The Engineer and the Fisherman – Peter Craig

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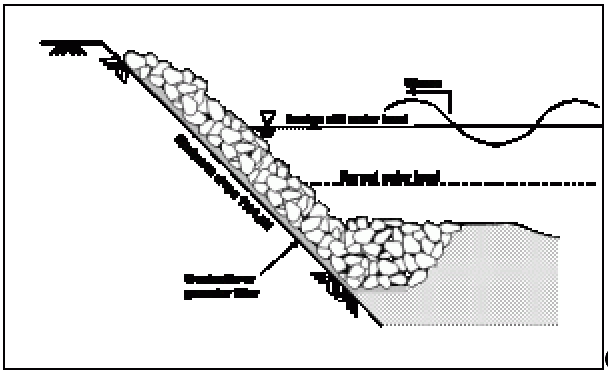
Engineering and fishing have a lot in common. The engineer and the fisherman must both understand the setting they are working in. They must both recognize and anticipate the natural properties and behaviors of the water and land. They must both work not with a strict formula, but with a goal in mind, adjusting their approach as conditions change.

As a civil engineer I've had the opportunity to work on several riverfront projects in the Portland area, and as a fly fisherman the good fortune to explore the western US's many rivers. Through these experiences, I have come to realize there is a large gap between how fish and I see and use our rivers. Even after fluid dynamics, hydraulics and hydrology classes, my ability to find the fish's favorite seam between protection from the current and a steady stream of food is crude at best. I have spent hundreds of hours standing in the river, watching the bank, but my trust of nature's methods in protecting land from water is still given only with hesitation.

The former is a fact of experience and there is probably little that can be done about it. The latter, though, hints at a basic conflict between nature and engineering – at least traditional engineering – in the area of bank stabilization. In short, nature doesn't stabilize banks, but instead leaves banks to stabilize themselves. Nature's system is based on balance. If that balance is maintained, the bank is "stable". If a characteristic of the river changes and upsets that balance, the bank changes, too. This is why river banks move from year to year and season to season as river levels go up and down; it is a natural and beneficial part of the river ecosystem.


Cross section of a typical riprap slope (source: FHWA)

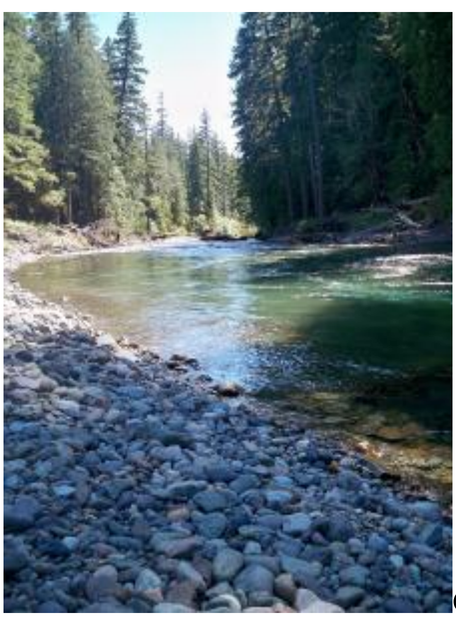
But engineers usually prefer to have more control than this system allows. Or, maybe better put, property owners prefer that the river stays where it is if they are going to invest in site development, and they hire engineers to make sure this happens. This is traditionally done by “armoring” the bank with a layer of rocks that are sized to be big enough that the river can’t move them, even during extreme flood conditions. Sizing these rocks involves analyzing the flow, forces and movements of the river in both its present and future forms.

The issue gets more complicated when you imagine multiple sites being developed along the same stretch of river over a period of time. Armored banks channelize stream flow, increasing the speed of the water flowing through the river and pushing erosion and bank stability problems downstream. Seeking balance, the river starts to move and downstream property owners are forced to either armor their banks or watch their land wash away. As more armor is added to the bank, there are more impacts to segments that are not armored and the cycle continues.

So, traditionally, engineers have had little choice but to armor up in response to upstream changes and imbalances, especially in urban environments. This is an unwelcome trend for fish and fishermen alike. Varying, vegetated bank lines provide fish traveling on the river with much needed feeding and resting ground. Channelization and armoring put pressure on resident fish like trout, making their survival more difficult, and create a sort of gauntlet for migratory fish like salmon and steelhead, decreasing their chance of ever reaching spawning ground.

Fish aren't alone in their dependency on natural river banks either. While the conditions necessary for them to thrive are a good baseline for other species, the net casts much wider. Osprey, hawks and eagles need a plentiful supply of fish near their nesting sites. Otter, beaver and other small river mammals need lush bank habitat. Even the plants that the ecosystem turns on need other vegetation to protect them while they take root and begin growing.

Recognizing these many needs, the current thrust in river bank design is toward naturalization – using nature's own systems to protect the bank. This bio-engineered approach has seen great success in many settings, creating extensive environmental benefits and decreasing downstream impacts. As with low impact development, bio-engineering techniques hold much promise. It is important to note, though, that they carry uncertainties and complications that more traditional methods do not.


Cowlitz River in Washington's Giford Pinchot National Forest

In a balanced system, all players do their part to maintain equilibrium. Conditions may change and the river may go through a period of instability, but it will eventually find a new balance point. But, after decades or more of channelization and armoring, many developed river stretches are far from balanced and are more inclined to wash out to sea with the first chance they get than to immediately establish any kind of natural order. The big picture planning in this type of environment can be as difficult to approach as the site specific engineering design.

Engineers like to use design elements that allow them to derive direct solutions to the problems posed on a site. Riprap bank protection is one example of this. The behavior of riprap slopes has been extensively studied and is well understood. For a given configuration, the engineer can determine expected damage that the slope will sustain in a particular storm, addressing site needs and defining and limiting the risk for everyone involved in the project. This is the definition of sound and responsible engineering.

Bio-engineered solutions present a challenge to this definition as there is less research to draw on and they often lead to more nuanced designs. Designs using these methods are developed empirically – instead of directly – by following available best practices and learning from failures that resulted from similar projects, and can require that the developer be willing to rework the bank in response to post-construction problems. Of course, uncertainty is usually a bad thing in this context as no one starts out with the goal of spending a large amount of money to create a failure that will inform future designs.

The challenges are even greater when a project attempts to naturalize a section of bank in a fully armored environment. Success or failure in such an instance can hang on characteristics like where the site is located with respect to movements along the river or what neighboring property owners are planning for their sites – issues that the project team doesn't have any control over. Blindly incorporating design elements without regard to these characteristics is irresponsible engineering and can lead to catastrophic problems. Similarly, though, disregarding bio-engineered solutions off hand forgoes ever starting the naturalization process and could lead to missing big opportunities.

The effort to transition from traditional to more naturalized bank designs highlights a clash between two responsibilities that all engineers share: a responsibility to the public to create safe, well founded designs and a responsibility to the profession to innovate and improve on traditional methods. Reconciling this conflict requires being realistic about what is possible, taking risks when appropriate and maintaining a consistent effort to change the paradigm. What does this mean in the context of bank design, then? How can we as a society and professions push process forward?

A rubble bank at Portland’s South Waterfront. The area has undergone a significant cleanup and restoration effort since this picture was taken.

As an example, consider Portland Harbor – the stretch of the Willamette River that runs through downtown Portland. An industrial area historically, the banks of many of the sites through the Harbor are protected by exposed concrete rubble from demolished buildings and roads. Planners and developers filled much of the Willamette’s flood plain with this rubble decades ago in an effort to create more developable land. As could be expected, the river has shaped the resulting bank over time into what is now a stable, but channelized and heavily armored system. Riprap placed to protect more recent development –

more or less an engineered equivalent to the rubble bank – has only reinforced this channelization.

Change in this system can only be made incrementally, with slow and steady progress made over a long period of time. The City of Portland has made a great effort in recent years to support, encourage and require the use of bio-engineered solutions on redeveloped waterfront sites. Since the protection offered by these solutions depends on where the site is along the river and what redevelopment is being planned on nearby properties, however, the results of pushing change through regulation can be mixed. Still, with few other options, it seems like there are two approaches within this system that combined could – and perhaps have started to – begin the process of naturalization.

First, there are almost always a few small changes that can be made to incorporate some level of bio-engineering into a site. Mixing bio-engineered and more traditional elements can result in a sort of stepping stone to the ultimate goal of a naturalized bank. Gradually, as sites are redeveloped again and again, these small changes will accumulate and result in noticeable progress. Of course, this process will take a long time. If every site in Portland Harbor were redeveloped every 20 years – they aren't, but just imagine – it could be sixty, eighty or a hundred years before the bank is naturalized. It took a long time for Portland Harbor to reach the state it is in and it is unrealistic to think that it will not take a long time to restore it to what it could be. That said, the process risks being abandoned if the community can't see meaningful changes within relatively short windows of time. Something must be done to accelerate this cycle.

Fortunately, just as a large variety of sites can support a few targeted solutions, a few targeted sites should be able to support a large variety of these measures. At least in theory, big changes could be made in short amounts of time by carefully identifying properties that require a lower level of protection, including sites that are in favorable locations along the river and those that support less critical development. Because of this promise, the temptation can be to focus on biting off these big chunks one at a time, but considering that the most attractive properties might be owned by people who can't or aren't inclined to redevelop in this way, the reality is that the slow and steady approach will likely have to be the backbone of the movement.

As with many other design issues surrounding the concept of increased sustainability, Portland and the Northwest in general are at the forefront of the issues surrounding river bank naturalization. Though some skepticism peaked through in this post, to me this is one of the most exciting areas of current engineering design. The problems posed by bio-engineering require careful attention to the fundamentals, in-depth analysis of past projects and the kind of creative problem solving that engineers savor. Along with the cascade of environmental benefits that could result, the fundamental issues presented in these more naturalized designs represent an opportunity to push the boundaries of our profession and make a lasting improvement for future engineers to build upon.


Restored low water habitat at Portland’s South Waterfront

This post is based on my experiences with riverbank design in Portland and exploring the rivers in the western US. How do they relate to your experience and and views on the subject?