the primary types of vegetation used in the wall design. Willows are hardy and thrive well in harsh, wet environments. Traditional live crib walls are built as gravity mass walls, but because of the embankment's 20-foot height, Tosomeen designed this structure as a retaining wall. Steel anchors bolt the log wall into the vertical embankment and provide security to the wall until the vegetation is established. In addition, the most critical point at the bottom of the live crib wall is secured with a solid riprap toe. To remedy the stream's four-foot drop in grade log weirs were placed in 6-inch increments over the project length.

Overexposure to sunlight can inhibit the establishment of a live crib wall. The vegetation needs plenty of shading to thrive. To ensure that the crib wall does not dry out, it is also important to choose appropriate backfill.

"If you pick too granular of a soil, the wall dries out and the stakes die," said Tosomeen. "Sun exposure is critical. You might have to consider watering if you have a lot of sun exposure and/or you use very granular backfill. One section of our wall got a lot of

"Once the water starts to get underneath the structure, concrete has nothing it can do but break and become a further obstruction, diverting more water into where it shouldn't be going."

-Craig Tosomeen



The restructured channel is now far easier for fish to traverse during migration.



The crib wall will overgrow with vegetation, which will ultimately become the structure itself when the logs finally decay.

sun exposure. It took a lot longer to establish than the section that was shaded by the big trees and not facing direct sunlight. That section had perfect establishment straight away."

The success of the project has been far-reaching. The live crib wall has stabilized the sheer embankments both up and downstream of the removed culvert. Over a mile of previously blocked fish passage leading into Black Lake, (the largest lake in the Olympia area,) is now accessible to fish. In addition, the site and adjacent walking trails have become a community gathering place. The City of Olympia has taken advantage of this educational environment and incorporated other ecologically friendly structures. Porous concrete, which allows rain water to absorb directly into the earth and improves water quality of streams by reducing storm water runoff, has been used to create bicycle lanes and sidewalks in the grounds surrounding the site.

Structural revetments require periodic inspections to ensure that they are working. A live crib wall engineered with nature becomes part of the natural processes and does not demand the same amount of maintenance. For erosion to destroy a live crib wall, water must undermine the entire structure. As the live crib wall develops, it becomes a natural part of the riparian corridor.

"The ability for nature to heal itself, to take up the long term maintenance for us is huge," said Tosomeen. "You know if the design isn't perfect, nature will tell you. It is very unforgiving, so to be able to make up for that with a structure that can be forgiving and can accommodate and grow and adapt to the changing environmental conditions is really the only way to go."

Little Washougal Creek: Woody Debris Catcher Prevents Erosion and Protects Bridge

The Lower Columbia Fish Enhancement Group (LCFEG) is a nonprofit organization that receives funding for stream restoration projects from the Washington State Recreation and Conservation Office Salmon Recovery Board. The LCFEG works closely with local communities on habitat restoration within Lower Columbia's watersheds. When a local landowner on the Little Washougal Creek in Clark County sought counsel from the LCFEG about a land erosion problem, a collaborative opportunity arose.

In October 2003, the Little Washougal began encroaching upon a bridge that provided access to six properties. Erosion along the approach to the bridge endangered residents' access to their homes. Riprap, which was placed upstream of the bridge in the aftermath of a large flood event in 1996, accelerated the erosion threatening the bridge. To amend the problem, the LCFEG designed and installed a woody debris catcher. The bank stabilization structure successfully diverted the Little Washougal Creek away from the bridge, preventing further embankment erosion along the bridge's approach and mitigating future damage to the bridge.

The success of a woody debris catcher largely depends

on how it is anchored and how the surrounding embankment is vegetated. At this particular site, the work crew laced, and then bolted, a large number of logs together. At points where two logs crossed, steel bolts were drilled into the wood, and the upper layers of logs were then bolted to a log frame which was buried in the ground.

Debris catchers are a practical choice in hydraulic systems that carry a large abundance of wood.

"A rock-based design is inappropriate for river systems in Western Washington that transport large amounts of woody debris," said Tony Meyer, Executive Director for the LCFEG. "Often, as debris comes downstream it will hit the stacked rocks, knocking them off, and destroying the shape of the vane."

Re-vegetation is the key to the longevity of any woody debris project aimed at bank stabilization. Ultimately, as the wood decays, the vegetative root system replaces its function by providing cohesion to the stream bank. To ensure the success of the vegetation stage of their projects, the LCFEG follows the protocols of Jeff Whittler, an Environmental Services Manager with Clark County Public Utilities District.



The porous design of the debris catcher allows fish to swim through the structure unimpeded.



Steel bolts lock the log frames together providing stability and strength to the structure.

“Whittler’s goal is to close the canopy within three years,” Meyer commented. “To close the canopy you have to have your spacing very close together, but once the sunlight is taken out from the ground, nothing else can grow. The key is to go in there, maximize the native species, and wipe out the nonnative species. Give those native species time to get up and close the canopy.”

In addition to providing bank stability, the woody debris catcher impedes erosion by slowing down the creek-water’s velocity. This is accomplished by reconnecting the watercourse to its adjacent flood plain. During the first major flood event, as a result of the debris catcher’s installation, the river was redirected onto the opposite side of a gravel point bar, giving the Little Washougal access to side channels that had previously dried up.

“Because the structure is porous, water is able to flow underneath it, maximizing the ability for fish and aquatic organisms to live inside the structure itself and be secure from predation.” - Tony Meyer

Essentially, this watercourse shift reduced the power of the stream by taking it out of a confined environment and allowing it to spread out among many smaller courses.

“As soon as the river exceeds that bankfull height and spreads out into the flood plain, the excess water has no velocity, so it doesn’t harm anything,” said Meyer. “When the river moved onto the other side of the gravel bar, it increased the interval in which it will go out into the flood plain and take the energy out of the system.”

Creating access for the Little Washougal to disperse into side channels has demonstrated the benefits of the bioengineered debris catcher to landowners. The river is no longer threatening the bridge and the access to the landowner’s property is protected. During periods of high water, the river flows into side channels and the concentrated destructive energy of the system is dissipated. This increase in off-channel area has created fish-rearing habitat. The nutrients deposited during high flows have stimulated the growth of plants and aquatic organisms.

The woody debris catcher also enhances fish habitat by providing shelter. As the debris catcher recruits wood from mature trees, complex habitat for fish and other aquatic organisms develops. In fact, the catcher provides ecological benefits that exceed State permitting requirements. The significance of this is that the Little Washougal provides spawning habitat for winter steelhead trout, coho and Chinook salmon, which are all listed under the Endangered Species Act (ESA).

“A woody debris catcher is a very porous structure,” explained Meyer. “When the current runs into the structure, its debris load gets trapped. Because the structure is porous, water is able to flow underneath it, maximizing the ability for fish and aquatic organisms to live inside the structure itself and be secure from predation.”

In November 2006, the biggest flood in the area’s recent history hit the Little Washougal and the site was subjected to severe high water conditions. Throughout the event, the woody debris catcher remained stable, and no damage was experienced at the site. The watercourse continued to flow on the opposite side of the gravel point bar away from the approach to the bridge. As a result, residents were able to easily cross the bridge and access their homes.



Tony Meyer, executive director for the Lower Columbia Fish Enhancement Group.

Schneider Creek: Adding Wood to Water Wins Over Rock



Wood added to the banks of Schneider Creek slows water flow and improves habitat diversity.

On Schneider Creek in Thurston County, Washington, landowner Sonny Bridges' property has been threatened with increasing erosion. Since buying the property several years ago, Mr. Bridges watched his land steadily erode at a rate of approximately 5 feet per year. In total, an estimated 2000-square feet of the Bridges' property has been lost along the banks of the creek.

Growing concerned with the constant loss of his property, Mr. Bridges contacted the South Puget Sound Salmon Enhancement Group for assistance. Schneider Creek serves as a migratory channel for at least five species of fish, including chum, Chinook and coho salmon, as well as steelhead and cutthroat trout, which made the problem and its solution very pertinent to the Salmon Enhancement Group.

"This is a very significant salmon spawning stream," said Mike Kuttel Jr., a Habitat Specialist for the Thurston Conservation District. "It flows into Totten Inlet, near the mouth of Kennedy Creek, which is one of the biggest chum salmon spawning streams in the area. Also, both the Chinook salmon and steelhead trout are listed under the Endangered Species Act (ESA), making their protection critical."

The Salmon Enhancement Group partnered with the Thurston Conservation District to initiate a project to

halt the erosion of the Bridges' property, while creating habitat for migrating fish. Mr. Bridges did not want this to be done through the use of hard armoring, and requested that the project remain as true to natural processes as possible.

Anchor Environmental, LLC was the company contracted by the Salmon Enhancement Group to design the project. Pat Powers, the engineer for Anchor, implemented two of the recommended techniques from Washington State's Integrated Streambank Protection



Mike Kuttel surveys the successfully completed project on the Bridges' property.

Guidelines to stabilize the Bridges' creek bank. The project was approached almost as a case study, with both techniques being examined for their feasibility.

On the upper portion of the creek, they installed several engineered woody debris logjams. Anchored to the creek bank, the jams are extended into the water, creating roughness elements which reduce Schneider Creek's flow speeds along this reach. The reduced water flow eases the pressure on impacted banks, significantly cutting down on erosion and protecting the Bridges' property.

"They use a vertical log that's sharpened like a pencil," said Kuttel. "They load the logs up and jackstraw them together. Then they take the sharpened log and drive it down into the bank through the middle of the other logs, pinning them all in place. Then they further secure the entire structure with rebar. It all worked very well."

In addition to preserving the bank integrity throughout the impacted area, the logjams also provide habitat for migrating fish. The introduction of the wood into the creek creates many areas for the fish to hide in and rest, as well as giving them protection from fast-moving floodwaters.

The second portion of the project involved the introduction of rock cobbling to the lower portion of the creek on the Bridges' property, which was intended to reduce the velocity of the water, while covering the



The logjams are extended into the water providing needed roughness.

unprotected sediment that had been exposed by the constant erosion. Unfortunately, during the flooding of November 2006, the cobble was blown out by high, fast water, which continued the threat of further erosion.

To address the problem, instead of replacing the destroyed cobble with additional rock, it was decided to add several new logjams to the creek. In subsequent flood events, (specifically the high water of December 2007,) the logjams were completely successful and held the banks in place, while protecting migrating fish by slowing down the water flow throughout the stream.

"It's ultimately better that they switched to using all wood for this project," said Kuttel. "The logjams stabilize the toe of the bank and improve the in-stream habitat. There used to be just a vertical bank with no shade and no place for the fish to hide. Historically, armoring eroding banks with riprap (angular basalt rock) was the method-of-choice to stop bank erosion. Unfortunately, the rock gathers heat, reflecting it out into the water, which is really bad for the fish. Not to mention, there's no habitat diversity when you do it that way. The logjams used on this project provide habitat diversity and give fish many places to hide."

In addition to the introduction of logjams to Schneider Creek, the project design also called for a widespread series of plantings. Willow cuttings positioned throughout the bank area are taking root, and once grown to significant size, the root structures will lend the bank further strength and stability. The intent is to recreate a riparian zone along the bank, which has virtually ceased to exist due to the constant erosion.

Though it takes years for the plantings to grow, the designers prefer to use smaller willow cuttings, approximately 24-inches in height, to start. Once the



The entire bank is covered with willow cuttings for root strength.

willow tree roots have taken hold and begun to reinforce the strength of the bank, they will go back to the site to perform additional rooted plantings with conifer trees and other larger species to further the strengthening process.

“I know that some people like to go in right away and use the really big ball and burlap plants,” said Kuttel. “The problem is they’re so expensive in terms of transportation and equipment to get them in the ground. A lot of the time they can die because of the transplant shock. You can plant a lot of small trees and keep them in good shape for the same cost of one big tree. It may take longer for the small trees to grow and do what you need them to, but if that one big, expensive tree dies, you’re basically out of all that money.”

The Schneider Creek bank stabilization was funded by a grant of \$20,000 provided by the National Fish & Wildlife Foundation. The wood for the logjams was provided by the contractor who performed the installations at no additional cost, and from donations by the Washington Department of Transportation, which considerably reduced the total cost of the project.

“The whole site is a lot more ecologically functional for fish and wildlife habitat now, not to mention the banks being protected” said Kuttel. “When you use plant materials, it actually slows the water down. When you armor a bank, it is protected from erosion, but the energy is often redirected to the opposite bank downstream, causing damage to someone else’s property. Then the next landowner has to do it, and then the next, just to protect their property. When you use something like willow cuttings, the water just lays them down and the energy is dissipated instead of tearing the banks all apart.”



The logs in the jams are secured to each other with rebar.

“When you armor a bank, it is protected from erosion, but often times the energy is redirected to the opposite bank downstream, causing damage to someone else’s property.” - Mike Kuttel Jr.



Conclusion

As the stories in this booklet illustrate, there are numerous options when it comes to the complex issues of riverbank stabilization. These examples merely scratch the surface, highlighting only some of the basic alternative measures successfully used. As technology advances, and our knowledge of the effects we have on our environment increases, it is inevitable that even more of these techniques will be discovered and improved upon and that the traditional approach of riprap or hard armoring a bank will no longer be the norm.

We tend to leave a large footprint in our interactions with our environment. As we manipulate and attempt to control the water we so love and depend upon, we need to look at the long-term effects we have on our immediate surroundings. Finding methods of restricting riverbank erosion while allowing natural processes to function normally is just one important step in achieving equilibrium with our environment and investing smartly for our future.

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Hamakami Strawberry Farm

Andrew Levesque
Engineer
River & Floodplain Unit
King County, Washington

Riverview Road

Jeff Jones
Engineering Geologist
Public Works Department
Snohomish County, Washington

Dave Lucas

River Engineer
Public Works Department
Snohomish County, Washington

Eatonville Logjams

Jose Carrasquero
Principal Scientist, Coastal and Fluvial
Habitat Biologist & Project Manager
Herrera Environmental Consultants
King County, Washington

Ian Mostrenko, P.E.

Senior Civil & Environmental Engineer
Herrera Environmental Consultants
King County, Washington

Burley Creek Brush Mattress

Richard Geiger
District Engineer
Mason County Conservation District
Mason County, Washington

Everson Overflow

James E. Lee, P.E.
River & Flood Engineer
Surface Water Division
Whatcom County, Washington

Hiddendale

Al Latham
District Manager
Jefferson County Conservation District
Jefferson County, Washington

Old Tarboo Road Bridge

Peter Bahls
Director, Aquatic Engineer & Fish Biologist
Northwest Watershed Institute
Jefferson County, Washington

Black Lake Drainage Ditch

Craig S. Tosomeen, P.E.
Project Engineer
City of Olympia Public Works Department
Thurston County, Washington

Little Washougal Creek

Tony Meyer
Executive Director
Lower Columbia Fish Enhancement Group
Clark County, Washington

Schneider Creek

Mike Kuttel
Habitat Specialist
Thurston County Conversation District
Thurston County, Washington

Project Manager

Mark Eberlein, Regional Environmental Officer
Federal Emergency Management, Region 10
130-228th Street SW, Bothell, WA 98021
Phone Number: (425) 487-4735
Email: mark.eberlein@dhs.gov

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