Definition and Purpose

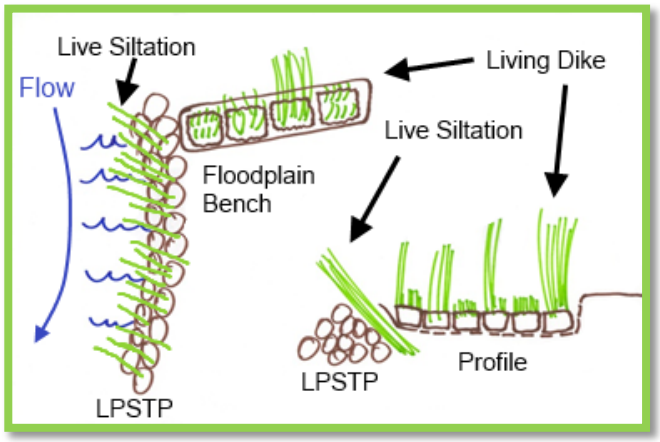

Figure 1: Profile and Plan views of Live Siltation and Living Dikes. Drawing by Dave Derrick

Bioengineering is the use of living plants to stabilize streambanks, wetlands, floodplains, and other near-stream areas. Bioengineering typically uses an assemblage of species to "jumpstart" what nature would do over time. It is essential in these disturbed areas to install dense rows of native plants parallel and perpendicular to flow to capture floating debris, increase roughness, and help shape the project's success by decreasing near-bank and overbank velocities. Several methods for incorporating native plants will quicken post-project recovery and enhance overall long-term project performance. Planting near streams not only protects a project's monetary investment, but enhances the ecological benefits. Rows of adventitious rooting poles (willow, dogwood, sycamore), in addition to rooted stock plants, can be installed perpendicular, parallel to, or in both directions to high flow. These "Living Dikes" create roughness, slow water and encourage nutrients, seed, and sediment to drop out, strengthening the project area.

Adventitious rooting plants, in which new plants can grow from an un-rooted cutting, are best harvested and planted when dormant (after the leaves have dropped and before the leaf buds appear in the spring).

Image 1: Vegetated Key on Ottawa River. Camp Miakonda, Sylvania, OH. Kyle Spicer

Bioengineering can be used to augment existing stone structures like Longitudinal Peaked Stone Toe Protection (LPSTP), Bendway Weirs (BW), and Keys. These structures can benefit from "Live Siltation" and "Vegetated Keys". Both of these methods differentiate themselves from Living Dikes by being integrated with the stone, yet provide similar benefits. A Vegetated Key is a row of native live poles planted deeply in the Key trench before the stone is installed, while Live Siltation is live poles placed on the bank side of the LPSTP before the area is backfilled, resulting in a parallel row of vegetation adjacent to, and hanging over the stream. All of the aforementioned methods for installing native vegetation result in improved performance for any restoration project, assist in stabilizing stone structures, bank and overbank soils, and creating roughness during high water.

Bioengineering Methods Sheet

Practice Applicability

Image 2: Live Siltation installed along an Engineered Rock Riffle and Keys. Camp Miakonda, Sylvania, OH. Kyle Spicer

Willows, dogwoods, Sycamore, and Cottonwood, in many areas of the USA, typically grow on the lower third of a stream bank, which makes utilizing them for bioengineering purposes ideal since their installation mimics their natural tendencies. If these live poles are planted deep in a trench, the poles will grow slightly further up the bank than would otherwise be found in nature. Other species of adventitious plants (River Birch, Ninebark, Brookside Alder) can be planted further up the bank. Combined with various species of rooted stock and container plants results in dense foliage and robust root systems that can hold the bank together until other slower growing species, or the seed bank establishes. Until then, these species provide shade, cover, vertical and horizontal structure, stabilize and/or lower water and air temperatures (microclimates), help maintain dissolved oxygen levels, and supply carbon to the stream. Essentially, installing these initial pioneer species plants helps to establish positive riparian buffer zone features while preparing a project for its long-term existence.

Willows and dogwood will not be long-term dominant species. They are short-term aggressors that will stabilize the bank quickly post-construction until other more slowly growing species can be established.

Image 1: Live Siltation installed over Longitudinal Peaked Stone Toe Protection at Camp Miakonda, Ottawa River. Kyle Spicer

Although Bioengineering is a broad category that includes the aforementioned specific examples for implementation, utilizing these methods has resulted in countless numbers of successfully grown plants in several restoration projects in the Maumee River Area of Concern (AOC). Ottawa River at Secor Dam Decommissioning Site, The University of Toledo sites, as well as the wetlands, floodplain, and surrounding upland habitat within Camp Miakonda have thousands of native plants installed. Hundreds of willow and dogwood were used as Living Dikes, Live Siltation, and Vegetated Keys. Other local restoration projects with these types of Bioengineering include Swan Creek at Highland Park, and Hill Ditch at The Toledo Botanical Gardens.

Methods Occasionally Combined with Bioengineering:

- Keys
- LPSTP and LFSTP
- Engineered Rocked Riffles
- Floodplain Benches
- Bendway Weirs and Single Stone Bendway Weirs

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Preparing for Bioengineering

The single most important feature of the described bioengineering practices is the use of the appropriate plant species. Take careful consideration of plant requirements (soil type, elevation above the stream, water table fluctuation, sun, shade, aspect, etc.), but specifically, what local plants would thrive in the environment they're needed to be installed in. Willow, dogwood, and several other species are adventitious rooting plants, meaning that a new plant can grow from an un-rooted cutting. These species require a lot of water, prefer a dynamic landscape (disturbance and stress are handled well) are fast growing, short lived (40-80 yrs), early pioneering species, and therefore will not become the long-term dominant climax community species that will remain for decades. Over the years these plants will be shaded by slower growing, longer lived, later successional species.

A list of known, successfully implemented, adventitious rooting plants follows:

Banker's Willow	*Salix x cottetii*
Streamco Willow	*Salix purpurea*
Black Willow	*Salix nigra*
Pussy Willow	*Salix discolor*
Red Osier Dogwood	*Cornus stolonifera*
Silky Dogwood	*Cornus amomum*
Buttonbush	*Cephalanthus occidentalis*
Sycamore	*Platanus occidentalis*
Cottonwood	*Populus deltoids*
Box Elder	*Acer negundo*
Speckled Elder	*Alnus rugosa*
Elderberry	*Sambucus Canadensis*
Elm	*Ulmus Americana*
Bow Wood, Hedge Apple, Horse Apple, Osage Orange	*Maclura pomifera*
River Birch	*Betula nigra*
Black Locust	*Robinia psedoacacia*
Northern Catalpa	*Catalpa speciosa*
Mulefat	*Baccharis salicifolia*

Image 2: Crews install Live Siltation at Camp Miakonda, Hartman Ditch, Sylvania, OH. Kyle Spicer.

Limitations

- Plantings need to be closely monitored for insect infestation and mortality; some spot replanting can be expected during the second growing season. If all plants in an area are dead, a more thorough investigation needs to be undertaken.
- Although willow and dogwood can sustain themselves in wetter conditions, too much water can cause the plants to not take root. Adaptive management is always encouraged when dealing with plantings.
- Is irrigation needed? Weed control? Fencing for browsing control and buck rub?
- Soil needs to be geotechnically stable.

General Guidelines for Construction

- First look up to analyze for amount of light and overhead power lines, then look down for suitable soil and pipeline right-of-ways, then look around for exotic plant competition, and where/if the plants of choice are growing naturally. Plants on opposite banks might grow in different elevation bands. If plants are not found naturally, why aren't they? What historic plants typically found in these settings are missing? Why?
- Plant materials can be obtained through commercial growers, NRCS plant material centers, grown in-house, or harvested from the wild.
- Harden off-rooted-stock plants (place outside greenhouse) before planting.
- Harvested cuttings should be kept moist and out of direct sunlight.
- Some cuttings benefit from soaking. Black Willow demonstrated 2,600% more roots when soaked for 10 days in one experiment. Water that plants are soaked in should be fresh and oxygenated.
- It's important to have good soil-to-stem contact, this must be carefully specified in contracts

Example Construction Sequence

Plants are harvested, bundled, tied together, placed in the shade, and then soaked until installation.

Live Siltation

Living Dikes

Vegetated Keys

After LPSTP is placed, some soil is added to cover the LPSTP, and then live poles are installed over the LPSTP (parallel to the body of water).

Live Siltation

Living Dikes can be straight or curved (Smiles), to capture and slow water flow. They must be keyed into the bank using additional vegetation.

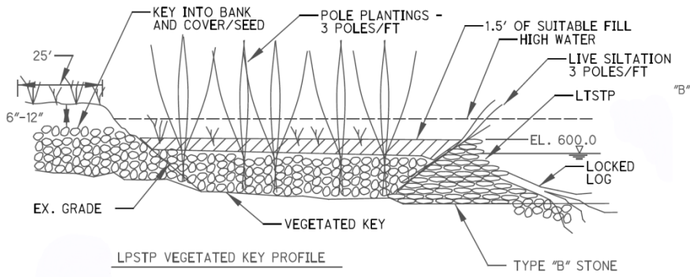
Living Dikes

Plants are installed by hand after Keys are dug and before rock is installed.

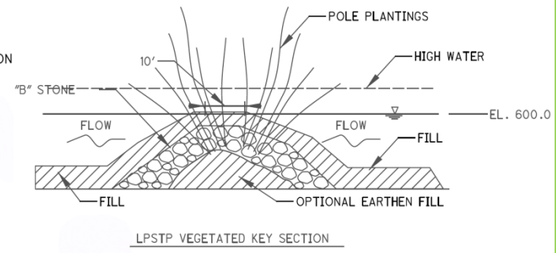
Vegetated Keys

Vegetation is backfilled and secured; typically overfilled to accommodate settling soil. Now just add time!

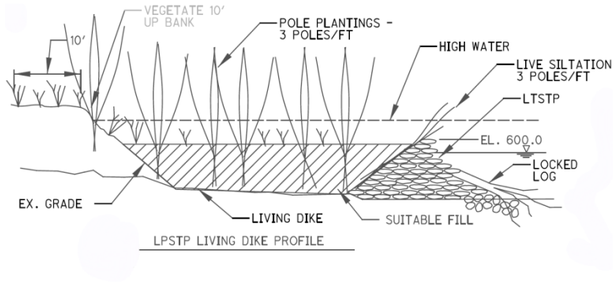
Example Plans Drawings



LPSTP VEGETATED KEY PROFILE



LPSTP VEGETATED KEY SECTION



LPSTP LIVING DIKE PROFILE

Estimating Time and Materials

If obtained commercially, the nursery might need some lead time. Instead of purchasing the hundreds to thousands of plants needed to support many stream restoration projects, consider reaching out to local agencies, park districts, and/or consultant groups that could potentially supply your project. Many local park districts have the ability to reserve maintained tracts of land containing dogwood and willow for any organization needing vegetation (especially if you contact them before their prescribed burn season). Take into account contractors or consultants who also have access to local greenhouses, and could help supply your project cheaper than if you were to buy the plants retail. Consider hosting a hands-on workshop to allow attendees to harvest and installed the needed bioengineering. Living Dikes, Live Siltation, and Vegetated Keys can be done while the structures they're associated with are also being built, so additional time during on-the-ground implementation is minimal.

Maintenance and Monitoring

Unlike stone structures, bioengineering practices can be detrimentally affected by a number of different factors. Weather, wildlife, and people all play a factor in whether or not you'll need to replant or otherwise repair any of these bioengineering practices. Low lying and near shore plants could be subject to inundation or flooding, deer and other wildlife might negatively affect your work through grazing or antler rub. Finally, depending on the location of your project, the human element might be cause for alarm too. Close monitoring of the project within the first few years will help to gauge the need for additional work. If visible growth or sprouting doesn't occur after the first growing season, understand why plants are not growing, redesign as needed, then replant.