Oak Park Conservancy District
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-04

Activity: Soil Bioengineering and Bank Stabilization

PLANNING CONSIDERATIONS:

Design Life:
N/A

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

BS

BS

Target Pollutants

Significant ♦ Partial ◈ Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◈ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◈ Construction Waste ◊

Description

Sediment reduction or prevention is the result of the occurrence of this BMP. By handling the amount of discharge into storm drain systems or watercourses slope stabilization is provided, protection and erosion reduction through the use of woody vegetative structures alone or in combination with simple retaining structures also takes place. Many of the measures presented in SMP-08 Bank Stabilization are applicable to this BMP fact sheet.

Suitable Applications

For protection of slopes against surface erosion, shallow mass wasting, cut and fill slope stabilization, earth embankment protection, and small gully repair treatment.

Installation Procedures

These systems should be designed by a licensed professional civil engineer.

Site Considerations

- Observe surrounding slopes for vegetation density and overall plant health. Also observe the directions they are facing (some plantings generally do better in eastern exposure and do not survive in southern exposure). Plant health is a good indicator of soil moisture and/or soil conditions. These will help indicate the success of your specific bioengineering project.
- Make geologic observations of the project site noting soil types and their proneness to slide or fail.
- Retain existing vegetation whenever possible.

Activity: Soil Bioengineering and Bank Stabilization

Installation Procedures (Continued)

- Limit removal of vegetation by keeping the cleared area to the smallest practical size, limiting duration of the surface disturbance, and retaining existing woody vegetation for future planting.

- Stockpile and protect topsoil removed during clearing.
- Protect areas exposed during construction with erosion prevention (EPP) and sediment management practices (SMP).

Construction Techniques and Materials

- Grade or terrace to flatten or make a steep undercut or slumping bank less severe.

- Make sure the vegetation chosen does not grow in such a way as to damage simple retaining structures in combination bioengineering systems.

- Retention backfill is to have sufficient fines and drainage so as to support chosen vegetation.

- Bioengineering systems' installation is best accomplished in the late fall at the onset of plant dormancy. Plants that are not dormant are less likely to survive.

- Live stake – the insertion of live, rootable vegetative cuttings into the ground.
  - Appropriate technique for repair of small earth slips and slumps that are frequently wet.
  - Live stakes shall be ½" to 1 ½" (1.3 to 3.8 cm) in diameter, 2 to 3' (0.63 to 0.94 m) long, with the basal end cut to an angled point for easy insertion. The top should be cut square.
  - Tamp the live stake into the ground at right angles to the slope. The installation may be started at any point on the slope face.
  - The live stakes should be installed 2 to 3 ft. (0.63 to 0.94 m) apart using triangular spacing. The density of the installation will range from 2 to 4 stakes per square yard (0.8 m^2).

  - The buds should be oriented up.
  - Four-fifths of the length of the live stake should be installed into the ground and soil firmly packed around it after installation.
  - Do not split the stakes during installation. Stakes that split should be removed and replaced.
  - An iron bar can be used to make a pilot hole in firm soil. Drive the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).

- Live fascine-long bundles of branch cuttings bound together into sausage-like structures.
  - An effective stabilization technique for slopes.
  - Live materials should be from species that easily root and have long, straight branches.

Activity: Soil Bioengineering and Bank Stabilization

Installation Procedures (Continued)

- Cuttings tied together to form live fascine bundles vary in length from 5 to 30 ft. (1.6 to 9.4 m) or longer, depending on site conditions and limitations in handling.
- The completed bundles should be 6 to 8 in. (15.2 to 20.3 cm) in diameter, with all of the growing tips oriented in the same direction. Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine.
- Live stakes should be 2 ½ ft. (0.8 m) long in cut slopes and 3 ft. (0.94 m) long in fill slopes.
- Dead stout stakes used to secure the live fascines should be 2 ½-foot (0.8 m) long, untreated, 2 by 4 (5.1 by 10.2 cm) lumber. Each length should be cut diagonally across the 4 in. (10.2-cm) face to make two stakes from each length.
- Prepare the live fascine bundles and live stakes immediately before installation.
- Beginning at the base of the slope, dig a trench on the contour just large enough to contain the live fascine. The trench will vary in width from 12 to 18 in. (30.5 to 45.7 cm), depending on the angle of the slope to be treated. The depth will be 6 to 8 in. (15.2 to 20.3 cm), depending on the individual bundle's final size.
- Place the live fascine into the trench.
- Drive the dead stout stakes directly through the live fascine every 2 to 3 ft. (0.63 to 0.94 m) to along its length. Extra stakes should be used at connections or bundle overlaps. Leave the top of the stakes flush with the installed bundle.
- Live stakes are generally installed on the down slope side of the bundle. Drive the live stakes below and against the bundle between the previously installed dead stout stakes. The live stakes should protrude 2 to 3 in. (5.1 to 7.6 cm) above the top of the live fascine. Place moist soil along the sides of the live fascine. The top of the fascine should be slightly visible when the installation is completed (Figure SPP-04-1).
- Next, at intervals on contour or at an angle up the face of the bank, repeat the preceding steps to the top of the slope (Table SPP-04-1).
- Long straw or similar mulching material should be placed between rows on 2.5:1 (H: V) or flatter slopes, while slopes steeper than 2.5:1 (H: V) should have jute mesh or similar material placed in addition to the mulch.

Installation Procedures (Continued)

Table SPP-04-1
Live Fascine Installation Guidelines

Slope (H:V)	Slope distance Between trenches (ft)	Maximum slope length (ft)
1:1 to 1.5:1	3 - 4 (0.94 – 1.26 m)	15 (4.7 m)
1.5:1 to 2:1	4 - 5 (1.26 – 1.57 m)	20 (6.3 m)
2:1 to 2.5:1	5 - 6 (1.57 – 1.89 m)	30 (9.4 m)
2.5:1 to 3:1	6 - 8 (1.89 – 2.51 m)	40 (12.6 m)
3.5:1 to 4:1	8 - 9 (2.51 – 2.83 m)	50 (15.7 m)
4.5:1 to 5:1	9 - 10 (2.83 – 3.14 m)	60 (18.9 m)

- Bushlayering - similar to live fascine systems, however, in brushlayering the cuttings are oriented more or less perpendicular to the slope contour.
- Branch cuttings should be ½ to 2 in. (1.3 to 5.1 cm) in diameter and long enough to reach the back of the bench. Side branches should remain intact for installation.
- Starting at the toe of the slope, benches should be excavated horizontally, on the contour, or angled slightly down the slope, if needed to aid drainage. The bench should be constructed 2 to 3 ft. (0.63 to 0.94 m) wide.
- The surface of the bench should be sloped so that the outside edge is higher than the inside.
- Live branch cuttings should be placed on the bench in a crisscross or overlapping configuration.
- Branch growing tips should be aligned toward the outside of the bench.
- Backfill is placed on top of the branches and compacted to eliminate air spaces. The brush tips should extend slightly beyond the fill to filter sediment.
- Each lower bench is backfilled with the soil obtained from excavating the bench above.
- Long straw or similar mulching material with seeding should be placed between rows on 3:1 (H: V) or flatter slopes, while slopes steeper than 3:1 (H: V) should have jute mesh or similar material placed in addition to the mulch.
- The brushlayer rows should vary from 3 to 5 ft. (0.94 to 1.57 m) apart, depending upon the slope angle and stability (Table SPP-04-2).

Table SPP-04-2
Brushlayer Installation Guidelines

Slope (H:V)	Slope distance between benches Wet slopes (ft)	Dry slopes (ft)	Maximum slope length (ft)
2:1 to 2.5:1	3 (0.94 m)	3 (0.94 m)	15 (4.7 m)
2.5:1 to 3:1	3 (0.94 m)	4 (1.26 m)	15 (4.7 m)
3.5:1 to 4:1	4 (1.26 m)	5 (1.57 m)	20 (6.3 m)

Activity: Soil Bioengineering and Bank Stabilization

Installation Procedures (Continued)

- Branchpacking – consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes.
  - Live branch cuttings may range from ½ in. to 2 in. (1.3 to 5.1 cm) in diameter. They should be long enough to touch the undisturbed soil at the back of the trench and extend slightly from the rebuilt slope face.
  - Wooden stakes should be 5 to 8 ft. (1.57 to 2.51 m) long and made from 3- to 4-inch (7.6 to 10.2 cm) diameter poles or 2 by 4 (5.1 by 10.2 cm) lumber, depending upon the depth of the particular slump or hole.
  - Starting at the lowest point, drive the wooden stakes vertically 3 to 4 ft. (0.94 to 1.26 m) into the ground. Set them 1 to 1 ½ ft. (0.31 to 0.47 m) apart.
  - A layer of living branches 4 to 6 in. (10.2 to 15.2 cm) thick is placed in the bottom of the hole, between the vertical stakes, and perpendicular to the slope face (Figure SPP-04-2). They should be placed in a crisscross configuration with the growing tips generally oriented toward the slope face. Some of the basal ends of the branches should touch the back of the hole or slope.
  - Subsequent layers of branches are installed with the basal ends lower than the growing tips of the branches.
  - Each layer of branches must be followed by a layer of compacted soil to ensure soil contact with the branch cuttings.
  - The final installation should match the existing slope. Branches should protrude only slightly from the filled face.
  - The soil should be moist or moistened to insure that live branches do not dry out.
  - Branchpacking is not effective in slump areas greater than 4 or 5 feet (1.26 to 1.57 m) wide.

- Live gully repair – utilizes alternating layers of live branch cuttings and compacted soil to repair small rills and gullies.
- Limited to rills or gullies which are a maximum of 2 ft. (0.63 m) wide, 1 foot deep (0.31 m), and 15 ft. (4.71 m) long.
- Live branch cuttings may range from ½ in. to 2 inches (1.3 to 5.1 cm) in diameter. They should be long enough to touch the undisturbed soil at the back of the rill or gully and extend slightly from the rebuilt slope face.
- Starting at the lowest point of the slope, place a 3- to 4-in. (7.6- to 10.2-cm) layer of branches at lowest end of the rill or gully and perpendicular to the slope (Figure SPP-04-3).
- Cover with a 6- to 8- in. (15.2 to 20.3 cm) layer of fill soil.
- Install the live branches in a crisscross fashion. Orient the growing tips toward the slope face with basal ends lower than the growing tips.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings.
- Live cribwall – a hollow, box-like interlocking arrangement of untreated log or timber members. The structure is filled with suitable backfill material and layers of live branch cuttings which root inside the crib structure and extend into the slope.

Installation Procedures (Continued)

- This technique is appropriate at the base of a slope where a low wall may be required to stabilize the toe.
- Live branch cuttings should be ½ to 2 inches (1.3 to 5.1 cm) in diameter and long enough to reach the back of the wooden crib structure.
- Logs, timbers or reinforced concrete beams should range from 4 to 6 inches (10.2 to 15.2 cm) in diameter or dimension. The lengths will vary with the size of the crib structure.
- Large nails or rebar are required to secure the logs or timbers together.
- Starting at the lowest point of the slope, excavate loose material 2 to 3 feet (0.63 to 0.94 m) below the ground elevation until a stable foundation is reached.
- Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability to the structure.
- Place the first course of logs, timbers or reinforced concrete beams at the front and back of the excavated foundation, approximately 4 to 5 feet (1.26 to 1.57 m) apart and parallel to the slope contour.
- Place the next course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course to overhang the front and back of the previous course by 3 to 6 inches (7.6 to 15.2 cm).
- Each course of the live cribwalls is placed in the same manner and nailed to the preceding course with nails or reinforcement bars.
- When the cribwall structure reaches the existing ground elevation, place live branch cuttings on the backfill perpendicular to the slope; then cover the cuttings with backfill and compact.
- Live branch cuttings should be placed at each course to the top of the cribwall structure with growing tips oriented toward the slope face. Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings. Some of the basal ends of the live branch cuttings should reach to undisturbed soil at the back of the cribwall with growing tips protruding slightly beyond the front of the cribwall (Figure SPP-04-4).

- Vegetated gabions – Vegetated gabions begin as rectangular containers fabricated from a triple twisted, hexagonal mesh of heavily galvanized steel wire. Empty gabions are placed in position, wired to adjoining gabions, filled with stones and then folded shut and wired at the ends and sides. Live branches are placed on each consecutive layer between the rock-filled baskets. These will take root inside the gabion baskets and in the soil behind the structures. In time the roots consolidate the structure and bind it to the slope.

- Vegetated rock wall – a combination of rock and live branch cuttings used to stabilize and protect the toe of steep slopes.
  - Live cuttings should have a diameter of ½ to 1 inch (1.3 to 2.5 cm) and be long enough to reach beyond the rock structure into the fill or undisturbed soil behind.
  - Inert materials consist of rocks and fill material for the wall construction. Rock used should normally range from 8 to 24 inches (20.3 to 61 cm) in diameter. Larger boulders should be used for the base.

Activity: Soil Bioengineering and Bank Stabilization

Installation Procedures (Continued)

- Starting at the lowest point of the slope, remove loose soil until a stable base is reached. This usually occurs 2 to 3 feet (0.63 to 0.94 m) below ground elevation. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability to the structure.
- Excavate the minimum amount from the existing slope to provide a suitable recess for the wall.
- Provide a well-drained base in locations subject to deep frost penetration.
- Place rocks with at least a three-point bearing on the foundation material or underlying rock course. They should also be placed so that their center of gravity is as low as possible, with their long axis slanting inward toward the slope if possible.
- When a rock wall is constructed adjacent to an impervious surface, place a drainage system at the back of the foundation and outside toe of the wall to provide an appropriate drainage outlet.
- Overall height of the rock wall, including the footing, should not exceed 5 feet (1.57 m).
- A wall can be constructed with a sloping bench behind it to provide a base on which live branch cuttings can be placed during construction. Live branch cuttings should also be tamped or placed into the openings of the rock wall during or after construction. The butt ends of the branches should extend into the backfill or undisturbed soil behind the wall.
- The live branch cuttings should be oriented perpendicular to the slope contour with growing tips protruding slightly from the finished rock wall face (Figure SPP-04-5).

- Joint planting – involves tamping live cuttings of rootable plant material into soil between the joints or open spaces in rocks that have previously been placed on a slope.
  - Roots improve drainage by removing soil drainage.
  - Effective with existing rip-rap structures.
  - The cuttings must have side branches removed and bark intact. They should range in diameter from ½ to 1 ½ inches (1.3 to 3.8 cm) and be sufficiently long to extend into soil below the rock surface.
  - Tamp live branch cuttings into the openings of the rock during or after construction. The butt ends of the branches should extend into the backfill or undisturbed soil behind the rip-rap.

  Orient the live branch cuttings perpendicular to the slope with growing tips protruding slightly from the finished face of the rock (Figure SPP-04-6).

Activity: Soil Bioengineering and Bank Stabilization

Maintenance

- During the establishment period, inspect cuttings daily removing any dead stock and replacing it with fresh stock.
  - Inspect biweekly for the first 2 months. Inspections should note insect infestations, soil moisture, and other conditions that could lead to poor survivability. Immediate action, such as the application of supplemental water, should be taken if conditions warrant.
  - Inspect monthly for the next 6 months. Systems not in acceptable growing condition should be noted and, as soon as seasonal conditions permit, should be removed from the site and replaced with materials of the same species and sizes as originally specified.
  - Needed reestablishment work should be performed every 6 months during the initial 2-year establishment period. This will usually consist of replacing dead material.
  - Extra inspections should always be made during periods of drought or heavy rains. Damaged sections should always be repaired immediately.

- Final inspection – A final inspection should be held 2 years after installation is completed. Healthy growing conditions should exist.

- Healthy growing conditions in all areas refer to overall leaf development and rooted stems defined as follows:

  Live stakes ---------- 70%-100% growing
  Live fascines ---------- 20%-50% growing
  Live cribwall ---------- 30%-60% growing
  Brushlayers ---------- 40%-70% growing
  Branchpacking ---------- 40%-70% growing
  Live gully repair ---------- 30%-50% growing
  Vegetated rock wall ---------- 50%-80% growing
  Vegetated gabion ---------- 40%-60% growing
  Joint planting ---------- 50%-70% growing

- Growth should be continuous with no open spaces greater than 2 feet in linear systems. Spaces 2 feet (0.63 m) or less will fill in without hampering the integrity of the installed living system.

Inspection Checklist

- ❑ Where labor is either scarce or extremely expensive, the cost of soil bioengineering systems may be higher than traditional structural measures. However, it should be noted that soil-bioengineering techniques generally are less expensive.
- ❑ Constraints on planting times or the availability of the required quantities of suitable plant materials during allowable planting times may limit soil bioengineering methods.
- ❑ Rapid vegetative establishment may be difficult on extremely steep slopes.
- ❑ Rocky or gravelly slopes can lack sufficient fines or moisture for plant growth.