United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

STREAMBANK AND SHORELINE PROTECTION

CODE 580

(ft)

DEFINITION

Treatment(s) used to stabilize and protect banks of streams or constructed channels and shorelines of lakes, reservoirs, or estuaries.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Prevent the loss of land or damage to land uses or facilities adjacent to the banks of streams or constructed channels and shorelines of lakes, reservoirs, or estuaries. This includes the protection of known historical, archaeological, and traditional cultural properties.
- Maintain the flow capacity of streams or channels.
- Reduce the offsite or downstream effects of sediment resulting from bank erosion.
- Improve or enhance the stream corridor or shoreline for fish and wildlife habitat, aesthetics, or recreation.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries susceptible to erosion. It does not apply to erosion problems on main ocean fronts, beaches, or similar areas of complexity.

This standard does not apply to protection along open and unprotected shorelines of the Great Lakes.

If a single site exceeds 500 feet, or the combination of existing and planned protection exceeds 1,000 feet in a ¼ mile reach (include both sides of the stream), complete the additional site assessment found under Open Channel (Code 582), Additional Criteria for Stream Restoration. Apply this practice as a component of stream restoration and address all identified channel impairments to the extent practicable.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct this practice to comply with all Federal, State, and local laws, rules, and regulations. The landowner must obtain all necessary permissions from regulatory agencies, or document that no permits are required. The landowner and/or contractor is responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

The landowner is responsible for removing hazardous materials or point source pollution (e.g. septic discharge) within the work limits and attaining regulatory compliance prior to the construction of stream and shoreline protection.

Do not use construction demolition for streambank and shoreline protection, e.g. concrete, asphalt, blocks, bricks, etc..

Assess unstable streambank or shoreline sites in enough detail to identify the causes contributing to the instability. The assessment should provide details necessary for design of the treatments and convey reasonable confidence that the treatments will perform adequately for the design life of the measure. If the failure mechanism for a streambank is a result of the degradation or removal of riparian vegetation, if possible, implement stream corridor restoration, along with bank treatment.

Causes of instability include—

- Livestock access;
- Watershed alterations resulting in significant modifications of discharge or sediment production;
- In-channel modifications such as gravel mining;
- Head cutting;
- Water level fluctuations; and
- Boat-generated waves.

Design streambank and shoreline treatments that are compatible with—

- Existing bank or shoreline materials;
- Planned improvements or improvements installed by others;
- Water chemistry;
- Channel or lake hydraulics; and
- Slope characteristics above and below the water line.

Avoid adverse effects on—

- Endangered, threatened, and candidate species and their habitats;
- Archaeological, historical, structural, and traditional cultural properties; and
- Existing wetland functions and values.

Design treatments that result in stable slopes based on the bank or shoreline materials and the type of measure proposed. Account for anticipated ice action, wave action, and fluctuating water levels. Ensure that installations are protected from overbank flows from upslope runoff and flooding. Include internal drainage where bank seepage is a problem. Use geotextiles, designed filters, or bedding to prevent piping or erosion of material from behind the treatment. Anchor end sections into existing treatments or existing stable areas. *Refer to NRCS NEH, Part 633, Chapter 26 for design of granular filters.*

Geotextile, granular filters, or bedding is not required to prevent piping or erosion of material from behind rock riprap protection if all of the following conditions are met:

- *Minimum thickness of the rock riprap layer is three times the* D_{50} *stone size*
- *Seepage is not evident during the soils investigation*
- *Soil base is cohesive i.e. no substantial layers of fine sand or non-plastic silt*
- *Soil base is free of organics and very soft clays*

Revegetate all areas disturbed during construction in accordance with NRCS Conservation Practice Standard (CPS) Critical Area Planting (Code 342). If climatic conditions preclude the use of vegetation, use NRCS CPS Mulching (Code 484) to install inorganic cover materials such as gravel. Protect the area from livestock and human traffic until the site is fully stabilized.

Additional Criteria for Streambanks

In addition to the assessment requirements under General Criteria, include the following information in the design report. Refer to WI NRCS Supplements to NEH, Part 650, Chapter 16 for assessment tools.

- *List the landowner’s objectives for protection, available materials for bank treatments, existing and desired riparian land use, willingness to carry out maintenance activities, and special conditions.*
- *Determine the elevation of the bankfull flow (i.e. channel-forming discharge or ordinary high water mark). Bankfull flow fills a channel to an elevation where flow begins to spill onto the active floodplain. Bankfull flow can be identified by field indicators in alluvial channels that have adjusted to hydrologic conditions and sediment delivery. Over the long term, bankfull flow typically completes the most work in transporting sediment relative to the magnitude and frequency of other flows. Bankfull flow has a typical recurrence interval range of 1 to 3 years on an annualized frequency curve, with a predominance of values in the 1.2 to 1.8-year range, although exceptions may include urban areas, wetland streams, or settings influenced by colluvium or glacial features.*
- *Determine the elevation of the highest active floodplain bench.*
- *Describe the bank erosion severity using both methods below. Refer to the WI Field Office Technical Guide, Section III >Erosion Prediction for erosion estimates.*
    - *Average annual rate of lateral migration (feet/year) measured at the apex of the channel bend using historic aerial imagery over a period of 20 years. This method may be excluded, or the evaluation period abbreviated, if imagery is unavailable or obscured by canopy. In this case, use the estimated age of trees bordering each side of the channel.*
    - *Bank Erosion Potential Index (BEPI) at the apex of the channel bend*
- *Describe the channel evolutionary stage (i.e. down-cutting, widening, aggrading, or stable) and indications of future direction. Refer to NRCS NEH Part 654.0305(c).*
- *Describe the type and cause of streambank instability. Determine the type of bank failure such as a shallow slip failure, cantilever failure, or rotational shear failure. Describe the cause of erosion such as concentrated flow around debris or sediment bars, seepage and soil piping, or high flow velocities along weak soil stratigraphy. Refer to NEH Part 653, Fig. 7-29.*

Perform a soils investigation along the planned improvement. Log the soil profile from the top of high bank to a depth of stable substratum using the Unified Soil Classification System. Identify the location and elevation of soil layers with seepage. Classify the bedload material.

Design streambank protection to be stable for all discharges from bankfull flow up to the 100-year flood or highest active floodplain bench. Estimate stream flows using the USGS Flood Frequency Characteristics of Wisconsin Streams or hydrologic models such as NRCS WinTR-20, WinTR-55, or USACE HEC-HMS.

Use the shear stress method to design rock riprap, soil bioengineering, or other protection components. Use a minimum safety factor of 1.2 for stability design. Refer to WI NRCS Website >Engineering > Spreadsheets >Streambank Protection, or NEH, Part 654, TS-14C for stone sizing criteria.

Extend inert bank protection to the elevation of bankfull flow or above. Limit structural treatment above the bankfull flow where vegetation establishment is adequate to stabilize the bank. Use a minimum slope of 1.5 horizontal to 1 vertical for rock riprap; 2:1 or flatter is recommended.

Do not install bank protection treatment in channel systems undergoing rapid and extensive changes in bottom grade and/or alignment unless designing the treatments to control or accommodate the changes. *Refer to Channel Bed Stabilization (Code 584).* Construct bank treatment to a depth at or below the anticipated lowest depth of streambed scour.

Refer to NRCS NEH, Part 654, TS-14B, or USACE EM 1110-2-1601, Chapter 3, Section IV for scour calculations. At minimum, key the treatment at least two feet below the streambed or into stable substratum. Investigate the thalweg for at least 150 feet downstream to anticipate advancing headcuts or knickpoints.

Start and end the treatment at a stable anchorage point, such as a crossover or well-vegetated bank. Key the upstream and downstream end of a revetment into the bank to prevent flanking by erosion. Consider the potential for lateral channel migration in determining the appropriate keyway depth. Key the ends of articulated concrete mats or gabion-type revetment at least 4 feet into the bank. Key the ends of a rock riprap revetment at least 2 times the blanket thickness into the bank—- a minimum length of 4 feet on each end.

Stabilize toe erosion by treatments that redirect the stream flow away from the toe or by structural treatments that armor the toe. Where toe protection alone is inadequate to stabilize the bank, shape the upper bank to a stable slope and establish vegetation, or stabilize with structural or soil bioengineering treatments.

Shape the vegetated portion of banks to a minimum slope of 3 horizontal to 1 vertical. A minimum 2:1 slope is acceptable for short reaches where physical structures, roadways, utilities, or property lines restrict space.

To the extent possible, retain or replace habitat-forming elements that provide cover, food, pools, and water turbulence. This includes stumps, fallen trees, debris, and sediment bars. Only remove these stream habitat elements when they cause unacceptable bank erosion, flow restriction, or damage to structures.

Design treatments to remain functional and stable for the design flow and sustainable for higher flow conditions. Evaluate the effects of changes to flow levels compared with the preinstallation flow levels, for low and high flow conditions. Ensure treatments do not limit stream flow access to the floodplain. Do not design treatments that result in negative offsite impacts such as increased channel or bank erosion downstream.

Evaluate the impact of flow-changing techniques (e.g. stream barbs) on the opposite bank. If the opposite bank is under different ownership, consult with that landowner about potential impacts. Refer to NRCS NEH, Part 650, TS-14H for flow-changing techniques.

***Critical Sites**. The following sites present a high risk of failure and require further analysis of the potential failure modes to ensure a stable design.*

- *Water surface slope > 0.8 percent*
- *Sites < 200 feet downstream from a bridge or culvert crossing*
- *Entrenched channels (floodprone width to bankfull width ratio <1.4) and headwater channels with colluvium cobbles and boulders. These conditions are indicative of Rosgen stream types (A, F, G, and D) at crossover sections immediately upstream and downstream of the channel bend.*

Flow at these sites is often classified as nonuniform, rapid, or supercritical. Flow is associated with high shear stress or heavy bedload. Consider a water surface profile model to evaluate a full range of flows to determine location and magnitude of sudden changes in water surface elevation (i.e. hydraulic jumps). Use the model to determine accurate flow parameters (e.g. energy slopes and depths) for rock size and scour depth calculations. This detailed hydraulic analysis may result in heavier revetment components, uniform rock gradations, flatter side slopes, or deeper keyways. Refer to USACE HEC-RAS software to develop a water surface profile model. Refer to rock sizing methods for hydraulically steep slopes, USACE EM 1110-2-1601, 3.7(e); bridge scour, FHWA HEC-23; and culvert discharge, FHWA HEC-14, Chapter 10. Refer to Open Channel (Code 582) when bank instability is caused by bedload transport issues; and Channel Bed Stabilization (Code 584) when the bank instability is caused by channel bed aggradation or degradation.

- *Home or building located near the top of bank.*

Conduct a geotechnical investigation and develop a slope stability model to determine the factor of safety when a home or building is located near the streambank. The distance of concern will vary depending on type of structure, bank slope, soil type, and presence of seepage, but will generally be horizontally within two to three times the height of the bank from the toe of the slope. Refer to NRCS NEH Part 631, Chapters 2 and 5 for Group B structures for geologic investigation guidance. Investigations typically include logging and sampling from top of bank to a depth below the thalweg. Soil tests typically include mechanical analysis and Atterberg Limits for Unified Soil Classification; in-place density, moisture content, and shear strength.

Additional Criteria for Shorelines

For the design of structural treatments, evaluate the site characteristics below the waterline for a minimum of 50 feet horizontally from the shoreline measured at the design water surface. Base the height of the protection on the design water surface plus the computed wave height and freeboard. Use mean high tide as the design water surface in tidal areas. Limit revetments, bulkheads, or groins to no higher than 3 feet above mean high tide, or mean high water in nontidal areas. Key-in structural shoreline protective treatments to a depth that prevents scour during low water.

When using vegetation as the protective treatment, include a temporary breakwater during establishment when wave run-up could damage the vegetation.

In addition to the assessment requirements under General Criteria, include the following information in the design report.

- *Landowner's objectives for protection, available materials for shoreline treatments, existing and desired riparian land uses, willingness to carry out maintenance activities, and special conditions.*
- *Elevation of the ordinary high water mark (OHWM) and range of lake level fluctuations.*
- *Height of watercraft waves and frequency of watercraft activity.*
- *Severity of shoreline erosion using average annual rate (feet per year) of shoreline recession with measurements from historic aerial imagery over a period of 20 years. This method may be excluded, or the evaluation period abbreviated, if imagery is unavailable or obscured by canopy. Refer to NRCS Field Office Technical Guide, Section III >Erosion Prediction for erosion estimates.*
- *Location, type, and quantity of existing shoreline protection adjacent to the site. Describe the effectiveness or success of those treatments.*
- *History of ice action or evidence of ice sheet thickness and push up elevations. This information may be determined from interviews.*
- *Type and density of riparian vegetation and invasive species.*
- *Lake designations: Areas of Special Natural Resource Interest (ASNRI), Outstanding Resource Waters (ORW), Exceptional Resource Waters (ERW), size and type of water body.*

Perform a soils investigation along the planned reach of protection. Log the soil profile from the top of bank to a depth of stable substratum. Use the Unified Soil Classification System. Identify the location, elevation, and soil layer(s) of observed seepage. Classify the littoral material.

Conduct a geotechnical investigation and develop a slope stability model to determine the factor of safety when a home or building is located near the shoreline escarpment. The distance of concern will vary depending on type of structure, bank slope, soil type, and presence of seepage, but will generally be horizontally within two to three times the height of the bank from the toe of the slope. Refer to NRCS NEH Part 631, Chapters 2 and 5 for Group B structures for geologic investigation guidance. Investigations typically include logging and sampling from top of bank to a depth below the lake bottom. Soil tests typically include mechanical analysis and Atterberg Limits for Unified Soil Classification; in-place density, moisture content, and shear strength.

Provide lakeshore protection to the highest elevation of the following:

- *OHWM plus the storm-wave height as specified in Wisconsin NR 328*
- *Height of watercraft generated waves*
- *Height of seep lines in the bank if not controlled by some other fashion*

Use a minimum slope of 1.5 horizontal to 1 vertical for rock riprap; 2:1 or flatter is recommended.

Additional Criteria for Stream Corridor Improvement

Establish stream corridor vegetative components as necessary for ecosystem function and stability. The appropriate composition of vegetative components is a key element in preventing excess long-term channel migration in reestablished stream corridors. Establish vegetation on channel banks and associated areas according to NRCS CPS Critical Area Planting (Code 342).

Design treatments to achieve habitat and population objectives for fish and wildlife species or communities of concern as determined by a site-specific assessment or management plan. Establish objectives on the survival and reproductive needs of populations and communities, including habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors, and native plant communities. Develop the requirements for the type, amount, and distribution of vegetation using the requirements of the fish and wildlife species or communities of concern.

Design treatments to meet aesthetic objectives as determined by a site-specific assessment or management plan. Establish aesthetic objectives based on human needs, including visual quality, noise control, and microclimate control. Use construction materials, grading practices, and other site development elements compatible with adjacent land uses.

CONSIDERATIONS

When designing protective treatments, consider changes that may occur in the watershed hydrology and sedimentation over the design life of the treatments.

Consider changes that may occur in the watershed hydrology, land use, and sedimentation due to climate change. The magnitude and duration of rainfall and streamflow events may have increased from historical averages. Use local forecasts of climate change in the design if available.

Incorporate debris removed from the channel or streambank into the treatment design when it is compatible with the intended purpose to improve benefits for fish, wildlife, and aquatic systems.

Use construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc. Avoid excessive disturbance and compaction of the site during installation.

Use vegetative species that are native and/or compatible with local ecosystems. Avoid introduced species that could become nuisances. Consider species that have multiple values such as those suited for biomass, nuts, fruit, browse, nesting, aesthetics, and tolerance to locally used herbicides. Avoid species that may be alternate hosts to disease or undesirable pests. Consider species diversity to avoid loss of function due to species-specific pests.

Select plant materials that provide habitat requirements for desirable wildlife and pollinators. The addition of native forbs and legumes to grass mixes will increase the value of plantings for both wildlife and pollinators. Consider and refer to NRCS CPS Wetland Wildlife Habitat Management (Code 644).

Use treatments that promote beneficial sediment deposition and the filtering of sediment and sediment-attached and dissolved substances.

Maintain or improve fish and wildlife habitat by including treatments that provide aquatic habitat in the treatment design and that may lower or moderate water temperature and improve water quality.

Stabilize side channel inlets and outlets, and outlets of tributary streams from erosion.

Maximize adjacent wetland functions and values with the project design to the extent practicable.

To maintain plant community integrity, exclude livestock during establishment of vegetative treatments and apply appropriate grazing practices after establishment.

Control wildlife during establishment of vegetative treatments. Use temporary and local population control methods with caution and within applicable regulations.

When appropriate, consider establishing a buffer strip and/or diversion at the top of the bank or shoreline protection zone to help maintain and protect installed treatments, improve their function, filter out sediments, nutrients, and pollutants from runoff, and provide additional wildlife habitat.

Consider the perennial vegetation requirement (35' min.) under Wisconsin NR 115.05(1)(c)2 "Minimum zoning standards for shorelands," in the operation & maintenance plan.

To the extent possible, excavate a floodplain bench to reduce the entrenchment ratio and stress on streambank protection measures.

Consider safety hazards to boaters, swimmers, or people using the shoreline or streambank when designing treatments. Place warning signs as necessary.

Consider installing self-sustaining or minimal maintenance treatments.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice according to this standard. Include provisions to minimize erosion and sediment production during construction and provisions necessary to comply with conditions of any environmental agreements, biological opinions, or other terms of applicable permits. At a minimum, include—

- A plan view of the layout of the streambank and shoreline protection.
- Typical profiles and cross sections of the streambank and shoreline protection.
- *If the planned treatment exceeds 300 feet, show a profile view along the channel improvement reach. Include the thalweg, top of high bank, bankfull elevation, vertical extent (top and bottom) of treatment and other planned structures. Include seepage locations and soil investigation logs.*
- Structural drawings adequate to describe the construction requirements.
- Requirements for vegetative establishment and mulching, as needed.
- Safety features.
- Site-specific construction and material requirements, *e.g. rock and bedding/filter gradations.*
- *Work limits —- extent of protection, ingress and egress locations for construction equipment, parking areas, borrow and spoil locations, areas of habitat requiring protection or avoidance (e.g. wetlands, regulated floodplains, riparian and upland areas, instream habitat), property lines, and buried/overhead utilities.*
- *Pollution control, e.g. staged construction, floating silt curtains, silt fences, erosion control wattles and logs.*

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator.

At a minimum, include—

- Instructions for operating and maintaining the system to ensure it functions properly.
- Periodic inspections and prompt repair or replacement of damaged components.
- Periodic inspections and prompt repair of erosion.
- Instructions for maintaining healthy vegetation, when required.
- Instructions for controlling undesirable vegetation.

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