

# TECHNIQUES FOR VEGETATING RIPRAP REVETMENTS

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# JUNEAU WATERSHED PARTNERSHIP

Our mission is to promote watershed integrity in the City and Borough of Juneau through education, research and communication while encouraging sustainable use and development.

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## Dormant Cuttings and Techniques for Vegetating Riprap Revetments in Juneau

### Purpose and Description

Improve riparian and fish habitat by using dormant cuttings and joint planting techniques to vegetate riprap revetments stabilizing eroding streambanks.

Riparian vegetation has several important ecological roles:

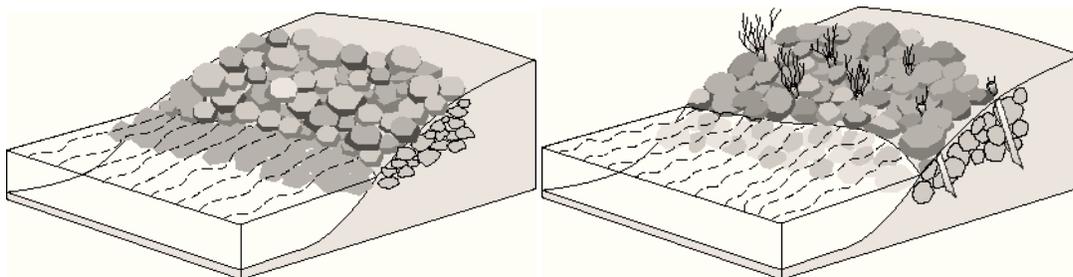
- Providing cover and food resources for terrestrial invertebrates, birds, and mammals;
- Shading streams to maintain cool water temperatures necessary for salmon and other aquatic organisms;
- Providing a source of large woody debris, allowing complexity in stream habitats;
- Delivering leaf litter, organic debris, and terrestrial invertebrates, which are sources of food for fish and aquatic invertebrates;
- Protecting streambanks from erosion; and
- Providing stormwater treatment

When riparian vegetation is removed and replaced with riprap revetments, these benefits are completely lost with the exception of erosion control.

Dormant cuttings are living, woody plant cuttings capable of establishing root systems and growing into shrubs or trees after being placed into the streambank. Dormant cuttings can be used in a variety of bioengineering techniques such as live staking, pole planting, brush layering, etc. Planting dormant cuttings will not provide immediate erosion protection, so they are best used in combination with other techniques. The two techniques discussed here are joint planting and vegetated riprap.

Joint planting uses a combination of rock and dormant cuttings to stabilize a streambank. In this application, dormant cuttings are prepared into live stakes and poles, and planted in the rock joints in order re-establish riparian vegetation and cover. The cuttings are planted after the construction of a new riprap revetment, or in an existing riprap revetment. This allows, over time, recovery of some riparian vegetation and the associated benefits.

Vegetated riprap is another method for using a combination of rock and dormant cuttings to stabilize a streambank. However, this typically refers to when dormant cuttings are placed during the construction of a new riprap revetment as part of the design. In addition to live staking and pole planting, brush layering techniques may also be incorporated to provide additional vegetative coverage.



**Figure 1.** A comparison between a standard riprap revetment (left) and a riprap revetment with joint planting (right). Figures from Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG), accessed online at [http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/restoration/?cid=nrcs143\\_026887](http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/restoration/?cid=nrcs143_026887)

## Applicability

Techniques discussed in this document are applicable where the primary objectives include habitat improvement, erosion control, water quality improvement, and aesthetics. These techniques are applicable for existing and new riprap revetments with slopes of 2:1 or flatter.

## Advantages/Disadvantages

Advantages	Disadvantages
<ul style="list-style-type: none"><li>• Inexpensive</li><li>• Relatively easy method</li><li>• Improves aesthetics</li><li>• Improves riparian and fish habitat</li><li>• Can be used to improve existing structures</li><li>• Easy installation when incorporated as part of new riprap revetment</li><li>• Over time, adds to stability of riprap revetment</li></ul>	<ul style="list-style-type: none"><li>• Limited to certain species</li><li>• Can be time intensive</li><li>• Harvest, preparation and planting of stakes is time sensitive</li><li>• Construction best during dormant season of selected species</li><li>• Plant loss of 30 – 50% is common</li><li>• Planting density will be dictated by the availability of voids.</li></ul>

Dormant cuttings can be placed after the installation of rock for new riprap revetments or in an existing riprap revetment. This is called joint planting. Installing cuttings during construction of a new revetment is called vegetated riprap.

For new construction, implementing vegetated riprap techniques will make it easier to install the dormant cuttings, though it will extend the time it takes to install the rock. This is because equipment will have to carefully place, not end dump, the rock in order to prevent damage to the cuttings. Installation after the rock has been placed, or in an existing revetment, may result in more difficult installation due to having to work between the rock. For this reason, it is encouraged to design and schedule installation to coincide with construction for new revetments. However, where there is existing riprap, joint planting provides a means to improve riparian and fish habitat along these previously modified streambanks.

## Preparation of Dormant Cuttings

The success of joint planting is largely dependent on properly selecting, collecting and preparing the dormant cuttings.

**Site and Species selection:** Dormant cuttings can only be prepared from certain plant species. Willow (*Salix* spp.) is the most common species used for live stakes throughout the country and has been used successfully in Juneau.

Other species from which dormant cuttings can be made are as follows:

Black cottonwood\* (*Populus balsamifera*)

Red-osier dogwood\* (*Cornus stolonifera*)

Nootka rose<sup>+</sup> (*Rosa nutkana*)

Salmonberry<sup>+</sup> (*Rubus spectabilis*)

Red elderberry<sup>+</sup> (*Sambucus racemosa*)

\*used with success in Juneau and recommended by Alaska Dept. of Fish and Game

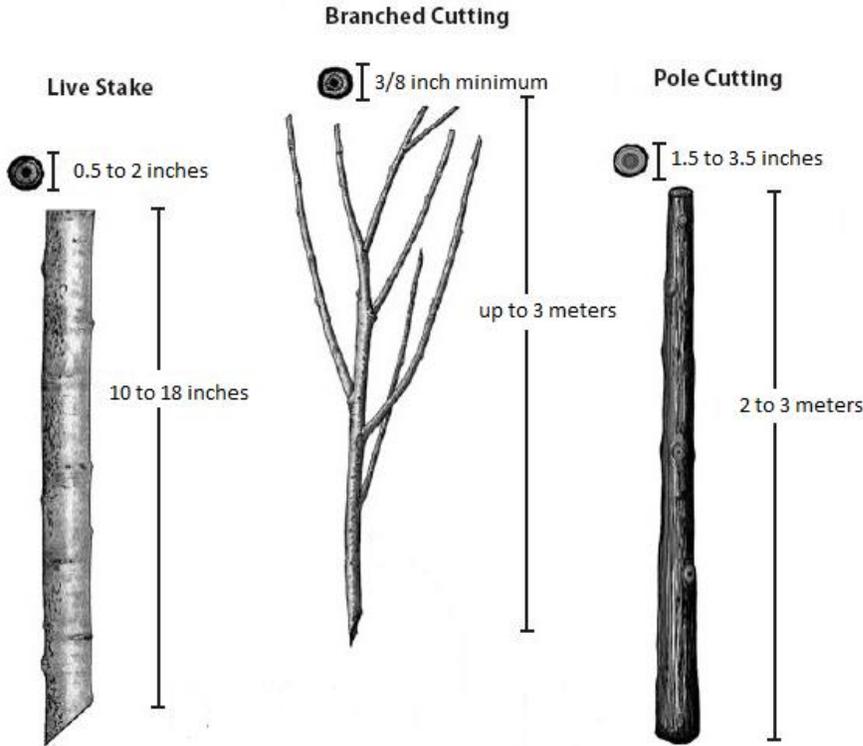
+ known to root well from cuttings but are less commonly used in this application

Identify a harvest site with healthy populations of the selected plant species. Harvest sites are easier to identify when leaves are present in the spring or summer. The site should have at least 3 times the needed harvest material. If necessary, harvest from multiple sites to prevent over harvesting.

Always get permission from the landowner for accessing the site and plant collection. Collecting dormant cuttings from State land may require a permit; contact the Department of Natural Resources prior to collecting cuttings from State land.

**Harvest:** Harvest must occur when the selected species are dormant (not actively growing), in winter or early spring, preferably before March 31. The best wood to use is healthy, live wood that is 2 – 5 years old with smooth bark that is not deeply furrowed and is reasonably strait. Younger wood will lack sufficient energy to sprout.

Dormant cuttings are generally harvested for three preparations as shown in Figure 2 and outlined in Table 1.



**Figure 2.** A comparison in dormant cuttings prepared into live stakes, branched cuttings and poles.

**Table 1.** Information for preparing dormant cuttings into live stakes, branched cuttings and poles.

Type	Diameter (inches)	Typical Length	Technique	Notes
Stakes	0.5 – 2	10 – 18 inches*	Joint planting and Vegetated Riprap	<ul style="list-style-type: none"> <li>• Smaller diameter stakes (diameter less than 1.5 inches) must be at least be 18 inches long</li> <li>• Harvest length can be up to 4 feet, and then trimmed to size of stake (Figure 3)</li> </ul>
Poles	1.5 – 3.5	2 – 3 meters*	Joint planting and Vegetated Riprap	<ul style="list-style-type: none"> <li>• Generally better survival due to size</li> <li>• Long enough to reach beyond the riprap, though may require mechanical measures for installation</li> </ul>
Branch cuttings	3/8 minimum	Up to 3 meters*	Vegetated Riprap	<ul style="list-style-type: none"> <li>• Branches kept intact</li> </ul>

\*length of the cutting should be long enough to reach moist soil (vadose zone).

**Fabrication of Cuttings:** Both stakes and poles are prepared in the same manner. When harvesting, make clean cuts without splitting the ends. Spread harvest activity throughout the site to minimize visual impact. Do not thin more than 2/3 of the donor plant to avoid harming it, and remove cuttings from inside the crown of the plant. Cuttings for stakes can be up to 4 feet in length, and trimmed to create stakes (Figure 3). However, the cutting length is dependent on the application and, in the case of joint planting and vegetated riprap, both live stakes and poles should be cut to lengths that allow the cuttings to extend 6 to 8 inches into the vadose zone.

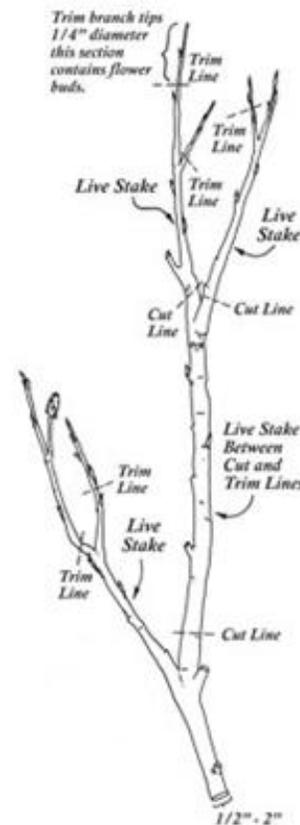
The end that will go into the ground shall be pointed or angled (hence “stake”) and the top cut straight across.

When using willow, trim off flower buds (pussy willows) on the top 2/3 of branch that was produced last growing season and trim all leaf buds except two leaf buds near the top of the stake

When using cottonwood, retain one side branch and trim all but the terminal bud on that side branch.

In preparing branched cuttings, some side branches are kept. Branched cuttings are not used joint planting and, therefore do not need to be prepared unless vegetated riprap is planned.

For easy storage and installation, cuttings can be placed so that they are oriented the same way, and bundled and labeled by species.



**Figure 3.** Preparing multiple live stakes from a dormant cutting. From ADFG 2005.

**Soaking and Storage:** After harvesting, the dormant cuttings should be bundled so that they are oriented the same way for ease of transport and installation. If different species were harvested, they can be group and labeled by species for identification. Dormant cuttings must not be allowed to dry out. All cuttings should be initially soaked in water for 1 to 4 days. Soaking significantly increases the survival rate of the cuttings. While soaking, the dormant cuttings should be stored in a location where they are protected from the sun, wind, cold, heat and physical damage.

Dormant cuttings are more successful when planted the same day they are removed from water. However, if it is necessary to harvest the dormant cuttings well before installation, the cuttings should be stored based on when they were harvested. If harvested at temperatures below freezing, freeze cuttings at no colder than 0 degrees Fahrenheit or refrigerate cuttings until planting. If harvested at temperatures above freezing, cuttings should be refrigerated between 31 to 40 degrees Fahrenheit and 60 to 70 percent humidity. Do not store plants beyond one season; instead, plan on preparing new cuttings (see Timing below). Stored stakes must be soaked in water for a minimum of 24 hours prior to installation, but not for more than 48 hours.

**Installation**

Dormant cuttings can be placed after the installation of rock for new riprap revetments or in the rock joints of an existing riprap revetment. This is called joint planting. Installing cuttings during construction of a new revetment is called vegetated riprap. Both methods are discussed separately, with timing and general installation guidelines that apply to both discussed first. All standard drawings for installation are provided in Appendix A.

**Timing:** Installation is most successful if the dormant cuttings are installed during the dormant season immediately after harvesting and soaking in water for 4 days. However, dormant cuttings can be installed any time of the year, except for when the ground is frozen and late summer. Installation outside of the dormant season will only be successful if the cuttings are properly stored (as described above) and are soaked for a minimum of 24 hours prior to installation.

Fall is the preferred installation time with early winter being the next best time for installation. If a spring installation is necessary, irrigation/watering will be essential for survival. Summer installation is generally not recommended due to dry conditions. If a summer planting is necessary, dormant cuttings should not be planted after July 1 as the ability of plantings to establish quickly declines after this date. If cuttings cannot be installed before July 1, do not store the cuttings until the following fall; instead, plan on getting new cuttings.

**Table 2.** Timing of activities associated with dormant cuttings.

Activity	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Harvest	→											
Storage	→											
Planting		Potential for Frozen Ground					→					

**General Guidelines:** If installation is expected to take multiple days, only the amount of material required for planting each day should be removed from soaking. Before installing, inspect the cuttings and do not use those that have begun to root or mold, or that have appeared to dry or leaf out. Cuttings

stored onsite should be kept soaking or wet, and protected from the sun, wind, cold, heat and physical damage.

In addition, during planting, be careful not to damage the buds, strip the bark or split the stake during installation. Any stakes or poles that have split during installation should be replaced as materials allow.

Dormant cuttings should be installed at random intervals between rocks in the available joint spaces above the Mean High Water (MHW) line, but not exceeding the number of cuttings per square meter recommended in Table 3. Soil around the cuttings should be kept moist for at least 6 weeks following planting.

**Table 3.** Spacing for joint planting and vegetative riprap techniques based on slope and soil cohesion. From Sotir (2007).

Slope Steepness	Spacing – Feet on Center	
	Cohesive soils	Non-Cohesive Soils
1.5:1	N/A	N/A
2:1	1.5 to 3	1.5 to 2
3:1 or flatter	3 to 5	2 to 4

### ***Joint Planting***

Joint planting involves driving live stakes and pole cuttings into the rock joints. Stakes and poles require slightly different installation methods, though all cuttings must be planted with the pointy-end in the ground and the leaf bud scars or emerging buds pointing up. As necessary add soil slurry (mix of soil and water) in the voids between rocks prior to planting the dormant cuttings in order to encourage rooting. Watering is also used to reduce air pockets and increase soil contact. Lack of soil contact, particularly within the rock joints, is one of the leading causes of mortality after installation.

Stakes: Use a rebar (3/4 inch or less in diameter) or other similar tool to establish a pilot hole for stakes. The hole must be perpendicular to the surface and must reach into the subsoil where existing rock or new rock has been placed. Much of the stake (3/4 of the length) should extend into the subsoil with only one or two leaf buds above the ground. Due to their size, stakes are generally planted towards the top of the

Poles: One-half to two-thirds of the pole should extend into the ground. While a rebar may be used to create a pilot hole, it may not be successful in creating a hole deep enough for pole installation. In this case, installation of poles may require the use of a “stinger,” which is a solid steel rod that attaches to a backhoe or excavator, or a power auger or similar tool. Some stingers have the ability to insert the cutting into the attachment so that the stinger can be used to drive the pole into the ground. When using a stinger without this capability, the attachment is used to make a pilot hole through the riprap, stopping when the softer subsoil is reached. Then the pole is placed through the pilot hole by hand and is pushed into the subsoil using the bucket of the excavator. The pole will make its own hole through the soil so there is a continuous tight fit between the soil and the pole.

Note about joint planting in existing riprap: Thick existing riprap may also require the use of a stinger, or a power auger or similar tool. Depending on the stinger attachment, they are capable of installing live stakes in riprap 4 to 5 feet thick. An excavator can also be used to lift and move rocks as needed. However, when replacing the rock, care must be taken not to damage the dormant cuttings.

### ***Vegetated Riprap***

In vegetated riprap, the cuttings are installed during construction of a new riprap revetment while the bank is being graded and the riprap is being placed. Live stakes and pole plantings are used in this application similar to joint planting. However, another technique called brushlayering, which uses branched cuttings, is also used in this application.

Live stakes and poles: Live stakes and poles are installed as described for joint planting with the exception that poles can be placed so they are angled to prevent the riprap from moving down the bank. Poles can also be placed to help key in the toe of the riprap. In addition, soil can be placed around the cuttings prior to installing the riprap. If filter fabric is being used, it may be necessary to cut a small hole in the fabric to make it easier to drive stakes and poles into the native soil.

Branched cuttings: Branched cuttings are installed just at Mean High Water (MHW) using the brush-layering technique. This requires excavating a filling terrace above the toe of the riprap. The terrace should slope back 10 to 20 degrees. Branched cuttings should be at least 6 feet long or long enough to allow at least 8 to 18 inches of the cutting to extend beyond the face of the slope. Branched cuttings are placed along the terrace at 5 to 8 branches per linear foot and should crisscross at random. After laying the cuttings the brushlayer should be covered with 6 to 18 of soil, compacted and watered (if necessary). Additional terraces can be created up the bank as desired.

Riprap: Unlike traditional riprap construction, do not end dump the rock when constructing vegetated riprap. Instead carefully place the rock in order to prevent damage to the cuttings. Some damage during placement of rocks is unavoidable and acceptable since some of the deeply rooted material will regenerate.

### **Maintenance**

Watering may be necessary to ensure the success of the dormant cuttings. Soil around the cuttings should be kept moist for at least 6 weeks following planting. More watering may be needed if installation occurred in the spring or if the site is experiencing dry conditions.

Examine the site at minimum twice during the first year, and once per year thereafter, preferably after the flood season. Examine the cuttings for adequate survival and growth. Before replacing dead plants, determine the reason they were unsuccessful and implement corrective measures with new plantings. Voles are known to girdle the cambium layer at the base of cottonwood stakes during winter. Protect these cuttings with a collar designed to protect tree bark from rodents.

When the vegetation becomes established (up to 3 years), maintenance becomes less over time.

### **Construction Costs**

Joint planting: According to Sotir and Fischenich (2007) the cost of joint planting can range from \$6 to \$15 per cutting. This estimate includes harvest, transportation, handling, fabrication and storage. This does not include the cost of the riprap component, which is assumed to be existing, or the labor and equipment costs.

Installation can vary depending on labor and equipment costs, and the size of the site. McCullah (2001) estimates 2 to 5 square meters per hour can be planted. This can be used to estimate labor costs based

on site size. In Juneau, equipment time is about \$150 to \$200 per hour for an excavator (Hanna, personal communication).

Vegetated riprap: For planting dormant cuttings during construction of a new riprap revetment, McCullah (2001) states that an additional 10% labor and equipment time should be added to the estimated labor and equipment costs of constructing a riprap revetment alone. This is required for careful placement of riprap to prevent damage to the cuttings.

Partnering to reduce costs: The Juneau Watershed Partnership (JWP) and the Southeast Alaska Watershed Coalition (SAWC) are willing to partner with landowners interested in implementing joint planting and vegetated riprap techniques on their property. These non-profit organizations are able to seek grant funding and solicit volunteers to pursue these projects at little to no cost to the landowner.

### **EXAMPLES IN JUNEAU**

Joint planting was used to successfully revegetate riprap revetments on the Mendenhall River in two locations: near Quay's subdivision in April 2012 and the Riverbend site in July 2013. Vegetation was well-established on both sites after 2 years (Figures 4 – 7).



**Figure 4.** The riprap revetment near the Quay subdivision on the Mendenhall River immediately after joint planting in June 2012. Photo courtesy of John Hudson, US Fish and Wildlife Service.



**Figure 5.** The riprap revetment near the Quay subdivision on the Mendenhall River immediately after joint planting in August 2014. Photo courtesy of John Hudson, US Fish and Wildlife Service.



**Figure 6.** The Riverbend riprap revetment on the Mendenhall River immediately after joint planting in July 2013. Photo courtesy of John Hudson, US Fish and Wildlife Service.



**Figure 7.** The Riverbend riprap revetment on the Mendenhall River after vegetation from the joint planting has become established in September 2015. Photo courtesy of John Hudson, US Fish and Wildlife Service.

## REFERENCES

Alaska Dept. of Fish and Game. 2005. *Streambank Revegetation and Protection: A Guide for Alaska*. [http://www.adfg.alaska.gov/static/home/library/pdfs/habitat/98\\_03.pdf](http://www.adfg.alaska.gov/static/home/library/pdfs/habitat/98_03.pdf)

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Cramer, Michelle L. (managing editor). 2012. *Stream Habitat Restoration Guidelines*. Co-published by the Washington Departments Of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, Washington. <http://wdfw.wa.gov/publications/01374/wdfw01374.pdf>

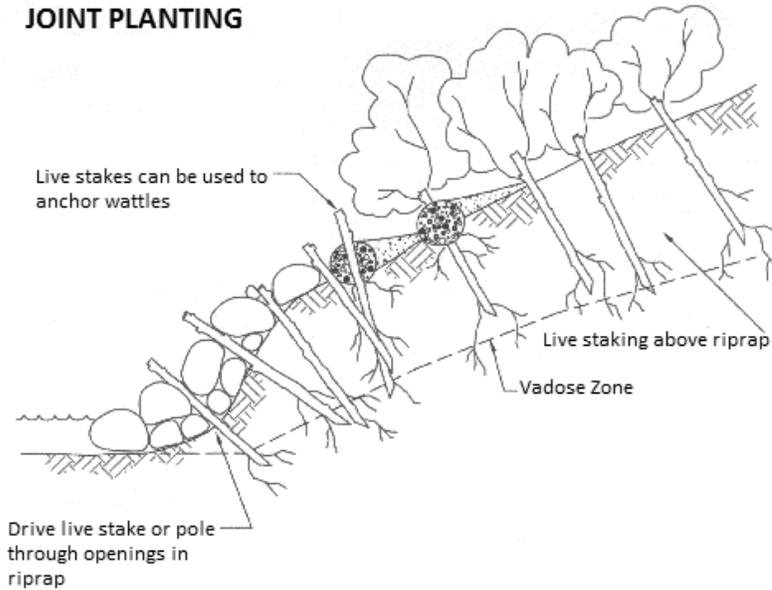
Hanna, D. Feb. 4, 2014. Personal communication (email) with Juneau Watershed Partnership regarding estimated project costs.

Sotir, R.B and J.C. Fischenich. 2007. *Live Stake and Joint Planting for Streambank Erosion Control*. U.S. Army Corps of Engineers, Ecosystem Management and Restoration Research Program. <http://el.erdc.usace.army.mil/elpubs/pdf/sr35.pdf>

## APPENDIX A:

### Standard Drawings for Joint Planting and Vegetated Riprap

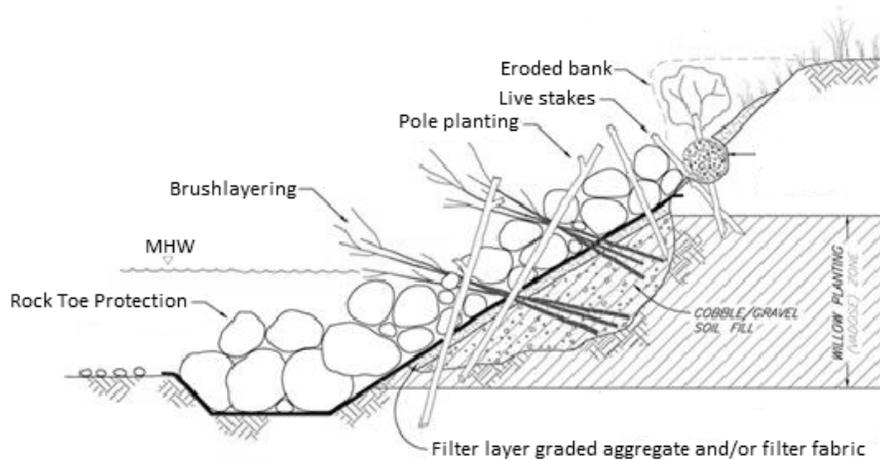
## JOINT PLANTING



### Joint Planting Notes:

1. Soak cuttings 24 hours (minimum) prior to installation.
2. Stakes driven so 3/4 length is in soil and at least 2 leaf buds are above the stone layer.
3. Poles driven so 1/2 to 2/3 length is in soil and can protrude 0.5 meter above the stone layer.
4. Filling joints with mud may be necessary.
5. Mechanical means may be needed to install poles

## VEGETATED RIPRAP



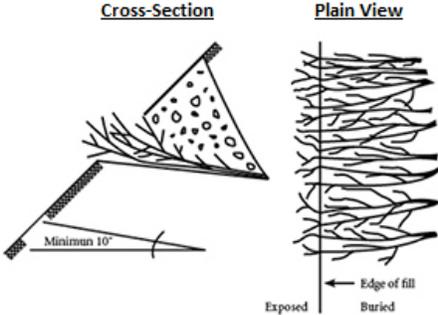
### Vegetated Riprap Notes:

1. Soak cuttings 24 hours (minimum) prior to installation.
2. Brushlayering and poles installed during bank grading and riprap placement.
2. Brushlayers tilt down into slope 10 to 20 degrees
3. Brushlayers should protrude 8 to 18 inches beyond the stone layer.
4. Place soil fill around cuttings
5. Place riprap carefully, do not end dump.

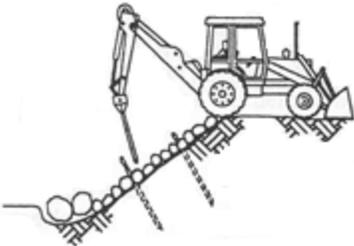
Standard drawings developed using ErosionDraw Software (© John McCullah), as modified by the Juneau Watershed Partnership to conform to the standards set forth by the Alaska Dept. of Fish and Game (2005).

# DETAIL SHEET

## BRUSHLAYERING DETAIL



## POLE PLANTING WITH "STINGER"



Standard drawings developed using ErosionDraw Software (© John McCullah), as modified by the Juneau Watershed Partnership to conform to the standards set forth by the Alaska Dept. of Fish and Game (2005).

## APPENDIX B:

Construction Specifications for

Joint Planting and Vegetated Riprap

## JOINT PLANTINGS

### *Construction Specifications:*

#### **Harvesting:**

- Dormant cuttings shall be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring, or before the buds start to break.
- When harvesting cuttings, select healthy, live wood that is reasonably straight.
- Use live wood at least 1 year old or older. Avoid suckers of current year's growth as they lack sufficient stored energy reserves to sprout consistently. The best wood is 2-5 years old with smooth bark that is not deeply furrowed.
- Make clean cuts with unsplit ends. Trim branches from cutting as close as possible. The butt end of the cutting shall be pointed or angled and the top end shall be cut square.
- Identification of the top and bottom of cutting as accomplished by angle cutting the butt end and cutting the top end.

#### Diameter:

- Dormant cuttings should generally be 1/2 inch or larger (Stakes = 1/2 inch to 2 inches; Poles = 1.5 to 3.5 inches). Highest survival rates are obtained from using cuttings 2-3 inches in diameter. Larger diameter cuttings are needed for planting into rock riprap.

#### Length:

- Dormant cuttings should generally be 10 inches or longer (Stakes = 10 to 18 inches; Poles = 2 to 3 meters).
- Cuttings of small diameter (up to 1.5 inches) shall be 18 inches (0.5 m) long minimum. Thicker cuttings should be longer.
- Cuttings should be long enough to reach into the mid-summer water table, if possible.
- No less than 1/2 total length must be into the ground.
- Stakes should be cut so that a terminal bud scar is within 1-4 inches of the top. At least 2 buds and/or bud scars shall be above the ground after planting.

#### **Installation:**

- Cuttings must be planted with butt-ends into the ground. Leaf bud scars or emerging buds should always point up.
- Stakes must not be allowed to dry out. All cuttings should be soaked in water for a minimum of 24 hours but no more than 48 hours prior to being planted. Soaking significantly increases the survival rate of the cuttings.
- Plant cuttings at random intervals between rocks in the available joint spaces above the Mean High Water (MHW) line, but at least 1 foot apart.
- Set cuttings as deep as possible into the rock joints, preferably with 80 percent of its length into the soil and in contact with mid-summer water table.

- It is essential to have good contact between the cuttings and soil for roots to sprout. This may require placing mud in the rock joints or watering to ensure good contact.
- Use an iron stake or bar to make a pilot hole in firm soil.
- Poles may require heavy equipment for installation.
- Do not damage the buds, strip the bark or split the stake during installation.
- Split or damaged stakes shall be removed and replaced.

***Inspection and Maintenance:***

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.
- Streambanks and steep slopes are highly susceptible to erosion and damage from significant storm events. Willow stakes alone provide very little initial site protection during the establishment period.
- Periodic inspection repair and maintenance will be required during the first two years or until the vegetation is established.
- All temporary or permanent erosion control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

## Vegetated Riprap

### *Construction Specifications:*

#### **Harvesting:**

- Dormant cuttings shall be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring, or before the buds start to break.
- When harvesting cuttings, select healthy, live wood that is reasonably straight.
- Use live wood at least 1 year old or older. Avoid suckers of current year's growth as they lack sufficient stored energy reserves to sprout consistently. The best wood is 2-5 years old with smooth bark that is not deeply furrowed.
- Make clean cuts with unsplit ends. Trim branches from cutting as close as possible. The butt end of the cutting shall be pointed or angled and the top end shall be cut square.
- Identification of the top and bottom of cutting as accomplished by angle cutting the butt end and cutting the top end.

#### Diameter:

- Dormant cuttings should generally be 1/2 inch or larger (Stakes = 1/2 inch to 2 inches; Poles = 1.5 to 3.5 inches). Highest survival rates are obtained from using cuttings 2-3 inches in diameter. Larger diameter cuttings are needed for planting into rock riprap.

#### Length:

- Dormant cuttings should generally be 10 inches or longer (Stakes = 10 to 18 inches; Poles = 2 to 3 meters).
- Cuttings of small diameter (up to 1.5 inches) shall be 18 inches (0.5 m) long minimum. Thicker cuttings should be longer.
- Cuttings should be long enough to reach into the mid-summer water table, if possible.
- No less than 1/2 total length must be into the ground.
- Stakes should be cut so that a terminal bud scar is within 1-4 inches of the top. At least 2 buds and/or bud scars shall be above the ground after planting.

#### **Installation:**

- Cuttings must be planted with butt-ends into the ground. Leaf bud scars or emerging buds should always point up.
- Stakes must not be allowed to dry out. All cuttings should be soaked in water for a minimum of 24 hours but no more than 48 hours prior to being planted. Soaking significantly increases the survival rate of the cuttings.
- Plant cuttings at random intervals between rocks in the available joint spaces above the Mean High Water (MHW) line, but at least 1 foot apart.
- Set cuttings as deep as possible into the rock joints, preferably with 80 percent of its length into the soil and in contact with mid-summer water table.

- It is essential to have good contact between the cuttings and soil for roots to sprout. This may require placing mud in the rock joints or watering to ensure good contact.
- Use an iron stake or bar to make a pilot hole in firm soil.
- Poles may require heavy equipment for installation.
- Do not damage the buds, strip the bark or split the stake during installation.
- Split or damaged stakes shall be removed and replaced.

***Inspection and Maintenance:***

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.
- Streambanks and steep slopes are highly susceptible to erosion and damage from significant storm events. Willow stakes alone provide very little initial site protection during the establishment period.
- Periodic inspection repair and maintenance will be required during the first two years or until the vegetation is established.
- All temporary or permanent erosion control practices shall be maintained and repaired as needed to assure continued performance of their intended function.