Jocko River Master Plan

A guide to ecological restoration activities in the lower main stem Jocko River corridor

Appendix A: Stream Channel and Revegetation Techniques

Prepared by the CSKT Fish, Wildlife, Conservation, and Wildland Recreation Program

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CONFEDERATED SALISH AND KOOTENAI TRIBES

Jocko River Master Plan: A Guide to Ecological Restoration Activities in the Lower Mainstem Jocko River Corridor: Appendix A

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Appendix A

Restoration Techniques

This appendix includes descriptions of some of the channel, floodplain, riparian and wetland restoration techniques appropriate for the lower mainstem Jocko River. In the future, additional techniques may be added to this list. Table A-1 summarizes all of the restoration related techniques described in this appendix.

Table A-1. *List and function of restoration techniques appropriate for the lower mainstem Jocko River.*

Restoration Techniques	Function
Channel Restoration Techniques	
Channel re-alignment and shaping	Restore floodplain connectivity, form and dimensions to the channel
Channel Structures	
Bank Stabilization Structures	
Rootwad revetments	Stabilize streambanks by dissipating energy directed at streambanks, creates cover for fish and provides food web functions such as trapping and retaining organic matter
Large woody debris jams	Stabilize streambanks by dissipating energy directed at streambanks, creates habitat for fish by providing cover and maintaining deep scour pools and provides food web functions such as trapping and retaining organic matter
Grade Control Structures	
Armored (cobble) tail-outs	Provides temporary grade control at pool tailouts during the period post-construction while bed materials are sorting/armoring
Straight and J-Hook Vanes	Reduces near bank shear stress, provide grade control, creates fish habitat through enhancing channel margin complexity
Cross vanes	Provides grade control and fish habitat through scour pool formation
W-weir	Provides grade control and fish habitat through scour pool formation
Floodplain rock/log sills	Prevents potential short-circuiting of flows and head-cutting during flooding event in floodplains which allows sufficient time for vegetation to establish and provide long-term floodplain stability
Floodplain, Riparian and Wetland Restoration Techniques	
Irrigation infrastructure modification	Restores riparian and wetland hydrology
Erosion control	Reduces sediment load entering the river in disturbed areas
Grazing management	Restores natural disturbance regimes such as flooding and reduce the negative impacts of grazing on the river such as streambank erosion, degraded water quality and unbalanced channel dimensions
Integrated pest (weed management)	Controls weed species to promote the restoration of diverse natural plant communities
Microtopographic enhancement	Diversifies habitat through increased surface roughness and diverse topography to provide niches for a variety of plant species
Plant installation	Promotes establishing native plant communities
Mature shrub salvage and transplant	Provides mature, site adapted native vegetation
Fire	Restores the natural disturbance regime that many native plant communities are tied to
Seeding	Establishes diverse plant communities, create future seed banks and provide soil stabilization
Soil amendments	Restores complex soil biology to support native plants
Soil bioengineering	Creates environments along the river suitable for woody vegetation establishment

Channel Restoration Techniques

Channel Re-alignment and Shaping

Channel construction includes channel realignment and channel re-shaping. These techniques are appropriate when a channel has lost its connection with its floodplain, or its pattern and profile do not support natural riverine processes. Along the Jocko River, channel realignment is most often used when levees have been constructed along the channel, or when re-locating the channel is shown to be the most cost-effective, long-term approach to achieving project objectives, such as sediment reduction or infrastructure protection. Channel realignment is only a preferred technique when other, less invasive techniques are shown to be less likely to achieve project objectives or the time frame for achieving those objectives is very long. Channel re-shaping addresses channel pattern, dimension and profile within an existing alignment by incorporating a combination of structures and other techniques described below.

Channel Structures

Channel structures function to stabilize streambanks, provide grade control for channel realignment and construction, provide habitat for fish and in some cases promote other ecosystem functions and processes such as food web support through woody debris decomposition or providing structure for trapping and retaining organic matter in the river. Bank stabilization structures appropriate for the lower mainstem Jocko River include **rootwad revetments** and **large woody debris jams**. Grade control structures appropriate for the lower mainstem Jocko River include **armored (cobble) tailouts**, **straight** and **J-hook vanes**, **cross vanes**, and **W-weirs**. All of these structures are constructed using primarily native materials, such as rock and wood. Some require large rocks to anchor the wood, and when large wood is not available or will not accomplish the objectives, the structures are constructed entirely of large rocks. Rock, because it is more stable and persistent in a river than wood, is often used near facilities or in cases where wood would not be stable enough, such as when structures need to extend a considerable distance to protect banks or infrastructure.

All channel structures are designed and constructed based on bankfull characteristics. However, channel structures are also designed to accommodate floods and other episodic events, such as ice scour. These channel structures have been used on streams and rivers of all sizes throughout the United States, and if properly designed and constructed, have survived major floods and other disturbances with little or no damage (Schmetterling and Pierce 1999).

Bank Stabilization Structures

Bank stabilization structures are necessary for maintaining bank integrity on restored stream reaches until planted vegetation is capable of providing long-term natural bank stabilization. Structures are expected to last for a limited period of time until vegetation or large wood provides bank stability in perpetuity. The duration of the structure depends on the types of materials used and the structure location.

In addition to bank stabilization, these structures serve to diversify available fish habitat by providing overhead cover, flow path complexity, interstitial hiding spaces, and visual separation for fish. Large woody debris jams are typically built with whole trees or rootwad composites of cottonwoods, fir, spruce, pine and other native riparian woody species. Large woody debris jams are built to emulate naturally occurring habitat arrays. Debris jam materials project varying distances from the bank to deflect scouring eddies away from the bank which functions to diversify fish habitat around the structures.

Rootwad Revetments

The purpose of bank placed rootwads is to dissipate water velocities and shear stress in the near-bank region until dense riparian vegetation becomes established. A secondary function and benefit of these structures is the diverse fish habitat that is created by providing in-channel cover and diversifying flow paths to create microscale habitat. Each rootwad revetment structure typically consists of a footer log, anchor rocks, and rootwad fan with attached bole. The footer log is typically two to three feet in diameter and 20 to 25 feet in length. The anchor rocks are placed on the footer log on either side of the rootwad revetment structure. Anchor rocks are typically 0.75 cubic yards to one cubic yard per rock with eight to ten anchor rocks required for each revetment structure. The rootwad bole is typically 25 feet in length with a bole diameter of two to three feet and a fan diameter of six to eight feet. To further increase the value of these structures as fish habitat, complementary woody debris will often be added to the rootwad revetments. For areas where additional stability is needed, high flow deflector logs may be placed on each structure and at approximately the bankfull elevation.

Spacing between rootwad revetments depends on their position relative to other channel and streambank structures. Rootwads used with complementary structures increases the amount of bank protection provided over using a sinle structure alone. Revegetation treatments will often be installed in conjunction with each rootwad revetment. For example, each revetment will typically have two to four mature willow transplants with attached root masses placed around the point where the structure intersects the streambank. In some cases, rootwads from cottonwoods send suckering roots up from the buried stems. Additional planting may also be completed to improve the long-term natural bank stability.

Large Woody Debris Jams

Large woody debris has many uses in stabilizing streambanks (Buffington and Montgomery 1999; Bilby 1984); and providing aquatic habitat (Bryant and Sedell 1995; Bilby and Ward 1989). Large woody debris jams are constructed to mimic naturally occurring wood jams that typically form in the lower half of outside meander arcs. Natural wood jams accumulate over time as high water events overtop the lower portion of the meander, depositing wood on the floodplain. Large wood traps smaller materials, increasing the wood jam volume. Jams vertically influence the stream from the channel bed to the floodplain, creating diverse aquatic and overhead habitat for fish (Shields and Knight, 2003), riparian habitat for mammals and birds (Dykaar and Wigington 2000), bank protection, fine sediment deposition areas (Shields et al. 2001; Piegay and Gurnell

1997), and protected growing sites (Abbe and Montgomery 1996; Malanson and Butler 1990).

Constructed woody debris jams are built with several large trees, various sized rootwads, small diameter woody material, and large anchor rocks (NRCS 2001). The large trees are trenched into the bank and anchored with large rocks. Other woody material is interlaced among the large key trees to create a diverse array of woody material. Several rootwads and logs are extended out into the channel to diversify the local aquatic environment (Figure A-1). Over time, the jams are expected to grow in size as the jam captures other woody debris transported during high water (NRCS 2001).

Figure A-1. Constructed woody debris jam.

Grade Control Structures

Grade control structure types and locations depend on site-specific goals and reach characteristics. Specified structures effectively address bed stability, bank integrity, and fish habitat concerns.

Grade control structures maintain the designed channel profile elevations in addition to satisfying fish passage and habitat needs. Structures typically concentrate flows to the thalweg, or deepest portion of the channel. Focusing flows in this manner sustains a deeper low flow water column providing better aquatic habitat connectivity during late season base flows. Flow concentration is also beneficial during flood events when the structures facilitate flow convergence and sediment transport. Convergence and hydraulic head are influenced by vane arm gradient, angle of departure from the bank, and structure elevations. A steeper vane arm gradient results in greater hydraulic acceleration over the structure and through the structure's scour pool. This acceleration is necessary for maintaining sediment transport through the pool and subsequently, the depth of the pool. The vane arm gradient and arm length also affect the degree of bank protection created by the grade control structure. A longer, flatter vane arm protects a greater bank distance than a short, steep vane arm.

Rootwad revetments and other large woody debris are typically incorporated into the grade control structure to increase pool habitat diversity. Woody materials are anchored in between or below vane arms. Material positioning influences vane hydraulics and pool scour, creating a range of aquatic habitats within the vicinity of the structure.

The designed structures maintain fish passage through the channel. Fish passage is typically a concern during base flows when portions of the wetted channel may become disconnected if the stream bed is too wide and the water too shallow. Grade control structures are designed to have no more than one-half foot to one foot of distance from the structure throat to the water surface during base flows to ensure fish passage over the structure. Gaps between structure rocks also allow fish passage from the downstream pool up through the structure. During the majority of the hydrograph, water depths over the vanes are sufficient for all species and most age-classes to pass. Fish have been observed inhabiting feeding positions on the downstream sides of vane throats where the focused flow concentrates food items and cold water. During high flows, fish likely seek refuge in the deep, complex pools. Although vanes create hydraulic acceleration, water velocities are unlikely to exceed the burst swim speeds of most fish species given the short distance of vane influence.

The hydraulic drop created by grade control structures also appears to attract spawning salmonids. The hydraulic drop formed by the vertical distance between the upstream and downstream water surfaces increases the inter-gravel flow on the upstream side of the vane. Pool tailouts downstream of the structures are also attractive spawning areas for trout. The combination of optimal gravel sizes, the short distance to deep water, and enhanced inter-gravel flow make pool tailouts downstream from grade control structures optimal spawning areas for salmonids.

Armored (Cobble) Tailout Structures
Natural stream channels sort and transport material in a manner that provides for natural grade control. Where grade control is necessary and log or large rock structures are not desired, channel materials are sorted during construction to generate material for grade control structures ranging from the D84 to the D100 of the channel bed material (the largest material that is generally not transported during bankfull flows). The material size for grade control structures varies, but is generally cobble sized rock for the Jocko River ranging from about 4 to 8 inches in diameter. Additional materials may be placed in the designed bed profile, usually at the pool tailout locations, to provide grade control downstream of grade control structures (Figure A-2). Cobble tailouts may also be used in lieu of cross-vanes where additional grade control is necessary.

Channels will convey the flows and transport the sediment made available by the Jocko River watershed. The bankfull channel will convey approximately the 1.5-year to 1.8-year flood-flow events while larger flows will access the adjacent floodplain. Bank stabilization and grade control structures benefit the resident and migratory fisheries by providing local habitat and enhancing spawning migration routes currently impaired by poor aquatic habitat conditions. These structures would not impede upstream or downstream fish migration for native and coldwater sport fish species.


Figure A-2. Cobble tail-out structure.

Log and Rock Straight Vanes

Straight vanes are built as log or rock vanes (Johnson et al. 2002). Vanes tie into the streambank at approximately the bankfull elevation and intersect the channel bed at a designed distance upstream. The slope and length of the vane are determined according to the local channel conditions and structure objectives. Straight vanes function by deflecting the high velocity thalweg away from the streambank thereby decreasing the near-bank shear stress. Log vanes (Figure A-3) are generally preferred over rock vanes as log vanes are more cost-effective to build due to lower material costs and construction time. Additionally, log structures typically appear more natural in the aquatic environment and decay over time. Rock vanes are generally used when large logs are not available, or when the long-term stabilization of the channel at the specific location is a necessity.

To improve structure stability and the length of protected bank, a single rootwad or large woody debris jams are typically constructed in combination with vanes. Woody debris anchored upstream and downstream of the vane increases bank roughness and fish habitat. Additionally, a tree with an attached rootwad set at the bankfull elevation at the vane tie-in point increases vane structural stability and reduces the potential for floodplain scour and resultant structure flanking.

Figure A-3. Log straight vane.

J-Hook Log and Rock Vanes

J-hook vanes are similar to straight vanes except that a log or rock “J-hook” is added to the straight vane to further concentrate the thalweg (Figure A-4). J-hook vanes are typically preferred over straight vanes for this reason. While providing protection for the local streambank and channel, vanes also maintain sediment transport. J-hook vanes provide grade control and are also used to help maintain extended pool lengths in meanders. Footer rocks are placed below the predicted scour depth to prevent undermining of the structure during high flows. Logs of sufficient size may be used in place of large rock where possible. Log vanes are typically less expensive and easier to install than rock vanes, though they are less permanent than rock structures

Similar to the straight log and rock vanes, woody debris structures are used in combination with J-hook vanes to increase habitat diversity and length of bank protection. A tree with an attached rootwad may also be used to improve vane stability and floodplain integrity.

Figure A-4. J-Hook vane.

Cross Vanes

Cross vanes (Figure A-5) provide long-term grade control in reconstructed stream channels. Natural channels maintain grade control through undulations in the bed profile (riffle-pool sequences). It is necessary to include a form of grade control in reconstructed channels due to the heterogeneous and disturbed nature of channel material (gravel, cobble, sand) following construction. Cross vanes are built as log or rock structures in a fashion similar to the straight log and rock vanes. Constructed scour pools below cross vanes enhance fish habitat and maintain deep water habitat for migratory and resident fish populations.

Figure A-5. Cross Vane.

W-Weirs

The design of the W-weir is similar to the cross vane in that both sides are vanes directed from the approximate bankfull elevation upstream to a point where the vane intersects the channel bed. The W-weir divides the river into fourths with the vane arms intersecting the bed at one-fourth and three-fourths of the channel width (Rosgen 2001). The center portion of the structure rises in the downstream direction to form a “W” looking from upstream to downstream. The multiple vane arms and center structure increase the number of flows paths, diversifying aquatic habitat around the structure. W-weirs maintain deep pools in a similar manner to the aforementioned vanes and cross vanes.

Floodplain, Riparian and Wetland Restoration Techniques

Floodplain, riparian and wetland restoration techniques appropriate for the lower mainstem Jocko River include modifying existing irrigation infrastructure, erosion control, grazing management, integrated pest (weed) management, microtopographic enhancement, plant installation and protection, plant salvage, prescribed fire, seeding (soil seed bank enhancement), soil amendment and streambank revegetation/bioengineering techniques. Table A-1 summarizes the overall function and purpose of each technique. A combination of these techniques will typically be necessary for successful restoration of floodplain, riparian and wetland areas within the lower mainstem Jocko River.

Irrigation Infrastructure Modification

Irrigation canals, drainage ditches, and water impoundment features (e.g., ponds) are common throughout the lower mainstem Jocko River floodplain. The construction of these artificial features often results in localized changes in floodplain hydrology and often leads to an increase in fish entrainment, spread of noxious and non-native plant species, and poor habitat for other aquatic species. Management and restoration plans for protected properties will prescribe techniques for removing or modifying existing water diversions and/or impoundments as an initial step to restore floodplain hydrology. The specific techniques described below to remove or modify water diversion and impoundment features are generally less intensive than stream channel restoration techniques and provide a cost-effective means for restoring the ecological potential of some restoration sites. With minimal effort, filling or plugging these features can allow the hydrograph to recover in a limited zone, thus enhancing the recovery of wetland vegetation. The removal or modification of these structures may also be incorporated as part of microtopography enhancements, a contour grading plan, wetland recovery design, or the channel-reconstruction design for a site. Technique descriptions are provided in following sections.

Irrigation Canal Water Control Modifications

Irrigation canals generally cannot be removed, especially secretarial or Flathead Agency Irrigation District (FAID) canals. If modifications to secretarial canals are considered, any changes will ensure that restoration activities will not impact downstream users. Modifications may include re-designing headgate structures on secretarial canals to ensure a more efficient delivery of irrigation water through protected properties. Water from existing irrigation canals (assuming the Tribes retain water rights on a given protected property) may be used at a restoration site to enhance restoration plantings, but this typically will not require any modifications of water control structures.

Ditch Plugging

Secondary canals may be removed to enhance restoration objectives, if the canals are fully contained on a protected property and do not deliver water to legitimate downstream users. Removal of a secondary canal may include plugging or completely filling the existing drainage ditches on a protected property. Disturbed soil resulting from ditch plugging and create microtopography enhancements associated with filling or plugging of drainage ditches will be revegetated using appropriate techniques (Figures A-6 and A-7). Revegetation and microtopography enhancement techniques are described later.

Figure A-6. Secondary irrigation canal immediately after complete ditch plugging, microtopgraphy enhancement and revegetation techniques were implemented.

Figure A-7. Secondary irrigation canal immediately after partial ditch plugging to enhance adjacent wetland hydrology was implemented.

Berm Removal or Re-contouring

In many cases, former owners of protected properties built artificial ponds in floodplain or wetland areas for stockwater or fish-rearing purposes. Landowners constructed many of these ponds by digging a deep hole and piling excavated soil in a high berm around the pond. These ponds generally have little or no shallow water habitat along the shoreline, and the high berms promote the establishment of weed species. Shallow water benches may be excavated along the shoreline of artificial ponds and the berms around the ponds may be regraded to removal the berms to create a naturally sloping shoreline (Figure A-8).


Figure A-8. Irrigation pond after berm removal, recontouring and revegetation techniques were implemented.

Erosion Control

Many restoration designs require some level of erosion control until seeded or planted material is sufficiently established and maintaining soil stability. This will be particularly true for streambanks, topsoil areas of the floodplain subject to frequent or high-velocity overbank flows, and on slopes steeper than 3:1 (horizontal to vertical). Streambank erosion control treatments include channel structures described in earlier sections and bioengineering techniques described later. Floodplain and slope erosion control treatments may include placement of logs, rocks, or other objects on slopes or in the floodplain to improve microtopography and reduce erosion. Other erosion control methods include: installing organic material layers (mulches), contour wattles (fascines), organic berms, and manufactured erosion control blankets. Erosion control techniques can also be a part of the grading plan developed for larger restoration efforts. Grading plans may include treatments such as: prescribing flattened slopes, reduced slope length, or additional surface roughness. Erosion control measures are often integrated with various revegetation techniques.

Erosion Control Blankets

Erosion control blankets (Figures A-9 and A-10) provide physical protection of the soil surface and are used for holding soil in place until vegetation establishes. They slow water at the soil surface and trap sediment and small debris, thereby building soil. Blankets also intercept rainfall, slow precipitation runoff, and maintain surface moisture. Woven and nonwoven types are available, as are blankets constructed out of a host of natural and synthetic materials. Blanket thickness and installation methods also vary widely, depending upon application. For lower mainstem Jocko River projects, blankets made of organic fibers are preferred and generally limited to weed-free straw and coir (coconut fiber). Examples of coir fabrics and their application are illustrated in the photos below.

Figure A-9. Erosion control blankets made of natural fibers including straw and coir showing both natural and synthetic netting.

Figure A-10. Coir erosion blanket along the Jocko River near Arlee.

Organic Mulches

Organic mulch is a layer of plant-based material applied to the soil surface, such as wood chips, wood fiber, conifer needles, cryptogamic crusts or compost (Figure A-11). Organic mulches can be blown-on, spread or applied via hydromulching. The primary use of organic mulch is to modify or protect the surface of bare soil. Heavy applications of mulch may be used to suppress weeds, control erosion and act as slow-release organic fertilizer, providing nutrients to developing plants. Lighter applications of organic mulch may be used to enhance seed germination and provide physical protection for newly applied seed. Treatment details typically stipulate the type mulch material, quantity, quality, application method, as well as binding agents (glues, tackifiers) if needed.


Figure A-11. Compost/seed applied on a road slope

Contour Wattles

Contour wattles (also called fascines) can be installed to reduce slope lengths and control slope erosion. Contour wattles also act to intercept runoff and trap sediments. Wattles are cylindrical bundles of organic material such as plant fiber, straw, brush or live willow stakes, bundled together with twine or packed into sausage-shaped organic or synthetic webbing. They are typically 9 to 18 inches in diameter and 6 to 20 feet long, depending upon the application and product. Wattles are laid across a slope on contour (perpendicular to the slope), typically within a shallow trench, and staked into place (Figure A-12). The horizontal distance between wattles varies depending on slope steepness, product used, and anticipated erosive forces.

On streambanks or slopes with seeps or springs, bundles of live willows can be installed similar to straw or coir wattles to control slope erosion. These bundles can be secured with live willow stakes. Developing willow shrubs will further stabilize the slope by consuming water and eventually binding the slope as deep roots establish.

Logs and whole trees can be used for the same purpose where standing trees are plentiful. Trees can be dropped onto a slope by contour felling (felled across the slope) or placed mechanically. Ideally, side branches are left on the trees to help anchor the tree to the slope. If whole logs are used, they must be staked or anchored into place. On slopes with seeps or springs, wattles constructed of live willows can be used for short-term erosion control and long-term revegetation. As the willow stakes take root, the developing shrubs consume soil moisture and dewater the slope, eventually establishing deep binding root systems to hold soils in place.

Figure A-12. Example contour wattle installed on contour to reduce slope length and control slope erosion.

Compost Berms

Compost berms may be used in place of, or in addition to, surface mulch layers and contour wattles. Compost berms consist of a linear mound of compost combined with seed and a natural binding agent (glue or tackifier). Placed to control runoff and slow surface flows, they provide excellent erosion protection, yet eventually degrade and revegetate, providing nutrients to surrounding vegetation as they degrade. They are an excellent replacement for woven plastic and wire silt fences. The method utilizes a compost blower outfitted with a seed injector and a berm-forming head on the end of the blower tube.

Grazing Management

Livestock have been heavily utilizing riparian and wetland areas of the Jocko Valley since permanent settlements started around 1860, and it is possible the use goes back even further, to tribal nomadic times when the tribes maintained large horse herds (Barrett 1980). Unregulated, open-range, season-long grazing occurred for many years. It was followed by privatization of the communal reservation lands, which began about 1880 and continued through 1920. During that time, the Flathead Indian Reservation was homesteaded. High stocking rates and season-long use have continued on many private and tribal lease lands since then. Grazing management techniques include: removal of grazing from the property, construction of riparian exclosures or other fencing, grazing timing, stocking rates, herding, pasture rotation, and off-site water. One of the most effective and economical restoration tools available is to drastically reduce or remove this grazing pressure or modify damaging uses associated with grazing. In most cases, a reduction or elimination of grazing will need to be coupled with weed management techniques.

Grazing Removal

Removing stock from the floodplain and other restoration areas may be achieved by acquisition and conversion of the land to a Tribal Conservation Area. For Tribal lease lands, trades or purchase may be used to remove livestock. On Tribal lands not available for purchase, phase-outs (retiring leases as current leaseholders retire or get out of the business) and buyouts (purchasing the leases from willing lessees) will be sought. Conservation easements will be used when possible on private lands that are not available for purchase; those easements will seek to remove or restrict livestock use in sensitive areas.

Riparian Exclosures/Other Fencing
In some cases, where acquisition is not possible, fencing of sensitive areas will be used to achieve restoration goals. Fencing options may include riparian fencing with water gaps, complete exclosures, and partial exclosures with gates (for seasonal or rotational uses).

Timing
Manipulating the season and timing of use are important tools for the livestock manager. In cases where damaging use is occurring, developing management plans with the livestock producer can make the use more compatible with the resource. Management planning can include adjusting use to preclude grazing during times of the year when streambanks and soils are saturated and unstable or before vegetation is sufficiently developed to withstand grazing or removing livestock when a certain vegetation utilization goal has been achieved.

Stocking Rates
Another grazing management tool is controlling stocking rates. Stocking rates generally require conducting a forage inventory. The Natural Resources Conservation Service (NRCS) has guidelines available on how to conduct inventories that incorporate habitat type, canopy cover, soil depth, and species composition of the understory. This information is used to characterize the vegetation by ecological condition and forage value, which leads to an initial stocking rate for a site. A grazability factor is also used to assess use of an area based upon slope, the presence of roads or trails or barriers such as downed timber and slash, and distance from water.

Herding
Herding is generally an appropriate grazing management technique for large open-range settings, such as in the forested Tribal range units of the Upper Jocko River watershed. It can also be used on smaller (several-hundred-acre) pastures and with small livestock like sheep and goats to prevent over-utilization of the resource.

Rotation
Rotational grazing, coupled with cross-fencing, can also be used to limit use on sensitive habitats. When instituted properly, it can provide the livestock user with more efficient and uniform utilization of forage without a herder, which is a labor-intensive solution.

Off-channel water
Spring developments, water tanks, stock ponds, and other off-stream water sources can be installed where appropriate or where water gaps are not feasible. In many cases, pastures provide access to the floodplain and river to provide dependable, year-round

livestock water. Replacing this water supply with water developments on upland benches or off the streambank, coupled with fencing of the banks, will assist in recovery of the site.

Integrated Pest Management

Integrated Pest Management (IPM) is the use of different techniques including biological, mechanical, barriers and chemical controls in combination to combat pest and weed species, with an emphasis on methods that are least injurious to the environment and most specific to the particular pest. IPM considers a targeted species' life cycle and intervenes in reproduction, growth, or development to reduce the population. Pests targeted in the lower mainstem Jocko River include a range of invasive species. Specific IPM techniques are described below and include: herbicide application, mechanical control techniques, biological control techniques, and physical barriers and mulches. It is often necessary to use a combination of control techniques and/or to integrate control techniques with revegetation techniques (seeding and/or planting of containerized plants). Exact techniques used will depend on site conditions, target species and existing and future land management. For example, irrigation, in combination with other techniques may help convert a site to favor desirable species and/or disadvantage more xeric weed species.

Herbicide application

Herbicide application includes the use of chemicals to control weed species and is typically used for large infestations of weed species. Use of herbicide for lower mainstem Jocko River restoraiton projects will follow application procedures specified in the Integrated Noxious Weed Management Plan developed for the Flathead Indian Reservation (USDI BIA 1993). In addition, herbicide use will be curtailed or modified if weed species are present in sensitive riparian or wetland habitats. Methods for applying herbicides include use of ATV- or truck-mounted spray rigs (Figure A-13), backpack sprayers, or by helicopter.

Figure A-13. Use of truck mounted spray rig to apply herbicide to weed infested area.

Natural herbicides

Corn gluten meal, a by-product of corn processing, has potential as a natural preemergence herbicide and may be appropriate for use as part of IPM for the lower mainstem Jocko River. Corn gluten meal (CGM) has been identified as an effective natural preemergence herbicide for use in turfgrass and other crops (Bingaman and Christians 1995; Christians 1993; Nonnecke and Christians 1993). CGM reduces germination of many broadleaf and grass weeds (Bingaman and Christians 1995). CGM allows seedling shoots to emerge, but inhibits root development. Therefore, after a period of water stress, the seedlings wilt and die because they do not have an adequate root system.

Mechanical control

Mechanical control of weeds includes techniques such as hand pulling, mowing or disking, and cutting of tree species (typically followed by herbicide application). Mowing and disking control methods reduce the growth of noxious weeds, prevent seed set, and/or prepare areas for herbicide application by reducing above ground biomass. The effectiveness of mechanical control methods varies by species.

Biological control

Biological control agents for weed control are insects that cause damage to the flowers, seeds, stems, and/or roots of weed species. Each insect species used for biological control is generally host-specific and has been introduced to this country from the weed species' place of origin (generally Europe or Eurasia). The use of biological control agents is not a "quick-fix" solution, but rather a long-term management action. Once introduced into an area, each insect species should, over time, gradually reduce the competitive edge of the weed species for which it has been released to control, eventually allowing other more desirable native plants to establish and/or to outcompete the targeted weed species.

Physical barriers and mulches

Physical barriers and mulches, either synthetic (Figure A-14) or organic (Figure A-15), can be effective at controlling various weed species. Physical barriers include pre-fabricated weed barriers made from plastic, coir, or straw. Mulches can include application of sufficient wood fiber mulch or composts to bury and kill weed populations. Mulches also act to modify soil nutrients, such as excess nitrogen levels.

Figure A-14. Use of synthetic weed barrier to suppress weeds in planting area.

Figure A-15. Use of wood mulch as a physical barrier to suppress weeds in planting area.

Microtopography Enhancement

Natural floodplain and wetland topography is often quite variable, allowing for great diversity in plant species establishment and distribution. This, in turn, optimizes the value of riparian and wetland areas for wildlife habitat and water retention. Elevational variation of as little as two inches may give one plant species survival and establishment advantages over other species. Land shaping and grading as part of the agricultural conversion process removed the natural microtopography that provided elevation heterogeneity and hydrologic variability. Microtopography will be designed back into the landscape, both through contour grading plans and enhancements on sites where minimal floodplain or wetland reconstruction is needed. These enhancements include construction or placement of brushpiles or woodpiles or larger diameter woody debris in the floodplain.

Woodpiles entrain wind and waterborne sediments, as well as plant propagules. The area under and around woodpiles provide microsites to shelter young plants as they become established and this, in turn, can evolve into islands of diversity in the dominant plant community. Excavating swales with heavy machinery also allows for the capture of seed, plant propagules, and debris during overbank or spring flows. These depressions also create islands of diversity. Restoration efforts involving water table control and contouring have successfully created a spectrum of hydrologic conditions, ranging from relatively dry conditions on the low water table management, smooth microtopography treatments to very wet conditions on the high water table\ management, rough microtopography treatments.

The addition of larger diameter woody debris to the floodplain increases surface roughness on bare floodplain surfaces (Figure A-16). Roughness creates resistance to flow which creates topographic diversity and microsites for container plants and naturally recruited plants and contributes to organic matter retention in the system. Similar to grading and woodpiles, woody debris creates microsites and microclimates favorable for seedling establishment. It traps debris that contributes to soil and floodplain building processes. Woody debris also contributes nutrients as it decays. Woody debris scattered across the floodplain provides refugia for small mammals, insects, and birds, in turn, contributing to the overall increase of biodiversity on site.

Large woody debris can be scattered by machine, while smaller debris may be placed by hand or used to construct woodpiles. Strategic grading and placement of debris in key planting areas and areas of frequent flooding will optimize its' potential to perform the functions listed above.

Figure A-16. Constructed microtopography as part of new floodplain construction.

Container Plant Installation

Installation of container plants restores woody species and dictates the development of plant communities. Woody species establishment provides bank stabilization in high stress areas, future seed sources, and diverse habitat. The recommended techniques for container plant propagation, installation, protection and maintenance are outlined in the following section.

Container Plant Propagation

Plant materials for use in restoration projects may be custom-grown from locally-collected seed or cuttings. Propagation on a contract-basis ensures that site-adapted plants of appropriate native species are available for each restoration project. Plants may be grown in a variety of container sizes—between seedling to one-gallon size for large-scale revegetation projects. Plant containers should be of a design that encourages deep rooting and constructed from a rigid material to protect the plants during holding, transport, and installation. At the time of installation, container plants should be pest- and disease-free, have an aboveground portion roughly equal in size to the rootball, and a main stem of sufficient caliper to support the plant. The rootball should be root tight such that soil does not fall away from the plant when extracted from the container.

Container plants may be inoculated with mycorrhizae during cultivation, to promote the establishment and survival of installed plants. Ectomycorrhizal species should be inoculated in the nursery; this is easily achieved by watering in commercially available inoculum. Most species of willow (*Salix* spp.), cottonwood (*Populus* spp.), birch (*Betula* spp.), currant (*Ribes* spp.), pine (*Pinus* spp.), and alder (*Alnus* spp.) form associations with this type of mycorrhiza.

Arbuscular mycorrhizae (AM, also called endomycorrhizae) spores must be obtained by harvesting and subsequently incubating soils containing roots of host plants. Therefore, plants requiring this type of mycorrhizal relationship are difficult to inoculate either in the nursery or in the field. Inoculation of endomycorrhizal species in the nursery will be determined on a case-by-case basis depending upon the capabilities of the grower, the timeframe for plant propagation, the species to be propagated, and the relative degree of soil disturbance at the restoration site.

Container Plant Installation

Revegetation with container plants involves many considerations for successful installation, plant survival and establishment (Figure A-17). Factors include: site preparation, planting site selection, planting methods, planting site modifications, and post-planting care. Plant spacing and container size should be determined for each restoration project, depending upon specific site conditions. For example, where native plant community restoration is the primary goal, it would be appropriate to plant large quantities of smaller containerized stock over a large area that has consistent hydrology. Alternatively, it would be appropriate to plant larger plant material on a small site where maintenance is cost-effective and where it is more critical to quickly establish shade, deep binding root mass, and other native plant functions. While it will be necessary to determine precise spacing and plant material type for each project, some general guidelines will be followed. The sample plant pallets reference below are included in Appendix E.

Tree spacing should average 12 to 20 feet on center. Shrub spacing should average one to four feet on center along streambanks and six to eight feet in other areas. Herbaceous plug spacing should average 12 to 36 inches on center, depending on each species' rate of spread, which is usually directly related to size of the mature plant.

Site preparation methods vary depending upon the site and soil conditions of the restoration area, with the basic purpose of optimizing the soil for plant installation and survival. Site preparation activities include: ripping or other methods of soil decompaction, addition or incorporation of compost to improve soil fertility and structure, and scattering of woody debris to create microsites for planting.

The selection of individual sites for planting also relates to the species to be planted, the plant communities to be restored, and the variety of environmental conditions across the restoration area. Species should be planted in locations appropriate to their natural distribution, according to the availability of soil moisture, soil type, sun or shade, or other conditions under which they are found naturally. Individual planting locations should be selected based upon the availability of microsites, such as slight depressions, locations with woody debris, stumps, rocks, or other natural features that provide shade, physical protection, and/or shelter to enhance plant survival and establishment.

Figure A-17. Containerized shrubs installed at 6 foot average spacing, protected by mesh to limit browse

The specific planting method to be used relates to the type of plant material (container plant, bareroot, salvaged plant, cuttings), the size of the plant material, and the accessibility of the planting site. Smaller plant materials are generally planted using hand tools such as shovels, dibbles, or hoedads. Larger container plants and salvaged materials may be planted using augers, tree spades or excavators. The accessibility of the site (topography, remoteness) and soil conditions (texture, plantability) will determine whether mechanical planting equipment may be used, or if plants must be installed by hand.

Soils used for backfill around each plant may be amended depending upon the amount of site preparation and quality of site soils. In some cases, backfill soil may be mixed with compost to increase moisture holding capacity and fertility. Fertilizers or mycorrhizal inocula may also be added to backfill soils. If supplemental irrigation is available, plants should be watered-in immediately after installation.

Plant protection

Once individual plants have been installed, additional planting site modifications and/or physical protectors may be installed, including watering basins, shade cards, browse protectors or repellents, mulch, or weed barriers (Figure A-18).

Figure A-18. Mesh browse protector

Plant Maintenance

Planted materials, including container plants, bare root and salvaged plants, cuttings, and seeded plants will require post-planting care to ensure survival and maximize the effectiveness of restoration plantings. Plants need to be maintained throughout the "establishment period", which is generally one to three growing seasons, until the plant has grown enough to be self-sustaining. Maintenance activities include: supplemental irrigation, weed control, plant replacement, and maintenance of browse protectors, shade cards, or other planting supplements.

Supplemental irrigation methods vary according to the accessibility of the site, the availability of irrigation, the types of plantings to be maintained, and other environmental conditions on the site. On restoration sites where infrastructure does not exist, irrigation may be done using watering trucks, portable water tanks, or by pumping from natural water bodies. Sites with irrigation infrastructure may be irrigated using overhead sprinklers, soaker hoses, or drip irrigation. The timing and duration of supplemental irrigation will be determined based upon climatic conditions and weather patterns at the restoration site, the size and species of plant material to be irrigated, and soil moisture and holding capacity.

Weed control will be implemented to reduce competition to desirable native vegetation and enhance the survival of planted species. Selected weed control methods must be the least injurious to planted materials and should be considered temporary, until native vegetation cover can be established. Weeds may be controlled around individual plants by using weed mat, a thick mulch layer, hand pulling, or careful spot spraying. Weeds may be controlled over larger restoration areas through the use of pre-emergent herbicides on areas to be seeded, spot-treatment of larger populations, prescribed fire, or biocontrols.

In cases where a target or minimum survival percentage has been defined, maintenance activities may include reseeding or the replacement of dead or dying plants. Reseeding or plant replacement efforts should take note of the causes of the original mortality, and seek to modify planting conditions, methods, or species selection accordingly.

Plant Salvage

Plant salvage refers to the excavation and relocation of mature plant specimens or patches of sod for use in revegetation. Salvaging plants and native sods can be a relatively inexpensive and a quick method for obtaining large, native, site-adapted planting stock for rapid vegetative reestablishment and bank stabilization. Weed occurrence in salvaged plant root-balls must be considered when identifying salvage stock. Cultural plants, stock needs for the restoration project, and off-site sources are other issues to be addressed when specifying salvage. Figure A-19 shows a tree spade attachment for a skid-steer used for plant salvage.

Plant salvage is most successful during the dormant season. Other factors that increase the success of plant salvage include:

- excavating the largest volume of root mass possible with the plant material,
- minimizing the distance to transplant site,
- minimizing the holding time before replanting,
- pre-watering the transplant hole,
- installing the plant at the same elevation as the surrounding grade,
- backfilling the planting hole and removing air pockets,
- trimming transplanted plants so the top is equal in volume to the root ball, and
- providing supplemental irrigation for two growing seasons.

Figure A-19. Tree spade attachment for skid-steer.

Prescribed Fire

Naturally occurring wildfire plays an important role in shaping many plant communities. Prescribed fire is a valuable tool for restoring native habitats in which fire has been suppressed or excluded. Periodic burns can improve plant community diversity and wildlife forage, and help combat the spread of invasive species. Other management techniques, such as thinning or mowing, may be used in conjunction with prescribed fire to reduce fuel loads, create firebreaks, or in areas where prescribed fire is not practical.

Direct Seeding

Direct seeding is the preferred method for establishing native grass and forb cover over large areas, as these species typically germinate readily and provide cover quickly. Seeding may also be done to enhance the “seed bank” in the soil. Using slower germinating species such as trees and shrubs encourages the long-term recruitment of desirable native species. Successful seeding and establishment of native cover is dependent upon many factors, including site and seedbed preparation, seed mix design, application methods, post-seeding treatments and maintenance.

Preparation of a friable seedbed is crucial for the optimal germination and establishment of seeded species. Ripping, scarification, or decompaction using heavy equipment may be necessary to loosen soils, encourage infiltration, incorporate compost or other amendments, and provide microtopographic variations on the soil surface. The seedbed may be further groomed by disking, harrowing, raking, ringrolling or cultipacking, to break sod and soil clods, and provide a uniform seedbed.

Whenever possible, seed mixes should consist of locally collected native species, obtained through custom collections or from appropriate commercial sources. For commercially available species (mostly upland and mesic graminoids), seed sources should be specified from varieties originating as close to the restoration site as possible.

Custom collections should focus on species that are not typically available commercially, species of significance to the plant community being restored, or locally rare or endemic species. Commercially available seed lots should be specified to include the least amount of weed species practicable.

Seeding rate should be calculated on a "pure live seed pounds per acre" basis. Bulk pounds, or actual seeding rate to be applied in the field will depend upon the amount of chaff, non-viable seed, and other inert matter in the individual seed lots. The seed mix may either be pre-mixed or applied individually by species, depending upon the composition and seeding method selected. In some cases, seeding may be done in two phases (two growing seasons) to facilitate simultaneous weed control efforts and/or plant diversity goals.

Seed may be applied in a variety of methods depending upon site conditions, revegetation design, and seed mix. Methods include: broadcast seeding, using hand-spreaders, ATV-mounted or heavy equipment mounted broadcasters, drill seeding where seed is applied to a specified depth in the soil, "Brillion" seeders or other types of drop-seeding equipment, "Terraseeding" which utilizes a compost blower outfitted with a seed injector, and hydroseeding where seed and mulch are applied in an aqueous slurry (Figure A-20).

Figure A-20. Hydroseeding.

After seed has been applied, additional seedbed treatments may be desired to facilitate germination and establishment. Ringrolling or cultipacking may be required to firm up the seed bed and lightly press the seed into the soil. Mulch may be applied to seeded areas to provide physical protection, enhance seed to soil contact, and create favorable soil conditions for germination. The type and quantity of mulch used is dependent upon the seeding method, species of seed, seeding location, and erosion control needs. Mulching options include: compost, utilizing locally-available composts as a blown-on or spread top-dressing; pine needles; straw mulch, using straw blowers and tractor-drawn crimpers; and hydromulching, using virgin wood fiber mulch and organic tackifiers applied in a slurry using specialized equipment.

Seeded Area Maintenance

Seeded areas will require post-seeding care to ensure survival and maximize the effectiveness of restoration seeding. Seeded areas will need to be maintained throughout the "establishment period", generally one to three growing seasons, until the seeded areas have become self-sustaining. Maintenance activities include watering, weed control, and reseeding.

Soil Amendments for Seeded Areas

Soil samples characterize the fertility of soils where revegetation activities are planned and help identify any amendments that may be needed. Soil amendments are used to address three basic factors: the immediate availability of nutrients to support vegetation establishment, the texture and composition of the soil, and the availability of organic material to provide nutrients and sustain vegetation cover over the long term. These factors are addressed by using fertilizers and compost, either applied to the surface, or incorporated into the upper soil horizons.

Organic, slow-release fertilizers are most appropriate for native plant revegetation projects because chemical fertilizers tend to benefit non-native weedy species that are tend to grow well high fertility conditions. Chemical fertilizers tend to release nitrogen and other nutrients into the soil and groundwater more rapidly than native plants can utilize them, thus becoming pollutants. In some cases, native plants can actually grow slower in high fertility soils because of suppression of mycorrhizal associations. Compost, compost tea, biosolids, manure, and pelletized organic fertilizers are examples of organic-based, slow-release fertilizers. If chemical fertilizers are to be used, a low-analysis, slow-release formulation should be specified.

Soil amendments that target soil structure or composition (compost, lime) should be applied during the site preparation phase, prior to seeding or planting. Amendments may be incorporated into the soil by spreading on the surface and ripping to a depth of 18 to 24 inches. If topsoil has been salvaged, soil amendments and fertilizers may be mixed while the soil is stockpiled, prior to replacement on the restoration site.

Fertilizers may be applied before or after seeding and planting, depending upon the revegetation design, methods, and product specified. Mulch may be applied as a final surface amendment to suppress weeds, retain soil moisture, and enhance the overall organic content of the soil.

Streambank Revegetation/Bioengineering

Bank stabilization treatments must be tailored to meet the needs of the specific site. “Hard fixes”, such as rip-rap used at bridge abutments, may be applied on banks where any level of bank migration is unacceptable. A treatment applied in the vicinity of a grade-control or other structure in the channel would be designed to hold the structure in place until the river reach has sufficient vegetation and root stability to allow for natural channel migration. In the significant, non-structured zones of the river, such as the banks adjacent to a riffle or run, planted vegetation will be sufficient to stabilize the channel. Often, this planted vegetation is combined with a matrix, such as coir, to provide short-term stability as roots establish.

Live Stake/Cutting Collection & Installation

All streambank bioengineering includes the use of plant materials. Dormant willow cuttings are the most common material used (Figure A-21). Cuttings or live stakes are portions of the woody stem used for vegetative propagation and revegetation. This planting method is practical only when using plant species known for their ability to root from the stem, where the installed cuttings have access to adequate soil moisture, and plant material can be installed during the dormant season. Cuttings are frequently used in riparian restoration projects since many riparian tree and shrub species propagate well from stems, and soil moisture is usually present throughout the growing season.

Factors to be considered during live stake and cutting installation include: cuttings species, health, and size of cuttings, collection timing, collection sites, handling and storage, proper installation, and sealing/watering.

Appropriate species will be determined for each restoration site. Disease free, vigorous shrubs and trees will be targeted for collection. Specific restoration techniques determine the size of the cuttings and will be specified per restoration project.

Figure A-21. Live willow cuttings installed between soil lift layers

For best results, live stakes and cuttings are collected immediately prior to installation, and can be temporarily stored with their ends in water (running water preferred). Cuttings should be collected during dormancy. If project schedules do not allow simultaneous collection and installation, cuttings may be kept in cold storage for a period of a few months (less than six months).

Cuttings should be collected as close to the project site as possible, preferably from locations upstream of the project. If a sufficient quantity of cuttings is not available within the project site's watershed, alternative cutting source sites should be selected based upon similarities in elevation, climate, landform, and the plant community to be restored.

The proper placement of cuttings and live stakes is essential to their survival (Figure A-22). Cuttings must have access to plentiful soil moisture in order to develop roots and support the growth of shoots and leaves. The availability of soil moisture is the primary factor in specifying the size of cuttings and their planting location.

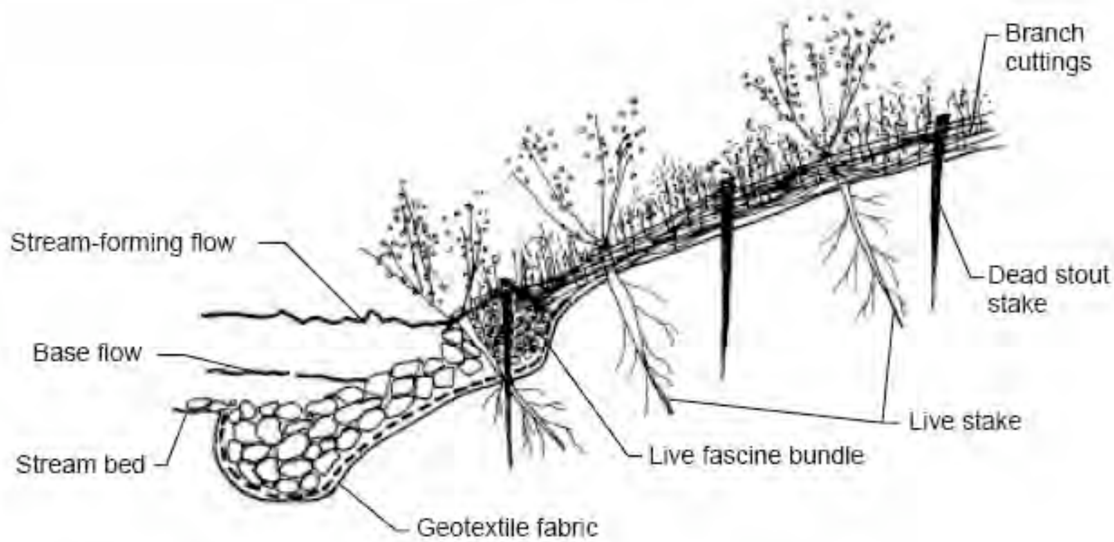

Figure A-22. The above drawing is a generalized view of a bank stabilization treatment using vegetation and small-diameter woody debris. Both the stakes and woody debris can be live or dead plant materials. From the USDA-NRCS Engineering Field Handbook (1996).

Bankfull Benches

Where appropriate, benches of varying dimensions will be constructed at the bankfull level of the stream channel (Figure A-23). These benches will then be aggressively planted with sod, containerized plants, and/or cuttings. This will facilitate reestablishment of the herbaceous and woody plant community in the near-bank zone, and reduce bank erosion as the root mass establishes. Bankfull benches are particularly useful for restoring woody plant communities in reaches where channel incisement has occurred, yet the new channel design will not be able to reactivate and rewet the historical floodplain.

Figure A-23. Bankfull benches facilitate the reestablishment of the herbaceous and woody plant community in the near-bank zone.

Sodding

Placement of sod on eroding and/or reconstructed banks is a rapid method for establishing vegetation and reducing bank erosion. Sod can be salvaged from the site before construction, or harvested from a "donor site" (the donor site must be seeded with appropriate species after sod removal). In both instances, consideration must be made for the depth of the root mass, species composition, and the presence of weedy or undesirable species, such as Kentucky bluegrass (*Poa pratensis*) and Dalmatian toadflax (*Linaria dalmatica*). Upland sods may be used, but will generally need to be planted with riparian and wetland species, such as sedge (*Carex* spp.) and rush (*Juncus* spp.) seedlings. This method allows for short-term erosion control by the upland sod, which will in time be replaced by the planted riparian adapted species. In all cases, sods will be planted with a combination of woody plant species, either containerized or cuttings. In some high-shear-stress applications, sod may need to covered with an erosion control blanket, such as a heavy woven coir (coconut fiber) blanket.

Streambank Bioengineering

Brush Mattresses

Installing high density erosion control blankets may be costly for some sites. Where there is a ready source of large shrubs, logging slash, or other small-diameter (less than two inches) woody material, brush mattresses can be installed on banks or in floodplain areas. Brush mattresses consist of a six-inch to 12 inch layer of six foot or longer brush placed on the soil, and anchored with stakes and/or ropes. This treatment can be applied to streambank and floodplain areas, and staked with live willow cuttings or wooden stakes. Some applications require cabling or roping across the top of the mattress. Brush mattress treatment descriptions for specific projects will include: the size of the treatment area, materials to be used, and the application method. Figure A-24 is an example of brush mattress application.

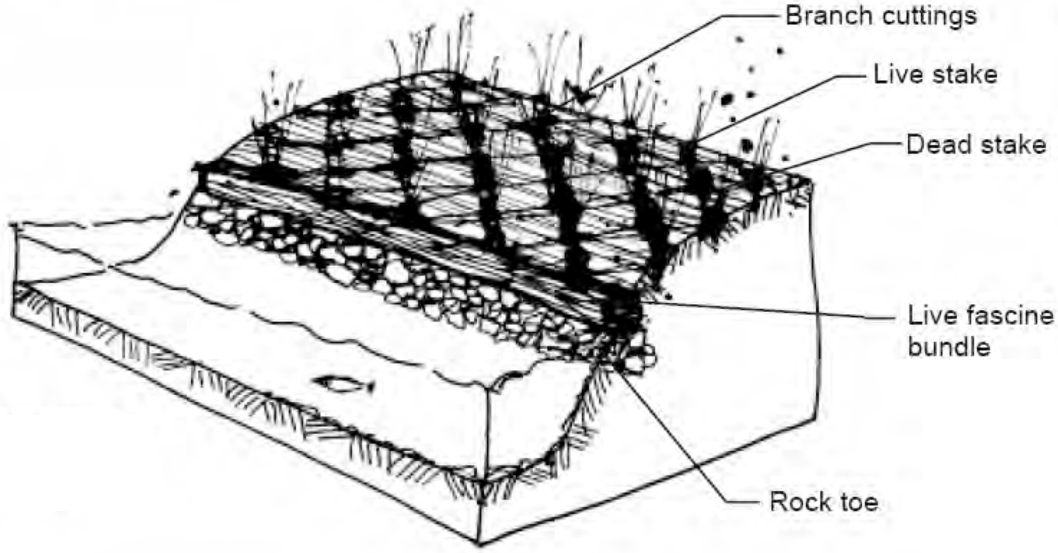

Figure A-24. Brush mattress (USDS-NRCS Engineering Field Handbook 1996).

Vegetated Soil Lifts

In areas where the banks of the river are dominated by finer textured materials such as soil and gravel, vegetated soil lifts, also called fabric-encapsulated lifts, vegetated geogrids, or geotextile soil lifts can be installed to hold banks in place as vegetation establishes. One or more soil levels, six to18 inches deep, are constructed in sequence, each stepped slightly back and faced with one or more layer of erosion control fabric. Seed is applied under the fabric, and the fabric is commonly made of woven coir fibers. The fabric is keyed in between each layer, and dormant willow cuttings or rooted plants are installed to further anchor the structure.

Vegetated soil lift treatment descriptions for specific projects will include the area of the treatment, materials to be used, and the installation method. Figure A-25 provides details for a sample geotextile soil lift application.

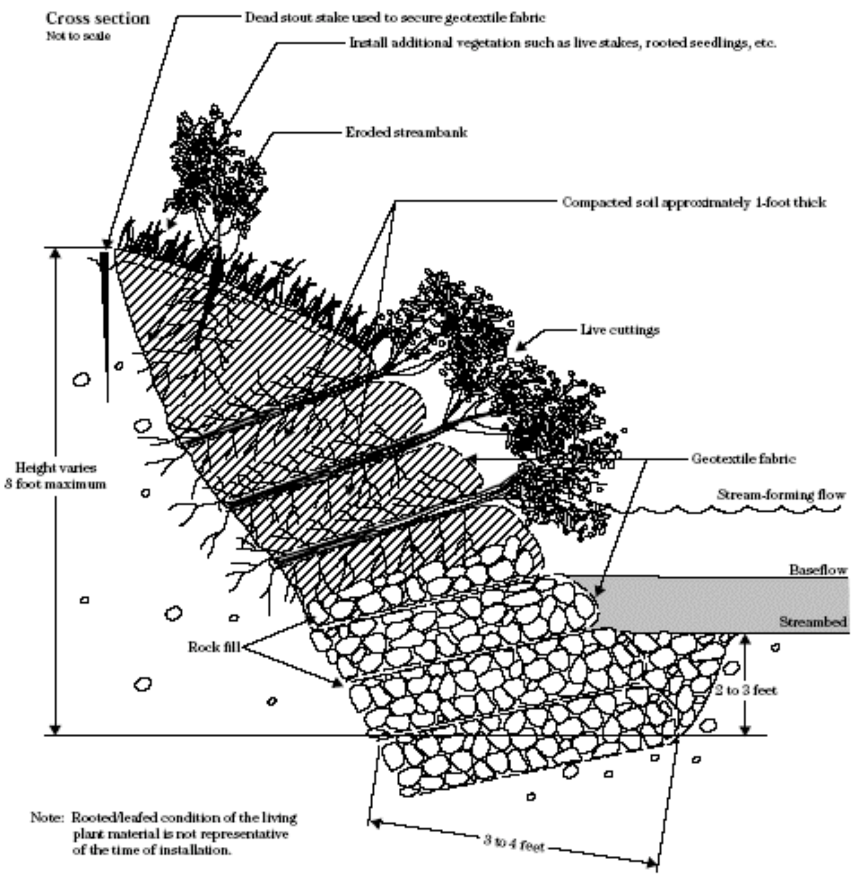

Figure A-25. Typical detail drawing of a geotextile vegetated soil lift for use in streambank stabilization and revegetation (USDA-NRCS Field Engineering Handbook 1996).

Coir Fascines

Coir fascines, also called wattles, fiber rolls, or coir logs, can be used to stabilize the toe of a reconstructed bank. Fascines used in this application are typically constructed out of willow branches or coir. Due to the size of the Jocko River, coir fascines will be specified, where appropriate, as they provide much greater shear resistance, decompose very slowly, and revegetate better than willow wattles. One or more (stepped) fascines are anchored to the toe with stakes (live or dead), and also with sometimes "earth anchors" in high-shear-stress applications. Rooted plants and/or cuttings are be installed in and around the fascine, and will in time replace the fascine's mass with living root mass and deposited soil.

Figure A-30. Coir log used to stabilize the toe of streambank.

Figure A-30 illustrates the use of coir logs in conjunction with a coir/straw blanket to stabilize a streambank. The planted vegetation shown in this picture, is rooting into the coir, which will decompose over approximately five years to be replaced slowly by roots and soil.

Coir logs can also be prevegetated in the nursery with a custom suite of plant species, either seeded or planted into the coir. This product, when installed on the restoration site, provides virtually complete and immediate plant cover, and is anchored to the substrate by the plants' roots much more quickly than "raw" coir products. However, this method is relatively expensive, and generally used for landscapes and other applications requiring "instant gratification".

Another variation in coir technology is coir pallets, or pillows, which are similar to coir fiber rolls except that they are flattened and thus cover more surface area. They do not handle the higher shear stresses that coir rolls can, but work well on wetland and pond margins, or on very low flow streams. Coir pallets are most commonly prevegetated at the nursery, and unrolled and staked down after the restoration site is regraded, providing instant revegetation.

Literature Cited

For references see the Literature Cited Section.