TECHNICAL NOTES

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NRCS CALIFORNIA

PLANNING AND DESIGN GUIDE FOR STREAM CORRIDOR RESTORATION

Purpose

This document presents an approach for planning and designing a stream corridor improvement or restoration project. It is intended to organize and ensure consistency to NRCS's three-phase, nine-step planning process which is critical for a successful stream corridor project.

Introduction

Whether the cause of streambank damage is natural or induced, it can often be mitigated by considering a variety of approaches and applying one or more alternatives. It is important to understand that streambank erosion results from the complex interaction of onsite and offsite factors, and the cause of accelerated erosion rates is not always obvious. The complex nature of stream systems requires that any protection or restoration project be approached in an *interdisciplinary* fashion and that NRCS's three-phase, nine-step planning process be followed.

A well conceived and developed stream restoration or improvement plan is critical to the success of the project. It provides the framework for addressing issues, problems and needs. It prevents disjointed decision-making and facilitates the organization of the restoration activities. The evaluation portion of the plan allows for transfer of knowledge. These activities define a successful project.

The planning process is dynamic. As the process unfolds, it needs to be tailored to the client and the client's unique situation. The process must be flexible. Each planning phase or step is vital and should be revisited as needed to develop and implement a quality plan.

A common approach is to quickly identify a problem (planning step 1), immediately select an alternative (planning step 7) and install a practice (planning step 8). This approach may not identify or address the true cause(s) of the problem.

This Planning and Design Guide for Stream Corridor Improvement/Restoration lists resources and processes to consider when doing riparian corridor work. Supporting appendices include:

- Appendix A, Stream Corridor Improvement/Restoration Design Criteria
- Appendix B, Stream Corridor Improvement/Restoration Planning Activity Checklist
- Appendix C, Selected Definitions
- Appendix D, Selected References
- Appendix E, Operation and Maintenance

PHASE 1 - COLLECTION AND ANALYSIS

(UNDERSTANDING THE PROBLEMS AND OPPORTUNITIES)

Step 1- Identify Problems and Opportunities

- As an interdisciplinary team, visit with the client and/or land manager onsite to observe existing conditions at, above and below the project reach, and to collect information about recent channel adjustments or other changes that prompted the client to seek technical assistance;
- Generally assess onsite and offsite attributes that collectively define the existing condition and health of the riparian area;
- Draft a preliminary inventory of information and data required to adequately characterize physical and biological riparian processes, define the system's capability and potential, identify and evaluate problems and causes, and develop alternatives. List potential resources and data gaps.

Step 2 - Determine Objectives

- Determine client's goals;
- Identify other individuals and groups who are potentially impacted by existing resource problems and project implementation. Are the client's objectives compatible with the watershed/community goals?
- Identify concerns, actions and impacts that will be addressed.
- Document input from the client and land manager.

Step 3 - Inventory Resources (Stream Corridor Structure)

Resource inventories provide factual, objective data about the planning area and are vital for sound decision-making. Resource inventories detail the condition of soil, water, air, plant, animal and human resources (SWAPA+H). Resource inventories are needed to determine the severity of resource concerns, identify opportunities for improvement, and determine which strategies may be most appropriate given conditions in the planning area. They help local stakeholders understand human interactions with the environment, and interrelationships among resources in the planning area. Inventories provide a description of current conditions called "benchmarks" that are compared with the system's capability and potential, and with the desired future condition. Inventories are also used to forecast potential impacts resulting from various resource management alternatives.

The types of inventories should be based on resource problems and causes, the client's concerns and objectives, the complexity of the natural resource setting, and pertinent local, state and federal regulations.

The scope of the inventories will vary depending on the size of the watershed, the complexity of the natural resource setting, project costs, regulatory requirements, landowner willingness to accept risk, watershed/community issues and concerns, and the magnitude of the potential impacts of project implementation and possible project failure.

Factors to consider in inventories are cost, time involved and accuracy of information needed as well as the following:

RESOURCE INVENTORY INFORMATION

- Watershed/Area-wide plans
- Land Use and Management (Current and Historic)
- Historic, current and future land use and management
- Aerial Photography (Current and Historic)
- Watershed Geology and Soils
- Reference Reach(es)
- Hydrology - Historic and Existing Flows
  - Total (annual) discharge
  - Seasonal (monthly) discharge
  - Peak flows
  - Minimum flows
  - Annual flow durations
  - Rainfall records
  - Size and shape of watershed
  - Bankfull stage and discharge
- Erosion and Sediment Yield
  - Watershed cover and soil health
  - Dominant erosion processes
  - Rates of surface erosion and mass wasting
  - Sediment delivery ratios
  - Channel erosion processes and rates
  - Sediment transport functions
- Floodplain/Riparian Vegetation
  - Community type
  - Type distribution
  - Surface cover
  - Canopy
  - Community dynamics and succession
  - Recruitment and reproduction
  - Connectivity
  - Floodplain scour
  - Wetlands
- Channel Characteristics/Processes
  - Flow channel characteristics
  - Channel dimension, shape, profile, and pattern
  - Substrate composition (d-50)
  - Floodplain connectivity
  - Evidence of entrenchment and/or deposition
  - Lateral (bank) erosion
  - Channel avulsions/realignments
  - Meander/sinuosity and braiding processes
  - Depositional features
  - Scour-fill processes
  - Sediment transport class (suspended, bedload)
  - Valley type
  - Ice impacts
- Water Quality
  - Color
  - Temperature
  - pH
  - Dissolved oxygen
  - Suspended sediment
- Aquatic and Riparian Species and Critical Habitats
  - Aquatic species of concern and associated habitats
  - Riparian species of concern and associated habitats
  - Native vs. introduced species
  - Threatened or endangered species
  - Benthic, macroinvertebrate, or vertebrate indicator species
- Corridor Dimension
  - plan view maps
  - topographic maps
  - width
  - linearity etc.
- Cultural Resources
- Threatened and Endangered Species
- Environmental Compliance
- Wild and Scenic Rivers
- Federal, State, and local Permits

Catalog the related resource conditions and social conditions relevant to the identified problem(s), providing benchmark conditions that will be used in determining the effects and identifying impacts. Sufficient data and information should be gathered to analyze and understand the natural resource conditions of the planning area. Collect data on the reference reach. *Each situation is unique and detailed data gathering may not be needed for all sites.*

Step 4. Analyze Resource Data (Stream Corridor Function)

Resource data analysis is an important step in identifying resource problems and the significance of the problem. Many times the resource analysis will show that what was perceived as a problem is not a problem or not as severe a problem as originally envisioned. Studying the resource data reveals how individual resources relate to each other, and identifies causes and effects of problems. Analysis also helps the planning team present the information in a meaningful way to the client.

Evaluate the relevant resource conditions, noting limitations as to their use and potentials. Determine management influence on stream corridor conditions.

- **Watershed and Geomorphic Processes**
  - Stream classification
    - Stream order
    - Montgomery & Buffington
    - Channel Evolution Model
    - Rosgen
    - Others
  - Channel and Valley type
  - Hydrogeomorphic Assessment (HGM)
  - Regional curves for estimating channel dimensions
  - Meander geometry
  - Sediment load and bed material
  - Bank stability
  - Historic and recent channel changes

- **Hydrologic Processes**
  - Flow duration curve
  - Flow frequency analysis
  - Daily mean flow
  - Peak flow
  - Flood frequency analysis
  - Bankfull discharge
  - Mean annual discharge

- **Channel Hydraulics and Sediment Transport**
  - Channel grade
  - Discharge frequency
  - Discharge velocities
  - Alignment
  - Channel and Floodplain Roughness
  - Manning's equation
  - Energy equation
  - Sediment transport processes
  - Sediment rating curve

- **Biological Characteristics and Water Quality**
  - Eutrophication
  - BOD, COD, and TOC
  - Other potentially significant chemical constituents
  - Stream visual assessment protocol
  - EPA's rapid bioassessment protocol (CK)
  - Aquatic macroinvertebrates
  - Diversity index
  - Habitat
  - Plants
  - Fish and Wildlife

- **Ecological Function and Dynamic Equilibrium**
  - Habitat
  - Source
  - Sink
  - Barrier
  - Conduit
  - Filter

- **List of Causes for the Problems**

PHASE II - DECISION SUPPORT
(UNDERSTANDING THE SOLUTIONS)

Step 5 - Formulate Alternatives

Alternatives are the resource management options developed by the planning team and owner/land manager. Viable alternatives are those that can solve the problems and meet the objectives of the owner/land manager.

Develop alternatives that will achieve the objectives of the client, directly address the problems not just the symptoms, take advantage of the opportunities, and prevent problems from occurring. Although detailed design of the project will be finalized after Step 7, Make Decisions/Plan Selection, design criteria (Appendix C) should be integrated into the formulation of alternatives as it affects the outcome or viability of various alternatives.

Remedies should be multi-faceted and practices should be chosen to solve more than one problem if possible. Design to opportunities not to limitations. All activity must conform fully to the National Environmental Policy Act (NEPA) procedures (General Manual Part 190).

Step 6 - Evaluate and Compare Alternative Plan(s)

Determine the effectiveness of the alternatives and describe the potential impacts. Do the alternatives:

- meet the client's objectives?
- mitigate identified resource problems?
- address community/watershed issues and goals?
- recognize opportunities for additional enhancement?,.

Step 7 - Make Decisions/Plan Selection

Planner assists the client in selecting technically feasible alternative(s). The preferred strategies will be documented in the plan. The types and degrees of risk and uncertainty should be reported and displayed in a clear manner as part of the decision process. Special consideration should be given to managing causes as opposed to treating symptoms, and tailoring the design to the appropriate scale.

PHASE III - APPLICATION AND EVALUATION
(UNDERSTANDING THE RESULTS)

Step 8 - Implement Plan

Provide technical assistance for installing practices and obtaining needed permits, funding, land rights, surveys, final designs, inspections and operation and maintenance plans for installed practices.

Step 9 - Evaluate Plan

Evaluate the effectiveness of the implemented plan to ensure that it is functioning as planned and achieving the objectives.

The evaluation action plan will contain two types of objectives. These are *management objectives* and *evaluation objectives*. Management objectives measure the success of implementation. They may be used to answer questions like:

- What improvements are being made?
- Where in the watershed are improvements occurring?
- Are all elements of the plan being applied according to schedule or are some actions lagging?
- Are producers or landowners in some areas of the watershed more reluctant to participate?

Management objectives are helpful in fine tuning the plan and ensuring continued implementation.

Evaluation objectives measure the success of the plan in protecting or improving natural resources. They may be used to answer questions like:

- Were the assumptions, upon which the alternatives were formulated and selected, actually true?
- Have there been changes (e.g., new technology, new programs, changes in technical standards, etc.) that should be incorporated into the plan?

Evaluating objectives helps to redirect the plan if it is missing the target or if there are significant changes.

APPENDIX A

Stream Corridor Improvement/Restoration Design Criteria

DEFINITION

Restoration or improvement of a modified or damaged stream to a more natural state.

Scope

This criteria applies to measures used to reestablish a stream corridor, using a geomorphic approach for stability. Measures to protect the bed and banks can include vegetation, structures, or a combination of the two.

CRITERIA

Because each reach of stream is unique, measures for corridor improvement must be installed according to a plan adapted to the specific site.

Designs for stream corridors shall conform to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.
2. The channel grade must be controlled, either by natural or artificial means, before any permanent type of structural protection can be considered feasible, unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of streambed scour.
3. Stream corridor improvement shall be started at a stabilized or controlled point and ended at a stabilized or controlled point on the stream.
4. Needed channel clearing and removal of stumps, fallen trees, debris, and gravel bars that force the streamflow into the streambank shall be an essential element of the work.
5. Changes in channel alignment shall be considered only after an evaluation of the effect on the land use, interdependent water disposal systems, hydraulic characteristics, existing structures, and fish and wildlife habitat.
6. Structural and vegetative measures must be effective for the design flow and capable of withstanding greater flows without serious damage. They shall also be designed to avoid an increase in erosion downstream or upstream of the planned measures.
7. Vegetation shall be appropriate for the landscape setting. Vegetation shall consider diversity, natural revegetation, opportunity for recruitment, and maintenance.

Grazing Management

If the stream corridor is to allow grazing; a grazing management plan shall be prepared and be an integral part of the application of this practice. Deferred grazing may be necessary to maintain the vegetative cover necessary to protect against erosion.

Fish and Wildlife

Special attention shall be given to maintenance, improvement, and minimizing damage of existing habitat for fish and wildlife.

Landscape Resources

Considerations shall be given to the use of 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.

CONSIDERATIONS

Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, deep percolation, and ground water recharge.
2. Effects on downstream flows and aquifers that affect other uses and users.
3. Effects on the water table of adjoining fields.
4. Effects of watershed discharge into streams.

Water Quality

1. Filtering effects of vegetation on movement of sediment, and sediment-attached or dissolved substances.
2. Effects on erosion and movement of sediment, and soluble and sediment-attached substances carried by runoff and streamflow.
3. Effects on sediment intrusion into spawning grounds.
4. Effects of phasing and timing of construction and the establishment of vegetation.
5. Effects of changes in water temperatures.
6. Short-term and long-term effects on wetlands, fish habitat, and water-related wildlife habitats.
7. Effects on the visual quality of onsite and downstream water resources.

Cultural Resources Considerations

NRCS's objective is to avoid any effect to cultural resources and to protect them in their original location. Determine if installation of this practice will have any effect on any cultural resources.

Document any specific considerations for cultural resources in the design docket and the Practice Requirements worksheet.

GM 420, Part 401, the California Environmental Handbook and the California Environmental Assessment Worksheet provide guidance on how the NRCS must account for cultural resources. The Field Office Technical Guide, Section II contains general information, with Web sites for additional information.

Endangered Species Considerations

Determine if installation of this practice, along with any others proposed, will have an effect on any federal or state listed Rare, Threatened or Endangered species or their habitat. NRCS's objective is to benefit these species and others of concern, or at least not have any adverse effect on a listed species. If the Environmental Evaluation indicates that the action may adversely affect a listed species or result in adverse modification of habitat of listed species which has been determined to be critical habitat, NRCS will advise the land user of the requirements of the Endangered Species Act and recommend alternative conservation treatments that avoid the adverse effects. Further assistance will be provided only if the landowner selects one of the alternative conservation treatments for installation; or at the request of the landowners, NRCS may initiate consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service and/or California Department of Fish and Game. If the Environmental Evaluation indicates the action will not affect a listed species or result in adverse modification of critical habitat, consultation generally will not apply and usually would not be initiated. Document any special considerations for endangered species in the Practice Requirements Worksheet.

PLANS AND SPECIFICATIONS

Plans and specifications for stream corridor improvement shall be in keeping with this standard or the standard for the component practice and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan will be prepared by the designer. The plan shall outline the minimum requirements needed for the corridor to function properly for the designed life period.
The maintenance plan is to include periodic inspections to observe performance and to identify need for repair or a change in management practices. Necessary maintenance and/or repair activities are to be initiated promptly.

APPENDIX B

STREAM CORRIDOR IMPROVEMENT/RESTORATION PLANNING ACTIVITY CHECKLIST

Pre-Planning:

Working with People

- ☐ Request for assistance received
- ☐ Initial planning area boundary established
- ☐ Interdisciplinary team formed

Planning
Phase I

1. Identify Problems and Opportunities

- ☐ Draft list of major problems (scoping) and opportunities created

2. Determine Objectives

- ☐ Major problems or opportunities restated as objectives

3. Inventory Resources

- ☐ Conditions needing to be inventoried identified including related ecological, social and economic factors
- ☐ Inventory techniques are selected and consistent with accuracy, available time, staff and funding
- ☐ Inventories conducted to determine current conditions and causes of impairment

4. Analyze Resources Data

- ☐ Existing conditions compared to Desired Future Conditions (DFCs) and Quality Criteria (QCs) and deficiencies and needs noted
- ☐ Causes of impairment validated
- ☐ At risk ecological, social and economic conditions and interactions with DFCs and QCs determined

Phase II

5. Formulate Alternatives

- ☐ All reasonable, acceptable measures, practices, and management identified and clearly documented

6. Evaluate Alternatives

- ☐ Consistent evaluation of all alternatives made (effectiveness, profitability, acceptability, environmental impact, etc.)
- ☐ Documentation of effects on critical ecological, social and economic factors (NEPA requirements as applicable)

7. Make Decisions

- ☐ Select alternatives that meet objectives, DFCs/QCs and other criteria

Phase III

8. Implement Plan

- ☐ Identify strategies and methods to carry out decision (e.g., information-education, financial assistance, technical assistance for consultation, regulatory)
- ☐ Develop schedule and carry out strategies

9. Evaluate Plan

- ☐ Determine application rate of decisions
- ☐ Determine achievement of DFCs/QCs
- ☐ Need for iterative planning and adaptive management determined

APPENDIX C

Selected Definitions

Altered reach--A length of stream impacted by natural or man induced activity.

Bankfull depth--The maximum depth at a section measured at bankfull discharge.

Bankfull discharge--In natural streams, it is the discharge that fills the channel without overflowing onto the flood plain and determines the stream's geomorphic planform dimensions. Bankfull discharge of natural streams tends to have a recurrence interval of one to two years based on the annual flood series.

Bankfull stage--The elevation of the water surface associated with the bankfull discharge.

Bankfull width--The stream width at bankfull discharge.

Belt width--The width of the full lateral extent of the bankfull channel measured perpendicular to the fall of the valley.

Bendway Weir--A flat or nearly flat low level rock sill projecting upstream 10° to 30° from a line perpendicular to the bank at the junction of the sill to the bank (i.e., 60° to 80° out from the bank extending upstream) for the purpose of redirecting stream flows. The sill length should not exceed one-third the mean channel width.

Crossover (or Inflection Point)--The point of change in curvature in the stream flow meander where the thalweg moves from one side of the stream to the other.

Cross Vane--An in-stream structure constructed across a stream which provides grade control and elevates upstream water surfaces while reducing near bank stress. The structure is trapezoidal in plan view with the narrow cross-stream member upstream of the base.

Entrenchment--The vertical containment of a channel and the degree to which it is incised in the valley floor.

Entrenchment ratio--The ratio of the width of the flood-prone area to the bankfull surface of the channel.

Flood prone width--The width measured at an elevation, which is determined at twice the maximum bankfull depth.

Geomorphology--The study of the characteristics, origin, and development of land forms.

Glide--A wide uniform channel bottom with low to moderate velocities, lacking pronounced turbulence.

Mean radius of curvature--The radius of a partial circular arc, which approximates the centerline of a stream meander curve.

Meander wavelength--The straight-line interval length of one complete sinusoidal cycle of stream bends.

Pebble count--A method of field classification of channel materials to determine the frequency distribution of particle sizes. Data is plotted as cumulative % and % of total distribution. (Example: D50 (median size) a size that 50% of the particles are the same size or finer.)

Pool--A deeper reach of slower velocity, lower gradient water.

Reference reach--A stable length of stream near the altered reach, or a stable reach on a nearby stream which has geomorphic characteristics like those of the altered reach with respect to area, depth, slope and discharge hydrology.

Riffle--A swiftly flowing reach of turbulent water with exposed substrate.

Run--A swiftly flowing reach with little surface agitation and no major flow obstructions.

Sinuosity--The ratio of stream length to valley length. Can also be described as the ratio of valley slope to channel slope.

Slope--The difference in water surface elevation per unit stream length for at least 20 channel widths (or 2 meander wavelengths).

APPENDIX D
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- Conservation Corridors Planning at the Landscape Level: Managing for Wildlife Habitat
- STREAM*A*SYST:
- Stream Corridor Inventory and Assessment Techniques
- Watershed Condition Series
- Assessing Conditions of Riparian-Wetland Corridors at the Areawide Level
- Let Rivers Teach Us: A paper presented by Luna Leopold

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OPERATION AND MAINTENANCE

Stream channel restoration/improvements require periodic operation and maintenance to ensure success of the project. Any repairs should be based on a careful analysis. Some readjustment is to be expected, and a continuing dynamic behavior is fundamental to successful restoration. Because establishment of a dynamic equilibrium condition is usually the intent, maintenance should be limited to actions that promote self-sustainability.

To the extent feasible, the entire stream corridor should be inspected annually to detect areas of rapid bank erosion or debris accumulation. A general inspection can also identify inappropriate land uses, such as encroachments of roads near banks, or uncontrolled irrigation water returns, that might jeopardize restoration measures, affect water quality, or otherwise interfere with restoration objectives.

A good operation and maintenance plan includes:

GENERAL RECOMMENDATIONS

- Inspect the integrity of fences, access roads, water access, crossings and other livestock control measures. Replace or repair as necessary.
- Soil bioengineering measures should be assessed during drought and immediately after high flows. Inspection of bank and channel measures should be conducted during low-water conditions to allow viewing of the measure as well as changes to the stream bed that may affect future integrity of the system. Early failure is an inherent risk of soil bioengineered structures systems that are not fully effective until the plants are well rooted and the stems reach a particular size and density. Repair and replant as required.
- Periodically remove bars that can cause reduced capacity and damage to stream channel stability and bank protection taking into consideration fish habitat, fill and removal permit regulation and period of the year work can be performed in the water portion of the stream.
- Routine maintenance of vegetation includes removal of hazardous trees and branches that threaten safety, buildings, fences, as well as vegetation along road shoulders, trails and similar features. Maintain vigorous growth of desirable vegetative coverings. This includes reseeding, fertilization, and controlled application of herbicides when necessary. Periodic mowing may also be needed to control height.
- Eradicate or otherwise remove all rodents or burrowing animals as their burrows may weaken earthen sections and develop flow paths for water and accelerate soil erosion or failure. Immediately repair any damage caused by their activity.
- Immediately repair any vandalism, vehicular, or livestock damage.
- Remove excess debris that may accumulate on or in the immediate area any structure.
- All fences, railings, and/or warning signs shall be maintained to provide warning and/or prevent unauthorized human or livestock entry.
- Check all timber or lumber sections for decay and other damage, especially sections in contact with earth or other materials. Repair damaged sections.
- Control livestock access to the structure. Livestock may be injured. Repair damaged vegetation and earthfills or accelerated soil erosion caused by livestock.

- Annually clean and repair restoration measures placed to benefit fish and wildlife (e.g. nest boxes and platforms, waterers). Repair or replace restoration materials displaced by erosion, animals, vehicles and vandalism.
- Maintain grade control structures necessary for stream bottom and bank stability.
- Maintain stream bank protection facilities, i.e. rock jetties, bank riprap, rock barbs, log revetments, etc.

ADDITIONAL SITE SPECIFIC OPERATION AND MAINTENANCE ITEMS WILL BE DEVELOPED FOR EACH INDIVIDUAL PROJECT.