Mobile District Guidelines for Stream Mitigation Design

Introduction

The following information is intended to give the stream designer an outline of the minimum information requirements needed by the Corps of Engineers in reviewing any proposed stream mitigation project. For instream channel restoration, there is no "one size fits all" simple approach to address achievement of a successful project. River corridors, and the channels which convey water and sediments through the corridors, are dynamic and influenced by an array of physical and ecological processes related to regional climate, geology, hydrologic regimes, hydraulics, geomorphic channel processes, connectivity to floodplain and riparian zones, and anthropogenic stressors within the upstream watershed. For each project, it will be important to take into consideration the effects of upstream land use changes on downstream delivery of water flow and sediment, particularly when developing the final instream restoration design to achieve a stable stream restoration project.

As a matter of policy, the Corps will determine, on a case-by-case basis, the net benefit of mitigation actions that do not involve direct manipulation of the entire length of stream. Stream creation other than for stream relocation or Priority 1 restoration is not authorized. Riparian buffer preservation may account for no more than 30% of credits generated by the mitigation plan. In-stream mitigation within 300 feet of a culvert, dam, or other man-made impact to waters of the United States generally will generate only minimal enhancement credit.

All restoration and enhancement measures should be designed with the goal of improving the entire stream system within a target stream reach. Designs should be based upon using approved reference stream systems to properly determine stable stream pattern, profile, and dimension, stable stream bank design, and target habitats. The same reference reach strategy can be used to identify the target vegetative species composition, density, and diversity within the adjacent riparian buffer ecosystem.

The level of detail required in a mitigation plan will be commensurate with the complexity of the mitigation project. All compensatory mitigation sites must be deed protected using either a conservation easement or restrictive covenant. The conservation easement or restrictive covenant must be approved by the Corps prior to being properly recorded with the appropriate local entity and it is highly recommended projects use the Mobile District's template found on the Mobile District web page at http://www.sam.usace.army.mil/RD/reg/.

Natural Stream Channel Design

Due to the variation in regional physical and ecological processes acting upon and affecting stream systems, natural stream channel design is the preferred approach endorsed by the Mobile District. This approach incorporates regional data from similar stream and valley-type, using a stable "reference reach", or reaches, near the restoration site to be used as a template for designing appropriate pattern, profile, dimension, and habitat characteristics for a stream restoration project. Reference reaches are streams of the same type (and possibly order) and position within the watershed that exhibit the least altered condition with stable stream pattern, profile, dimension, and appropriate substrate and habitat.

To provide a consistent and standardized framework for communicating stream information when presenting an instream channel restoration project, applicants should discuss the existing stream type and condition, preferably using the standardized Rosgen stream classification system and the current stage using the Lane Stream Channel Evolution Model. This discussion should center on the assessment of the upstream watershed issues that could influence stream hydrology and sediment load, verification of bankfull indicators, and a geomorphic stability assessment of the current stream dimension as well as pattern and profile. Vertical stability metrics include, but are not limited to, width depth ratio, bank height ratio, and the stream entrenchment ratio. Lateral stability metrics include, but not limited to, slope, riffle and pool bed features, sinuosity, meander width ratio, and radius of curvature (see appendix B Summary Data Worksheet). There may be instances, particularly when there is a significant level of degradation of the stream channel, where applicants may be requested to discuss a hydraulic assessment to quantify flood stage, stream velocity, sheer stress and stream power. The level of information collected will be commensurate with the level of instream features proposed for restoration. The following sections provide a helpful outline of the information needed for adequate review of stream restoration projects. Generally, all of the following information is required; however if the stream designer has cause and rationale for excluding some information they can submit a request for consideration.

1. Watershed Assessment

The watershed assessment provides information regarding how activities (i.e., development and agriculture) in the upstream watershed influence stream restoration goals and objectives. For significantly degraded streams, the watershed assessment may require hydrologic calculations to assess channel hydraulics and floodplain access. A comprehensive hydrologic evaluation may not be necessary for projects which have gage station or regional curve data, an undeveloped (i.e., forest) surrounding land-use cover, or have unaltered access to a floodplain. Information for the watershed assessment, at a minimum, is as follows:

a) Identify project watershed drainage area
b) Identify past, current and planned land use(s) and land cover(s) in the upstream watershed
c) Discuss surrounding land use and land cover trends for the project
d) Discuss soils and geology for the watershed and project site
e) Discuss the climate characteristics of the watershed
f) Discuss the topography of the watershed and project site (e.g., basin relief, basin shape, Rosgen valley type, etc.)
g) Discuss the flow regime and drainage characteristics of the watershed above the project site (e.g., drainage density, length of natural stream channel, length and relative amount of impacted reaches.)

2. Existing Stream Assessment

A baseline assessment of the stream itself should be completed prior to beginning the design of a stream restoration project. The stream assessment will evaluate the current vertical and lateral stability of the stream and identify any causes of departure from target stable stream conditions. Stream assessment metrics must be science-based, but also practicable, repeatable and appropriate for future comparative analysis (see appendix B Summary Data Worksheet).

a) Identify Rosgen stream type and Lane’s stream evolution stage.

b) Identify any impairment to stream pattern, profile, dimension, or stream characteristics (e.g., vertical instability, lateral instability, stream habitat).
c) Identify the magnitude of stream impairment (e.g., localized or widespread).
d) Identify the cause(s) of the stream impairment.
e) Discuss bankfull indicator characteristics and bankfull discharge.
f) Discuss how bankfull determination results were identified and validated (the accurate identification of bankfull is critical to assessing the appropriate stream classification, its current condition, and its departure from a potential stable state. The validation of bankfull is often a comparison to a regional bankfull and channel characteristic curve, however a more intensive validation may be required for a more complex site).
g) Discuss channel bed substrate and methods used to determine appropriate channel bed materials.
h) Provide discussion of hydrologic analysis of critical flows including frequency of bankfull events as well as extent and flows for the 2-year; 5-year; 10-year; 50-year; and 100 year flood events. This discussion should include the method used to determine this information.
i) Hydraulic analysis may be requested on significantly degraded stream channels and will be requested on a project-by-project basis.
h) Provide a detailed basemap that shows the existing stream reach, existing channel alignment, utilities, large trees, roads, wetlands, property boundaries, and any other physical elements which might affect the design of the stream restoration project. The basemap is also used to associate the documentation of the stability and geomorphic assessment results (e.g., the location of eroding banks, head cuts, and cross-section data points).

3. Stream Restoration Design Phase

a) Restoration objectives

Developers of stream restoration projects should utilize available information collected within the watershed, existing stream, and reference reach streams for assessing the cause(s) and levels of stream impairment and appropriate goals and objectives for the stream restoration project. The objectives should be both well defined and have measurable performance standards to evaluate their success. Both temporal and spatial objectives may be developed that are reflective of the goals of the overall restoration process. In addition to identifying the objectives of the project, the stream restorationist should also identify and discuss project limitations. There may be physical limitations which may affect the design, such as historical structure preservation, property access, or infrastructure conflicts. The design should address both objectives and limitations of their stream restoration project. The following provides examples of stream restoration objectives which should be identified early in the project development phase (amended from Eng et.al. 2009):

<u>Stream Mitigation Project Objectives </u>(select all appropriate objectives for a project)

Hydrologic Objectives

1. Restore flood flows above the bankfull stage to an abandoned floodplain. Convert a terrace into an active floodplain by raising the channel bed and associated water

table.
2. Restore channel-forming flows to the appropriately sized channel.
3. Restore wetland and floodplain hydrology to meet the U.S. Army Corps of Engineers definition of a wetland.
4. Dissipate flood energy by creating a meandering channel and new floodplain at the existing bankfull elevation. Partially restore lost floodplain and wetland functions.
5. Dissipate flood energy by creating a step-pool channel and floodplain bench at the existing bankfull elevation. Restore floodprone area functions.
6. For urban channels, restore bankfull discharge to pre-development levels by providing grade control and/or recreating large floodplains.
7. Create a riparian buffer to reduce flood velocities on the floodplain and encourage infiltration and sediment deposition.

Fluvial Geomorphologic Objectives
8. Create a stable channel (pattern, profile, and dimension) that neither aggrades nor degrades over time.
9. Create streambanks that do not erode at rates above natural levels for reference reach streams of the same stream type.
10. For alluvial systems, restore a riffle-pool bedform sequence such that the pool to pool spacing and percent riffle-pool matches' reference reach streams of the same stream type.
11. For colluvial systems, restore a step-pool bedform sequence such that the pool to pool spacing matches reference reach streams of the same stream type.

Biological Objectives
12. Create instream features and structures to increase aquatic habitats within a stream reach.
16. Create a riparian buffer using native plants to improve channel shade, terrestrial habitat, and improve water quality.

b) Use of reference reaches data for design criteria

The collection of reference reach data and the subsequent development of design criteria are important to the natural channel design process because the criteria provide the template for design of the restored channel dimensions, pattern and profile, as well as appropriate aquatic habitat types.

At a minimum the discussion of the reference data should include:

a) Stream metric data presented at the same level of detail as reach data for the impaired/proposed restoration reach (Appendix B Summary Data Worksheet).
b) Discuss the suitability of the reference reach as an appropriate design template.
c) Identify any limitations to reference reach data and discuss how the restoration design addresses these limitations.
d) Develop and document proposed design criteria of pattern, profile, and dimension. Provide discussion of appropriate stream channel substrate and stream habitat.

c) Conceptual Stream Design

For a mitigation bank or in lieu fee project, the conceptual stream designs should be submitted with the Prospectus. The conceptual designs must be submitted early in the permit evaluation process for permittee responsible compensatory mitigation.

Conceptual designs should include:

a) A general location map showing the location and directions to the restoration project.
b) Detailed scale map(s) of restoration project reach showing existing conditions, utilities, delineated wetlands, existing 100-year FEMA floodplain boundary, any additional waters of the U.S., and major topographic features such as roads and buildings, etc.
c) Scale map(s) of the restoration reach showing existing and proposed stream alignment (pattern).
d) Longitudinal profile of existing and proposed conditions showing channel thalweg, and bankfull stage, proposed bankfull width and type and location of instream structures
e) Typical before and after cross sectional designs (dimension)
f) Provide a conceptual level stream flow analysis to evaluate existing and proposed stream flows at bankfull, and provide a discussion how they were incorporated into proposed stream designs.
g) Provide a conceptual analysis of sediment transport issues by identifying the status of the existing sediment supply and competency, and whether the stream is aggrading or degrading. This section should also address the ability of the stream restoration design to address any aggradation or degradation issues.

5) SIXTY PERCENT DESIGN PLAN

For a mitigation bank or in lieu fee project, the 60% stream designs should be submitted with the Mitigation Banking Instrument or Project Management Plan. The design plans must be submitted during the permit evaluation process for permittee responsible compensatory mitigation. The sixty percent design and accompanying documentation are required for all projects that propose stream channel modifications. The 60% design plans will build upon the conceptual design plans and incorporate with the reference reach information by including alignment geometry (pattern), proposed grading and sloping, revised longitudinal profiles, detailed cross sectional (cut sheets) designs (dimensions), target benthic substrate, target stream habitats, erosion and sediment control plans, and the riparian buffer management plan. If requested, the 60% design plan will include the results of the hydrologic and hydraulic analysis along with the results of the flood modeling and sediment transport analysis.

a) Sixty percent design plans include:
    - A detailed revised scale map(s) of the stream restoration reach showing existing conditions, utilities, delineated wetlands, existing 100-year FEMA floodplain boundary, any additional waters of the U.S., and major topographic features such as roads and buildings, etc.

- A detailed revise scale map(s) of the steam restoration reach showing proposed conditions including the stream alignment, proposed bankfull width, detailed grading, type and location of instream structures and proposed FEMA 100-year floodplain boundaries
- A revised longitudinal profile of existing and proposed conditions showing channel thalweg and bankfull stage, utilities and instream structure locations, and the alignment geometry.
- Typical riffle and pool cross sections designs reflecting existing topography and proposed grading
- Instream structure details and design
- A time sequence of construction and construction specifications

b) Erosion and sediment control plans

c) Maintenance Plans

d) Hydrologic and Hydraulic Analysis Report (certain components of the analysis may be requested on a project-by-project basis depending on the condition of the stream channel). The hydrologic and hydraulic analysis will evaluate flood stages, (stream velocity, shear stress, and stream power if requested) and compare existing with reference stream and proposed flood stage conditions. The analysis will also evaluate and compare existing and proposed sediment transport, both competency (i.e., size) and capacity (i.e., load). The method used to evaluate the hydrology, hydraulics and sediment transport must be stated and explained. The hydrologic and hydraulics analysis will include (at a minimum):
    - Review existing FEMA floodplain studies and include a discussion of the existing floodplain model and discharges used to develop existing floodplain limits
    - Document the development of a revised existing floodplain model based on revised discharges, and the floodplain model used (if the existing FEMA floodplain delineation is inaccurate)
    - Prepare water surface profiles for the existing floodplain model, and the revised or new proposed floodplain model
    - Discuss any changes in floodplain limits. It must be demonstrated that proposed profiles and data are consistent with floodplain management requirements
    - Discuss any changes in stream sediments and sediment transport capacity

If requested, the following comparative hydrologic and hydraulic analysis will also be included in the 60% design plan:

- Prepare a tractive force analysis that evaluates boundary shear stress for existing and proposed reference condition;
- Compare existing and proposed shear stress
- Compare existing and proposed stream power and stage or discharge
- Determine the appropriate sediment transport capacity and competence for the stream
- Document that the proposed design will provide the correct sediment transport capacity and competence.

6) Proposed 60% Design Plan Requirements (Required in approved mitigation bank MBI's and In-Lieu Fee Project Management Plans)

Cover Sheet
- Project name, owner contact, design firm contact

Table of contents
Introduction
- Project summary
- Scaled detailed vicinity map containing north arrow
- Aerial plan view of site, project boundaries, GPS coordinates

Boundary Survey Plans
- North arrow, drawing scale, graphic scale
- Boundary description
- Road names, stream names, area of tract
- Reference survey notes and dates
- Easements, utilities, restrictions, sensitive areas (cultural resources)

Topographic Survey
- Location of streams and wetlands (including reference sites)
- Detailed topographic map showing areas of in-stream restoration or enhancement
- FEMA floodplain boundaries
- Current and historic aerial or other data sources

General Description of Work
- For each stream, a description of the linear feet of in-stream restoration or enhancement and more specific priority type
- For each stream, a description of the linear feet of stream requiring structure removal
- For each stream, a description of the lengths and widths of riparian buffer restoration, enhancement, or preservation
- General sequence of construction and construction specifications

Stream Specific Restoration Detail Plans
- Scaled site plan views showing locations of stream restoration, enhancement, or preservation polygons along each stream reach
- Site plans showing locations of reference reaches
- Completed Appendix B Data Summary Worksheet for current, proposed, and reference reach streams
- Scaled site plans showing locations of existing and proposed stream alignment, bankfull widths, channel thalweg, and type and location of instream structures
- Scaled stream plans reflecting comparison of existing and proposed pattern, profile, and dimension. At minimum, typical cross sectional dimensions for riffles and pools (or ripple and pool in low gradient streams) that include bankfull dimensions
- Design plans for proposed in-stream structures and their specifications
- Bank stabilization plans
- Erosion control plans
- Maintenance Plan

Riparian Buffer Detail Plans. All streams proposed as mitigation must be protected with riparian buffers. Except for urban streams, the minimum riparian buffer that can be placed on a stream is 50 feet. Riparian buffer restoration and enhancement actions and target ecological performance standards should be based upon success criteria developed for each wetland type by the Mobile District and found on the Regional Internet Banking Information Tracking System (RIBITS) on the Mobile District Regulatory Division website.

- Scaled site plan views showing locations of riparian buffer restoration, enhancement, or preservation polygons along each stream reach
- Proposed Riparian buffer land management strategy and success criteria
- Upland riparian buffer restoration and enhancement and target ecological performance standards should be based upon target species composition, diversity, and structure metrics similar to that required for forested wetlands, gathered from high quality reference upland riparian buffers in the same watershed.

Summary Data Worksheet (next page). The following worksheet must be completed and provided for any in-stream mitigation proposal. For mitigation banks and in-lieu fee projects, the sheet must be provided for any request for a project success determination, and request for a stream credit release associated with in-stream work by a mitigation bank.
A data sheet should be completed for each established cross section along the restored reach

Parameter	Existing Stream			Design Stream			Reference Stream		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
Stream name									
Stream type									
Drainage area, DA (sq mi)									
Mean riffle depth, d_{bkf} (ft)									
Riffle width, W_{bkf} (ft)									
Width-to-depth ratio, [W_{bkf}/d_{bkf}]									
Riffle cross-section area, A_{bkf} (sq ft)									
Max riffle depth, d_{mbkf} (ft)									
Max riffle depth ratio, [d_{mbkf}/d_{bkf}]									
Mean pool depth, d_{bkfp} (ft)									
Mean pool depth ratio, [d_{bkfp}/d_{bkf}]									
Pool width, W_{bkfp} (ft)									
Pool width ratio, [W_{bkfp}/W_{bkf}]									
Pool cross-section area, A_{bkfp} (sq ft)									
Pool area ratio, [A_{bkfp}/A_{bkf}]									
Max pool depth, d_{mbkfp} (ft)									
Max pool depth ratio, [d_{mbkfp}/d_{bkf}]									
Low bank height, LBH (ft)									
Low bank height ratio, [LBH/d_{mbkf}]									
Width flood-prone area, W_{fpa} (ft)									
Entrenchment ratio, ER [W_{fpa}/W_{bkf}]									
Bankfull discharge, Q_{bkf} (cfs)									
Meander length, L_m (ft)									
Meander length ratio [L_m/W_{bkf}]									
Radius of curvature, Rc (ft)									
Radius of curvature ratio [Rc/W_{bkf}]									
Belt width, W_{blt} (ft)									
Meander width ratio [W_{blt}/W_{bkf}]									
Pool length, L_p (ft)									
Pool length ratio [L_p/W_{bkf}]									
Pool-to-pool spacing, p-p (ft)									
Pool-to-pool spacing ratio, [$p\text{-}p/W_{bkf}$]									
Stream length, SL (ft)									
Valley length, VL (ft)									
Valley slope, VS (ft/ft)									
Average water surface slope, S (ft/ft)									
Sinuosity, k = SL/VL (ft/ft)									
Riffle slope, S_{rif} (ft/ft)									
Riffle slope ratio, [S_{rif}/S]									
Run slope, S_{run} (ft/ft)									
Run slope ratio, [S_{rif}/S]									
Pool slope, S_p (ft/ft)									
Pool slope ratio, [S_p/S]									
Glide slope, S_g (ft/ft)									
Glide slope ratio, [S_g/S]									
Riffle length, L_{rif} (ft)									
Riffle length ratio, [L_{rif}/W_{bkf}]									