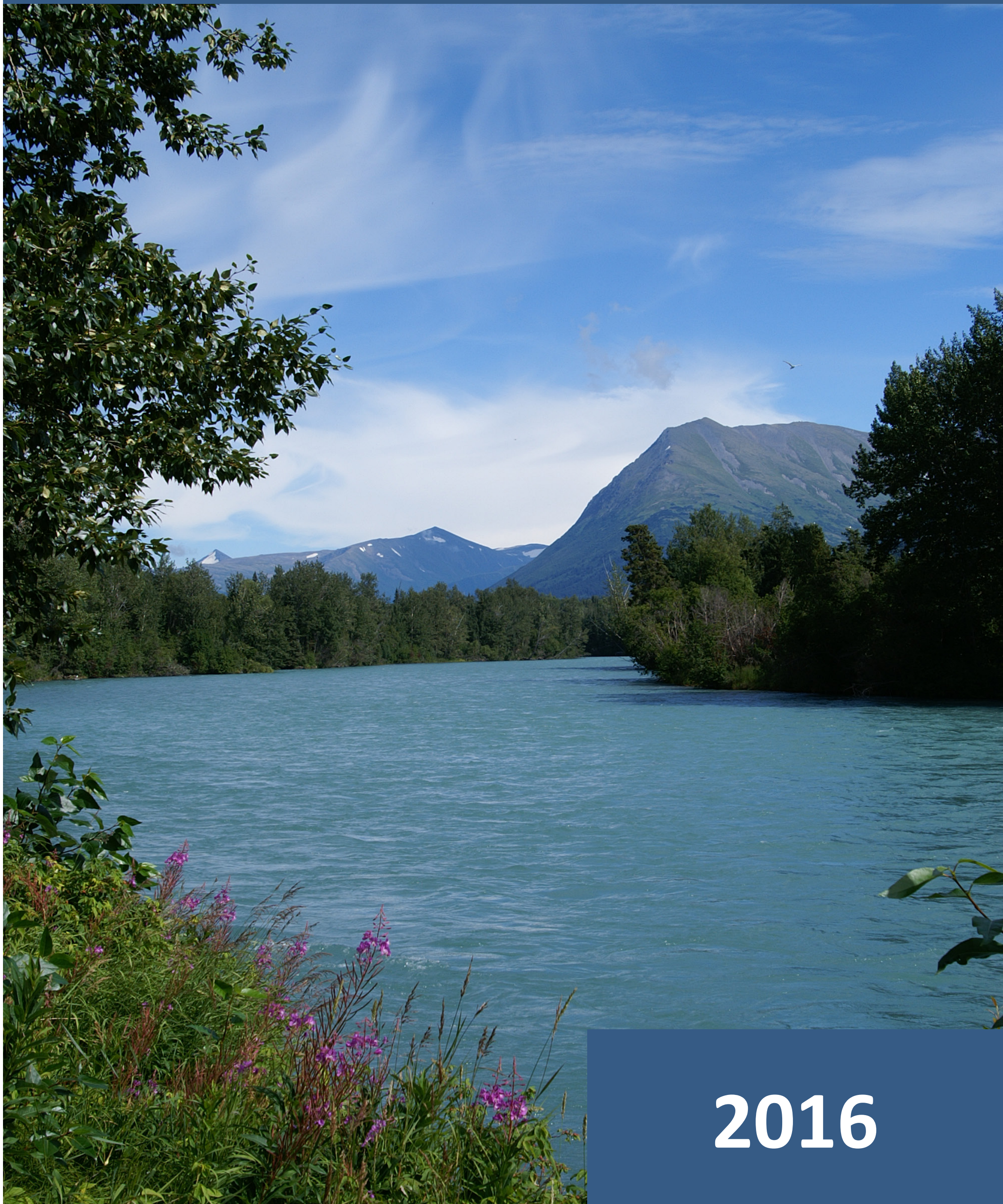
Stream Mitigation: Science, Policy, and Practice

Environmental Law Institute, Stream Mechanics, and The Nature Conservancy



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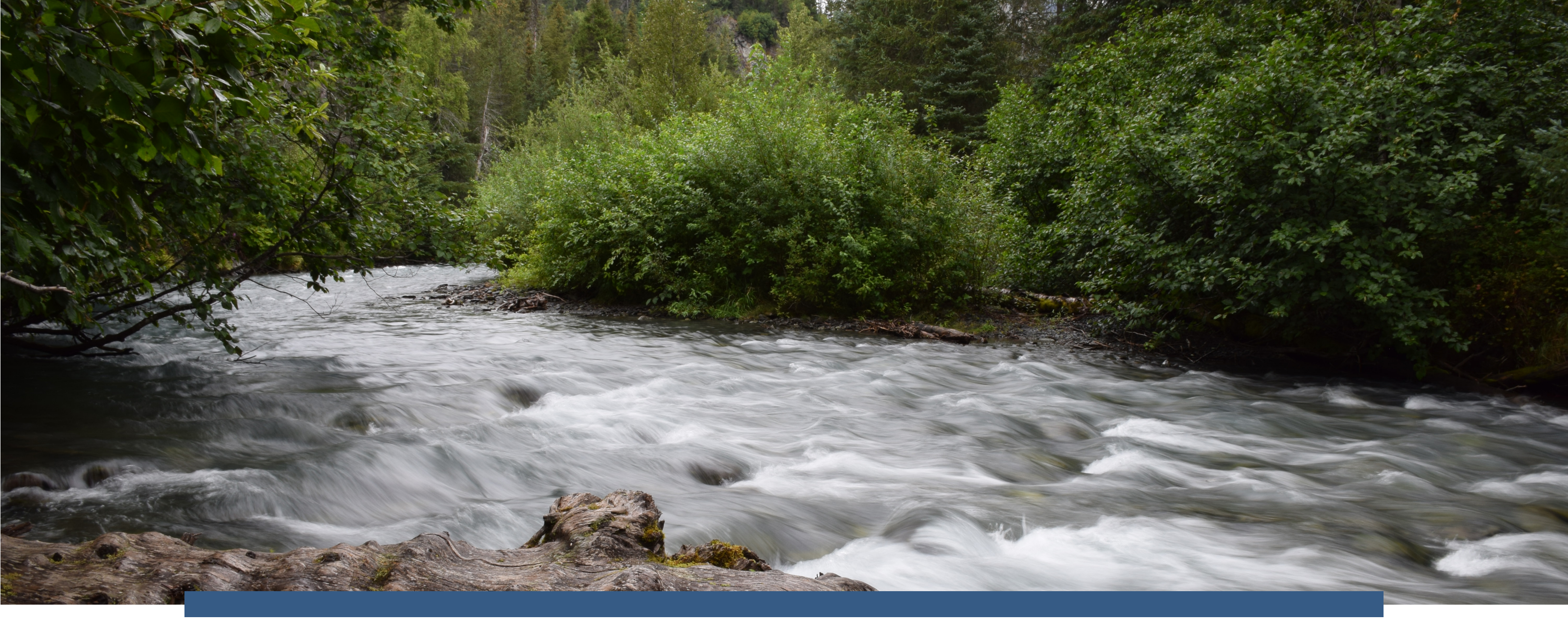

INTRODUCTION

In 2008, the U.S. Army Corps of Engineers (Corps or USACE) and the U.S. Environmental Protection Agency (EPA) released regulations on compensatory mitigation under Section 404 of the Clean Water Act (33 C.F.R. Parts 325 and 332; 40 C.F.R. Part 230 Subpart J). These regulations ("the 2008 Rule") were intended to improve compensatory mitigation planning, implementation, and management by applying similar standards to all compensation projects and emphasizing a watershed approach to selecting project sites (USACE-EPA 2008). The Rule also clarified the agencies' interest in requiring compensation for impacts to streams. At the same time, stream compensation has been on the rise, as demonstrated by an increase in the percentage of mitigation banks and in-lieu fee programs that provide credits for impacts to streams. The Environmental Law Institute (ELI) reported that in 2005, 12 percent of all approved mitigation banks provided stream credits (Wilkinson and Thompson, 2006).[1] By the end of 2014, the Corps reported that 22 percent of all approved mitigation banks provided stream credits (USACE, Institute for Water Resources, 2015).

As the science of stream restoration continues to evolve rapidly, so too does the development of state and Corps policies governing stream assessment and compensation requirements. Thirteen states have formalized stream mitigation programs, the majority of which were initiated after the Corps and EPA issued the 2008 Rule (ASWM, 2014), and at least 32 stream mitigation guidance documents and policies have been developed by states and Corps districts across the country. Even so, many decisions are still made on an ad hoc basis, depending on a regulator's own experience or expertise, and there are few resources available to guide the development of science-based policy on stream assessment and mitigation.

ELI, Stream Mechanics, and The Nature Conservancy (TNC) have partnered to provide a wide-ranging view of the state of stream compensatory mitigation. This report examines how stream compensatory mitigation has evolved in policy and practice in the more than eight years since the 2008 Rule; identifying trends, areas for improvement, and best practices. We also examine

[1]The 2008 Rule defines mitigation banks and in-lieu fee programs at 33 C.F.R. § 330 (I).

how stream restoration science continues to evolve and what progress can still be made. Our goals are to improve understanding about how well stream compensatory mitigation policies are integrating best available science and how well practice aligns with these policies. Ultimately, we hope to inform the development of best practices and comprehensive, science-based stream assessment and mitigation programs.

This report is based on a series of white papers. The papers include:

- *Assessing Stream Mitigation Guidelines at the Corps District and State Levels* (*Guidelines Paper*). This paper includes a review of the credit determination methods, performance standards, and other program components currently being applied.
- *Assessing Stream Mitigation Practice* (*Practice Paper*). This paper includes a review of the amounts of stream compensatory mitigation being required and the methods of compensation that are being used to meet permit requirements.
- A Function-Based Review of Stream Restoration Science (Science Paper).
- Aligning Stream Mitigation Policy with Science and Practice (Aligning Science, Policy, and *Practice Paper*). This paper integrates the first three white papers and evaluates how stream mitigation guidelines align with current mitigation practice and science.

We refer to the white papers in this series using the abbreviations shown in parentheses.

BACKGROUND

Section 404 of the Clean Water Act regulates the discharge of dredge and fill material in waters of the United States, including many wetlands and streams. The Corps and EPA are responsible for implementing and enforcing Section 404. The Corps is responsible for the day-to-day administration of the program, while EPA has responsibility for enforcement and development of the environmental criteria used by the Corps in Section 404 permitting decisions.

Under the Section 404 regulatory program, no discharge may be permitted if it would cause significant degradation to the Nation's waters or if there is a practicable alternative that is less damaging to the environment. Before an individual permit can be issued, the permittee must show that steps have been taken to avoid impacts, potential impacts have been minimized, and compensation may be required for all remaining unavoidable impacts to the extent that compensation is appropriate and practicable. Permittees may be required to restore, enhance, establish, or preserve streams or other aquatic resources to satisfy their compensatory mitigation requirements. Nationwide, it is estimated that more than $2.9 billion is spent annually on Section 404 compensatory mitigation projects (ELI, 2007). However, studies on stream and wetland compensatory mitigation suggest that, historically, a significant proportion of compensation sites were failing to meet administrative (permit) and ecological performance standards (Bernhardt *et al*., 2007; Doyle & Shields, 2012; Kihslinger, 2008; Miller & Kochel, 2010; NRC, 2001; Tullos *et al*., 2009).

The foundations for the current mitigation program under Section 404 were established in the 1990 joint Corps-EPA Memorandum of Agreement, "The Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines" (MOA). The memorandum "articulate[d] the policy and procedures to be used in the determination of the type and level of mitigation necessary to demonstrate compliance with [Section 404]" (MOA, 1990). By adopting the "no net loss of wetlands policy" and embracing the long-disputed sequence of avoidance, minimization, and compensation, the MOA provided a shared framework in which mitigation could take place (Hough and Robertson, 2009). The agencies subsequently released guidance on mitigation banking in 1995 and in-lieu fee programs in 2000. In 2002, the Corps and EPA released a Regulatory Guidance Letter addressing compensatory mitigation (USACE and EPA, 2002), which drew on recommendations in a 2001 National Research Council report, including the use of a watershed approach, the use of functional assessments for evaluating sites, and inclusion of monitoring and long-term management requirements (NRC, 2001).

When the MOA was issued in 1990, nearly all compensatory mitigation focused on wetlands. Impacts to streams received less attention, and often those impacts were compensated with wetland projects, not streams (ASWM, 2014). In the decade preceding the 2008 Rule, some states and Corps districts (especially in the Southeast) gradually began requiring "in-kind" mitigation for streams—that is, stream compensation for stream impacts (Doyle and Shields, 2012; Lave *et al*., 2008). Although the first national acknowledgement of stream compensatory mitigation as a practice was in the 2002 Nationwide Permits and the 2002 Regulatory Guidance Letter, more detailed stream mitigation policies were not formally established at a national level until 2008, when EPA and the Corps promulgated the 2008 Rule. In the 2008 Rule, EPA and the Corps explained that projects permitted under Section 404 impact streams and other open waters in addition to wetlands, and that the Rule would therefore apply to all aquatic resources. The Rule notes that stream mitigation is an evolving practice, and states that including streams in the Rule will improve current standards and practices.

At the outset, the Rule recognizes that streams are "difficult-to-replace" resources. It acknowledges "that the scientific literature regarding the issue of stream establishment and re-establishment is limited and that some past projects have had limited success" (73 Fed. Reg. 19596). While the rule is clear that all of its requirements apply not only to wetlands but also to streams, a few policies were included to specifically apply to streams, including the following:

- Discourage stream establishment and reestablishment (73 Fed. Reg. 19596);
- Favor in-kind rehabilitation, enhancement, or preservation for streams and other difficult-to-replace resources if more avoidance and minimization are not practicable (33 C.F.R. § 332.3(e)(3)); and
- Include planform geometry, channel form, watershed size, design discharge, and riparian area plantings as possible additional elements in stream mitigation work plans (33 C.F.R. § 332.4(c)(7)).

Although the Rule's requirements are an important step forward, and the Rule is more comprehensive and detailed than prior policies and guidance, it leaves regulators and practitioners substantial discretion on many components of compensatory mitigation. Although flexibility is necessary to address variation in resource types, project impacts, and compensatory mitigation practices, flexibility can also undermine consistent application of the Rule (Stokstad, 2008) and may lead to increased regulatory risk (i.e., risk that the required mitigation may not adequately offset permitted impacts) (BenDor and Riggsbee, 2011). Some researchers have also commented that the Rule is insufficiently rigorous or focused on avoidance and minimization to ensure improvement in resource functions (Doyle and Shields, 2012). The Rule's extension to streams raised particular challenges because the science of stream restoration is considerably younger than the science of wetland restoration, and evidence suggests that some stream functions are very difficult, if not impossible, to restore (Science Paper; Stokstad, 2008; Murphy *et al*., 2009). This is particularly relevant where project goals include the restoration of biology back to a reference condition, but the contributing watershed is impaired. Furthermore, few regulators have specialized training in stream processes, potentially leading to policies that focus on vegetation (or other more wetland-focused criteria) more than fluvial processes specific to streams (Harman *et al*., 2012).

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CHAPTER 1: LESSONS LEARNED AND GUIDANCE FROM A FUNCTION-BASED REVIEW OF STREAM RESTORATION SCIENCE

(*Adapted from* Stream Mechanics. 2016. A Function-Based Review of Stream Restoration Science, Environmental Law Institute, Washington, D.C. *Available at* http://www.eli.org/compensatory-mitigation/state-stream-compensatory-mitigation-science-policy-and-practice)

INTRODUCTION

A Function-Based Review of Stream Restoration Science was written as part of a white-paper series led by the Environmental Law Institute (ELI) and funded by a U.S. Environmental Protection Agency, Water Program Development Grant. The purpose of the white paper was to review the scientific literature about stream restoration through a function-based approach. The literature review included an assessment of how well the scientific methods used in the research matched with practitioner goals and objectives. In addition, the literature review identified the most common stream restoration approach used by designers and addressed whether external forces like watershed land use, project age, and length of monitoring affected the results. The Stream Functions Pyramid Framework (SFPF) (Harman *et al.*, 2012) was used to organize and provide structure for the discussion and review of parameters assessed in the studies. In all, 172 projects were assessed from a total of 52 papers (i.e., some papers evaluated multiple projects). Seventy-seven percent of the studies were in the United States, with 19% in Europe and 4% in Canada. Approximately one third of the projects evaluated were associated with compensatory mitigation.

To make the literature review manageable, the following criteria were established to determine which studies would be included.

- Studies were collected from peer-reviewed journal articles and technical publications in order to analyze the best available scientific data.
- To ensure that the studies evaluated current stream restoration techniques, they had to be published after 2000 with all projects implemented after 1990.
- Restoration project design had to achieve a certain level of complexity, including the application of more than one technique. For example, projects that included changes to floodplain connectivity, bed form diversity, and lateral stability were included. Projects that implemented only riparian buffers or large woody debris were not included. There is a large body of research on the effectiveness of riparian vegetation/buffers and large woody debris and fewer reviews on stream restoration projects implementing multiple techniques.
- Finally, the research had to include actual measurements of stream condition or function; that is, no studies that used only surveys of practitioners or database searches were included within the review.

Like other studies, we show that stream restoration is not improving certain stream functions. However, we also show that restoration is improving other functions. We differ from other studies in that we look at a wide range of function-based parameters within each functional category shown on the Stream Functions Pyramid. Much of the existing literature focused on biological functions or conditions. We also tried to determine if the research goals aligned with the practitioner's stated goals for the project. This is something that hasn't been done in past studies that we've reviewed.

Key lessons learned from the white paper are provided below. These lessons, along with practical experience gained from working with regulators, the academic community, and practitioners is used to provide guidance and suggestions for improving stream mitigation programs, the practice, and the science.

LESSONS LEARNED FROM THE WHITE PAPER

The white paper provides detailed insights obtained from the literature review about the following topics:

- Restoration and Research Objectives,
- Evaluating Stream Function Improvement,
- Watershed and Land Use Analysis,
- Restoration Approaches,
- Project Age, and
- Project Monitoring.

A summary and recommendations from the white paper are provided below for each topic. Each summary is followed by key takeaways and recommendations for researchers, practitioners, and policy makers as appropriate. The last section in this chapter expands on these findings and provides more detailed guidance for regulators, scientists, and practitioners who are developing or working with stream mitigation programs.

RESTORATION AND RESEARCH OBJECTIVES

All projects should have goals and objectives explaining why the project is being completed. This information is helpful to reviewers and researchers who want to evaluate project outcomes against the stated project goals. Our literature review found that a specific restoration objective was stated for 70% of papers reviewed.[2] The most common objectives included improving channel stability, in-stream habitat enhancement, and improvement to some aspect of biological function. Thirty percent of the papers reviewed had minimal or no information about project objectives provided by the studies. It was not clear in the literature review if researchers chose not to publish the objectives for a given restoration project, or if the information was not provided in project documents written by the designer. In addition, some studies included research objectives that did not match the stated project objectives. For example, physicochemical parameters (i.e., water quality, nutrients, organic carbon) were measured by the researcher to evaluate projects where the designer-stated objective was simply to improve channel stability.

Based on the results of the literature review, the following recommendations were provided for stream restoration researchers, practitioners, and policy makers.

Researchers

- More detail needs to be included in published studies about the restoration project's goals and objectives. These details should also be included when research objectives are chosen, ensuring that the research parameters measured match the stream restoration goals and objectives.
- The literature review found that 70% of the papers referred to the project's objective(s). This number should be 100%. All research papers that evaluate a stream restoration project should state the intended project objective. If the practitioner did not provide a project objective, the researcher should contact the practitioner to obtain the information. However, clear project goals and objectives should be provided in project documents by the practitioner.
- The researcher should develop study methodologies and select metrics that *first* evaluate whether or not the project objectives were achieved. There are instances where the researcher may choose to assess whether a restoration approach has additional, synergistic effects. However, these additional metrics and analyses should be secondary to the evaluation of the project objectives—and clearly communicated. The literature review showed that when the restoration objective was stated by the practitioner, only about two-thirds of the studies included variables that evaluated the specific project objectives. This led

[2]The project reviewed typically did not distinguish between the terms goals and objectives. Therefore, for consistency, the term objective (rather than goals) was used to compare results.

to discrepancies between the restoration objective and the research objective used to evaluate project success. If the researcher determines that important objectives or other opportunities for functional improvement were missed by the practitioner, these new objectives should be clearly stated and evaluated separately. This is especially important if conclusions are stated about the success or failure of the evaluated project, and if conclusions are then extrapolated about the overall success or failure of stream restoration as a general practice.

Practitioners

- Practitioners should provide function-based goals and objectives for every project. Guidance can be found in 33 CFR §332.4(c)(2) where the Rule speaks of project objectives, Chapter 11 of *A Function-Based Framework for Stream Assessment and Restoration Projects,* Chapter 2 of the *National Engineering Handbook*, *Part 654*: Stream Restoration Design, and Chapters 6 and 7 of *Stream and Watershed Restoration:* A Guide to Restoring Riverine Processes and Habitats.
- Restoration goals and objectives should be project specific, clearly stated, and feasible to attain in the environment and location chosen for the project. Practitioners should avoid vague goals like improve function; restore dimension, pattern, and profile; or improve habitat.

Policy Makers

- Stream mitigation guidelines should require practitioners to state programmatic goals and design goals and objectives (See 33 CFR §332.4(c)(2)). Programmatic goals refer to the funding driver for the project and could include mitigation, grants, etc. An example of a programmatic goal is: the goal of this project is to provide 1,000 mitigation credits. Design goals and objectives should be articulated as discussed in this section. Having clear goals and objectives will make it easier for Interagency Review Teams (IRTs) and other regulators to review stream mitigation projects.
- Mitigation plans should include a section on restoration potential, which describes the highest level of restoration that can be achieved based on watershed health, the reach condition, and constraints (See 33 CFR §332.3(d) and 33 CFR §332.4(c)(3)). Performance standards should then be developed that match the project's goals and objectives (See 33 CFR §332.5). This method will help prevent practitioners from overpromising restoration benefits and allow the IRT to align the monitoring and performance standards with the design goals and objectives.

EVALUATING STREAM FUNCTION IMPROVEMENT

Efforts were made during the literature review to identify function-based parameters that describe stream functions and to determine if these parameters were successfully improved through stream restoration. The SFPF was used to make the linkage between parameters assessed and stream functions assessed (See Table 1). A project was determined to show functional improvement or no functional improvement for each function-based parameter within each stream functional category. For example, bed form diversity (parameter) may be improved within the geomorphology functional category. A project can have both functional improvement and no functional improvement within a single functional category. For example, a project may have improved lateral stability but not bed form diversity within the geomorphology category. This project would be counted as both a functional improvement and a no functional improvement project.

Functional Category	Function-Based Parameter
Level 1: Hydrology	Channel Forming Discharge Precipitation/Runoff Relationships Flow Duration
Level 2: Hydraulics	Floodplain Connectivity Flow Dynamics Groundwater/Surface Water Interaction
Level 3: Geomorphology	Sediment Transport Competency and Capacity Large Woody Debris Channel Evolution Bank Migration / Lateral Stability Riparian Vegetation Bed Form Diversity Bed Material Characterization
Level 4: Physicochemical	Water Quality Nutrients Organic Carbon/Matter
Level 5: Biology	Microbial Communities Macrophyte Communities Benthic Macroinvertebrate Communities Fish Communities Landscape Connectivity

TABLE 1:* *List of Function-based Parameters provided in the Stream Functions Pyramid Framework (SFPF). Each study was evaluated to determine which functional categories and parameters were assessed.

The number of projects showing functional improvement and/or no functional improvement per functional category is shown in Figure 1. Overall, more than half of the projects showed some improvement in Hydrology, Hydraulics, and Geomorphology, while less than half of the projects showed improvement in Physicochemical and Biology. Figure 1 also shows that very few projects included hydrology assessments, followed by hydraulics, physicochemical, biology, and geomorphology in increasing order. The hydraulics category included the highest amount of improvement in proportion to all projects assessed within the category. Conversely, biology showed the least amount of proportional improvement. The hydraulic improvement is likely due to the fact that practitioners can control hydraulic functions by reconnecting streams with their floodplains and changing flow properties like velocity and shear stress. The practitioner has less control over hydrology, physicochemical, and biology function, which is strongly affected by upstream watershed conditions.

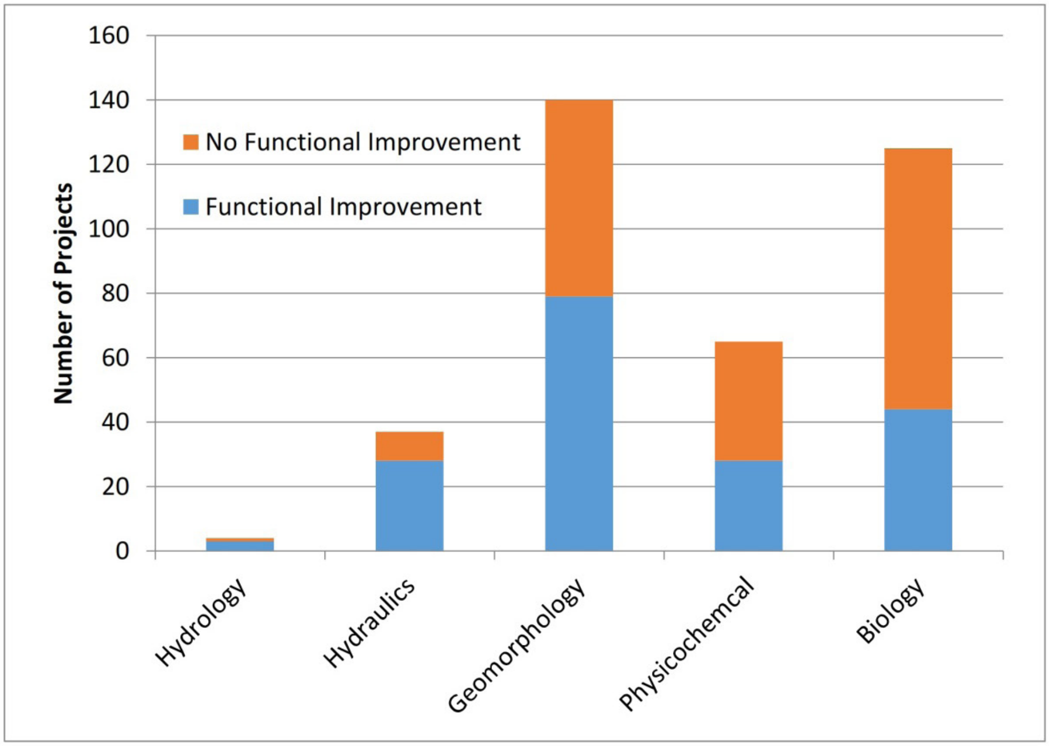

FIGURE 1: ***Functional Improvement and No Functional Improvement by functional category. Notes: The y-axis is number of projects from a total of 172 projects, so the total value for each stacked bar is the number of projects that assessed that functional category out of 172. For example, there were 137 projects out of 172 total projects that assessed Geomorphology.***

The results from Figure 1 were further analyzed based on the function-based parameters measured for each functional category and are shown in Figure 2. (The white paper includes a more detailed discussion of the results per functional category with one exception. The hydrology category is not included in the white paper due to the low number of projects.)

For hydraulics, projects demonstrated functional improvement across all function-based parameters measured. Flow dynamics, like velocity, was assessed most often and included projects showing functional improvement and no improvement. Floodplain connectivity was assessed the least often even though this is a known major contributor to functional improvement in higher-level functions. Those projects that were assessed for floodplain connectivity, which typically was assessed by floodplain inundation, did show improvement.

Within the geomorphology category, bed material characterization was assessed the most often and showed a fairly even split between improvement and no improvement. The next most common parameters assessed were lateral stability, bed form diversity, and then riparian vegetation. Large woody debris and sediment transport were the least assessed parameters. For all of these remaining parameters, there were more projects showing no improvement than improvement.

For physicochemical functions, the nutrient parameter demonstrated improvement in over half of the projects. The projects were not as successful improving water quality parameters, such as temperature and dissolved oxygen, and organic carbon parameters, such as course particulate organic matter and dissolved organic matter retention.

For the biology functional category, benthic macroinvertebrate communities was the most common function-based parameter evaluated. The literature review demonstrated that only one fourth of the projects had functional improvement for benthic macroinvertebrate communities. Functional improvement was evident in slightly greater than half of the projects that evaluated

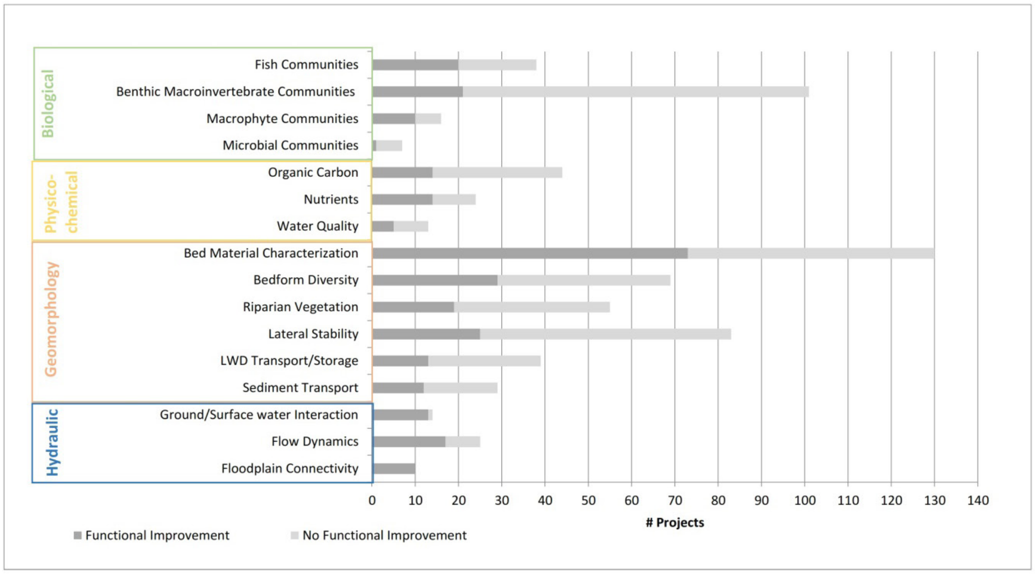

***FIGURE 2:* Functional Improvement and No Functional Improvement per Function-Based Parameter. Figure 2 does not include Hydrology parameters, the Channel Evolution parameter within the Geomorphology category, and the Landscape Connectivity parameter within the Biology category due to the limited number of projects that included these parameters.**

macrophyte and fish community parameters. There was little improvement in the microbial community parameter, but only six percent of projects evaluated microbial metrics. Of the 111 projects that measured biology function-based parameters, 15 projects had 3 underlying functions measured, 31 had 2 underlying functions measured, 48 had 1 underlying function measured, and 17 evaluated only biology function-based parameters (Note, an underlying function refers to lower level functional category from the SFPF).

Based on the results of the literature review, the following recommendations were provided for researchers, practitioners, and policy makers:

Researchers:

- Accurate and useful conclusions concerning stream restoration and its effects on biological function within the project reach should include an assessment of underlying functions that support biology. This will of course vary based on the biological endpoint that is desired. For example, a native trout species will have different supporting functions (and therefore function-based parameters) than a macroinvertebrate species. Although it may not be feasible to measure all function-based parameters, better efforts need to be made to determine why biological function is or is not improved.
- Hydrology functions need more attention in stream restoration research. At a minimum, this should include some form of catchment assessment to determine if watershed hydrology is stable or changing. For example a watershed that is transitioning from rural to urban may negatively affect runoff to the project reach. This information can be included in a watershed health assessment to assist in determining restoration potential. In addition, there should be more research on how stream restoration projects can improve overall flow regimes.
- Project sites should be assessed based on restoration potential. Geomorphology or stability focused projects should be clearly identified and not penalized for showing a lack of functional improvement in physicochemical or biological functional categories.

Practitioners:

- Refer to recommendations provided in Restoration and Research Objectives Section. Clear goals and objectives make it easier to evaluate functional improvement. All projects should include well-articulated function-based goals and objectives and a description of the restoration potential, which will include a description of the catchment health and stressors, and project constraints.
- At a minimum, describe the functional lift that will occur in floodplain connectivity, bed form diversity, lateral stability, and riparian vegetation. Provide an explanation of parameters that will likely not change after restoration activities. Other function-based parameters should be included based on project condition and objectives.

Policy Makers:

- Refer to recommendations provided in Restoration and Research Objectives Section.

- As funding allows, support more intensive monitoring of select projects. Monitoring should include before and after restoration, upstream and downstream of the project reach, and paired-watershed studies including the project reach and a reference-condition reach.

WATERSHED AND LAND USE ANALYSIS

The literature review included papers that evaluated projects implemented in watersheds with different land uses. Three land use categories were chosen for analysis based on information provided in the studies: urban, agriculture, and rural. The rural versus agricultural determination was used because some studies referred to the watershed as agricultural and others used the term rural. We assume that both categories include forms of agriculture; however, in rural watersheds, agriculture is not the predominant land use according to descriptions in the studies. The rural designation includes watersheds with majority forest cover and low-density housing. The agricultural watersheds have more crop and pastureland than the rural designation.

Figure 3 shows the percentage of each land use for the projects. Almost one third of the projects did not have a watershed land use specified. When land use was specified, more than half of the projects were in rural and agricultural settings (62%), while the remainders were in urban settings. Although most studies provided some information on land use, the amount of detail included was variable and not always thorough.

The white paper provides more detail for each land use category shown in Figure 3, including functional improvement or no improvement by functional category. Overall, the studies included in the literature review provided minimal information about how watershed land use affected functional improvement. It is widely known in the literature that land use plays a critical role in determining stream health; therefore, the following recommendations were provided for researchers and practitioners.

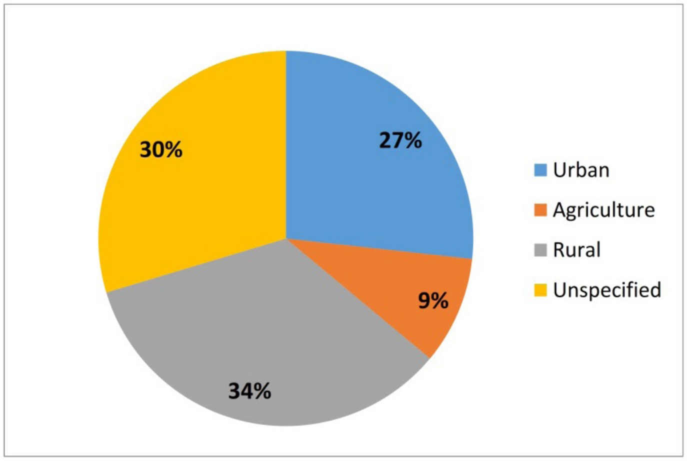

FIGURE 3:* *Watershed land use percentage by project.

Researchers:

- Studies should identify and discuss the watershed and floodplain land use to determine what impact this has on restoration potential and functional lift.

Practitioners:

- Site selection may be as important as reach-scale restoration for improving physicochemical and biological functions. For example, water quality from upstream sources must be able to support biological communities after the reach-scale improvements are made in order to see substantial improvements in reach-scale biology. When feasible, include multiple stakeholders (researchers, policy makers, and community-based organizations).

RESTORATION APPROACHES

A restoration approach is simply the method used by a practitioner to design a project. Within a restoration approach, practitioners use various techniques, like floodplain excavation, in-stream structures, and planting vegetation to meet project goals and objectives. The literature review showed that the primary restoration approach is natural channel design developed by Dave Rosgen. However, it is unknown if the projects followed the natural channel design process outlined by Rosgen versus simply calling their approach natural channel design, i.e., natural channel design is sometimes used as a surrogate for stream restoration. Approximately, 55% of the projects used the natural channel design approach, while 38% of the projects were unspecified and 8% cited another approach like process-based, a European approach, or a sport fishing approach. More detail is provided in the white paper about the function-based parameters that showed improvement or no improvement for natural channel design projects. Other approaches were not analyzed due to the low sample size. The recommendations provided in the white paper are included below.

Researchers:

- Studies should identify the restoration approach and provide adequate details of techniques used within the design to help evaluate the approach and improve the science.
- Studies should seek to determine if the approach was appropriately used. This will allow evaluations to determine if the project design or design approach is flawed or successful.

Practitioners:

- All design and mitigation reports should clearly state the restoration approach *and* techniques used. For example, natural channel design was used as the design approach, and floodplain excavation, channel realignment, installation of large wood, and planting riparian vegetation were the techniques.

Policy Makers:

- Mitigation guidelines should include a procedure for determining if restoration practitioners have the necessary training and experience for whatever approach they propose.
- Work with researchers and practitioners to develop guidelines for selecting the appropriate restoration approach and techniques for common types of functional problems.

PROJECT AGE

We divided projects into two categories: those constructed between 1990 and 1999 and those constructed between 2000 and 2008. This division resulted in about two thirds of the projects being in the 2000 to 2008 category. A visual comparison of the results showed no considerable difference in functional improvement based on project age. We also found no positive trend over time when comparing functional categories and function-based parameters. The reasons for a lack of improvement could not be determined based on our review; therefore, further analysis is needed to determine if stream restoration practices are getting better at improving function over time.

PROJECT MONITORING

Stream mitigation protocols require that post-restoration monitoring be used to verify that performance standards have been met. Beyond mitigation, monitoring is always helpful to show if project goals and objectives were met. The literature review showed that about 20% of projects evaluated included pre-restoration-monitoring data and that 60% of these projects showed functional improvement across all function-based parameters evaluated, compared to only 10% of projects without pre-monitoring data collection. The results demonstrate how important pre-monitoring data may be in verifying functional improvement attributed to stream restoration. The literature review also showed that upstream (or downstream) control reaches within the same stream were selected for comparison in approximately 70% of the projects. The remainder used stream data from other stream reaches with similar conditions and/or from reference reaches for comparison with the restored reach.

When control reaches were chosen outside the impact stream, 65% of these projects showed no functional improvement across all function-based parameters evaluated. Our results seem to show that using upstream and downstream reaches for comparison is a good way to show functional lift because it explicitly shows how the project reach changed values of the parameters assessed. However, using a reference condition (maybe in addition to upstream/downstream assessments) is a good way to determine the overall health of the project reach and provides a way to compare all projects in a given region to the same reference condition, e.g., it puts projects on the same scale. For example, an urban restoration project may improve a biological community from upstream to downstream of the project reach, which is functional lift. However, it may not restore the community back to a forested reference condition.

Based on the literature review analysis of project monitoring, the following recommendations are made for researchers and policy makers:

Researchers:

- Studies should include pre-restoration monitoring to determine whether a project has achieved functional improvement. Pre-monitoring data should also come from upstream/downstream control reaches, where possible.
- Studies should also relate the functional capacity of the project reach to a reference condition.
- Studies should evaluate restoration projects over the long term to ensure recovery of the natural system and to ensure that a large storm event has occurred.

Policy Makers:

- Develop monitoring programs that focus on functional lift and not just channel stability.

GUIDANCE FOR POLICY MAKERS DEVELOPING STREAM MITIGATION PROTOCOLS

This section includes lessons learned from the Function-Based Review of Stream Restoration Science white paper, the other white papers in this series, and practical experiences from the authors to provide specific guidance for developing stream mitigation protocols. The focus is on restoration potential, function-based goals and objectives, selecting and evaluating restoration approaches, and quantifying functional lift.

RESTORATION POTENTIAL

Restoration potential is a key concept from the SFPF and is defined as the highest level (on the pyramid) of restoration that can be achieved based on the health of the watershed, the condition of the reach, and anthropogenic constraints. A restoration potential of Level 5 means that the project has the potential to restore biological functions to a reference condition. This can only happen if the catchment health is good enough to support that level of biology and the constraints do not prevent the practitioner from implementing the required activities.

If the catchment health is somewhat impaired and/or the constraints limit the restoration activities, then the restoration potential will be less than Level 5. Typical stability focused projects in impaired watersheds would reach Level 3 (Geomorphology). Level 3 projects can improve floodplain connectivity, lateral stability, bed form diversity, and riparian vegetation (function-based parameters describing geomorphology functions) to a reference condition, but not physicochemical or biological functions. Biological or physicochemical improvement can still be obtained; however, the improved condition will remain in the functioning-at-risk or not functioning category. This doesn't mean that Level 3 projects shouldn't be pursued; however, the design goals and objectives should focus on reaching reference condition for lower-level functions and pursue smaller incremental improvements in biology if possible.

Level 4 projects are less common and would typically include a stormwater BMP. The most common example would be a headwater urban project where the stream reach is restored and BMPs are installed to reduce runoff and nutrients from lateral sources, e.g., parking lots that drain directly to the project reach. Level 4 projects can improve physicochemical functions to a reference condition, but not biological function. Biological improvement can still be obtained; however, the improved biological condition will remain in the functioning-at-risk or not functioning category.

Restoration potential can be a narrative that is included within the mitigation plan. It will help everyone (policy maker, practitioner, and researcher) understand how stressors within the watershed become limiting factors for improving stream functions. The restoration potential is then used to create function-based goals and objectives.

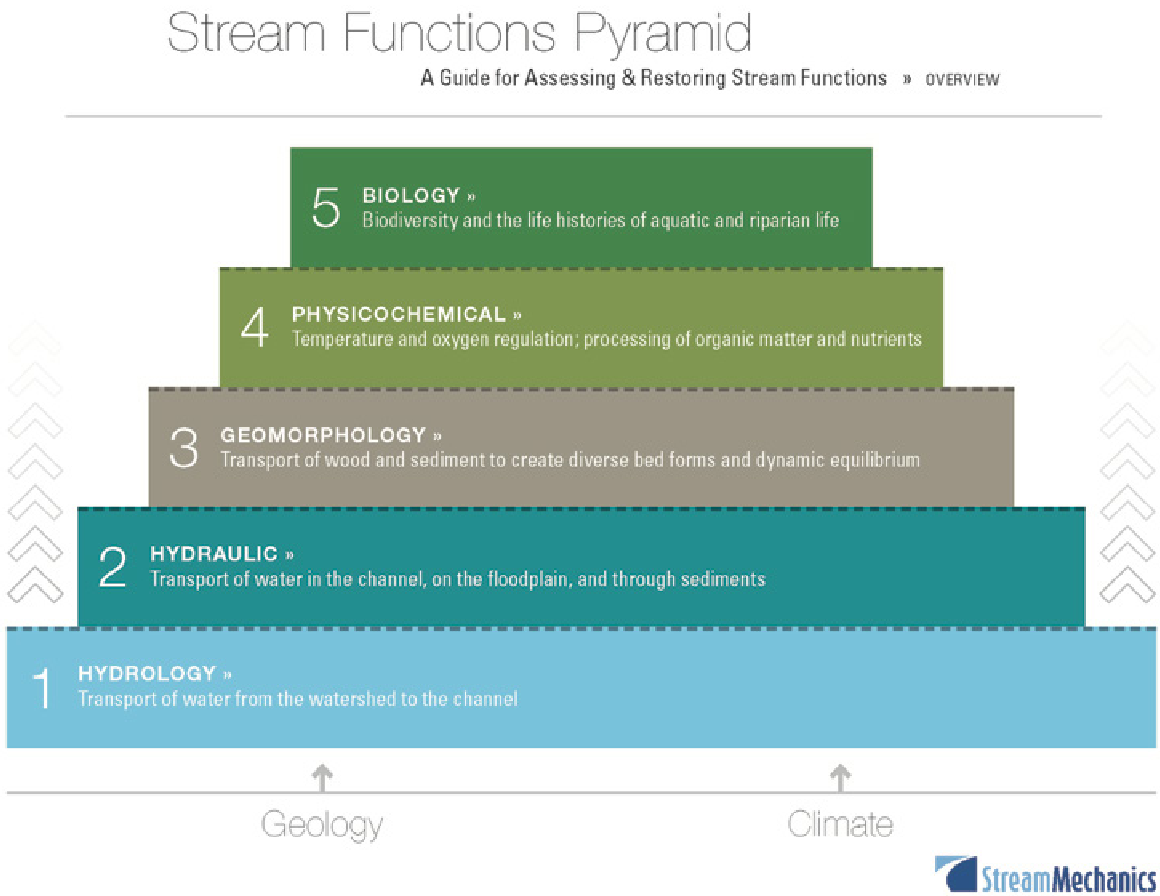

***FIGURE 4:* Restoration Potential and the Stream Functions Pyramid.**

FUNCTION-BASED GOALS AND OBJECTIVES

Most stream mitigation protocols require the practitioner to provide goals and objectives; however, many do not provide specific guidance. This section provides one method for developing function-based goals and objectives once the restoration potential has been determined.

Function-based design goals are different than programmatic goals that identify the funding source of the project. Programmatic goals are bigger-picture goals that are often independent of the project site. For example, a programmatic goal might be to create mitigation credits. Design goals are statements about why the project is needed at the specific project site. They are general intentions and often cannot be validated. Objectives are more specific. They help explain *how* the project will be completed. Objectives are tangible and can be linked to performance standards, which can then be validated through monitoring.

Examples of design goals include: restore native brook trout habitat (Level 3 goal), restore native brook trout biomass (Level 5), restore the stream to a biological reference condition

(Level 5), reduce sediment supply from eroding streambanks (Level 3), and reduce nutrient inputs from adjacent sources (Level 4). All of these goals communicate why the project is being undertaken. Example objectives (not tied to the above goal examples) include: increasing floodplain connectivity, establishing a riparian buffer, and increasing bed form diversity. These objectives can't stand alone, but with compatible goals, they can describe what the practitioner will do to address the functional impairment. The objectives can be quantitative as well. For example: floodplain connectivity will be improved by reducing the bank height/bankfull depth ratio from 2.0 to 1.0. Now, functional lift is being communicated and the performance standard is established for monitoring.

The design goals and objectives must be communicated in a narrative form in the mitigation plan. The design goals are compared to the restoration potential to ensure that the goals do not exceed the restoration potential. For example, it is not possible to have a design goal of restoring native brook trout biomass (Level 5) if the restoration potential is Level 3, meaning that the catchment health and constraints will not support brook trout, e.g., because the watershed is developed and water temperature entering the project reach is too high for brook trout. However, the goal could be revised to restore the physical habitat for native brook trout, e.g., provide riffle-pool sequences, cover from a riparian buffer, and appropriate channel substrate. This is a Level 3 goal that matches the Level 3 restoration potential. If watershed-level improvements are implemented, over time, the restoration potential could shift from a Level 3 to 5. Notice however, that this requires reach-scale and watershed-scale restoration.

SELECTING AND EVALUATING STREAM RESTORATION APPROACHES

The white papers showed that natural channel design was the most widely used approach throughout the United States. Based on our experience from attending stream restoration conferences and participating in stream mitigation programs, this is a trend that is likely to continue. However, other restoration approaches like valley restoration, analytical methods, and regenerative stormwater conveyance are becoming more popular in the Mid-Atlantic region (see practice white paper). The US Fish and Wildlife Service has developed guidance and assessment documents to help regulators in this region select the restoration approach that provides the most functional lift for a given site. The guidance is based on a rapid assessment methodology and series of questions. Once an approach has been selected, an approach-specific checklist is provided to assist regulators and practitioners in determining if the approach was applied correctly. These materials are available at: http://www.fws.gov/chesapeakebay/stream/index.html.

The Pacific Northwest and other regions use a process-based approach to design stream restoration projects. The National Oceanic and Atmospheric Administration (NOAA) developed a River Restoration Analysis Tool (River RAT) to assist regulators and practitioners in screening and reviewing stream restoration projects. This tool can be downloaded from https://www.webapps.nwfsc.noaa.gov/apex/f?p=275:1. These tools provided by FWS and NOAA can help stream mitigation programs to select the appropriate stream restoration approach and then evaluate if the approach was applied correctly.

QUANTIFYING FUNCTIONAL LIFT

The white papers show that determining functional improvement of stream restoration projects, and thereby mitigation credits, is a challenge for many mitigation programs. Currently, several districts use rapid assessment methods to calculate a net improvement factor. Examples include the NC Stream Assessment Method (NC SAM) and the TX Rapid Assessment Method (TX RAM). Oregon is working with the US Environmental Protection Agency to develop a new rapid assessment method that will ultimately be tied to credit determination.

Our experience working with rapid assessment methods with stream mitigation programs shows that rapid methods are effective at screening potential mitigation projects and helping private landowners with small projects. However, rapid methods often create problems when working with large projects and mitigation banks because the assessment methods are too coarse. This means that rapid assessment methods make it difficult to determine if the mitigation activity created a meaningful amount of improvement in a given function. For example, many rapid assessment methods will state that the aquatic habitat is good, fair, or poor without quantifying the definition of habitat or the definition of good, fair, or poor. This can create disagreements between the regulators and practitioners about the adequacy of the mitigation activity.

To help address this problem, quantitative methods for showing functional lift are needed. The specific needs include:

1. A simple calculator to determine the quantifiable differences between an existing (degraded) stream condition and the proposed (restored or enhanced) stream condition. This difference can be used in a credit determination method, as defined by the 2008 Federal Mitigation Rule.

2. A way to link restoration activities to changes in stream functions by selecting function-based parameters that can be manipulated by stream restoration practitioners.

3. A way to link restoration results to restoration potential.

4. Incentivize high-quality stream restoration and mitigation.

A stream functional lift quantification tool (SQT) developed by Stream Mechanics and the Environmental Defense Fund is a new approach to addressing these needs. The SQT was developed primarily for stream restoration projects completed as part of a compensatory mitigation requirement. However, the tool can be used for any stream restoration project, regardless of the funding driver. The needs discussed above translate into at least six different uses for the SQT, and include the following.

1. <u>Site Selection</u> – The tool can help determine if a proposed project has enough lift and quality to be considered for a stream restoration or mitigation project. Rapid field assessment methods can be used to produce existing and proposed scores.

2. <u>Functional Lift or Loss</u> – The tool can quantify functional lift or loss from a proposed or active stream restoration project. This first happens during the design or mitigation plan phase and is re-scored for each post-construction monitoring event.

3. Credit Determination Method – Existing ratio based credit determination methods can use the proposed condition score minus the existing condition score as a way to select the appropriate ratio. This can be done without changing the existing ratio method. New credit determination methods can simply use the difference in the proposed functional foot score minus the existing functional foot score.

4. Permittee Responsible Mitigation – The tool can be applied to on-site, permittee-responsible mitigation to help determine if the proposed mitigation activities will offset the proposed impacts.

5. Debit Determination Method – A separate version of the tool can calculate stream debits for permitted impacts. The structure of the tool is the same; however, the output is functional loss rather than lift.

6. Stormwater Best Management Practices (BMPs) in Conjunction with Stream Restoration – There is a subroutine in the tool that can be applied to stream restoration projects that include BMPs to treat adjacent runoff. The tool should not be used for projects that only install stormwater BMPs and do not include stream restoration (in channel) work.

The SQT can be downloaded from www.stream-mechanics.com.

CONCLUSION

This chapter provides a summary of the lessons learned from A Function-Based Review of Stream Restoration Science white paper, along with related lessons from the other white papers. Then, more detailed guidance is provided for the critically important topics of determining restoration potential, setting goals and objectives, selecting and evaluating a restoration approach, and quantifying functional lift. Hopefully, these insights and ideas will help regulators, researchers, and practitioners continue to advance the science and application of stream restoration.

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U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), 2007. Part 654 — Stream Restoration Design. In: NRCS National Engineering Handbook Part 654—Stream Restoration Design, H.210.NEH.654. Accessed at www.nrcs.usda.gov/technical/ENG.

See Appendix A for list of papers reviewed for the analysis presented above.

CHAPTER 2: ASSESSING STREAM MITIGATION PROGRAM COMPONENTS

This chapter is intended to provide an overview of the range of stream mitigation practice in the United States today. This chapter draws extensively from two related reports, *Assessing Stream Mitigation Guidelines at the Corps District and State Levels* (*Guidelines Paper*, ELI, 2016), and *Assessing Stream Mitigation Practice* (*Practice Paper*, ELI, 2016). The former is a review of 28 stream mitigation policies and four additional policy documents (hereinafter SOPs) developed by U.S. Army Corps of Engineers (Corps) districts and state governments. The latter is an analysis of interviews with practitioners from the Corps districts, federal and state agencies, nongovernmental organizations, and consultants. For more detailed analysis, please refer to the papers at http://www.eli.org/compensatory-mitigation/state-stream-compensatory-mitigation-science-policy-and-practice.

METHODOLOGY

To better understand stream mitigation guidelines and procedures, we analyzed 32 stream mitigation standard operating procedures, guidelines, and additional documents developed by states and Corps districts (and one Corps division) (Table 2 and Figure 5). The set of documents reviewed here is not intended to be comprehensive; we have sought to identify the main publicly available guidance documents in each district or state, with occasional reliance on a supplementary document for particular topics. We did not find guidance documents for all 38 Corps Districts. More specific mitigation-related documents (such as documents focused on one topic or program component) are generally not included here. Whereas some policies apply to an entire district, others cover a particular state, and may have been developed by a state agency or as a joint effort of state and federal agencies with jurisdiction in that state. The documents vary in level of scope and detail, and range from checklists and guidance letters to more comprehensive regulatory guidelines. Some of the SOPs are complete and designed to be used alone, while in other districts what are often referred to as SOPs are collections of documents (e.g., in the Fort Worth, Wilmington, Norfolk, and Sacramento Districts), such as assessment methodologies, site selection guidelines, or mitigation bank instrument templates. Eleven of these policies were developed prior to the 2008 Rule and twenty-two were developed (either as new documents or revisions to pre-Rule policies) after the Rule. For convenience, we refer to all of the documents (single documents or collection of documents) as SOPs throughout this paper. We obtained most of the documents from Corps district websites or RIBITS, but some draft documents were obtained directly from Corps or state agency personnel.

TABLE 2: Some of the Guidelines Reviewed for this Study. Some of the documents are comprehensive and designed to be used alone, while others are targeted to specific topics, such as assessment methodologies, site selection guidelines, or mitigation bank instrument templates, and may be part of a collection of documents guiding district decision-making. All documents posted at http://www.eli.org/compensatory-mitigation/state-stream-compensatory-mitigation-science-policy-and-practice and most are also available on RIBITS.

SOP or Guidance Document	Year Issued
U.S. Army Corps of Engineers, Charleston District, *Joint State/Federal Administrative Procedures for Establishment and Operation of Mitigation Banks in* ***South Carolina*** (2002)	2002
Washington State Aquatic Habitat Guidelines Program, *Integrated Streambank Protection Guidelines* (2003)	2003
U.S. Army Corps of Engineers, Wilmington District, **North Carolina** Division of Water Quality, U.S. Environmental Protection Agency, Region IV, Natural Resources Conservation Service, and North Carolina Wildlife Resources Commission, *Stream Mitigation Guidelines* (2003)[a]	2003
U.S. Army Corps of Engineers, **Memphis** District, *Public Notice for Mitigation Guidelines and Monitoring Requirements, Public Notice No. MVM-MGMR* (2004)	2004
U.S. Army Corps of Engineers, **Philadelphia** District, *Mitigation and Monitoring Guidelines* (2004)	2004
U.S. Army Corps of Engineers, **Savannah** District, *Standard Operating Procedure, Compensatory Mitigation, Wetlands, Openwater & Streams* (2004)	2004
U.S. Army Corps of Engineers, **Tulsa** District, *Aquatic Resource Mitigation and Monitoring Guidelines* (2004)	2004
U.S. Army Corps of Engineers, *Guidance for Compensatory Mitigation and Mitigation Banking in the* ***Omaha*** *District* (2005)	2005
U.S. Army Corps of Engineers, **New York District**, *Public Notice Announcing the Compensatory Mitigation Guidelines and the Mitigation Checklist for Review of Mitigation Plans for the U.S. Army Corps of Engineers, New York District* (2005)	2005

Kentucky Division of Water, *Stream Relocation/Mitigation Guidelines* (2007)	2007 (draft)
U.S. Army Corps of Engineers, Norfolk District, **Virginia** Department of Environmental Quality, *Unified Stream Methodology for use in Virginia* (USM, 2007) [b]	2007
<u>JOINT EPA/CORPS COMPENSATORY MITIGATION RULE ISSUED</u>	**<u>2008</u>**
U.S. Army Corps of Engineers, **Detroit** District, *Mitigation Guidelines and Requirements* (2008)	2008
U.S. Army Corps of Engineers, **Illinois**, *Illinois Stream Mitigation Guidance* (2010)	2010
U.S. Army Corps of Engineers, Kansas City District, ***Kansas*** *Stream Mitigation Guidance* (2010)[c]	2010
U S. Army Corps of Engineers, St. Louis District and U.S. Environmental Protection Agency, *Mitigation Banking Instrument Outline For Proposed Mitigation Banks Within the State of* ***Missouri*** (2010)	2010
U.S. Army Corps of Engineers, **Charleston** District, *Guidelines for Preparing a Compensatory Mitigation Plan* (2010)	2010 (working draft)
Virginia Department of Environmental Quality, the U.S. Army Corps of Engineers, Norfolk District, and the Interagency Review Team, ***Virginia*** *Mitigation Banking Instrument Template* (2010)	2010
U.S. Army Corps of Engineers, **Fort Worth** District, *Public Notice to Publish New Guidelines Covering Specific Elements for the Establishment of New Mitigation Banks in the Fort Worth District*, CESWF-10-MITB (2011)[d]	2011
U.S. Army Corps of Engineers, **Little Rock** District, *Little Rock District Stream Method*, CESWL-RD (2011)	2011
Maryland Nontidal Wetlands and Waterways Division, ***Maryland*** *Nontidal Wetland Mitigation Guidance* (2011)	2011
U.S. Army Corps of Engineers, Savannah District, *Draft Guidelines to Establish and Operate Mitigation Banks in* ***Georgia*** (2011)	2011
West Virginia Interagency Review Team, ***West Virginia*** *Stream and Wetland Valuation Metric* (2011)	2011
U.S. Army Corps of Engineers, **Mobile** District, *Compensatory Stream Mitigation Standard Operating Procedures and Guidelines,* SAM-2011-317-MBM (2012)[e]	2012 (draft)

Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Natural Resources Section, *Draft Stream Mitigation Guidelines for the State of* ***Tennessee*** (2012)	2012 (draft)
U.S. Army Corps of Engineers, **Galveston** District, *Galveston District Stream Condition Assessment Standard Operating Procedure* (2013)	2013
U.S. Army Corps of Engineers ***et al***., *State of* ***Missouri*** *Stream Mitigation Method* (2013)	2013
U.S. Army Corps of Engineers, Omaha District, ***Montana*** *Stream Mitigation Procedure* (2013)	2013
U.S. Army Corps of Engineers, Omaha District, ***Wyoming*** *Stream Mitigation Procedure* (2013)	2013
U.S. Army Corps of Engineers, Buffalo, Huntington, and Pittsburgh Districts, *Guidelines for Stream Mitigation Banking and In-Lieu Fee Programs in* ***Ohio*** (2014)	2014
Pennsylvania Department of Environmental Protection, Bureau of Waterways, Engineering and Wetlands, Division of Wetlands, Encroachments and Training, ***Pennsylvania*** *Function Based Aquatic Resource Compensation Protocol* (2014)	2014
U.S. Army Corps of Engineers, **South Pacific** Division, *Final 2015 Regional Compensatory Mitigation and Monitoring Guidelines* (2015)f	2015
U.S. Army Corps of Engineers, **New England** District, *New England District Compensatory Mitigation Guidance* (2016)	2016

(Reproduced from *Guidelines Paper*)

[a] Also see U.S. Army Corps of Engineers, Wilmington District, *Stream Mitigation Considerations Checklist* (2011) and U.S. Army Corps of Engineers, Wilmington District and North Carolina Interagency Review Team, *Requirements and Performance Standards for Compensatory Mitigation in North Carolina* (2013).
[b] Also see U.S. Army Corps of Engineers, Norfolk District, *Public Notice: Virginia Offsite Mitigation Location Guidelines* (2008) and U.S. Army Corps of Engineers, Norfolk District, Virginia Department of Environmental Quality, *Suggestions for Proposing Compensatory Mitigation Sites (Dos and Don'ts)* (2009)
[c] Also see U.S. Army Corps of Engineers, Kansas City District, *Mitigation Banking Instrument Outline for Proposed Mitigation Banks within the State of Kansas* (2015)
[d] Also see Fort Worth District and Texas Interagency Review Team, *Guidelines Covering Specific Elements for the Establishment of New Mitigation Banks in the Fort Worth District*, CESWF-12-MITB (2012); U.S. Army Corps of Engineers, Fort Worth District, *Fort Worth District Stream Mitigation Method (2013)*; and U.S. Army Corps of Engineers, Fort Worth and Tulsa Districts, *The Texas Rapid Assessment Method (TXRAM)* (2010)
[e] Also see U.S. Army Corps of Engineers, Mobile District, *Proximity Factor Method* (2009)
[f] Also see South Pacific Division, *Regulatory Uniform Performance Standards for Compensatory Mitigation Requirements* 12505-SPD (2012) and South Pacific Division, *Regulatory Program Standard Operating Procedure for Determination of Mitigation Ratios* (2011)

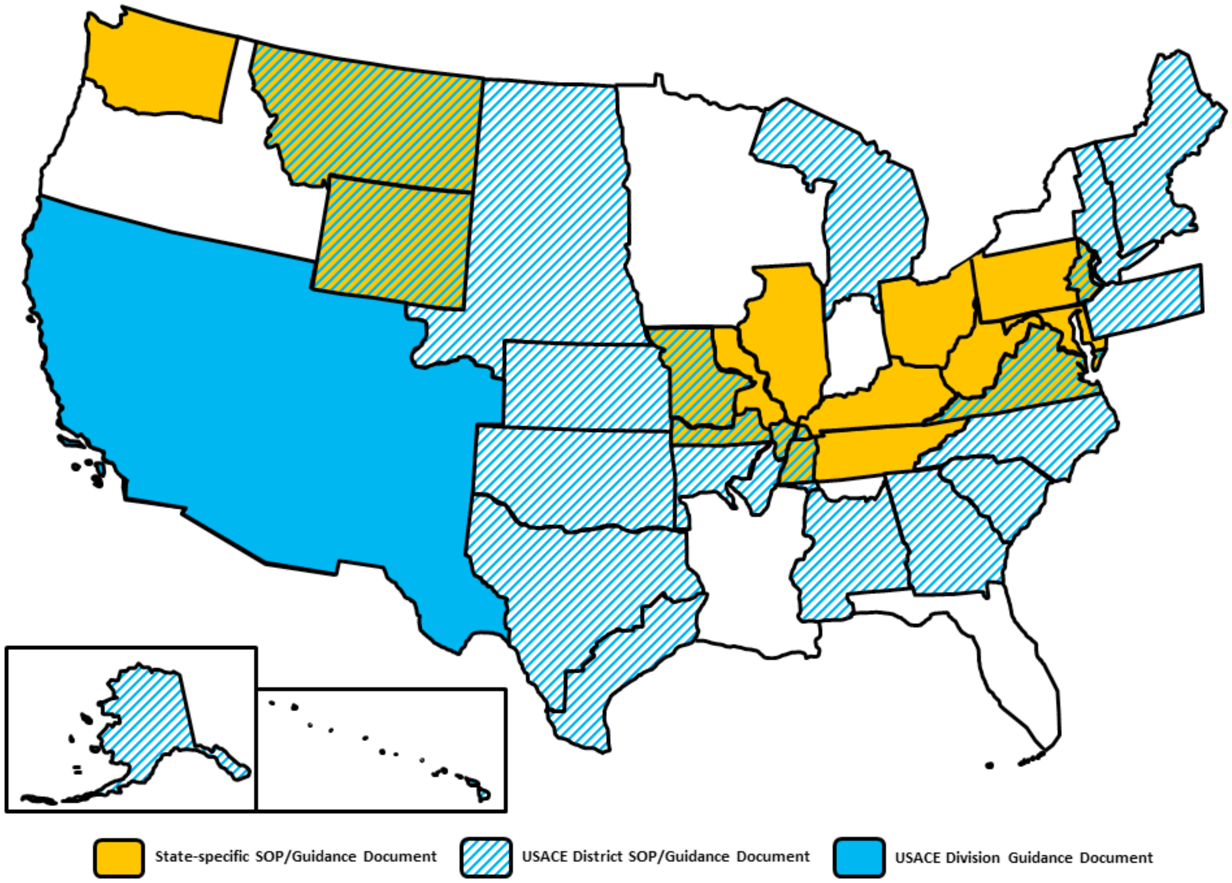


FIGURE 5: ***Areas of Coverage for SOPs and Guidance Documents Reviewed for this Report.*** For our policy review, we sought to identify the main publically available guidance documents in each district or state, with occasional reliance on a supplementary document for particular topics. We did not find guidance documents for all 38 Corps Districts. We conducted telephone interviews with staff from 12 U.S. Army Corps of Engineers (Corps) districts, representatives from three other federal agencies, five state agencies involved in overseeing stream compensatory mitigation projects, five individuals who practice or consult on stream mitigation, and two representatives from nongovernmental organizations (NGOs) involved in stream mitigation.

(Reproduced from *Guidelines Paper*)

We investigated the following fundamental components of the SOPs: (1) Threshold for Requiring Mitigation, (2) Stream Mitigation Approaches and Techniques, (3) Stream Mitigation Methods, (4) Service Area Requirements, (5) Site Selection and the Watershed Approach, (6) Determination of Debits, (7) Determination of Credits, (8) Buffer Credits, (9) Credit Release Schedules, (10) Performance Standards, and (11) Monitoring Requirements. We examined whether the SOPs addressed these topics, or failed to provide guidance on some of them; when SOPs did cover a topic we reviewed and compared their responses.

TABLE 3:* *State and Federal Agencies Interviewed To Assess Mitigation Practice. The participating Corps districts were selected in collaboration with Corps headquarters. The remaining interviewees were selection in collaboration with an Advisory Committee of Stream Mitigation Experts.

Corps Districts Interviewed

- Fort Worth
- Galveston
- Little Rock
- Los Angeles
- Mobile
- New England
- Norfolk
- Omaha
- Portland
- Seattle
- St. Louis
- Wilmington

Other State and Federal Agencies

- Missouri Department of Conservation (MDC)
- New Hampshire Department of Environmental Services (NHDES)
- North Carolina Ecosystem Enhancement Program (NCEEP)*
- Virginia Department of Environmental Quality (VDEQ)
- Washington Department of Fish and Wildlife (WDFW)
- National Oceanic and Atmospheric Administration (NOAA Marine Fisheries, Northwest Fisheries Science Center)
- U.S. Fish and Wildlife Service (FWS, Field Office)
- U.S. Environmental Protection Agency (EPA) Region 4

*NCEEP has been renamed the Division of Mitigation Services, but for convenience and ease of understanding we refer to it as NCEEP throughout. (Reproduced from *Practice Paper*)

In 2014, we conducted telephone interviews with staff from 12 U.S. Army Corps of Engineers (Corps) districts, representing a range of regions, ecological systems, and regulatory settings (Table 3). The participating districts were selected in collaboration with Corps headquarters. We also spoke with representatives from three other federal agencies (the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency) and five state agencies involved in overseeing stream compensatory mitigation projects (Table 3). Finally, we interviewed five individuals who practice or consult on stream mitigation and two representatives from nongovernmental organizations (NGOs) involved in stream mitigation. Each interview lasted between one and two hours, and participants were given the list of questions in advance. Some interviewees followed up on interview answers with additional written responses.

Interview questions covered a range of topics (Appendix A). First, questions addressed the extent and evolution of stream compensatory mitigation in each interviewee's region, including the amount of compensatory mitigation required and the number of credits generated, major sources of impacts requiring compensation, the impact (if any) of the 2008 Rule on stream compensatory mitigation, and the existence of any guidelines for stream mitigation in the district or state. Next, the interviews examined the details of stream compensatory mitigation practice, including (1) what stream compensation approaches and techniques are used to generate credits; (2) how debits, in-stream credits, and buffer credits are determined; (3) what assessment methodologies are used in the region and the time required to conduct assessments; (4) how compensation sites and bank service areas are selected and how the watershed approach is integrated into stream compensatory mitigation; (5) how performance standards and monitoring requirements are developed; and (6) whether and how adaptive management is applied. Finally, interviewees were also asked to identify any gaps or challenges in the current practice and regulation of stream compensatory mitigation.

RESULTS

We investigated the following fundamental components in our research and interviews: (1) Site Selection and Service Areas, (2) Watershed Approach, (3) Stream Restoration Approaches and Techniques, (4) Debit Determination Methods, (5) Determination of Credits, (6) Buffers, (7) Credit Release Schedules, (8) Performance Standards, (9) Monitoring, (10) Land Protection, (11) Long-Term Management, and (12) Adaptive Management.

SITE SELECTION AND SERVICE AREAS

District and state stream mitigation policies include a number of requirements related to site selection. However, the ultimate approval of compensation sites takes place on a case-by-case basis much of the time (*Guidelines Paper*, *Practice Paper*, see ASWM, 2014 for a discussion of site selection at the state level).

In practice, districts report that nearly all compensation takes place in the same watershed as impacts (*Practice Paper*, and Table 4 below for those districts able to estimate percent of mitigation occurring in the same watershed as impacts), though they may define watershed in different ways. The 2008 Rule defines "watershed" as "a land area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the ocean" (33 C.F.R. § 332.2), but it does not specify the appropriate scale

"A HUC may in reality only be a portion of an actual watershed and not the entire land area draining water to a particular waterbody, which could be important to understand when making site selection decisions."

of a watershed. In guidelines and practice, many districts define a watershed as equivalent to an 8-digit Hydrological Unit Code (HUC) (*Guidelines Paper*, *Practice Paper*).[3] However, a HUC may in reality only be a portion of an actual watershed and not the entire land area draining to a particular waterbody, which could be important to understand when making site selection

TABLE 4:* *Estimated Amount of Mitigation Occurring in the Same Watershed as Impacts (using each district's watershed definitions). Some districts we interviewed were able to estimate the percent of mitigation occurring in the same watershed as impacts in practice. Districts report that nearly all compensation takes place in the same watershed as impacts, though they may define watershed in different ways.

Corps District	Percent of mitigation
Galveston	90% (HUC-8)
Los Angeles	More than 75% (HUC-8, occasionally HUC-10)
New England	Close to 100% (Varies by state)
Norfolk	All (same or adjacent HUC-8 in the same river basin and physiographic province)
Omaha	99% (HUC-8)
Portland	More than 50%
Seattle	Close to 100% (Typically use water resource inventory areas)
St. Louis	95% (Varies by state, HUC-8)
Wilmington	95% (HUC-8)

(Reproduced from *Practice Paper*)

[3]The U.S. Geological Survey uses a hierarchical system to categorize hydrological features, or units, across the country. Each unit is assigned a unique Hydrologic Unit Code (HUC). There are six different levels of units, which are arranged by size. The more digits are in a HUC, the smaller the corresponding geographic area. Thus, the fewest digits are used for regions and sub-regions, the largest units, and the most digits are used for watersheds and sub-watersheds, the smallest units. Basins and sub-basins fall in between, as follows: 2-digit HUC: first level (region); 4-digit HUC: second level (sub-region); 6-digit HUC: third level (basin); 8-digit HUC: fourth level (sub-basin); 10-digit HUC: fifth level (watershed); 12-digit HUC: sixth level (sub-watershed).

decisions. It is important for policy makers to be clear when discussing the term watershed within their mitigation guidelines. Reach-scale scale assessments will often accompany a watershed assessment, meaning an assessment of the land area draining to the project reach. However, the project site may be within an 8-digit HUC as part of the service area requirement. In this case, the HUC is not the watershed for the project reach. It is best to not use the terms watershed and service area as interchangeable.

Stream compensation SOPs often expressly authorize both onsite and offsite compensatory mitigation under certain circumstances (*Guidelines Paper*). For example, regulators generally confine offsite mitigation to within the same watershed as impacts. The principal basis of site selection requirements for offsite mitigation is often HUCs- most of the SOPs that state requirements require or encourage mitigation to occur within the same 8-digit HUC as the project impacts, although guidance ranges from 6-digit to 12-digit HUCs (Table 5). A few SOPs specifically mention ecoregions as geographic boundaries in their site selection guidance, and these are often secondary requirements. SOPs that refer to ecoregions generally encourage compensation that occurs close to the project site, although specific policies differ in their treatment of distance between sites (*Guidelines Paper*). Such a two-tiered approach—using HUC codes and then ecoregions for site selection—may allow for more holistic consideration of some ecological functions, such as habitat, than do HUCs alone, because they are based on ecological and biotic factors rather than just hydrologic drainage patterns. However, there may be challenges with this approach, especially in flat areas where there may be errors in HUC maps. In these cases, it may be better to only use Ecoregion rather than a combination of HUC and Ecoregion.

"Such a two-tiered approach - using HUC codes and then ecoregions for site selection – may allow for more holistic consideration of some ecological functions, such as habitat, than do HUCs alone, because they are based on ecological and biotic factors rather than just hydrologic drainage patterns."

TABLE 5: Site Selection Guidelines. The principal basis of site selection requirements for off-site mitigation is often HUCs. A few SOPs specifically mention ecoregions as geographic boundaries in their site selection guidance, and these are often secondary requirements.

	HUC	Site Selection Requirements	Ecoregions Considered?
State-Specific Guidance			
Georgia (Savannah District)	8-digit	8-digit HUC, offsite	
Illinois	12-digit		
Kansas	8-digit	Onsite, offsite	Yes
Kentucky	6-digit		
Maryland			

Missouri	8-digit		
Montana	8-digit	Onsite, offsite, outside watershed	
Ohio	8-digit		
Pennsylvania			
Tennessee	12-digit	Within same HUC 8, outside HUC 8, within same HUC 10, within same HUC 12	
Virginia (Norfolk District)	8-digit	Onsite, offsite, 8-digit HUC required for banks (or adjoining HUC 8 in same river basin) otherwise 8-digit HUC or adjacent preferred IRT has in practice limited service areas to the same physiographic province as the bank (i.e. coastal plain, piedmont)	
Washington			
West Virginia			
Wyoming	8-digit	Onsite, offsite HUC 8, offsite HUC 10, outside HUC 8	
District-Wide Guidance			
Charleston (State of South Carolina)	8-digit	8-digit HUC, adjacent 8-digit HUC, drainage basin, case by case	"Mitigation sites should be located within the same Level III eco-region"
Detroit			
Fort Worth	8-digit	Primary is 8 digit HUC, Secondary is any 8 digit HUC adjacent to primary HUC-8 in same Level III Ecoregion; Tertiary is any HUC-8 adjacent to primary but in another Level III Ecoregion	Yes
Galveston			
Little Rock	8-digit	8-digit HUC, out-of-kind	
Memphis			
Mobile	8-digit	8-digit HUC	
New England	8-digit	Onsite, offsite	Yes/Optional
New York District	11-digit		
Omaha		Onsite, offsite	
Philadelphia			

South Pacific		Onsite, offsite	Yes
Tulsa	8-digit	Onsite, offsite	
Wilmington (State of North Carolina)	8-digit	8-digit HUC, streams with similar habitat designations, within same Physiographic Region	Three major ecoregion types

(Reproduced from *Guidelines Paper*)

In terms of banks and ILF programs, compensation occurs within a service area. Federal regulations impose few mandatory service area requirements (Box 1), so Corps districts and state agencies generally have substantial discretion in their establishment. The 2008 Rule provides examples of possible service areas, such as an 8-digit HUC in urban areas or multiple contiguous HUC-8 areas or a single HUC-6 area for rural regions (33 C.F.R. § 332.8(d)(6)(ii)(A)). Many ILF programs have developed detailed site selection and watershed analyses, though these were not included within the scope of our analysis.

Not every stream-compensation SOP addresses service area requirements, and few provide extensive guidance on the subject (*Guidelines Paper*). Several districts merely state that regulators will review and approve service areas after receiving a proposal, while others may only describe the maximum size of primary service areas or the type of instruments that must describe the proposed service area. Ohio, Maryland, and several others list the factors they consider in determining service area, such as ecoregions, the watershed approach, and proposed location relative to likely impact sites in determining the service area (*Guidelines Paper*).

Box 1: The 2008 Rule Service Area Provisions

- *Definition*: "the geographic area within which impacts can be mitigated at a specific mitigation bank or an in-lieu fee program, as designated in its instrument" (33 C.F.R. § 332.2).
- Service areas "must be appropriately sized to ensure that the aquatic resources provided will effectively compensate for adverse environmental impacts across the entire service area" (33 C.F.R. § 332.8(d)(6)(ii)(A)).

(Reproduced from *Guidelines Paper*)

Many SOPs that discuss service areas use an 8-digit HUC service area as a starting point and require any proposal for a larger service area to provide a rigorous and ecologically based justification. Others districts choose to use a smaller HUC-10, a larger HUC-6, or bioregions to define a watershed. Washington and Missouri use their own watershed categorization systems to limit service areas and define watersheds (*Practice Paper*).

It is common for SOPs that provide service area guidance to allow secondary service areas explicitly, which can be used if no credits are available in the primary service area or if an impact site is not within a primary service area. These SOPs establish two or three levels of service area, with less preferred levels further away from the primary service area. The ratio of mitigation required to size of impact varies depending on the level of service area in which an impact is located—a higher ratio is required in the tertiary service area, and a lower in the primary (see example in Box 2). Some SOPs also provide a range of credits based on site selection within the service area. If the compensation site is close to the impact site and within the same ecoregion, it may result in higher mitigation credit. Fewer credits are allowed as the distance to the impact site increases (sometimes into adjacent service areas).

In practice, regulators rely on a variety of considerations in reviewing stream compensatory mitigation sites. Some districts and states rely on, or are developing, formal site selection guidance, while others do not have formal policies, although they consider a range of information, such as site gradient, site viability, distance from impact site, and preservation of unusual flora and fauna, when making site selection decisions (*Practice Paper*). Practitioners often also consider a range of factors and criteria when making stream site selection decisions, including priority watersheds, natural heritage sites, species of concern, land cover, stream size, presence or absence of cattle, potential credit demand, and likely service areas, for example. State watershed plans and other similar documents, where available, may also aid in site selection since they often identify "hotspots" and other areas where compensation projects would be useful (*Practice Paper*).

Stream site selection is also often driven by opportunity, as well as by practical and economic considerations, in addition to watershed needs (*Practice Paper*). In our interviews, we heard that it is rare to identify an ideal mitigation site in terms of watershed needs and then obtain permission to develop a compensation project there; rather, a permit applicant will often propose a project on a property they already own, and the regulator will review and may approve the site. Opportunistic site selection can also be true for mitigation banks and ILF programs, and economic considerations can be important factors in site selection (*Practice Paper*). The use of a decision matrix that includes multiple criteria (land availability could be one, but it would have appropriate weight against other criteria) in site selection could help to address this issue. There are also some available tools that could serve this purpose, including River RAT (http://www.restorationreview.com/) and the Fish and Wildlife Service's Function-based Stream Restoration Project Process Review Checklist (https://www.fws.gov/Chesapeakebay/stream/protocols.html).

Box 2: An Example of Tiered Service Areas: Fort Worth

Fort Worth's SOP establishes three levels of service area: primary, secondary, and tertiary. The primary service area is one 8-digit HUC. The secondary service area is any part of an adjacent 8-digit HUC that is within the same Level III Ecoregion as the bank (using Ecoregions of Texas). Finally, the tertiary service area is any portion of an 8-digit HUC adjacent to the primary service area but in a different Level III Ecoregion than the bank. Furthermore, all service areas must be in the same major river basin, and tertiary service areas must be in an adjacent Ecoregion to the bank.

The ratio of mitigation required to amount of impact varies depending on the service area in which an impact is located—a higher ratio is required in the tertiary service area, and a lower in the primary. In Fort Worth, the mitigation:impact ratio is 1:1 for the primary, 1.5:1 for the secondary, and 3:1 for the tertiary (Fort Worth, 2011 p. 6).

WATERSHED APPROACH

The 2008 Rule requires that the Corps "use a watershed approach to establish compensatory mitigation requirements in DA permits to the extent appropriate and practicable. Where a watershed plan is available, the district engineer will determine whether the plan is appropriate for use in the watershed approach for compensatory mitigation. In cases where the district engineer determines that an appropriate watershed plan is available, the watershed approach should be based on that plan" (33 C.F.R. § 332.3(c)(1)).

Although many districts and states are working to implement the watershed approach with respect to stream compensation, progress has been uneven. Most stream compensation SOPs require or encourage mitigation projects to consider broader watershed problems, or at least to strive to do so, but, recognizing that there must be a nexus and rough proportionality between each impact and compensation site, fewer SOPs provide further guidance for mitigation providers on matching mitigation activities to the particular impacts at a project site (*Guidelines Paper*). Little Rock, Fort Worth, Los Angeles, New England, Seattle, and Omaha consider project site impacts to some degree, but broader watershed issues, not particular project impacts, generally have more weight. In these cases, regulators may try to focus on improvements to overall stream function in the watershed and take into account where compensation would be most viable. Mobile, Wilmington, and St. Louis, among others, avoid examining projects at a granular level to avoid fragmented, incomplete projects (*Practice Paper*).

Stream compensation SOPs generally do not address in detail what a watershed approach entails or provide specific instructions on how watershed concerns should influence site selection or mitigation design, especially when watershed plans are absent (*Guidelines Paper*). However, most stream compensation SOPs require that mitigation plans discuss how watershed concerns influenced site selection or how the mitigation takes into account watershed concerns and will benefit the watershed. For example, the Kansas City District, Wyoming (Omaha District), and state of Kentucky SOPs grant additional credit for mitigation work in designated priority watersheds, while the Mobile district SOP considers competition and permit loads within the watershed area when assessing bank locations and service area. Other SOPs (e.g., New England district, Ohio (state specific), Charleston district, Omaha district, Mobile district, Tulsa district, Detroit) list general site selection criteria, such as current and future hydrology (e.g., availability of sustainable water uses), current and future landscape features, adjoining land uses, physical and chemical factors, foreseeable effects of mitigation on ecologically important resources, overall watershed goals, and other features. For example, the SOP for the state of Ohio lists a number of criteria that should be used in site selection, including site channel stability, floodplain connectivity, riparian buffer habitat, substrate and in-stream habitat, faunal assemblage, water chemistry, nutrient enrichment, hydrology, adjacent upstream and downstream land use, ownership, relationship to other programs, unique features, hazardous substances, inclusion in land use plan, service area considerations, and relation of bank and ILF service areas to other regulatory criteria (Ohio, p. 12). The Wilmington district SOP lists general criteria for selecting stream mitigation sites, including preferences for projects on streams with similar habitat designations as impact sites (i.e., in kind compensation) and for sites that have the potential to improve habitat for state or Federally threatened and endangered species (Wilmington, p. 15) (*Guidelines Paper*).

The state-specific SOP for Maryland requires that the mitigation plan "describe how the proposed mitigation is consistent with goals and recommendations for the watershed, as listed in MDE's Priority Areas for Wetland Restoration, Preservation, and Mitigation" (Maryland, p. 73). The Maryland SOP also specifies that lands preferred for mitigation should have the following criteria: "disturbed areas, areas in agricultural production, former wetland areas that may now be degraded, areas adjacent or connected to existing nontidal wetlands, waterways or within the 100-year floodplain, and that are accessible to necessary construction equipment." The Memphis and Savannah district SOPs reference the NRC's recommendations for mitigation site selection (i.e., (1) consider the hydrogeomorphic and ecological landscape and climate; (2) adopt a dynamic landscape perspective; (3) pay attention to subsurface conditions, including soil and sediment geochemistry and physics, ground water quantity and quality, and infaunal communities; (4) pay particular attention to appropriate planting elevation, depth, soil type, and seasonal timing; and (5) provide appropriately heterogeneous topography) (NRC, 2001).

A couple of SOPs (e.g., Detroit, Savannah, and Philadelphia) mention that the mitigation plan should describe how the mitigation project will contribute to aquatic resource functions in the watershed. The South Pacific Division SOP requires a watershed overview as part of the description of the site selection process in the mitigation plan. For mitigation projects in a watershed with a watershed plan, a brief description of general watershed condition as well as a description of how the proposed compensatory mitigation site is consistent with restoration priorities identified in the plan is required. For watersheds without a plan, the division requires a general watershed analysis be completed for large projects with substantial impacts (South Pacific Division, p. 32). The SOP also requires the applicant to describe information on landscape setting and position as well as site-specific information.

A few SOPs, such as Kansas and Kentucky, grant additional credit for mitigation work in designated priority watersheds. Wyoming, for one, substantially increases the credit calculation if applicants use a watershed approach, and the SOP for the state of Ohio states that the watershed approach should be considered in service area selection (Wyoming, p. 13; Ohio, p. 15). The Wyoming SOP defines watershed approach as "the applicant/permittee has effectively demonstrated to the Corps that the mitigation site and resource was strategically selected based on local watershed needs and goals (33 CFR 332.2 definition and 332.3(b)). For example, a watershed approach may be demonstrated where a mitigation site addresses an identified priority from a watershed plan, wildlife action plan, or species recovery plan; addresses a TMDL or known source of water quality impairment; restores critical habitat for listed species; and/or improves landscape or ecosystem connectivity" (Wyoming, p 13). The Albuquerque SOP states that it is moving toward a watershed approach (Albuquerque, p. 3). Virginia's Unified Stream Methodology (USM) grants an additional 10—30% credit for each stream reach that is conserved/protected to the drainage divide. This "adjustment factor" is an important consideration in mitigation project site selection (USM, p. 26).

In practice, state regulators are also focusing on watersheds, with varying levels of experience and success (*Practice Paper*). While the watershed approach is "the basis for their work" in Missouri, the watershed approach is not usually used in New Hampshire. One practitioner and former regulator we interviewed observed that the watershed approach is a good tool to encourage buffers, setbacks, and connectivity, but that emphasis on watersheds can draw attention from urban stream mitigation and its water quality benefits. In many cases, practitioners try to incorporate broader watershed considerations into their work (*Practice Paper*). Other challenges impeding the use of the watershed approach in practice include the generally small scale of stream restoration in relation to the watershed and addressing watershed issues in urban areas, where water quality is a bigger problem.

In some areas, particularly at the state level, watershed plans are more complete. For example, Missouri has a watershed inventory assessment for 60 out of 67 of its HUC-8 regions and Washington's Department of Ecology has studied the watersheds across most of the state. Corps districts often rely on plans from the state level, or from NGOs or other federal agencies when taking the watershed approach. For instance, Table 6 provides examples of plans and tools from a variety of sources that can inform the identification of watershed needs – a primary element of a watershed approach (ELI and TNC, 2014). Such plans and tools, often developed by other regulatory and non-regulatory programs, can also include analyses of historical loss, current condition, and trends and future threats within the watershed. For example, Maryland's Watershed Resources Registry uses 303(d) listed waters as one layer of information in its multi-metric approach. Areas that are closer to 303(d) listed waters are identified as areas in need of water quality improvement. This type of water quality information could be folded into an analysis of watershed need as part of a broader watershed approach. In another example, the Duck-Pensaukee Watershed Approach Pilot brought together agencies and partners in Wisconsin and made use of existing plans and tools, including the state's Wildlife Action Plan, to identify the top tier of wetland conservation sites based on their potential to provide ecosystem services and to meet watershed needs. Factors such as current wetland coverage, historic wetland coverage, and current land use were used to identify suitable sites for restoration projects. Sites were ranked based on their potential to provide ecosystem services, such as flood abatement, water quality protection, surface water supply, shoreline protection, carbon storage, fish habitat, and wildlife habitat. The pilot used priorities identified in Wisconsin's State Wildlife Action Plan to

TABLE 6: Types and Examples of Watershed Plans and Tools. Examples of watershed plans and tools that originate from a variety of sources that can be used to support a watershed approach to compensatory mitigation.

Type	Example
Endangered Species Act Habitat Conservation Plans	Etowah Habitat Conservation Plan (https://www.fws.gov/athens/rivers/Etowah_River_HCP.html)
Flood Management Plans	New Hampshire Flood Protection Tool (http://www.eli.org/sites/default/files/docs/nhdes_wram_factsheet.pdf)
Special Area Management Plans	Rhode Island Salt Pond Special Area Management Plan (http://www.crmc.ri.gov/regulations/SAMP_SaltPond.pdf)

State Wildlife Conservation Plans	Idaho Wetland Conservation Prioritization Plan (http://www.recpro.org/assets/Library/SCORPs/id_scorp_2012-wetland_consv_plan.pdf); Duck-Pensaukee Watershed Approach Pilot (https://www.conservationgateway.org/Files/Pages/duck-pensaukee-watershed-aspx140.aspx)
USACE Watershed Assessments	The Monongahela River Watershed Assessment (http://www.lrp.usace.army.mil/Missions/Planning-Programs-Project-Management/Key-Projects/Monongahela-River-Watershed-Assessment/)
Water quality standards and implementation plans	Maryland Water Resource Registry (http://watershedresourcesregistry.com/overview.html)

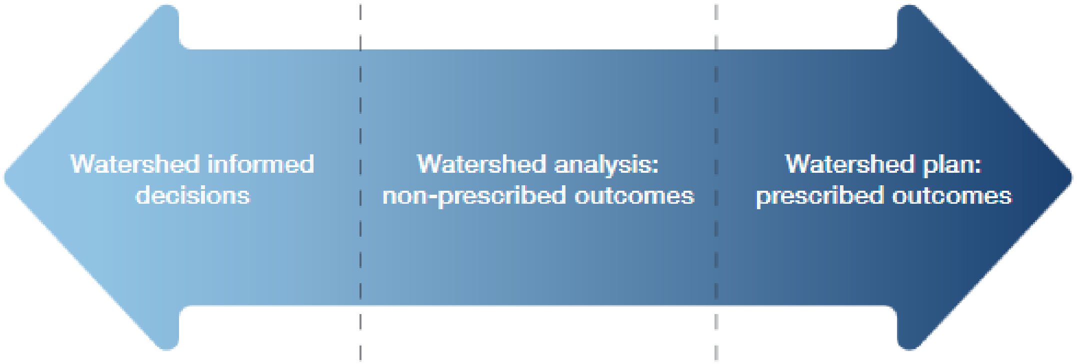
(Reproduced from *Practice Paper*)

conduct a spatially explicit analysis of wildlife habitat services, which received particular focus in the planning effort.

The absence of watershed plans, especially on the regional level, is a commonly cited impediment to implementing a comprehensive watershed approach (*Practice Paper*). The frequent absence of watershed plans may be holding back the efforts of both state and federal regulators to fully embrace the watershed approach. However, even when a suitable watershed plan is not available or there are not sufficient resources to develop a formal plan; there is a role for and value to watershed analyses or watershed informed decision-making as important steps that can improve project outcomes at the site and watershed levels (see the Watershed Approach Handbook, (ELI & TNC, 2014)). In other words, the lack of a watershed plan should not preclude the use of available data to identify and evaluate sites within a watershed context. For example, in 2009 and 2010, the Washington State Department of Ecology published frameworks to guide users in evaluating potential wetland compensatory mitigation sites in the western and eastern portions of the state (Hruby *et al*.; 2009, 2010). The handbooks include decision trees to help the user to evaluate the ecological functions/values supported by a potential wetland mitigation site and then provide users with specific recommendations based on some consideration of watershed needs and benefits. The tool does not require thorough comparison of the relative ability of many or all potential mitigation sites in the watershed to address watershed needs; instead, a single site or a limited number of sites are considered in the context of watershed stressors and needs.

Numerous planning tools and methods have been developed that are useful for informing a watershed approach to stream compensation site selection and design. The Army Corps issued guidance on watershed planning and the preparation of watershed plans in 2010 (U.S. Army Corps of Engineers. Watershed Plans. Circular No. EC 1105-2-411 (January 15, 2010)). The guidance includes four specific considerations to take into account when engaging in watershed planning: systems approach; public involvement, collaboration, and coordination; leveraging resources during implementation; and study area.

Watershed Approach Spectrum



Decision-tree or some consideration of watershed factors.	Identifies watershed need(s).	Identifies watershed need(s).
Includes some consideration of watershed need(s).	No or little translation of watershed needs (s) into specific desired watershed outcome(s}.	Describes specific, measurable desired watershed outcomes.
Potential of site to develop and persist is determined through individual site assessments.	Includes analysis of the potential of sites to develop and persist in a particular location.	Includes analysis of the potential of sites to develop and persist in a particular location.
No assessment of the potential of sites to meet watershed needs.	Assesses the potential of sites to meet watershed needs.	Assesses the potential of sites to meet watershed needs.
No comparison of the relative ability of sites to sustain desired characteristics and to address watershed needs.	Compares sites to evaluate their relative ability to sustain desired characteristics and to address watershed needs.	Compares sites to evaluate their relative ability to sustain desired characteristics, address watershed needs, and contribute to desired outcomes.
Examples: • WA Dept. of Ecology approach (esp. flow charts 2 and 3) • DU VT ILF Compensation Planning Framework (prioritization strategy)	Examples: • Duck-Pensaukee Watershed Approach Pilot, WI (TNC/ELI) • MD Watershed Resources Registry (Corps/EPA pilot) • MO DNR Wetland Potential Screening Tool • Sunrise River, MN Watershed Approach Pilot (Corps)	Examples: • NC Ecosystem Enhancement Program Local Watershed Plans • CA Regional Advance Mitigation Plan

Reproduced from ELI and TNC, 2014, p. 42.

FIGURE 6: Watershed Approach Spectrum. The Watershed Approach Handbook (ELI and TNC, 2014) provides an overall framework for the spectrum of watershed approaches. The watershed approach is characterized along a spectrum of categories from watershed informed decisions to watershed analyses with non-prescribed outcomes to watershed plans with prescribed outcomes.

As described above, ELI and TNC's Watershed Approach Handbook provides an overall framework for the spectrum of watershed approaches, examples of specific types of watershed approaches, examples of types of analysis that may be useful for using a watershed approach, and a list of national data sources that might inform all of the above. The watershed approach is characterized along a spectrum of categories from watershed informed decisions to watershed analyses with non-prescribed outcomes to watershed plans with prescribed outcomes (ELI and TNC, 2014). Further information on each category on the spectrum is provided in Figure 6 above.

STREAM RESTORATION APPROACHES AND TECHNIQUES

A range of approaches and techniques for stream restoration are employed across the country (*Guidelines Paper*). Through our analysis we sought to determine how these varied approaches and activities are used to develop plans and credits (*Guidelines Paper*, *Practice Paper*). We defined an approach as a comprehensive assessment and design methodology that includes multiple techniques. A technique is a single activity that helps accomplish an element of stream restoration, like planting a riparian buffer or adding large woody debris. Stream mitigation techniques are narrower in scope than approaches and are often used to address a specific problem, such as preventing streambank erosion or increasing buffer width and composition. For more information on selecting stream and watershed restoration techniques, see Chapter 5 "Selecting Appropriate Stream and Watershed Restoration Techniques" in Roni and Beechie (2013). Here the authors include a table that links the process or habitat restored with example techniques.

Relationship Between Restoration Technique, Functional Lift, and Credit Determination

As Corps Districts and IRTs well know, compensation ultimately entails a provider implementing an activity on the ground in order to generate a credit. The hope is that the mitigation activity will also lead to an improvement in stream function. However, the linkages between activities/ techniques, credits, and functional lift vary greatly, and range from weak to moderate to strong. For example,

- Weak Linkages – Credits are provided based on changes to dimension, pattern, and profile. The problem with this approach is that there are many ways to change channel geometry and the changes may or may not improve stream functions. In addition, specific stream functions improved are not identified. Currently, many SOPs rely on this method for creating credits (*Guidelines Paper*). For example, in the Wilmington District, restoration credits require changes to channel dimension, pattern, and profile. Enhancement I includes changes in two out of the three, e.g., dimension and profile, and Enhancement II requires changes in one, e.g., the profile.
- Moderate Linkages – Credits are proportional to the level of benefit provided by a restoration technique. This is a better approach, but it's often oversimplified. Many times, credits are generated for just in-channel work and riparian re-vegetation. Some districts relate credits to Rosgen's Priority Levels of Restoration. This approach is better than the first option, but it still does not assess the baseline functional condition of the site and relate it to the proposed/monitored condition. In addition, there are cases where a Rosgen Priority 3 stream may function at a higher level than a Rosgen Priority 2 stream.

- Strong Linkage – Credits are based on functional/conditional difference between the existing or baseline and proposed or monitored condition. This method uses a functional or conditional assessment using quantitative methods to calculate the difference in the restored and existing conditions. Several states and districts are evaluating methods to do this and plan to revise their SOPs. The NC Division of Mitigation Services and the states of Tennessee and Wyoming are using the Stream Functional Lift Quantification Tool developed by the Environmental Defense Fund and Stream Mechanics. The state of Oregon and the Environmental Protection Agency are developing a rapid function-based assessment method to determine mitigation debits and credits.

Use of Natural Channel Design

Natural Channel Design remains a predominant approach for stream compensatory mitigation. Approximately one-third of SOPs expressly mention Natural Channel Design. However, it was not clear if they meant Rosgen's version of Natural Channel Design, simply another term for stream restoration, or their own tailor-made version. Some SOP's explicitly require that Natural Channel Design be used to inform stream mitigation activities, while others explicitly mention Natural Channel Design as an option for informing stream mitigation activities without requiring the approach. Another third of SOPs do not use the term "Natural Channel Design," but refer to

TABLE 7: ***Use of Natural Channel Design.*** Approximately one-third of the SOPs we reviewed expressly mention Natural Channel Design. Some explicitly require that the approach be used to inform stream mitigation activities, while others explicitly mention Natural Channel Design as an option for informing stream mitigation activities without requiring the approach. Another third of SOPs do not use the term "Natural Channel Design," but refer to at least one of four concepts closely associated with the approach.

SOP	Discusses Natural Channel Design?
State-specific Guidance	
Georgia (State guidance, Savannah District)	Defines restoration categories by reference to priority levels of restoration (Attachment C)
Illinois (State guidance, Chicago, Rock Island, and St. Louis Districts)	"[A] stream relocated to a new location to accommodate construction of an authorized project must incorporate Natural Channel Design features" (p. 11).
Kansas (State guidance, Kansas City District)	"Note: No mitigation credit is provided for either constructing channels that do not incorporate the principles of Natural Channel Design or replacing a span bridge with a floored culvert design" (p. 16).

Kentucky (State guidance, Kansas City District)	"In general, Natural Channel Design is composed of three main components: • Naturally stable planform and profile. • Appropriate in-stream habitat (structures and self-perpetuating features). • Minimum 50' wide riparian zone on each side of the stream channel" (p. 3).
Maryland (State guidance, Baltimore District)	No
Missouri (State guidance, Kansas City, Little Rock, Memphis, St. Louis, and Rock Island Districts)	"Restoring stream channel to its former location and/or restoring sinuosity, channel dimensions, width/depth ratio, and bankfull width..." (p. 12). "A stream moved to a new location to accommodate construction of an authorized project should incorporate Natural Channel Design features relative to a morphologically stable and appropriate stream channel [dimension (cross-section), pattern (sinuosity), profile (slope)]" (p. 13).
Montana (State guidance, Omaha District)	Restoration or improvement activities include "stream channel restoration of pattern, profile, and dimensions . . . and reconnection of a stream with its floodplain" (p. 3).
Ohio (State guidance, Buffalo, Huntington, Pittsburgh Districts)	"Activity Level 1 applies to both perennial and intermittent streams. The associated activities may include but are not limited to a full-extent channel restoration involving dimension, pattern and profile work to provide for a stable stream that is reconnected to its original floodplain by using a relic channel or constructing a new channel. Stream restoration plans should be developed in conjunction with a reference reach assessment" (p. 27).
Pennsylvania (State guidance, Pennsylvania, Pittsburgh, and Baltimore Districts)	No
Tennessee (State guidance, Memphis and Nashville Districts)	Defines Natural Channel Design (p. 8). "Stream mitigation projects often involve a Natural Channel Design approach, which consists of returning a severely degraded, disturbed, or altered stream, including adjacent riparian buffer and flood-prone area, to a natural stable condition based on reference conditions or other appropriate standards" (p. 23).
Virginia (State guidance, Norfolk District)	"Streams that will be relocated using the principles of Natural Channel Design may be considered self-mitigating in most cases, eliminating the need to apply the USM" (p. 2). Calls for natural stream channel design methods for restoration projects (p. 20).

Washington (State guidance, Seattle District)	Does not mention the term "Natural Channel Design," but does include channel modification techniques (pp. 6–189).
West Virginia (State guidance, Huntington and Pittsburg Districts)	No
Wyoming (State guidance, Omaha District)	Mitigation activities may include "stream channel restoration of pattern, profile, and dimensions" (p. 3)
District-Wide Guidance	
Charleston	"Stream Enhancement and Maintenance/Improvement activities are designed to … restore natural channel features" (Appendix D, p. 5).
Detroit	No
Fort Worth	No
Galveston	"Restoration projects should focus project designs, using Natural Channel Design, on creating landforms and water flows that streams can maintain naturally that focus on the restoration of the chemical, physical, and biological functions" (p. 20).
Little Rock	Excellent restoration can include "Stream channel restoration that involves the re-establishment of a channel on the original floodplain, using a relic channel or constructing a new channel. The new channel is designed and constructed with the proper dimension, pattern and profile characteristics for a stable stream" (p. 9)
Memphis	Stream Restoration "should be based on a reference condition/reach for the valley type and includes restoring the appropriate geomorphic dimension (cross-section), pattern (sinuosity), and profile (channel slopes)" (p. 12).
Mobile	"The final plans will incorporate appropriate stream restoration techniques based on a reference stream and will be designed as required by the Natural Channel Design methods" (p. 2).
New England	No
New York District	Requires use of Natural Channel Design or bioengineering techniques and principles (p. 15).
Omaha	No
Philadelphia	No
South Pacific	No

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at least one of four concepts closely associated with the approach.[4] The remaining SOPs do not mention Natural Channel Design either expressly or implicitly (Table 7).

Techniques

Of 22 identified restoration techniques, defined as discrete activities, such as buffer reestablishment or bioengineering, that generally serve a specific purpose as part of the broader goal of stream restoration, all appeared in at least one SOP, with the exception of groundwater dams (Figure 7, Tables 8a and 8b). Beyond groundwater dams, the least commonly mentioned techniques were engineered logjams, controlled burning, agricultural BMPs, levee removal, large woody debris placement, and fish passage structures. The other techniques appeared in at least ten SOPs and were generally well represented.

Each technique we have identified serves one or more stream restoration purposes. Some techniques are used for one primary purpose. For example, removing a dam or a levee is done for the primary purpose of removing channel obstructions. Other techniques can be used to achieve several purposes. Restoring floodplain connectivity, for example, can improve vertical stability, bed-form diversity, and groundwater/surface water interactions, reduce nutrient loading from adjacent land uses, and lower stream temperature. Finally, multiple different techniques may be used to achieve the same purpose. For example, bioengineering and fencing can both improve lateral stability.

SOPs most often mention the various techniques in sections on credit determination and mitigation plan requirements; but techniques could also be discussed in other sections of the SOP. Several SOPs categorized techniques according to the level of benefit they provided. The Kansas SOP, for instance, lists several "possible mitigation activities" in its general guidelines for mitigation, and then explains each type of activity in more detail (Kansas, pp. 4—7). Then, in the section on credit calculation, the Kansas SOP categorizes different techniques according to whether they are substantial, moderate, or minimal stream restoration actions, which is a factor in determining how much credit per linear foot a mitigation project can receive (see Box 3). Little Rock, Missouri and Illinois list techniques in a similar fashion to Kansas, though they each use slightly different categories. Missouri divides mitigation activities into moderate, good, or excellent net benefits, Illinois uses the terms minimal, moderate, good, or excellent, and Little Rock uses moderate, good, and excellent within the category of stream restoration/enhancement.

[4]These concepts are: bankfull channel dimension; priority levels of restoration; restoring dimension, pattern, and profile; and restoring a channel so that the dimension, pattern, and profile doesn't aggrade or degrade over time.

Box 3: The Kansas SOP categorizes different techniques according to whether they are substantial, moderate, or minimal stream restoration actions, which is a factor in determining how much credit per linear foot a mitigation project can receive.

"Substantial stream channel restoration actions are those which address key multiple functions on a large scale and include (but are not limited to):

- Removing stream impoundments, pipes, culverts, or other man-made structures, then restoring the stream reach to a stable, appropriate channel configuration as per reference stream reaches.
- Replacing inappropriately designed culverts with a span bridge.
- Restoring appropriate bankfull discharge width, stream sinuosity, entrenchment ratio, length and width/depth ratio to a referenced morphologic pattern.
- Building a new, morphologically stable channel at a higher elevation to connect it to the floodplain.
- Creating or re-connecting floodplains adjacent to streams artificially disconnected from their floodplain.
- Where relocation of an incised stream is impracticable, modifying the existing channel and re- establishing a floodplain in situ, but not at the abandoned/disconnected floodplain elevation.
- Construction of off-channel storm water detention facilities in areas where runoff quantities are accelerating.
- Removing a dike, levee or berm that is within the 100-year floodplain to re-connect the floodplain to the stream channel.
- Reconnecting abandoned side channels or meanders that were artificially cut off, blocked, or filled where functionally appropriate.
- Removing riprap and reconstructing the stream banks to the proper radius of curvature, at the appropriate bank heights, then stabilizing all disturbed surfaces with either biodegradable erosion control fabric, native sod mats, and/or seeding with local native vegetation, and if necessary, bank modifications per guidance stated in Section 5.2.2.

Moderate stream channel restoration actions are those that address multiple or single functions on a smaller, reach-specific scale and include (but are not limited to):

- Restoring stability in highly eroded areas or areas with artificially accelerated erosion, using non- rigid (soft) methods such as native vegetative stabilization, root wads with a relatively small percentage of rock, resloping and reshaping banks and creating a vegetated floodplain bench.
- Restoring natural channel features (i.e., riffle/run/pool/glide habitat) using morphology appropriate to target stream type, but not a comprehensive channel reconstruction/relocation.
- Where relocation of an incised stream is not practicable and modifying the existing channel to create a stable stream channel is impracticable due to belt width constraints (limited land width available to form the meanders necessary for C or E stream types), modifying the existing channel and floodplain at its current elevation to create a stable channel. This converts the stream to a new stream type at the existing elevation of the channel but without an active floodplain.
- Routing a stream around an existing impoundment by creating a morphologically stable reach.
- Constructing fish ladders or other fish passage structures where appropriate.
- Replacing inadequate culverts/structures with a bottomless culvert or low water crossing.

Minimal stream channel restoration actions are those that address single or no functional objectives and include (but are not limited to):

- Restoring stream bank stability by hardening the existing channel in place where accelerated erosion is documented. It should only be allowed when there are insurmountable constraints to using other restoration solutions, as may be the case in urban settings. Some proposals undertaken by this methodology may be considered to have adverse aquatic impacts and require compensatory mitigation.
- Incorporation of a bankfull planting bench into a rock riprap project.
- Culverting floodplains at existing road crossings to facilitate flood flows.
- Replacing inadequate culverts with a conservation-designed culvert or a buried culvert that conforms to the appropriate configuration per hydrology and AOP.
- Removing check dams, weirs, car bodies, foreign materials/junk, debris and artificial in-stream structures and/or other structures that are directly contributing to bank erosion, scour or blocking stream processes and aquatic organism movements without any additional measures.

- Excluding livestock with a fence that meets NRCS design standards."

(Kansas Stream Mitigation Guidance (2010), pgs. 15—16)

The fact that a technique does not appear in an SOP does not necessarily imply that the technique cannot be used as a mitigation action in that district. Many Corps districts and states allow mitigation providers flexibility in developing mitigation plans. As a result, a district may allow the use of a technique as a mitigation action even if the SOP does not explicitly identify that technique as a permissible action.

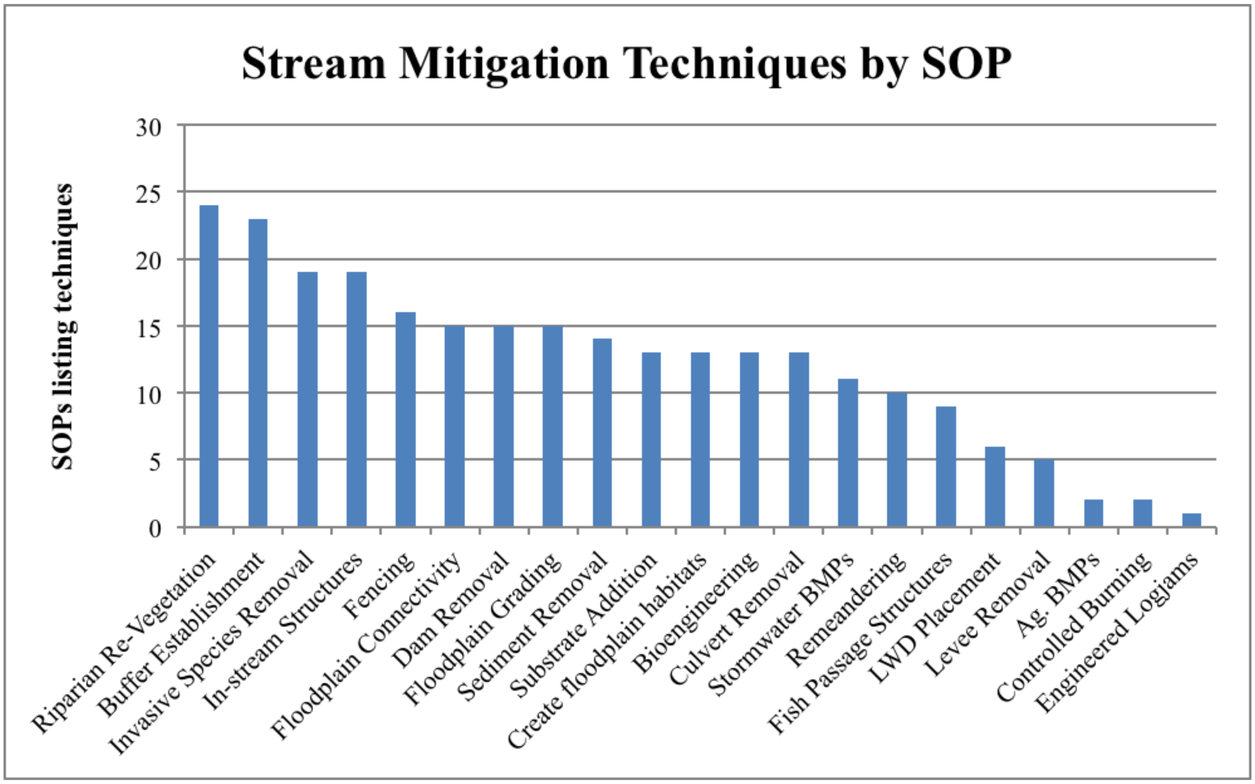

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FIGURE 7: ***Restoration Techniques:*** Restoration techniques are defined as discrete activities, such as buffer reestablishment or bioengineering, that generally serve a specific purpose as part of the broader goal of stream restoration. Of the 22 identified techniques, all appeared in at least one SOP, with the exception of groundwater dams. Beyond groundwater dams, the least commonly mentioned techniques were engineered logjams, controlled burning, agricultural BMPs, levee removal, large woody debris placement, and fish passage structures. The other techniques appeared in at least ten SOPs and were generally well represented. In SOPs, restoration techniques are generally mentioned in discussions of credit determination methodologies or mitigation plan requirements.

TABLE 8A: Identified Techniques and their Potential Purposes explicitly mentioned in state-specific SOP/Guidance Documents. Each technique we have identified serves one or more stream restoration purposes. Some techniques are used for one primary purpose. On the other hand, multiple different techniques may be used to achieve the same purpose. For example, bioengineering and fencing can both improve lateral stability. Techniques can also be categorized by the function or functions addressed by the activity. We have identified the dominant or 'best fit' functional categories for each technique in parentheses in the potential purposes column.

Techniques	Potential Purposes (Functional Categories)	State SOPs												
		GA	IL	KS	KY	MD	MO	MT	OH	PA	TN	VA	WA	WY
Agricultural BMPs	Runoff treatment, reduce nutrient loading from adjacent land uses, reduce stream temperature (Hydrology/ Physiochemical)					X		X						
Bio-engineering	Improve lateral stability / bank erosion (Geomorphology)	X	X	X	X						X	X	X	
Buffer Establishment	Runoff treatment, reduce nutrient loading from adjacent land uses, reduce stream temperature (Geomorphology and Physiochemical)	X	X	X		X	X	X	X		X	X	X	X
Controlled Burning	Improve floodplain/riparian vegetation composition/ complexity (Biology)													
Floodplain Habitat Creation	Improve floodplain/riparian complexity by creating microtopography, vernal pools, oxbows, sloughs, etc. (Hydraulics and Geomorphology)	X	X	X	X	X	X	X	X			X	X	
Culvert Removal	Remove channel obstructions (Hydraulics)	X	X	X	X	X	X	X			X	X		
Dam Removal	Remove channel obstructions (Hydrology, Hydraulics, Geomorphology, Physiochemical, and Biology)	X	X	X	X		X	X			X	X		X
Engineered Logjams	Improve bed-form diversity, improve groundwater/ surface water interaction, improve bed material sorting (Hydraulics and Geomorphology)												X	
Fencing	Improve lateral stability/bank erosion (Geomorphology)			X		X		X			X	X	X	X
Fish Passage Structures	Remove channel obstructions (Hydraulics)		X	X			X	X	X				X	
Floodplain Connectivity	Increases the frequency of overbank flooding and possibly increases attenuation for larger projects. This can include floodplain grading or raising the streambed. (Hydraulics)		X	X	X	X	X	X	X			X		X
Floodplain Grading	Improve floodplain inundation by excavating (lowering) the floodplain. (Hydraulics)		X	X	X	X	X	X	X				X	
Groundwater Dams	Improve groundwater/surface water interaction by constructing underground dams (e.g., with clay) that increase the elevation of the water table. This technique is most common in mining applications where channels are reconstructed in porous fill material. (Hydrology and Hydraulics)													

In-stream Structures	Improve lateral stability/bank erosion, improve vertical stability, improve bed-form diversity, improve groundwater/surface water interaction, reduce stream temperature (Hydraulics and Geomorphology)	X	X	X	X		X	X	X			X	X	X
Levee Removal	Improve floodplain/riparian complexity (Hydraulics)		X	X			X							
Large Woody Debris Placement	Improve bed-form diversity, groundwater/surface water interaction, substrate complexity, and flow complexity. (Hydraulics and Geomorphology)												X	
Remeandering of Straightened Channel	Improve vertical stability, improve bed-form diversity, improve groundwater/surface water interaction, reduce stream temperature (Hydraulics and Geomorphology)		X	X	X			X	X		X		X	X
Removal of Invasive Species	Improve floodplain/riparian complexity (Biology)	X		X	X	X	X	X	X	X	X	X		X
Riparian Re-vegetation	Improve lateral stability/bank erosion, improve floodplain/riparian complexity (Geomorphology)	X	X	X	X	X	X	X	X	X	X	X	X	X
Sediment Removal	Improve bed-form diversity (Geomorphology)	X	X		X	X			X	X			X	
Stormwater BMPs	Runoff treatment, reduce nutrient loading from adjacent land uses (Hydrology and Physiochemical)	X				X		X					X	
Substrate Addition	Improve bed-form diversity (Geomorphology)					X			X	X			X	

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TABLE 8B: Identified Techniques and their Potential Purposes explicitly mentioned in District-wide SOP/Guidance Documents. Each technique we have identified serves one or more stream restoration purposes. Some techniques are used for one primary purpose. On the other hand, multiple different techniques may be used to achieve the same purpose. For example, bioengineering and fencing can both improve lateral stability. Techniques can also be categorized by the function or functions addressed by the activity. The functional categories directly affected by each technique are indicated in parentheses.

		District SOPs						
Techniques	**Potential Purposes/ Functional Categories**	Charleston	Detroit	Galveston	Little Rock	Memphis	Mobile	New England
Agricultural BMPs	Runoff treatment, reduce nutrient loading from adjacent land uses, reduce stream temperature (Hydrology/ Physiochemical)							
Bio-engineering	Improve lateral stability / bank erosion (Geomorphology)		X				X	
Buffer Establishment	Runoff treatment, reduce nutrient loading from adjacent land uses, reduce stream temperature (Geomorphology and Physiochemical)	X	X	X	X	X	X	X

Controlled Burning	Improve floodplain/riparian vegetation composition/complexity (Biology)	X	X					
Floodplain Habitat Creation	Improve floodplain/riparian complexity by creating microtopography, vernal pools, oxbows, sloughs, etc. (Hydraulics and Geomorphology)				X		X	
Culvert Removal	Remove channel obstructions (Hydraulics)	X					X	X
Dam Removal	Remove channel obstructions (Hydrology, Hydraulics, Geomorphology, Physiochemical, and Biology)	X					X	X
Engineered Logjams	Improve bed-form diversity, improve groundwater/surface water interaction, improve bed material sorting (Hydraulics and Geomorphology)							
Fencing	Improve lateral stability/bank erosion (Geomorphology)	X	X	X	X	X	X	X
Fish Passage Structures	Remove channel obstructions (Hydraulics)	X					X	X
Floodplain Connectivity	Increases the frequency of overbank flooding and possibly increases attenuation for larger projects. This can include floodplain grading or raising the streambed. (Hydraulics)	X		X	X		X	X
Floodplain Grading	Improve floodplain inundation by excavating (lowering) the floodplain. (Hydraulics)		X		X	X	X	X
Groundwater Dams	Improve groundwater/surface water interaction by constructing underground dams (e.g., with clay) that increase the elevation of the water table. This technique is most common in mining applications where channels are reconstructed in porous fill material. (Hydrology and Hydraulics)							
In-stream Structures	Improve lateral stability/bank erosion, improve vertical stability, improve bed-form diversity, improve groundwater/surface water interaction, reduce stream temperature (Hydraulics and Geomorphology)	X	X	X	X		X	X
Levee Removal	Improve floodplain/riparian complexity (Hydraulics)	X			X			
Large Woody Debris Placement	Improve bed-form diversity, groundwater/surface water interaction, substrate complexity, and flow complexity. (Hydraulics and Geomorphology)							X
Remeandering of Straightened Channel	Improve vertical stability, improve bed-form diversity, improve groundwater/surface water interaction, reduce stream temperature (Hydraulics and Geomorphology)						X	
Removal of Invasive Species	Improve floodplain/riparian complexity (Biology)	X	X	X		X	X	X
Riparian Re-vegetation	Improve lateral stability/bank erosion, improve floodplain/riparian complexity (Geomorphology)	X	X	X	X	X	X	X

Sediment Removal	Improve bed-form diversity (Geomorphology)	X	X		X	X	X	
Stormwater BMPs	Runoff treatment, reduce nutrient loading from adjacent land uses (Hydrology and Physiochemical)	X	X					X
Substrate Addition	Improve bed-form diversity (Geomorphology)	X	X		X	X	X	

TABLE 8B: Techniques in District-Wide SOP/Guidance Documents (continued)

Techniques	Potential Purposes/ Functional Categories	District SOPs					
		New York District	Omaha	Philadelphia	South Pacific	Tulsa	Wilmington
Agricultural BMPs	Runoff treatment, reduce nutrient loading from adjacent land uses, reduce stream temperature (Hydrology/ Physiochemical)						
Bio-engineering	Improve lateral stability / bank erosion (Geomorphology)	X	X		X		X
Buffer Establishment	Runoff treatment, reduce nutrient loading from adjacent land uses, reduce stream temperature (Geomorphology and Physiochemical)	X	X	X	X	X	X
Controlled Burning	Improve floodplain/riparian vegetation composition/complexity (Biology)						
Floodplain Habitat Creation	Improve floodplain/riparian complexity by creating microtopography, vernal pools, oxbows, sloughs, etc. (Hydraulics and Geomorphology)						X
Culvert Removal	Remove channel obstructions (Hydraulics)	X					
Dam Removal	Remove channel obstructions (Hydrology, Hydraulics, Geomorphology, Physiochemical, and Biology)	X		X		X	
Engineered Logjams	Improve bed-form diversity, improve groundwater/surface water interaction, improve bed material sorting (Hydraulics and Geomorphology)						
Fencing	Improve lateral stability/bank erosion (Geomorphology)					X	X
Fish Passage Structures	Remove channel obstructions (Hydraulics)	X					
Floodplain Connectivity	Increases the frequency of overbank flooding and possibly increases attenuation for larger projects. This can include floodplain grading or raising the streambed. (Hydraulics)						X
Floodplain Grading	Improve floodplain inundation by excavating (lowering) the floodplain. (Hydraulics)				X	X	

Groundwater Dams	Improve groundwater/surface water interaction by constructing underground dams (e.g., with clay) that increase the elevation of the water table. This technique is most common in mining applications where channels are reconstructed in porous fill material. (Hydrology and Hydraulics)						
In-stream Structures	Improve lateral stability/bank erosion, improve vertical stability, improve bed-form diversity, improve groundwater/surface water interaction, reduce stream temperature (Hydraulics and Geomorphology)	X				X	X
Levee Removal	Improve floodplain/riparian complexity (Hydraulics)						
Large Woody Debris Placement	Improve bed-form diversity, groundwater/surface water interaction, substrate complexity, and flow complexity. (Hydraulics and Geomorphology)	X		X	X	X	
Remeandering of Straightened Channel	Improve vertical stability, improve bed-form diversity, improve groundwater/surface water interaction, reduce stream temperature (Hydraulics and Geomorphology)					X	X
Removal of Invasive Species	Improve floodplain/riparian complexity (Biology)	X	X	X	X		
Riparian Re-vegetation	Improve lateral stability/bank erosion, improve floodplain/riparian complexity (Geomorphology)	X	X			X	X
Sediment Removal	Improve bed-form diversity (Geomorphology)					X	
Stormwater BMPs	Runoff treatment, reduce nutrient loading from adjacent land uses (Hydrology and Physiochemical)	X					
Substrate Addition	Improve bed-form diversity (Geomorphology)	X				X	

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DEBIT DETERMINATION METHODS

The 2008 rule allows for considerable variation in determining debits (Box 4), and the guidance in stream compensation SOPs varies accordingly. Some SOPs provide substantial guidance on debit determination, with detailed instructions and relatively standardized methodology, while others contain little or no guidance on the topic. At the state level, just over half of the states with state or Corps stream mitigation programs have a procedure for determining debits or credits (ASWM, 2014).

Of those states and districts that do establish more detailed debit procedures, no one approach predominates, but several approaches have gained use across several districts (*Guidelines Paper*). In most, but not all cases, size of the impact, rather than functions lost, is the main factor in calculating debits.

Box 4: The 2008 Rule's Definition of Debit

"A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the loss of aquatic functions at an impact or project site. The measure of aquatic functions is based on the resources impacted by the authorized activity" (33 C.F.R. § 332.2).

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Debit Table Approaches

Many SOPs (e.g., Charleston, Illinois, Little Rock, Missouri, Mobile, Montana, Savannah, and Wyoming) provide tables that allow district staff to determine debits by quantifying the impacts to each affected stream reach, based on a set of adverse impact factors (Table 9). These table-based procedures share a basic framework, though the numeric multipliers vary among SOPs. The tables generally include the same factors, including **stream type** (most commonly ephemeral, intermittent, or perennial), **priority area/category** (usually primary, secondary, or tertiary; definitions for these categories vary, but generally, priority streams are those that provide very important functions or services on a watershed scale, occupy important positions in the landscape, or are considered important because of rarity; secondary streams are vulnerable or uncommon, but do not meet the definition of primary; and tertiary streams are those that are not primary or secondary), **existing condition of the impacted stream**, the **duration of the impact**, the **dominant impact**, and the **cumulative impacts** (See Table 9 and Figure 8 for an example).

Each adverse impact factor is assigned a range of multipliers. For example, the Missouri table has three multipliers for the factor "stream type impacted." If the impacted stream is ephemeral, the multiplier is 0.3; if the impacted stream is intermittent, the multiplier is 0.4; and if the impacted stream is perennial, the multiplier is 0.8. In general, for each stream reach, the multipliers for each adverse impact factor are added together to create a total mitigation factor. This number is multiplied by the linear feet of that reach to determine the number of debits from that reach. The process is repeated for each affected reach, and the debit amounts are added together for a total debit amount.

The Charleston, Savannah, Illinois, Little Rock, and Missouri SOPs, among others, include type of activity as a factor. Some SOPs recognize more types of impacts than others, although there is substantial overlap among the SOPs. The most commonly identified dominant impacts are clearing vegetation along the stream, utility crossing/bridge footing, below grade culvert

***FIGURE 8:** Example of a Debit Determination Table from the Missouri SOP*

<table>
<tr><th colspan="10">ADVERSE IMPACT
FACTORS WORKSHEET</th></tr>
<tr><td>Stream Type Impacted</td><td colspan="2">Ephemeral
0.3</td><td colspan="3">Intermittent
0.4</td><td colspan="4">Perennial
0.8</td></tr>
<tr><td>Priority Area</td><td colspan="2">Tertiary
0.1</td><td colspan="3">Secondary
0.4</td><td colspan="4">Primary
0.8</td></tr>
<tr><td>Existing Condition</td><td colspan="2">Functionally Impaired
0.1</td><td colspan="3">Moderately Functional
0.8</td><td colspan="4">Fully Functional
1.6</td></tr>
<tr><td>Impact Duration</td><td colspan="4">Temporary
0.05</td><td colspan="5">Permanent
0.3</td></tr>
<tr><td>Impact Activity</td><td>Clearing
0.05</td><td>Utility Crossing/ Bridge Footing
0.15</td><td>Below Grade Culvert
0.3</td><td>Armor
0.5</td><td>Detention
0.75</td><td>Morphologic Change
1.5</td><td>Impoundment (dam)
2.0</td><td>Pipe
2.2</td><td>Fill
2.5</td></tr>
<tr><td>Linear Impact Calculation</td><td colspan="9">0.0002 multiplied by linear feet of stream impact recorded in each column [in subsequent table]</td></tr>
</table>

Source: Missouri, p. 23.

installations, streambank and bed armoring, in-channel detention, morphological change or disturbance, impoundment, piping, and in-stream filling.

Other SOPs include additional adverse impact factors. The Wyoming SOP includes special resources and type of loss as factors in its adverse impact table. The Montana adverse impact table is slightly more detailed than the other tables, including factors such as stream status, location of mitigation, comparative stream order of the mitigation site, legal protection on the mitigation site, and mitigation timing. New England's SOP uses a similar table, but the only factors on which the amount of debits depends are impacted stream condition, determined by using a visual assessment protocol, and the type of impact (impoundment or dredging, for example).

TABLE 9: ***Debit Table Factors and Ranges.*** The primary adverse impact categories used to calculate debits in state-specific and district-wide guidance. Each adverse impact factor is assigned a range of multipliers. In general, for each stream reach, the multipliers for each adverse impact factor are added together to create a total mitigation factor. This number is multiplied by the linear feet of that reach to determine the number of debits from that reach. The process is repeated for each affected reach, and the debit amounts are added together for a total debit amount. Impact factors include: Lost stream type (e.g., ephemeral, intermittent, perennial); priority area/category (e.g., primary, secondary, tertiary- definitions for these categories vary, but generally, priority streams are those that provide very important functions or services on a watershed scale, occupy important positions in the landscape, or are considered important because of rarity; secondary streams are vulnerable or uncommon, but do not meet the definition of primary; and tertiary streams are those that are not primary or secondary); existing condition (e.g., fully functional, somewhat impaired, impaired); duration of impact (e.g., temporary, recurrent, permanent); dominant impact; and cumulative impact/scaling factor.

	Lost Stream Type	Priority Area/ Category	Existing Condition	Duration of Impact	Dominant Impact	Cumulative Impact/ Scaling Factor
State-specific Guidance						
Georgia (Savannah District)	Intermittent, Perennial (>15 feet wide), Perennial (<15 feet wide). *Debits*: 0.1–0.8	Tertiary, Secondary, Primary. *Debits*: 0.5–1.5	Fully Impaired, Somewhat Impaired, Fully Functional. *Debits*: 0.25–1.0	Temporary (<1 year), Recurrent, Permanent (>1 year). *Debits*: 0.05–0.2	9 impact types with successively greater adverse impact on stream systems *Debits*: 0.05–3.0	If <1000 LF, 0.0-0.2. For impacts >1000 LF, 0.4 for every 1,000 LF.
Illinois	Ephemeral/ intermittent, Intermittent with Seasonal Pools, Perennial Streams. *Debits*: 0.1–0.8	Tertiary, Secondary, Primary. *Debits*: 0.1–0.8	Functionally Impaired, Moderately Functional, Fully Functional. *Debits*: 0.2–1.2	Temporary (less than 180 days), Short-term (180 days – 2 years), Permanent (>2 years). *Debits*: 0.05–0.3	Clearing, Utility Crossing/Bridge Footing, Below-grade Culvert, Armor, Detention, Morphological Disturbance, Impoundment, Pipe, Fill. *Debits*: 0.05–2.5	Total linear feet impacted by the project (0.0003 x length of stream impacted).
Kansas	Ephemeral/ Intermittent Without Pools, Intermittent w/ Pools, Perennial. *Debits*: 0.4–0.8	Tertiary, Secondary, Primary. *Debits*: 0.1–0.8	Functionally Impaired, Moderately Functional, Highly Functional. *Debits*: 0.04–4.0	Temporary (<1yr), Short-term (1-2 yr), Permanent (>2yr). *Debits*: 0.05–0.3	Clearing, Utility Crossing, Below Grade Culvert, Temporary Inundation Zone, Armor, Diversion/ Weir, Morphologic, Impound, Pipe, and Fill. *Debits*: 0.05–2.5	0.0003 x length of stream impacted.

Missouri	Ephemeral, Intermittent, Perennial. *Debits*: 0.3–0.8	Tertiary, Secondary, Primary. *Debits*: 0.1–0.8	Functionally Impaired, Moderately Functional, Fully Functional *Debits*: 0.1–1.6	Temporary (<6 months), Permanent. *Debits*: 0.05–0.3	Clearing, Utility Crossing/Bridge Footing, Below-Grade Culvert, Armor, Detention, Morphologic Change, Impoundment, Pipe, Fill. *Debits*: 0.05–2.5	0.0002 per linear foot of impacted stream.
Montana (also comparative stream order, mitigation location, site legal protection, & timing)	Ephemeral, Intermittent, Perennial. *Debits*: 0.2–0.6	High Resource Value, All Others. *Debits*: 0.25–0.75	Impaired, Somewhat Impaired, Fully Functional. *Debits*: 0.25–1.5	N/A	Bank Stabilization (w/ 5 subtypes), Morphologic, Channelization, Impound, Pipe, Fill. *Debits*: 0.2–2.5	<1000 LF (LF x 0.0005), 1001-3000 LF (LF x 0.001), >3000 LF (LF x 0.002)
Tennessee	N/A	High Priority and Standard Priority. *Debits*: 0.3, 0.6	Separate assessment scores for Water Quality, Geomorphology, Riparian Buffer, Aquatic Habitat.		Rip Rap One Bank, Stream Relocation, Rip Rap Lined Channel, Bottomless Culvert, Impoundments/Tail Water, Pipe, Fill. *Debits*: 0.6–2.5	0.2 x total linear feet in 12-digit HUC watershed or same stream reach.
Wyoming	Class 4 (B, A), Class 3 (D, C or B), Class 2 (D, C, A, AB, or B), Class 1. *Debits*: 0.1–2.0	Red Ribbon, Conservation, Blue Ribbon, Wild & Scenic, Threatened & Endangered Species. *Debits*: 0.6–2.0	Non-functional, Deficient, Functional. *Debits*: 0.5–2.0	N/A	Type of Loss: Partial Functional, Functional, Physical. *Debits*: 1.0–6.0	Multiply total length of all stream disturbances (feet) by 0.005.
District-Wide Guidance							
Charleston	Non-RPWs, 1st and 2nd order RPWs (Relatively Permanent Waters), all other streams. *Debits*: 0.1–0.8	Tertiary, Secondary, Primary. *Debits*: 0.1–0.6	Very Impaired, Impaired, Partially Impaired, Fully Functional. Based on functional assessment score. *Debits*: 0.1–1.5	Temporary (<1 year, Recurrent (repeated impacts of short duration), Permanent (>1 year) *Debits*: 0.05–0.3	Armor, Clear, Culvert, Detention/Weir, Fill, Impound/Flood, Morphologic Change, Pipe, Shade, Utility Crossings *Debits*: 0.05–2.5	Between 0.01–1.5 for <6000 linear feet; 3.0 for > 6000 linear feet

Little Rock	Ephemeral, Intermittent, Perennial (with OHWM <15’, 15’-30’, >30’). *Debits*: 0.1–0.8	Tertiary, Secondary, Primary. *Debits*: 0.1–0.8	Functionally Impaired, Moderately Functional, Fully Functional. *Debits*: 0.1–1.6	Temporary (<6 months), Recurrent (repeated impacts of short duration), Permanent. *Debits*: 0.05–0.3	Clearing, Utility Crossing/Bridge Footing, Below-Grade Culvert, Armor, Detention, Morphologic Change, Impoundment, Pipe, Fill. *Debits*: 0.05–2.5	If <1000 LF, 0.0-0.2. For impacts >1000 LF, 0.1 for every 500 LF (example: scaling factor for 5,280 LF of impacts = 1.1)
Mobile	Ephemeral, Intermittent, Perennial. *Debits*: 0.3–1.15	Tertiary, Secondary, Primary. *Debits*: 0.1–0.8	Geomorphologically Stable, Partially Unstable, Unstable. *Debits*: 0.1–1.6	Temporary, Recurrent, or Permanent. *Debits*: 0.05–0.3	Share/Clear, Utility Crossing, Below-Grade Culvert, Armor, Detention/Weir, Morphologic Change, Impoundment, Pipe, Fill. *Debits*: 0.05–2.5	If <1000 LF, 0.0-0.2. For impacts >1000 LF, 0.1 for every 500 LF, max. 2.0.

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Mitigation Ratio Approaches

The Ohio SOP relies on debit ratios, determining debits by multiplying the number of linear feet of impacts by a set multiplier. In some cases, stream value or type is taken into account when determining how many debits to count per linear foot. For example, the Ohio SOP classifies streams into three categories (groups 1, 2, and 3). Each group contains several types of streams—for example, headwater perennial streams and coldwater streams are both in Group 3—and the SOP provides suggested debit ratios for each type. Except for in the first group, the debit ratio is the same for all of the stream types within a particular grouping; all Group 3 stream types, for example, have a suggested requirement of 3 debits for every linear foot of impact. Unlike the tables used in Illinois, Missouri, and several other SOPs, this approach relies only on the quality of the stream impacted, and does not make more fine-grained distinctions based on the type or duration of impact.

Approaches that incorporate assessment methodologies

Nebraska's Stream Condition Assessment Procedure (2012) includes a calculator and stream assessment procedure that allows users to assess impacts and compensation (USACE–Omaha District, 2012 a, b). Evaluation factors include Hydraulic Conveyance and Sediment Dynamics, In-stream Habitat/Available Cover, Floodplain Interaction–Connectivity, Vegetation Composition, Riparian Buffer Continuity and Width, and Riparian Land Use: An artificial convention of 100' from the top of each bank.

The South Pacific Division has developed a mitigation ratios checklist that applies to the Albuquerque, Los Angeles, Sacramento, and San Francisco Districts (South Pacific Division Mitigation Ratios). The checklist provides a methodology to determine a mitigation ratio for compensatory mitigation requirements that incorporates scientific understanding and assessment data if available. The checklist takes into account the location of the impact and mitigation project, net loss of aquatic surface area, the type of conversion, risk and uncertainty, and temporal loss associated with the mitigation site. It allows for the integration of functional assessment data, if available. "Acceptable functional/condition assessment methods must be aquatic resource-based, standardized, comparable from site to site, peer-reviewed, unmodified, and approved by the applicable Corps District" (South Pacific Division Mitigation Ratios, 2011). If an approved functional/condition assessment is approved, then a before-after-mitigation-impact (BAMI) spreadsheet is used to determine a baseline ratio.

The Pennsylvania SOP (portions of Baltimore, Pittsburgh, and Philadelphia Districts) takes yet another approach. It considers similar factors such as resource quality and condition, size of impact, and intensity of impact, but the approach is more closely focused on aquatic resource functions. Pennsylvania established several functional groups each for rivers, wetlands, and lakes, including hydrologic, biogeochemical, habitat, and recreation or resource support. Each group contains a list of multiple functions with similar attributes, and the categories are designed to capture the main functions of each type of aquatic resource. For each impacted function group four values are determined. First, the project area is calculated. Second, Pennsylvania groups different types of streams into Aquatic Resource Value Categories: significant resource waters, special resource waters, quality resource waters, support resource waters, and minimal resource waters. A table lists criteria for each aquatic resource type, generally with reference to categories established under Pennsylvania statute. Each resource category is assigned a value between

1.0 and 3.0; for example, significant resource waters have a value of 3, while minimal resource waters have a value of 1. Third, a separate table is used to determine the Project Effect Factor, a score between 0.0 and 3.0, with more severe impacts having a greater score. For each function, different potential impacts are grouped according to their severity and the corresponding score: for example, a potential impact to biogeochemical function is elimination of a floodplain's ability to support vegetation. This is categorized as a severe impact, with a Project Effect value of 3.0. A moderate impact to the recreational function would be a limited and temporary loss of or interference with recreational use, with a Project Effect value of just 1.0. Fourth, the condition of the resource is assessed, using Pennsylvania's rapid assessment protocols for waterways, lakes, and wetlands, and given a score between 1.0 and 0.0.

Under the Pennsylvania process, for each function group, the compensation requirement, or debits, is the product of the four factor scores. In other words:

Compensation Requirement (CR) = AI x PE x RV x CI, where

CR = Compensation Requirement

AI = Area of Impact (in acres, 0.00)

PE = Project Effect Factor (Table 3)

RV = Resource Value (Table 4)

CI = Condition Index Value (0.00) (from applicable resource condition assessment)

Source: Pennsylvania, p. 21

The calculation is repeated for each impacted function and the score totaled for the overall debit amount. Galveston uses a similar process to calculate debits, though its methodology does not determine the effect for each function separately. In Galveston, the debits are the product of the projected change in resource condition, multiplied by an impact factor score between 1 and 5 that likewise depends on the intensity of impact, multiplied by the linear feet of impact.

Norfolk also takes a similar approach. The compensation requirement, or debits, is determined by multiplying the length of impact, the reach condition index, and the impact factor. The **reach condition index** (RCI) is determined by evaluating condition indices (CIs) for each of the following four parameters: 1) Channel Condition, 2) Riparian Buffer, 3) In-Stream Habitat, and 4) Channel Alteration. Channel Condition is an assessment of the cross-section of the stream, along the stream reach. The channel condition categories include optimal, sub-optimal, marginal, poor, and severe. Riparian buffer condition is determined by evaluating the extent of each cover type (e.g., forest, cropland, pavement) over the total riparian buffer area (length of stream reach multiplied by 100 feet) for each side of the stream channel. Riparian buffer categories include optimal, high suboptimal, low suboptimal, high marginal, low marginal, high poor, and low poor. The In-Stream Habitat assessment considers the habitat suitability for effective colonization or use by fish, amphibians, and/or macroinvertebrates. Categories include optimal, suboptimal, marginal, and poor. This Channel Alteration Parameter considers direct impacts to the stream channel from anthropogenic sources. The categories include negligible, high minor, low minor, high moderate, low moderate, and severe. The reach condition index is then calculated by taking a weighted average of each of the above condition indices (RCI = Sum of all CIs ÷ 5). The Channel Condition index is valued twice because a stream's physical stability heavily influences its condition. The **Impact Factor** (IF) is determined based on the severity of the impact. The more severe the impact the higher the IF (Severe = 1, Significant = 0.75, Moderate = 0.5, Negligible = 0). The Compensation Requirement is then calculated using the following equation:

(CR) = LI x RCI x IF; where,

CR = compensation credits required

LI = length of impact (in linear feet)

RCI = Reach Condition Index (Form 1)

IF = Impact Factor (Table 1)

The West Virginia Stream and Wetland Valuation Metric (WV SWVM) is an example of a more complex table approach that incorporates assessment methodologies. The SWVM includes direct measures of water quality and biological condition in the debit (and credit) calculations. The methodology synthesizes multiple established assessment methodologies (e.g., USEPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers2 (RBP), A Stream Condition Index for West Virginia Wadeable Streams3 (WVSCI), and water quality data utilized by the WVDEP (Water Quality Data Sheet)) to correlate impacts with proposed compensatory mitigation projects. The methodology requires multiple inputs including project-specific data (for impacts and proposed compensatory mitigation); stream classification; stream description; the extent of a proposed impact; the form of mitigation (choices are provided in a drop down list); a broad spectrum of physical (using RBP), chemical (using water quality data sheet) and biological indicators (using WVSCI); and other factors including temporal loss and mitigation site protection. The individual assessments are used to indicate the physical, chemical and biological integrity of the site. The SWVM then generates an index score (ranging from 0 (poor condition) to 1.0 (best condition)) that is multiplied by the linear feet to result in a unit score. Unit scores are calculated for the impact site, the mitigation site existing condition, the mitigation site projected upon completion, and the mitigation site projected at maturity. The unit score for the impact site must be less than or equal to the score for the mitigation project at maturity to adequately offset proposed impacts (West Virginia, 2011, p. 3).

Box 5: The 2008 Rule's Definition of Credit

"A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the accrual or attainment of aquatic functions at a compensatory mitigation site. The measure of aquatic functions is based on the resources restored, established, enhanced, or preserved" (33 C.F.R. § 332.2).

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Cumulative Impacts

Twelve of the SOPs include some way to account for the cumulative impact of permitted activities on streams: Charleston, Illinois, Kansas, Little Rock, Missouri, Mobile, Montana, Pennsylvania, Savannah, South Pacific, Tennessee, and Wyoming. Many of the districts use a table approach (e.g., Charleston, Savannah, Illinois, Missouri). Others use linear or cumulative impact as a numeric factor that is added into the total debit multiplier number (Table 9). For example, in

Kansas, the cumulative impact factor is the overall length of impact in feet multiplied by 0.0003; the resulting amount is added with the other factors to create the overall debit multiplier. In Pennsylvania, cumulative impact (as measured by overall linear footage of project impact) is one of the criteria for assessing project effect on the recreation/resource support function group: a project with more than 2,000 feet of total impact will have a "severe" effect on that function group, a project with between 1,000 and 2,000 feet will have a "moderate" effect, and so forth. The South Pacific division SOP does not have a quantitative way to account for cumulative impact, but it does explain that the landscape and cumulative impacts should be taken into consideration, stating as an example that "if an action's impacts, when considered in the context of impacts of past, present, and reasonably foreseeable actions, could exceed a scientifically based threshold for the watershed (such as watershed impervious cover of 10 percent, exceedance of which research in many parts of the country has shown leads to a decline of most stream quality indicators), additional compensatory mitigation for the action's incremental impacts may be required" (South Pacific p. 13).

DETERMINATION OF CREDITS

As with debits, the 2008 rule allows for considerable variation in determining credits and the guidance in SOPs varies accordingly. The SOPs we reviewed vary considerably in their treatment of credits (Box 5), as they did with debits. Roughly one-third of SOPs include credit determination tables and/or worksheets, whereas the other two-thirds contain little or no guidance about how to determine credits. The credits granted are generally not a direct measurement of function gained, but instead are calculated and awarded on a linear-foot basis.

Districts including Wyoming, Fort Worth, Tulsa, Charleston, and Tennessee use or have developed assessment methodologies to support debit and credit determination. These methodologies determine credits based on conditional assessments of the mitigation site and the baseline condition of the impact site, often using various ratios according to the type of mitigation activity and the anticipated improvement in stream quality. Although multiple practitioners describe using mitigation ratios as a less current approach, they continue to be used to at least some degree in these districts.

Many other districts use interactive worksheets to calculate the number of credits that a given project will generate. These SOPs provide credit tables that identify mitigation factors, along with multipliers for each factor (Table 10, see Figure 9 for example). These tables operate essentially the same as the debit determination table method shared by most of these SOPs. The tables are generally similar to each other, although there are some differences among the factors and multipliers, and the terminology occasionally differs. In addition, some of the SOPs include factors relating to riparian buffers in their credit tables, while others include separate buffer tables. (Buffer credit determinations are discussed in the following section).

The Charleston, Illinois, Kansas, Little Rock, Missouri, Mobile, Savannah, Tennessee, and Wyoming credit determination tables include at least some of the following factors: stream type, (e.g., ephemeral, intermittent, or perennial), priority area/category (e.g., primary, secondary, or tertiary), existing condition of the stream, net benefit (e.g., minimal, moderate, good, or excellent), monitoring/contingency (e.g., Level I, II, or III; higher levels require more monitoring and thus generate more credits), site protection (e.g., deed restriction, conservation easement), mitigation construction timing/timing of mitigation (e.g., before, during, or after impacts; the earlier mitigation takes place, the more credits it will generate), location of mitigation (e.g., in the same 8-digit HUC as the impacts, or outside the 8-digit HUC), and temporal lag or loss (the time needed for the mitigation site to fully replace the functions that were lost at the impact site). As with its debit method, New England uses a simplified credit calculation table, taking into account the mitigation technique used and the condition of the mitigation stream site.

TABLE 10:* *Credit Table Factors and Ranges. Many SOPs provide credit tables that identify mitigation factors, along with multipliers for each factor. As with the debit determination process used by most of these districts or states, the multipliers for each credit factor are added together to create a total mitigation factor for each reach or mitigation project. This number is multiplied by the linear feet of that reach to determine the number of credits. The process is repeated for each reach or mitigation type within the project, and the credit amounts are added together for a total credit amount for the mitigation project.

	Net Improvement/ Benefit	Priority Area/ Category	Control/Site Protection	Credit Schedule/ Construction Timing	Kind/Stream Type	Location	Monitoring
State-specific Guidance							
Georgia	Streambank stabilization, Structure removal, Priority 4 Restoration, Priority 3 Restoration, Priority 1-2 Restoration. *Credits*: 1.0–8.0	Tertiary, Secondary, Primary. *Credits*: 0.05–1.0	Restricted covenant on restored channel and 25’ buffer (Required), Required RC & conservation easement or government/public protection, or all three protections. *Credits*: 0.1–0.5	Schedule 3, 2 (required for banks), or 1. *Credits*: 0 – 0.5	N/A	N/A	Minimal, Moderate, Substantial, Excellent levels of monitoring rigor. *Credits*: 0.0–1.0
Illinois	Minimal, Moderate, Good, Excellent. *Credits*: 1.0–3.5	Tertiary, Secondary, Primary. *Credits*: 0.05–0.4	Deed restriction, Conservation easement/title transfer. *Credits*: 0.1–0.4	Mitigation after impacts, Concurrent with impacts, Before impacts. *Credits*: 0–0.3	N/A	N/A	Level I, II, or III. *Credits*: 0.1–0.25
Kansas	Minimal, Moderate, Substantial. *Credits*: 1.0–3.5	Tertiary, Secondary, Primary. *Credits*: 0.05–0.4	Site protection w/o third party OR Site protection w/ third party grantee or transfer of title to a conservancy *Credits*: 0.05–0.2	Schedule 1 (prior to impacts), 2 (at least 75% completed prior to and/or concurrent with impacts), 3 (less than 75% completed prior). *Credits*: 0–0.15	Ephemeral/ intermittent w/o pools, Intermittent w/ permanent pools, or Perennial. *Credits*: 0.05–0.4	N/A	N/A

Missouri	Stream relocation to accommodate authorized project, Moderate, Good, Excellent. *Credits*: 0.5–3.5	Tertiary, Secondary, Primary. *Credits*: 0.05–0.4	Site protection w/o third party grantee OR Site protection w/ third party grantee or transfer of title to a conservancy. *Credits*: 0.1–0.4	Schedule 1 (80-100% mitigation before impacts), 2 (50-80% before or concurrent with impacts), 3 (<50% before or concurrent with impacts). *Credits*: 0–0.3	Ephemeral, Intermittent, Perennial. *Credits*: 0.15–0.4	For permittee-responsible mitigation, reduce overall credit by half if outside HUC-8 or out-of-kind.	N/A

Tennessee	Mitigation score – existing condition score = change in value	Standard or High. *Credits*: 0.3–0.6	Non-third party or Third party. *Credits*: 0.1–0.4	Schedule C (prior to impacts), B (75% of mitigation prior to impacts), A (less than 75% prior to impacts). *Credits*: 0–0.3	N/A	Outside HUC 8, W/ in same HUC 8, W/in same HUC 10, W/in same HUC 12. *Credits*: 0–0.3	N/A
Wyoming	Minimal (improvements to buffer or other select function rather than stream as a whole), Moderate (deficient to functional or nonfunctional to deficient), Substantial (nonfunctional to functional). *Credits*: 1.0–5.0	Red Ribbon, Conservation, Blue Ribbon, Wild & Scenic, T&E Species. *Credits*: 0.6–2.0	Deed restriction, Permittee easement, Agency-owned, Conservation easement, Fee title *Credits*: 0.5–5.0	Schedule 3 (after impacts), 2 (concurrent), 1 (prior to impacts). *Credits*:-1.5–4.0	Class 4 (B, A), Class 3 (D, C or B), Class 2 (D, C, A, AB, or B), Class 1. *Credits*: 0.1–2.0	Outside watershed, Off-site HUC 10, Off-site HUC 8, On-site. *Credits*: -1.0–0.4	N/A

District-Wide Guidance							
Charleston	Minimal, Moderate, Significant, Maximum. *Credits*: 0.5–3.0	Tertiary, Secondary, Primary. *Credits*: 0.05–0.3	N/A	N/A, mitigation after impact, concurrent with impact, before impact. *Credits*: 0–0.1	Non-RPWs, 1st & 2nd Order RPWs, All Other Streams. *Credits*: 0.05–0.2	Case by case, Drainage basin, Adjacent HUC, 8-digit HUC. *Credits*: 0–0.1	N/A
Little Rock	Relocation, Preservation (moderately or fully functional), Restoration/ Enhancement (four sub-levels). *Credits*: 0.1–4.0	Tertiary, Secondary, Primary. *Credits*: 0.05–0.4	Deed restriction/ restrictive covenant or Third party easement and monitoring. *Credits*: 0.1–0.4	Schedule 1 (mitigation before impacts), 2 (majority concurrent with impacts), 3 (majority after impacts). *Credits*: 0–0.3	N/A	N/A	Levels I, II, III. *Credits*: 0.05–0.5
Mobile	Relocation, Enhancement, or Restoration. *Credits*: 1.0–4.5	Tertiary, Secondary, Primary. *Credits*: 0.05–0.4	N/A	Mitigation before impact, during impact, or after impact. *Credits*: 0–0.15	Ephemeral, Intermittent, Perennial (<15’, 15-30’, 30’-50’, >50’). *Credits*: 0.2–1.3	N/A	N/A

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For each factor, the tables include a range of categories with different multipliers. For example, the Kansas table (derived from the 2002 Charleston method) has three multipliers for the factor "net benefit," with lists of the mitigation activities that fall under each level. If the net benefit is minimal, the multiplier is 1.0; if the net benefit is moderate, the multiplier is 2.0; and if the net benefit is substantial, the multiplier is 3.5. As with the debit determination process used by most of these districts or states, the multipliers for each credit factor are added together to create a total mitigation factor for each reach or mitigation project. This number is multiplied by the linear feet of that reach to determine the number of credits. The process is repeated for each reach or mitigation type within the project, and the credit amounts are added together for a total credit amount for the mitigation project.

Kansas, Tennessee, Mobile, and Savannah, among others, do include methods for determining the appropriate level of "net benefit" or improvement. Missouri, Kansas, Illinois, and Little Rock are among the few that attempt to link functional lift to the amount of credits generated, but it is more common to require changes to dimension, pattern, and profile. When an activity addresses multiple functions on a larger scale, it is likely to provide a higher net benefit, and therefore generate more credits. So, for example, the Kansas SOP indicates that "[c]reating or re-connecting floodplains adjacent to streams artificially disconnected from their floodplain" would generally count as "substantial" restoration, whereas "[c]onstructing fish ladders or other fish passage structures where appropriate" would be only "moderate" restoration. While some determine the level of benefit by considering the mitigation activities and techniques used, they do not clearly measure or estimate the functional lift associated with each technique. They generally say that the Corps will assess the credit/debit analysis on a case-by-case basis but do not say how the Corps will do so (See section above on Relationship Between Restoration Technique, Functional Lift, and Credit Determination and the *Guidelines Paper*).

Mobile and Savannah both assign different levels of net benefit based on the mitigation method. In the Mobile SOP, different benefit levels are assigned to relocation, enhancement, and restoration, with changes to dimension, pattern, and profile required for restoration and changes to at least one of those factors required for enhancement. Savannah uses streambank stabilization, structure removal, and four levels of stream channel restoration or relocation to categorize net benefit. Like Mobile, Savannah states that restoration should involve changes to dimension, pattern, and profile. It determines the level of restoration or relocation according to the changes in Rosgen stream classification. If mitigation activities do not involve "direct manipulation of a length of stream," like retrofitting stormwater facilities, the Savannah Corps will determine the net benefit case-by-case.

Wyoming's SOP instructs applicants to use an assessment method to calculate anticipated benefit, but it does not specify a particular method, instead suggesting multiple potential assessment methods. Fort Worth and Tulsa districts use the Texas Rapid Assessment Method (TXRAM) to evaluate ecological conditions and assess potential stream impacts. Charleston and Tennessee also appear to calculate net benefit based on assessment methodologies. Charleston uses a functional assessment, and the score from the assessment is converted to one of four levels of net benefit. Tennessee uses the Tennessee Stream Mitigation Assessment to produce scores in four categories: water quality, geomorphology, riparian buffer, and aquatic habitat. The anticipated change in scores at the site between pre- and post-mitigation is factored directly into the crediting worksheet. Tennessee therefore incorporates some functional considerations, but is still based on the basic methodology of assigning a certain number of credits per linear foot of mitigation.

Many SOPs address temporal loss in some way, whether with regard to in-stream work, buffer vegetation, or both. For in-stream work, temporal loss generally refers to the temporary loss of function resulting when mitigation takes place after the permitted impacts rather than before. In SOPs, this is often called mitigation “timing” or “credit schedule” rather than temporal loss (Table 10). Some SOPs discuss this only generally, stating that permit applicants must describe the timing of mitigation construction in their work plan and explain the need for any lag between impact and mitigation. Others account for mitigation timing as a factor in their credit tables, assigning different numerical factors depending on whether mitigation construction takes place primarily before, concurrent with, or after permitted impacts. An example of the credit multipliers by various factors is shown in Figure 9.

FIGURE 9: Example of a Credit Determination Table from the Missouri SOP

<table>
<tr><th colspan="5">Mitigation Measures (Credits)</th></tr>
<tr><th>Factors</th><th colspan="4">Multipliers</th></tr>
<tr><td>Stream Type</td><td>Ephemeral
0.15</td><td colspan="2">Intermittent
0.2</td><td>Perennial Stream
0.4</td></tr>
<tr><td>Priority Waters</td><td>Tertiary
0.05</td><td colspan="2">Secondary
0.2</td><td>Primary
0.4</td></tr>
<tr><td>Net Benefit</td><td>Stream Relocation to Accommodate Authorized Project
0.5</td><td>Moderate
1.2</td><td>Good
2.4</td><td>Excellent
3.5</td></tr>
<tr><td>Site Protection</td><td>Corps approved site protection without third party grantee
0.1</td><td colspan="3">Corps approved site protection recorded with third party grantee, or transfer title to a conservancy
0.4</td></tr>
<tr><td>Credit Schedule</td><td>Schedule 1
0.3</td><td colspan="2">Schedule 2
0.1</td><td>Schedule 3
0</td></tr>
</table>

Source: Missouri, p. 24.

The Ohio and Pennsylvania SOPs include credit tables as well, but these tables (like their debit tables, discussed in Part IV.b, *supra*) are structured differently from the other tables. The Ohio SOP credit table, like the debit table, operates on ratios. It divides mitigation into four types: restoration/enhancement, preservation, buffer work, and extra buffer efforts. The SOP also identifies different activity levels within each mitigation type. A different credit ratio is provided

Box 6: The 2008 Rule Buffer Requirements

Buffer: "an upland, wetland, and/or riparian area that protects and/or enhances aquatic resource functions associated with wetlands, rivers, streams, lakes, marine, and estuarine systems from disturbances associated with adjacent land uses" (33 C.F.R. § 332.2).

"District engineers may require the restoration, establishment, enhancement, and preservation, as well as the maintenance, of riparian areas and/or buffers around aquatic resources where necessary to ensure the long-term viability of those resources. Buffers may also provide habitat or corridors necessary for the ecological functioning of aquatic resources. If buffers are required . . . compensatory mitigation credit will be provided for those buffers" (33 C.F.R. § 332.3(i)).

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for each activity level. The ratios are defined as upper limits on the number of credits that may be generated per linear foot for a particular type of mitigation and a particular activity level. For example, rehabilitating a buffer has a credit ratio of up to 1.4 credits per linear foot. The ratios vary widely depending on the activity level, from 16 linear feet of mitigation per credit to 0.5 linear feet per credit.

The Pennsylvania SOP credit method, like its counterpart for debits, requires resource condition assessment protocols and calculates credits for different functions separately. As with the debit process, the expected credit amount for a mitigation project is the product of four factors, measured separately for each functional group: the area of the project, the resource value, the compensation value, and the condition index differential. The resource value is calculated from the same table used in the debit process. Compensation Value is a score between 1.0 and 3.0, based on a level of benefit (extensive, moderate, limited, or minimal). This score may be adjusted upward if the project involves conservation of the surrounding area, subject to certain conditions, or if the project addresses impairments for which a Total Maximum Daily Load (TMDL) exists. Finally, a condition index differential is calculated based on the difference between a resource's existing condition and projected condition after mitigation, using assessment protocols. As defined in the SOP:

Functional Credit Gain (FCG) = AP x RV x CV x CIdiff

FCG = Functional Credit gain

AP = Area of Project for applicable function group (in acres, 0.00)

RV = Resource Value (Table 4)

CV = Compensation Value (Table 5)

CIdiff = Condition Index Differential Value (0.00)

Source: Pennsylvania, p. 23

The West Virginia Stream and Wetland Valuation Metric (WV SWVM) is also an example of a more complex table approach to credit determination. As described above, the methodology synthesizes multiple established assessment methodologies (e.g., USEPA Rapid Bioassessment

Protocols for Use in Wadeable Streams and Rivers (RBP), A Stream Condition Index for West Virginia Wadeable Streams (WVSCI), and water quality data utilized by the WVDEP (Water Quality Data Sheet)) to correlate impacts with proposed compensatory mitigation projects.

BUFFERS

Federal regulations allow Corps districts and states to require buffers as part of a compensation project, but do not require them to do so (Box 6). Stream compensation SOPs exhibit considerable variation in their treatment of buffers. Many SOPs authorize credits for restoration, enhancement, or preservation of buffers, and they determine the number of buffer credits generated using separate credit tables (Table 11). In general, credits are based on buffer size (that is, X number of credits are generated per foot of buffer, based on a required buffer width such as 100 feet on both sides of the stream channel). Often the type of mitigation activity influences the amount of buffer credits that are generated. Buffer preservation generates the fewest number of credits, and restoration typically generates the most (*Guidelines Paper*).

TABLE 11: ***Buffer Credit:*** Many SOPs authorize credits for restoration, enhancement, or preservation of buffers, and they determine the number of buffer credits generated using separate credit tables. In general, credits are based on buffer size and the type of mitigation activity (generally preservation generates the fewest number of credits, and restoration typically generates the most).

SOP	Minimum Width (Ft)	Maximum Width (Ft)	Buffer Credit (Credits/Ft)		
			Restoration	Enhancement	Preservation
State-specific Guidance					
Georgia	50	200	0.1 to 2.0	0 to 0.4	0 to 0.3
Illinois	25	300	0 to 2.4	0 to 0.95	0 to 0.65
Kansas	50	300	0.16 to 0.56	0.08 to 0.28	0.04 to 0.14
Missouri	50	300	0.5 to 1.1	0.25 to 0.55	0.13 to 0.27
Ohio	50	150	Up to 0.25 (reestablishment)	Up to 0.125 (rehabilitation)	Up to 0.0625
Virginia*	100 (per bank)	200 (work beyond 100 credited less)	0.2 to 0.4 (reestablishment)	0.15 to 0.38 (planting)	0.07 to 0.14 per percent area
District-Wide Guidance					
Charleston**	50	300		0.2 to 0.39	0.075 to 0.2
Galveston	100/side, or 200 total with both >25	200 (work between 100-200 credited less)	0.5	0.25 to 0.5 (planting)	0.05 to 0.1

Fort Worth	25 (ephemeral) 50 (intermittent) 100 (perennial)				
Little Rock	25	100	0.4 to 1.6	0.2 to 0.8	0.1 to 0.4
Los Angeles		300			
Mobile* **	50	200	0.4 to 1.6	0.2 to 1.2	0.1 to 0.4
New England	100				
Norfolk	100 (narrower buffers may be considered, but will not receive full credit)	300 (in practice)			
Tulsa	50	100			
Wilmington	30-mountain/ 50-piedmont				

(Adapted from the *Guidelines and Practice Papers*)
* Smaller or wider buffers require approval
**Depends on slope and land use
*** Buffer requirements variable based on stream type

Districts that authorize buffer credits often impose minimum and maximum width requirements (Table 11). Most SOPs that include these policies require a minimum buffer width of 50 feet. A minority requires a minimum width of 25 feet. Minimum buffers may vary based on slope, land use, stream type, geography, etc. (See Table 11 for examples). Requirements for maximum buffer width vary more widely, ranging from 100 to 300 feet (with 300 feet being the most common). Practitioners generally believe that wider buffers should receive more credits, at least up to a point (at which point they are capped by maximum limits on buffer width). The rationale for this is that functional value of the buffer changes with width (Fischer & Fischenech 2000, Wenger 1999). Low widths (e.g., less than 20 feet or so) can provide channel stability and organic matter to the stream. Larger widths (50 meters or more) are generally better for denitrification and thermal regulation (Mayer *et al*. 2007. Therefore, IRT's should consider the functional purpose as they are setting width requirements. Although generally not discussed in stream compensation SOPs, allowing average buffer widths rather than absolute widths (e.g., 50 feet everywhere) may result in more efficient management. "Meandering" widths are very hard to manage and it is more effective to re-vegetate a straight riparian corridor and let the stream meander within that corridor.

Illinois, Kansas, Little Rock, and several other SOPs include buffer credit tables that generally operate like the standard credit tables do, with a range of numerical values for different factors that contribute to an overall number of credits per linear foot. They include some of the same factors as the standard credit tables do, such as stream type, priority area/category, existing condition, net benefit, monitoring, location, and mitigation timing. Most districts consider credits generated from buffers as stream credits, not as a separate credit classification. Charleston considers compatibility of adjacent land use in determining minimum buffer widths and assigns credit for buffers beyond minimum necessary width (Charleston SOP, p. 6).

"Functional value of the buffer changes with width. Low widths (e.g., less than 20 feet or so) can provide channel stability and organic matter to the stream. Larger widths generally are better for denitrification and thermal regulation. Therefore, IRT's should consider the functional purpose as they are setting width requirements.

Although generally not discussed in stream compensation SOPs, allowing average buffer widths rather than absolute widths (e.g., 50 feet everywhere) may result in more efficient management. "Meandering" widths can be very hard to manage. Further, re-vegetating a straight riparian corridor and letting the stream meander within that corridor may improve outcomes."

Montana takes a different approach. It includes a buffer credit table with buffer-specific factors depending on the mitigation activities conducted, such as removing buffer disturbances, fencing buffers, revegetating riparian

***FIGURE 10:* Montana Buffer Credit Table**

Factors		Multipliers
a	Buffer Width	Width of Riparian Buffer Preserved ÷ 100
b	Remove Disturbance to Riparian Buffer	0.5
c	Fence around Buffer	0.5
d	Re-vegetate Riparian Buffer	1.0 x % of buffer re-vegetated
e	Micro Topography in Floodplain	0.5
f	Addition of Woody Debris in Floodplain	0.5
g	Management of Invasive Species	0.5
h	Removal of Riprap Below Ordinary High Water	1.0 X % of Riprap removed
i	Removal of Floodplain Fill (Berms or Impervious Materials)	1.0 X % of fill removed
j	Restoration of Channel Morphology	1 (both sides will earn 1 as a multiplier)

Source: Montana SOP, p. 5

buffers, managing invasive species, and others. Available credits are the same (0.05 to 1.0) for each mitigation approach (restoration, enhancement, or preservation) (See Figure 10).

Many of the same SOPs that consider loss from mitigation construction timing in credit determination tables also consider temporal loss (or "temporal lag") in riparian vegetation. Temporal loss accounts for the lag between the lost function at the impact site and the maturity of new buffer vegetation at the mitigation site. This appears as a factor in buffer credit tables or combined credit tables for several SOPs (*Guidelines Paper*).

CREDIT RELEASE SCHEDULES

The 2008 rule outlines provisions for credit release schedules (Box 7). Only a few stream compensation SOPs include credit release schedules (Table 12). However, credit release schedules must be included in mitigation bank instruments and in-lieu fee program project plans.

Box 7: The 2008 Rule Credit Release Provisions

Mitigation banking credits may not be "released for debiting until specific milestones associated with the mitigation bank site's protection and development are achieved" (33 C.F.R. § 332.3(b)(2)).

Using a phased credit release schedule can "help reduce risk that mitigation will not be fully successful" (33 C.F.R. § 332.3(b)(2)).

Mitigation bank draft instruments and ILF program project plans must include a credit release schedule, subject to approval by the District Engineer (33 C.F.R. § 332.8(d)(6)(iii)(B), (j)(1)).

Credit release schedules must be tied to performance-based milestones, and a "significant portion" of the credits must be reserved until the ecological performance standards have been met (33 C.F.R. § 332.8(o)(8)).

(Reproduced from *Guidelines Paper*)

The SOPs that have specified credit release schedules share many similarities, especially in terms of withholding a significant portion of credit releases until the restoration has met monitoring criteria over several years. However, the extent to which credit releases are tied to meeting performance standards and surviving one or more bankfull events varies considerably from district to district (Table 12).

A few SOPs refer to credit release schedules, but do not actually establish a schedule. Instead, they may supply a sample credit release schedule while emphasizing the need for independent credit release schedules for each site mitigation plan. Others are significantly less detailed, simply requiring the existence of a credit release schedule linked to the achievement of specific milestones.

PERFORMANCE STANDARDS

As with credit release schedules, federal regulations leave substantial discretion to Corps districts and states in developing performance standards. A large number of the SOPs do not mention performance standards at all (*Guidelines Paper*). Other SOPs include general language about performance standards, but do not provide specific examples. A few provide examples of performance standards for wetlands, such as measures of hydrology or vegetation (e.g., species

TABLE 12: Credit Release Schedules. Only a few stream compensation SOPs include specific guidance on credit release schedules. Numbers represent the percent of credits released after reaching specified milestones.

	State-specific Guidance		District-Wide Guidance			
	Virginia	Georgia (Financial Assurance Schedule #2)	Fort Worth*	Mobile	South Pacific	Wilmington
Initial Release	15	10	30	20	15 (bank establishment)	15 (bank site establishment)
Construction					25	
As-Built	10	10 beginning, 10 end	10	10		15 (bank) 30 (ILF) (Completion of all initial physical and biological improvements)
Bankfull event 1 (BFE)				20		
BFE 2				30		
2 BFEs			10			
Year 1	10, 25 if BFE	10				10 (bank) 10 (ILF)
Year 2	10, 25 if BFE	10	10		15	10 (bank) 10 (ILF)
Year 3	10, 25 if BFE	10	10		15 (plus WOUS determination)	15 (bank) 15 (ILF)
Year 4	10, 25 if BFE	10			15	5 (bank) 5 (ILF)
Year 5		5	10	10	15 (plus WOUS determination)	15 (bank) 15 (ILF)
Year 6		5				5 (bank) 5 (ILF)
Year 7						10 (bank) 10 (ILF)
Final	25 for each BFE	20	20	10		

(Reproduced from *Practice Paper*)
*Complete (75% or more) channel restoration only

diversity required), but do not provide detailed information about performance standards for streams. Finally, a handful of SOPs, or associated mitigation banking templates, provide detailed information and specific examples of performance standards for streams, which may serve as models for others (See Table 13).

SOPs that include general language on performance standards essentially track the language in the 2008 Rule, without providing additional guidance. These SOPs explain that such standards are used to determine whether a project is satisfying its objectives. In all cases, performance standards should be objective, verifiable, meaningful, achievable, and enforceable. They should also be clear, precise, and quantifiable. Various measures may be used to help develop performance standards; these include measures of functional capacity, measures of hydrology or other aquatic resources (e.g., vegetation, fauna, or soil), or comparisons to reference aquatic resources (*Guidelines Paper*).

Only a small number of SOPs provide specific examples of performance standards for streams. Performance standards in formal guidance (alternately referred to as success criteria) primarily focus on physical criteria such as stream pattern, profile, dimension, pebble counts, and erosion. Most of these performance standards also address riparian buffers, often with specific quantitative vegetation requirements (see also Doyle *et al*. 2013). Specific criteria for chemical and biological success are much less common because mitigation providers cannot directly control the outcome. However, new tools are being developed that incentivize monitoring that documents functional improvement in water quality and biology (Harman and Jones, 2016). Overall, identified performance standards include a mix of qualitative and quantitative criteria. Wilmington, for example, requires projects to demonstrate performance of certain criteria, like channel aggradation or degradation or bank erosion, through photographs rather than specific measurements. In contrast, the Ohio SOP provides a sample numeric standard for water quality and vegetation and refers to several indices that help to quantify more descriptive criteria, such as habitat quality or stream biological function.

TABLE 13: ***Performance Standard Examples:*** A few SOPs, or associated mitigation banking templates, provide detailed information and specific examples of performance standards for streams. This list provides a number of examples, but is not comprehensive of all of the examples found in these SOPs.

	Physical	Chemical	Biological	Buffer
State-specific Guidance				
Georgia	Streambanks are stable, (using Bank Erosion Hazard Index).	Temperature < 90ºF (32ºC) for warm water streams.	Set increase over baseline in Fish Index of Biotic Integrity.	For Restoration: 150 planted stems (bare root trees and shrubs) per acre.

Ohio	Stream channel is vertically stable and connected to its floodplain-- neither aggrading nor degrading.	Increase in pH, decrease in acid loading (case-by-case).	Target biological index score (case-by-case).	A minimum of 400 native, live and healthy (disease and pest free) woody plants per acre (of which at least 200 are tree species).
Virginia	The sinuosity of the stream does not increase or decrease by an amount greater than 0.1 of the approved as-built pattern.			Native non-invasive herbaceous plant coverage shall be at least 60% by the end of the first growing season, and at least 80% each monitoring year thereafter. There are also invasive species and woody stem requirements.
District-Wide Guidance				
Mobile	Riffle/pool and depth variation meets reference conditions.	Water pH, turbidity (not required).	Target aquatic habitat reflects appropriate composition, density, and diversity present (not required).	Tree and plant species density, diversity, and composition meet target approved by Mobile District.
Omaha	Adequate amount of hydrology present for the stream types.			Dominant species present ratios should be based on regional conditions and benefit/protect the wetland or streams.

South Pacific	"Annually, as viewed along representative cross-sections has at least two benches or breaks in slope, including the riparian area, above the channel bottom, not including the thalweg."	Dissolved oxygen.	Meet target natural species recruitment by year 5	Minimum percentage native vegetation, soil undisturbed
Wilmington	Pool/riffle spacing		Minimum planted stems per acre for woody vegetation.	80% survival of planted species required after 5 years).

(Reproduced from *Guidelines Paper*)

The following table provides an example (not the entire set) of suggested performance standards in different categories from each jurisdiction that provides them (Table 13).

Most SOPs generally emphasize that standards will be created on a case-by-case basis and depend on the project at hand. In practice, as with the criteria we identified in the SOPs we reviewed, most IRT's have created performance standards that are based on channel dimension, pattern, profile, and bed material. For example, practitioners are required to measure riffle and pool cross sections, longitudinal profiles, and collect bed material samples. Graphs are produced showing the cross sections, profiles, and cumulative frequency curves. These measurements occur annually and each year is overlaid with other years. However, these data are rarely converted into useful information. Instead, performance standards often include things like the bankfull width/depth ratio cannot change, the stream type cannot change, etc. In the end, performance standards are often subjective and based on the IRT's perception of a stable channel. A lot of emphasis is placed on bank erosion and the stability of in-stream structures. Biologically, almost all of the focus is on the development of riparian vegetation.

This is starting to change. Some Districts are starting to use function-based assessments to determine the pre- and post-condition scores and thus provide more useful information than just overlays of cross sections and profiles. The stability metrics like profiles and cross sections are still used; however, they provide ancillary information and are not the primary performance standard. For example, the profile may be used to determine if the channel is well connected to the floodplain after the restoration activities. The focus is on floodplain connectivity and not profile overlays.

Another way to evaluate the SOPs containing performance standards is through the Stream Functions Pyramid Framework (Harman *et al.*, 2012). The pyramid framework recommends including assessment of and performance standards for floodplain connectivity, lateral stability, bed-form diversity, and riparian vegetation as a minimum number. Bed-form diversity, for example, can be evaluated by measuring the percent of riffles and pools, the facet slope, pool-to-pool spacing, or depth variability. Again, this information is taken from the profile, but the focus is on bed-form diversity and not just profile overlays.

Table 14:* *Stream Performance Standards in Guidelines and the Stream Functions Pyramid Framework: Mobile, Ohio, and Savannah included performance standards for all four Framework parameters (Floodplain Connectivity, Lateral Stability, Bed-Form Diversity, and Riparian Vegetation). Norfolk, South Pacific, and Wilmington listed standards for three of the four. The only parameter that all seven SOPs had a performance standard for was riparian vegetation.

	Floodplain Connectivity	Lateral Stability	Bed-form Diversity	Riparian Vegetation
Mobile	X	X	X	X
Omaha				X
Ohio	X	X	X	X
Georgia (Savannah)	X	X	X	X
Virginia (Norfolk)	X	X		X
South Pacific	X	X		X
Wilmington	X	X	X	X

Of seven SOPs with performance standards, three included performance standards for all four parameters listed in the above paragraph: Mobile, Ohio, and Savannah (Table 14). Another three, Norfolk, South Pacific, and Wilmington, listed standards for three of the four, excluding either bed-form diversity or floodplain connectivity. The only parameter that all seven SOPs had a performance standard for was riparian vegetation.

MONITORING

The 2008 Rule requires mitigation plans to establish a monitoring period "sufficient to demonstrate that the compensatory mitigation project has met performance standards, but not less than five years." Also, "[a] longer monitoring period *must* be required for aquatic resources with slow development rates" (emphasis added). However, the district engineer can reduce or waive the monitoring period after a mitigation project has been implemented if he or she determines that the performance standards have already been achieved. The monitoring period can also be extended if the performance standards have not been met or if the project is not on track to meet them (33 C.F.R. § 332.6(b)).

After a mitigation project has been completed, stream compensation SOPs require the site to be monitored for a number of years (Table 15). Monitoring requirements range from at least three years to five years and longer; several SOPs establish five years as a minimum for at least some streams. Only Washington requires monitoring for at least 5 years, but several districts require as many as 10 years of monitoring for certain projects. Stream policies also mandate additional monitoring until performance standards are met or according to the severity of concerns about the site, the project's complexity, or the project's success.

Most SOPs that outline specific monitoring criteria require physical (abiotic) monitoring; some also require biological (biotic) monitoring. Examples of what must be monitored include: hydrology, such as flooding frequency and duration, vegetation (cover and/or density), soils, geomorphology, nutrients, riffle photos, riffle and channel pebble counts, bar samples, stream channel stability, streambank erosion patterns, period of inundation, substrate characteristics, wildlife usage, fauna (native and nonindigenous/invasive species), aquatic species, and habitat assessment (Table 15). While SOPs tend to require measurements of floodplain connectivity, bed-form diversity, and lateral stability, only a few, such as Fort Worth and Norfolk, assign credits based on these metrics (the methodologies for doing so are described in the section, "Determination of Credits"). In contrast, most districts do assign credit for riparian vegetation, which is commonly a monitoring requirement.

The general content of monitoring requirements does not vary significantly among SOPs, but some SOPs impose more specific requirements than others. In the most flexible SOPs, monitoring requirements are determined on a case-by-case basis. Others, such as Little Rock, establish

TABLE 15: Monitoring Requirements: SOPs varied in the number of years required for monitoring as well in what must be monitored for a mitigation site. Only one SOP explicitly required that monitoring requirements be tied to performance standards.

	Years	What Must be Monitored	Explicitly Tied to Performance Standards?
State-specific Guidance			
Georgia	"Monitoring efforts should usually include periodic reviews in the first year and annually thereafter"	Soils, hydrology, vegetation, and wildlife	No

Kansas	Annually; no less than 5 years, longer depending on resource type and adaptive management measures occurring after initial site work	Physical and biological	No
Kentucky	Annual physical monitoring for 3-8 years	As-built survey, permanent picture stations, riffle and channel pebble counts, bar samples, vegetative monitoring, habitat assessment of stream projects	No
Maryland	5 years	Description of how the mitigation project meets the mitigation requirements, performance standards; photographs, description of any modification which have been made or need to be made to satisfy mitigation requirements.	No
New York District	5-10 years	Restatement of goals, objectives, and performance standards; identification of any structural failures; description of management activities and corrective actions; summary and full presentation of data collected; site map showing locations of data collection; assessment of the presence and level of occurrence of invasive species; vegetation cover map; photographs; assessment of degree to which performance standards are being met; proposed corrective actions; narrative summary of monitoring results	No
Ohio	Project-specific	Monitoring requirements are based on project activities. Examples include substrate sampling, stream stability rating, water chemistry, hydrology monitoring, vegetation monitoring, qualitative habitat evaluation index, qualitative macroinvertebrate sampling, invertebrate community index, index of biotic integrity, amphibian/salamander sampling.	Yes

Tennessee	Five annual monitoring reports; if longer than 5 years then "monitoring may be conducted on a less than annual timeframe (such as every other year)"	Photos, riparian vegetation survey, aquatic species survey, channel morphology survey	No
Virginia	10 years	Aerial photograph; narrative summarizing condition of the site; results of vegetation survey; comparison of as-built, current, and previous years monitoring data; discussion of any deviation from as-built or previous year's data, corrective action plan; report including detailed resource documentation, tables summarizing attainment of success criteria, revised summary table of action credits based on field measurements	No
Washington	At least 3 years	Bank protection, upstream and downstream geomorphic impacts, high-flow hydraulics, fish habitat, vegetation establishment	No
District-Wide Guidance			
Charleston	Minimum of five annual monitoring reports	Stream channel stability and improved biological integrity	No
Detroit	Emergent or aquatic systems will require monitoring for 3-5 years; those with scrub-shrub component require monitoring no less than 5 years; forested component require 10 years of monitoring	Percent vegetation cover and/or density; plant species diversity; realization of targeted vegetative communities and/or habitat types; soil must support targeted vegetation; hydrology (meet criteria of Corps of Engineers Wetlands Delineation Manual (USACE, 1987)); control/absence of certain exotic and/or undesirable species; wetland delineation, with land survey, verified by the Corps	No
Fort Worth	5-10 years (7-10 years for certain projects); monitoring begins one year after irrigation ceases		No

(Reproduced from *Guidelines Paper*)

several levels of monitoring requirements depending on the type of mitigation project. The lowest level of monitoring may consist of only basic physical monitoring, including vegetation success and species composition, or even simple reference photographs. The next level may require both physical and biological monitoring (of vegetation and macroinvertebrates, for example). The highest level of monitoring often requires physical and biological monitoring to continue over a period of several years.

Several SOPs that provide specific performance standards expressly tie monitoring requirements to performance standards. Accordingly, these districts require monitoring data to provide evidence that the goals of the project are met. As Doyle *et al*. (2013) also observed, monitoring requirements occasionally exceed performance standards, particularly for chemical or biological indicators. However, if mitigation plans lack specific and measurable project goals or performance standards, and standards and credits are not linked to functional lift as described above, it is difficult for monitoring to determine project success.

LAND PROTECTION

Most state and Corps district SOPs discuss site protection instruments needed to protect compensation sites in perpetuity by reiterating the language in the 2008 Rule. Per the regulations, mitigation plans for each compensation project must identify the party or parties responsible for long-term management and the role of each party, address all water and mineral rights, and describe an appropriate real estate instrument to ensure long-term site protection (33 C.F.R. § 332.7). Site protection is provided through the creation of a legally binding instrument, such as an easement or a deed restriction, that expressly precludes certain activities that would threaten stream function, both in-stream or out-stream (33 C.F.R. § 332.7(a)). Mitigation plans should also detail that funding adequate for monitoring and maintenance will be provided and, if a non-profit resource management, government agency, or other third party is designated to carry out long-term management, they should have a right to enforce site protections. Although only Savannah and Wilmington SOPs require a licensed attorney to draft legal site protections, all SOPs that discuss site protection require review and approval of the instrument by the Corps district. In considering approval, the districts may also consider how the proposed protections may improve public recreation and the conservation of surrounding lands, but they must be directly linked to the long-term viability of the project.

The rule recognizes three forms of site protection: title transfer or sale for a restricted purpose; a conservation easement; and a deed restriction placed on the mitigation site (33 C.F.R. § 332.7(a)). The rule also acknowledges other mechanisms, such as federal facility plans or integrated natural resources management plans on government property (33 C.F.R. § 332.7(a)(1) and (2)). Several stream compensation SOPs, such as New England, state that conservation easements held by a third party are the preferred method for long-term site protection, stating that easements are the most secure method to ensure perpetual protection of the site. Most SOPs expressly require conservation easements to designate and fund a third party to monitor and enforce site protections (see Table 16). SOPs acknowledge that conservation easements are site-specific in terms of goals and management responsibilities, but indicate easements must describe incompatible uses, such as the destruction, cutting, mowing, or harming of any native vegetation on the property. New York District's SOP notes that soliciting and securing potential easement holders and negotiating the terms of the easement and management fees is complex and requires considerable time.

While direct title transfer and conservation easements are the preferred means of long-term site protection, the use of title deed restrictions is both allowed and expressly discouraged among the various SOPs (see Table 17 to see how deed restrictions differ from conservation easements). The Memphis District SOP defines a deed restriction as, "A provision in a deed limiting the use of the property and prohibiting certain uses" (Memphis, p. 11). Many state and district SOPs discourage deed restrictions because they can be difficult to enforce if there is no third party accepting legal responsibility and/or monitoring the site (e.g., New England 2015, p. 12). In addition, they can be easily changed and, in some cases, state statutes may limit the number of years a deed restriction is in force (South Pacific, p. 43, see also ELI and Land Trust Alliance, 2012). Even when in force, several states may circumvent deed restrictions if enforcement would be adverse to 'public policy.' Nonetheless, deed restrictions are allowed because it is not always possible to secure a party to accept either title transfer or a conservation easement. When used, many stream compensation SOPs require the deed restrictions to expressly allow for the creation of protections and associated monitoring activities to preserve the mitigation site. For example, the South Pacific Divison SOP states that when deed restrictions are approved by the Corps as sufficient protection, the permittee or landowner of the mitigation site may be required to report periodically on the status of the deed restriction in order to monitor whether the restriction remains in the chain of title in perpetuity (South Pacific, pp. 46—47). The burden of enforcement is on the property owner, as well as, in theory, the Corps and/or state regulatory agencies. In reality, these agencies may not have sufficient staff and resources to inspect all mitigation sites on a regular basis (South Pacific, p. 43). Nevertheless, Corps oversight may deter violations. A common approach to overcome this hurdle is to establish third-party enforcement rights in the deed restrictions, although caution must be exercised to ensure these rights are not so broad as to expose the landowner to legal action (ELI and Land Trust Alliance, 2012, pp. 89, 92, 99).

TABLE 16: ***SOP and Guidance References to Site Protection Instruments (Title Transfers, Easements, and Deed Restrictions/ Covenants)***

	Reference to Title Transfers	Reference to Easements	Reference to Deed Restrictions/Covenants	Explicit Preference for Title Transfers/Easements over Deed Restrictions/Covenants
State-Wide Guidance				
Illinois	X	X	X	
Kansas	X	X	X	
Kentucky		X	X	
Maryland	X	X	X	
Missouri	X	X	X	
Montana	X	X	X	
New York	X	X	X	X
Ohio	X	X	X	
Pennsylvania		X	X	
Tennessee	X	X	X	
Washington		X	X	
West Virginia	X	X	X	

District-Wide Guidance				
Charleston	X	X	X	
Detroit	X	X	X	
Fort Worth		X	X	X
Galveston				
Little Rock	X	X	X	
Memphis	X	X	X	
Mobile		X	X	
New England	X	X	X	X
Norfolk		X	X	
Omaha	X	X	X	
Philadelphia	X	X	X	
Savannah		X	X	X
South Pacific	X	X	X	X
Tulsa		X	X	
Wilmington	X	X	X	X

TABLE 17:* *Site Protection – Conservation Easements vs. Deed Restrictions: While direct title transfer and conservation easements are the preferred means of long-term site protection in many SOPs, the use of title deed restrictions is both allowed and expressly discouraged among the various SOPs. There are a number of differences among these site protection instruments, and pros and cons for each.

Conservation Easement		Deed Restriction
Holder holds a conservation easement on property owned by landowner	*Property Right*	Grantee owns the property, but the deed to the property limits allowable uses or development on the property
Holder will enforce the easement against the landowner in the event of a violation; Army Corps or another agency may be a third-party enforcer	*Enforcement*	Agency or other enforcer may choose to enforce the deed restriction against the landowner in the event of a violation
Long term, though state law may require that this be explicit in the easement or may set limit on duration	*Duration*	Subject to termination, i.e. through state marketable title laws; may be maintained in perpetuity with proper re-recordation
Protection more challenging, because landowner is owner and primary user of property; Easement holder may need to go to court to ensure protection	*Protection of Conservation Values*	Depends on owner; Landowner voluntarily agrees to comply, but parties with third party rights of enforcement may not have resources or support to provide necessary protection
Poorly written easement could create responsibility for mitigation success or failure; insufficient enforcement could threaten easement status; insufficient funding for easement defense could hinder conservation goals	*Legal and Financial Risks*	Land ownership creates traditional tort liabilities associated with duties of care, nuisance and trespass (which could even be triggered by the failure of a restoration/ enhancement feature); violation of the deed restriction by the landowner could prompt suit against it

May limit who may hold a conservation easement; may dictate how duration must be specified in easement terms or how easement must be re-recorded	*Impacts of State Law*	May require re-recordation of deed restrictions to prevent termination
Negotiation between (at least) three parties (grantee, agency, landowner); may require use of an agency easement template; more complex instrument may mean more complex negotiations	*Negotiation Challenges*	Negotiation between (at least) two parties (landowner, agency); must ensure compatibility with original donor/funder intent (if applicable); may require use of an agency deed restriction template; simpler instrument may mean simpler negotiations
Less likely; once an easement is placed on the land, agency is unlikely to require additional site protection	*Layered Site Protection*	More likely; land under deed restriction may also have a conservation easement placed on it
Both: Must prohibit incompatible uses, like clear cutting or mineral extraction May recognize compatible uses, like fishing or grazing Must give the Corps 60-day advance notice of changes to the instrument (including amendments and transfers) Should, where practicable, establish third-party enforcement rights		

Adapted from ELI and Land Trust Alliance, 2012, p. 91. See also Wood and Martin 2016.

LONG-TERM MANAGEMENT

Approximately half of district and state SOPs we reviewed have provisions relating to long-term management, most of which reiterate the language in the 2008 Rule. Specifically, long-term management plans must identify the responsible party, list possible long-term management needs, provide estimates of the annual cost needed to address them, and establish a funding mechanism to meet those needs in perpetuity. Described in the final mitigation plan, long-term management plans are intended to ensure continued provision of aquatic resource functions at mitigation sites after mitigation activities are completed. SOPs generally require the identification of the party responsible for long-term management of the mitigation site. Several SOPs outline the necessary qualifications of the responsible party, such as, "resources and expertise in long-term management and stewardship of mitigation properties" (New England, p. 33).

Although the SOPs require long-term management plans to describe long-term management needs, these are generally left undefined. The only SOP to provide examples of long-term management needs is Ohio, which lists invasive plant control, maintenance of water control structures, site access restriction, monitoring, and administrative costs as potential needs (Ohio, p. 17).

The funding mechanism for long-term management identified in SOPs is usually a non-wasting endowment (e.g., South Pacific, p. 47), but the rule explicitly allows other forms of financing, such as trusts and contractual arrangements with future responsible parties (33 C.F.R. § 332.7(d)). SOPs may also stipulate that this must be fully funded before the final release of credits (Fort Worth, p. 5). In several SOPs, including New York District, Savannah, and the South Pacific, the practicability of long-term management at a mitigation site is listed as a factor in site selection.

ADAPTIVE MANAGEMENT

The 2008 Rule describes the process for initiating and implementing adaptive management (33 C.F.R. § 332.7(c)). When a compensatory mitigation project cannot be constructed as planned or the project is not on track to meet its performance standards, the responsible party must notify the district engineer, who may consider and approve a significant modification of the project so as to ensure it provides the aquatic resource functions described in the original plan. Performance standards may also be revised to address project deficiencies, changes to comparable or superior management strategies and objectives, or in light of natural disasters (33 C.F.R. § 332.7(c)).

SOPs generally recognize the importance of adaptive management for stream projects and incorporate it into compensation requirements, but they tend to do so in one of two different ways. First, several SOPs require some minimum adaptive management discussion in the mitigation plan. This tends to be brief and simple, recognizing that the problems that require adaptation are often unforeseeable, but adaptive management must be at least considered in the plan from the outset. In addition, if the responsible party fails to implement necessary actions or demonstrate meaningful progress towards performance standards, the Corps may require corrective action, including purchasing mitigation credits from a mitigation bank (Mobile, p. 40). One regulator observed that the adaptive management discussion tends to describe a process for forming an adaptive management plan if the need arose later. Mobile's SOP also notes that monitoring also collects information that describes whether the site is meeting its objectives, helping determine whether adaptive management is necessary (Mobile, p. 41). Alternatively, a few districts require adaptive management if and when a project encounters difficulty, rather than up front in the mitigation plan.

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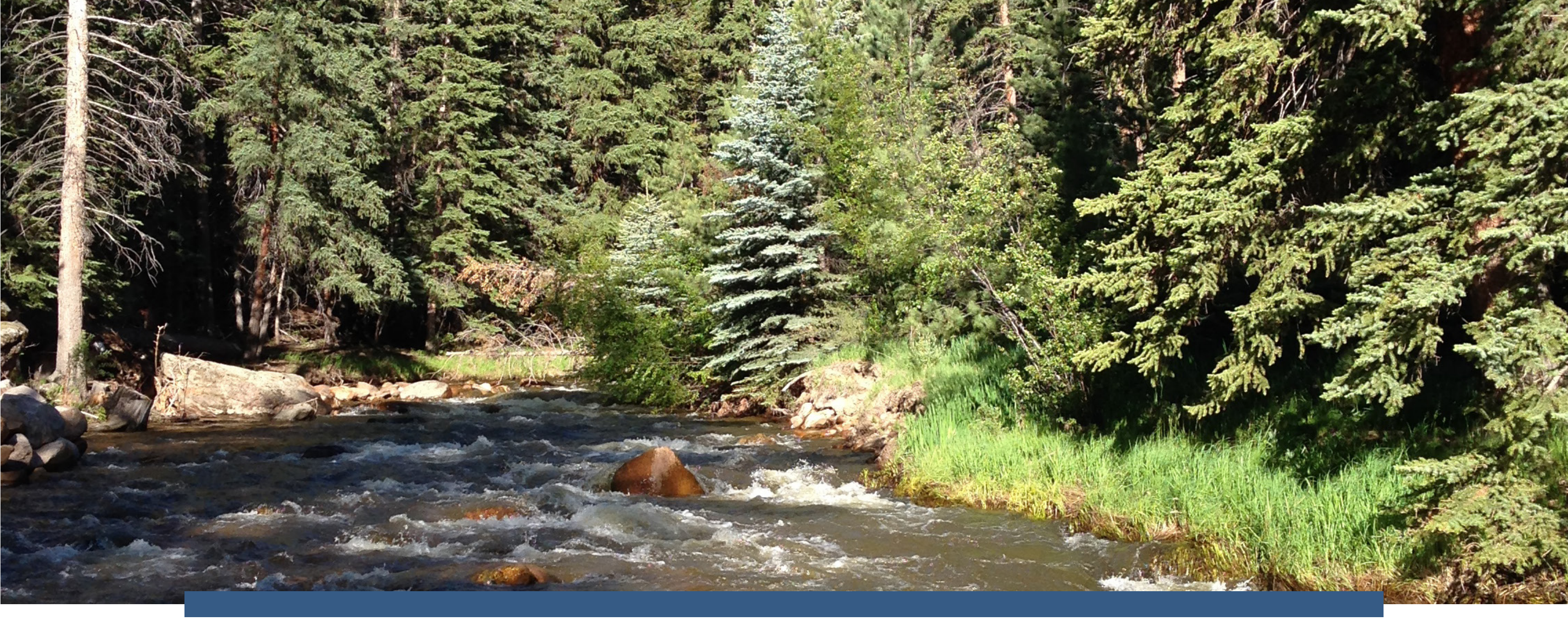

CHAPTER 3: EFFECTIVE STREAM MITIGATION PROGRAMS

(*Adapted from* The Nature Conservancy, Aligning Stream Mitigation Policy with Science and Practice, *Available at* http://www.eli.org/compensatory-mitigation/state-stream-compensatory-mitigation-science-policy-and-practice)

Over the past two decades the important functions and services streams perform in the landscape have been increasingly understood and recognized. At the same time, the field of stream restoration science has also continued to grow, and restoration practice improved as new techniques were developed and tested. As stream mitigation continues to grow, lessons learned from stream restoration science and practice can inform the development of guidance on compensatory mitigation and ultimately outcomes on the ground. Based on our assessments of stream restoration policy, practice, and science, we have identified a number of key criteria that underpin a successful stream compensatory mitigation program. These criteria include:

a. Program Components Should be Science-Based
b. Project Success Should be Tied to Functional Improvement
c. Programs Should be Adaptive
d. Mitigation Data Should be Publicly Available and Used to Improve Mitigation Guidance
e. Mitigation Programs Should be Regularly Evaluated to Address Gaps and Shortcomings

PROGRAM COMPONENTS SHOULD BE SCIENCE-BASED

An effective stream compensation program requires that all aspects of the program – including site selection, credit determination, performance standards, credit release schedules, adaptive management, and monitoring – be founded on ecological criteria and best available science. While the flexibility allowed in the Rule may increase inconsistency in decision-making, it also allows for new advances in science to be incorporated into program implementation.

This flexibility, however, leaves a considerable amount of responsibility on districts, states, and practitioners. As suggested in the Preamble to the Mitigation Rule, the lack of fully tested hypotheses and techniques should not preclude the use of best available science to ensure successful outcomes (FR Vol 73, 19633). An expanding body of literature on stream restoration science documents successful outcomes for stream restoration projects and provides the basis for advances in agency guidance. There are specific areas of the mitigation program where existing science could improve implementation over the short-term, including:

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SITE SELECTION AND THE WATERSHED APPROACH

One of the focal points of the 2008 Rule was the establishment of a watershed approach for compensatory mitigation decisions (33 C.F.R. § 332.3(c)(1)). The watershed approach uses a landscape perspective to identify the types and locations of compensatory mitigation projects to benefit watersheds and offset impacts to aquatic resources. The watershed unit provides the basis for mitigation decisions because of the important physical, chemical and biological processes and changes that occur at this scale. The watershed thus provides a context for evaluating mitigation projects and developing comprehensive goals for projects across the watershed (ELI and TNC 2011). It is expected that the use of a watershed approach, rather than mitigation occurring ad hoc throughout a service area, will result in ecologically successful compensatory mitigation that more effectively offsets the loss of aquatic resource functions and services (33 C.F.R. § 325 (2007); 33 C.F.R. § 332 (2008); 40 C.F.R. § 230 (2006)). To achieve this, mitigation activities need to be clearly linked to the desired site-level functional lift while also addressing functional loss at the watershed scale. If applied successfully, the watershed approach could also encourage connectivity between compensatory mitigation sites and already protected areas and areas identified as priorities for restoration or protection, ensuring the long-term sustainability of key functions.

For stream compensation projects, it is critical to holistically take into account watershed scale processes and the role and function of rivers and streams when selecting sites and designing projects. The condition of the watershed upstream from a specific project site can greatly influence the types of impairments that exist on-site and the resulting restoration potential of a particular stream reach or segment. Areas both upstream and downstream from a project site are critical to the current and long-term condition of the site (Moerke and Lamberti 2003, Walsh *et al*. 2005, Roni *et al*. 2002). Thus, the ability of the site to achieve desired ecological and physical outcomes depends as much on position in the watershed and watershed context as do site conditions or quality of the restoration work itself. The scale of the watershed is also important. However, the Rule does not specify the

"Areas both upstream and downstream from a project site are critical to the current and long-term condition of the site. Thus, the ability of the site to achieve desired ecological and physical outcomes depends as much on position in the watershed and watershed context as do site conditions or quality of the restoration work itself."

appropriate scale of a watershed. Many districts define a watershed as equivalent to an 8-digit Hydrological Unit Code (HUC) (*Guidelines Paper*, *Practice Paper*). A few SOPs specifically mention ecoregions as geographic boundaries in their site selection guidance. It is important to be clear about the size of the watershed when developing watershed plans and making decisions about the siting of mitigation projects within the same watershed as impacts.

Per the compensatory mitigation regulations, in undertaking a watershed approach, the Corps will consider needs of the watershed as a whole and evaluate whether a proposed compensatory mitigation site would efficiently address those needs. The watershed approach allows decisions to be made in the context of a science-based analysis of watershed needs so that these projects can achieve broader conservation outcomes.

- Important elements to consider in a watershed analysis include:
- Landscape scale,
- Historic aquatic resource losses,
- Development pressures and threats within the watershed,
- Functional impacts associated with resource losses, and
- Scientific data regarding water quality and habitat characteristics influenced by the surrounding landscape, among other criteria.

By integrating these scientific elements, the watershed approach helps managers target priority areas based upon scarce or damaged functions in the watershed.

Where there is an appropriate watershed plan available, regulations state that the watershed approach should be based on that plan. Watershed plans integrate science-based information across multiple spatial scales. Understanding that site-specific data is not independent from the larger influences of the watershed, watershed plans identify degraded resources and immediate or long-term needs to restore those resources. Watershed plans help identify rapidly-developing or threatened areas throughout the watershed, as well as high land values, pristine parcels, or landscapes surrounded by development where aquatic function is threatened or could be lost. Watershed plans often define specific desired outcomes, or specific, measurable goals for the watershed. Mitigation projects should ideally link project-level goals and objectives to the larger goals identified in the watershed plan by integrating site-level, science-based data with identified functional impacts within the watershed. Ultimately, watershed plans can lead to timely decision-making because they provide a vision for potential compensatory mitigation opportunities outside the context of individual permit decisions.

Whether or not there is a suitable watershed plan, there is a role for and value to watershed analyses or watershed informed decision-making as important steps that can improve project outcomes at the site and watershed levels (see the Watershed Approach Handbook, (ELI & TNC, 2011)). The Rule states that the watershed approach should be based on an analysis of information provided by the project sponsor or available from other sources ((33 § C.F.R. 332.3(c)(1)). Such information includes: current trends in habitat loss or conversion; cumulative impacts of past development activities, current development trends, the presence and needs of sensitive species; site conditions that favor or hinder the success of compensatory mitigation projects; and chronic environmental problems such as flooding or poor water quality (33 § C.F.R. 332.3(c)

(3)(i)). The Etowah (Georgia), Stones (Tennessee), and Duck-Pensaukee (Wisconsin) watershed analyses are great examples of how available local data can inform a watershed approach. These pilot programs can help guide districts to develop needed guidance on a watershed approach (ELI and TNC 2011).

As described above, SOPs across the country generally do not provide substantial guidance to providers on how to implement the watershed approach, and this has led to the continuation of case-by-case project site selection without coordination across the larger watershed. In general, many districts only require identification of challenges and opportunities within the watershed and a description of how projects will contribute to the conservation or restoration of priority watershed habitats (Guidance Paper). Some districts, like New England, report not even using a watershed approach. States like North Carolina, on the other hand, have developed an extensive process for developing watershed restoration plans, prioritizing sub-basins and targeting local watersheds. The state developed their prioritization method in order to understand where restoration can be more effective or feasible, and which areas are particularly time-sensitive and subject to degraded status without intervention. This process clarifies data needs at both the sub-basin and local watershed level, and how the analysis contributes to larger watershed objectives (North Carolina Division of Mitigation Services, http://portal.ncdenr.org/web/eep).

Districts, states, and other organizations should put significant effort, and continued grant funding, toward developing guidance on the watershed approach using available watershed plans or other suites of information (e.g., aquatic habitat conservation plans, etc.). In addition, more effort should be directed at monitoring and evaluation to determine whether or not a project is contributing to watershed goals or how mitigation activities address the functions lost at the impact site in relation to the goals for the watershed.

As described above, ELI and TNC's Watershed Approach Handbook (2011) provides an overall framework for the spectrum of watershed approaches, examples of specific types of watershed approaches, examples of types of analysis that may be useful for using a watershed approach, and a list of national data sources that might inform all of the above. The Handbook characterized the watershed approach along a spectrum of categories from watershed informed decisions to watershed analyses with non-prescribed outcomes to watershed plans with prescribed outcomes (ELI and TNC 2011). Where the watershed effort lies along this spectrum depends on how it addresses some key science-based steps common to watershed approaches. The five key elements include (ELI and TNC 2011):

1. Identification of watershed needs (e.g., specific ecological functions or ecosystem services) necessary for the improvement or sustainability of a watershed and for which a future desired condition has or can be identified. Watershed needs may include those identified by various regulatory and non-regulatory programs or in existing state, local, or regional plans.
2. Identification of desired outcomes (i.e., the specific and usually measurable results desired in the future).
3. Identification of potential project sites where streams can develop and persist into the future.

4. Assessment of the potential of sites to meet watershed needs through a science-based analysis that ranks the relative ability of a site to support desired ecosystem functions and services.
5. Prioritization of project sites based on their relative ability to sustain ecosystem functions and/or contribute to achieving desired watershed outcomes.

To assist practitioners in using the watershed approach, it would be useful for districts to provide guidance on the type of criteria most useful for understanding the watershed context of mitigation sites. In other words, what criteria are most useful to understand the impacts of surrounding land use on the functional capacity of sites to meet hydraulic, geomorphic, physicochemical and biological functions? Districts could develop criteria such as:

- Percent natural vegetation in catchment (e.g. forested, grasslands, wetlands)
- Percent agriculture and urban land use in catchment
- Percent impervious surface
- Identify point source and non-point source discharges
- Percent of stream length with riparian zone
- Road density
- Ecological connectivity

These criteria were identified in a National Biological Assessment and Criteria Workshop in 2003. They were developed to help create a framework for understanding thresholds for reference condition, but could also be used to develop a better understanding of how much sites have deviated from a reference state, and what the potential is for sites to return to a reference state given the watershed characteristics. Developing specific watershed criteria can also help with monitoring and evaluation to determine whether or not a project is contributing to watershed goals, or how mitigation activities address the functions lost at the impact site in relation to the goals for the watershed.

"Where project-level and watershed goals are clearly linked, watershed needs can be adequately addressed, projects can more successfully offset permitted impacts and lost functions at a watershed scale, and project success or failure can be objectively evaluated."

Development of a rule-based approach, such as that developed in Washington, may be another alternative (ELI and TNC 2011, Hruby *et al*. 2009, Hruby *et al*. 2010). The Washington State Department of Ecology (WSDOE) developed a field-based approach for selecting mitigation sites based on a series of decision trees containing yes/no questions, instructions, and recommendations. Each series of yes/no questions are contained in a variety of charts (depending on the geomorphic setting of the site) and relate to the ecological functions/values supported by potential mitigation sites in a watershed. The recommendations guide users to specific actions that will provide the largest watershed-scale benefit given the project criteria. WSDOE created two versions of the approach – one for Eastern Washington and the other for Western

Washington. The versions account for the hydrologic and geomorphic differences between the regions that may affect decision-making regarding the selection of mitigation sites.

Numerous planning tools and methods have been developed that are useful for informing a watershed approach to stream compensation site selection and design. For example, the Army Corps issued guidance on watershed planning and the preparation of watershed plans in 2010 (U.S. Army Corps of Engineers, 2010). The guidance, which goes beyond application of a watershed approach to compensatory mitigation, includes four specific considerations to take into account when engaging in watershed planning: systems approach; public involvement, collaboration, and coordination; leveraging resources during implementation; and study area. In addition, various suites of information and existing plans (i.e., GIS aquatic analysis, aquatic habitat conservation plans, etc.) can also help direct a watershed approach. A list of some of the types of inputs is below. These various efforts yield a rich diversity of experiences, methods, and models on which to base a watershed approach to stream and wetland restoration and protection projects. Sources of information for a watershed approach include:

- Existing plans, reports, or analyses (e.g., water quality standards and implementation plans, special area management plans, state wildlife action plans, ESA habitat conservation plans, flood management plans)
- Analysis of historical loss of aquatic resources in the watershed
- Analysis of current condition of aquatic resources in the watershed
- Analysis of trends and future threats within the watershed
- Stakeholder input
- Function and condition assessments
- Ecosystem service assessments
- Wildlife and habitat assessments
- Analysis of priority hydrologic units

SETTING FUNCTION-BASED GOALS AND OBJECTIVES

Each stream compensation project should state clear and measurable goals and objectives that reflect the watershed context and the restoration potential of the site (*Science Paper*). Where project-level and watershed goals are clearly linked, watershed needs can be adequately addressed, projects can more successfully offset permitted impacts and lost functions at a watershed scale, and project success or failure can be objectively evaluated. When setting project objectives, it is important to first identify what functions were lost or reduced and then develop goals and objectives that are quantifiable and relevant to the functional loss (Ossinger 1999). In addition, where project-level goals and objectives take into account watershed characteristics and limitations with the site given the surrounding land use (i.e., restoration potential), mitigation activities can be tailored to existing conditions and credit determination can better reflect the actual functional lift that can be expected from mitigation activities given the watershed characteristics. The number of potential credits should appropriately align with the capacity of the site to improve the identified functions that offset those lost within the watershed. As we reported above, a sizeable number of stream restoration studies in the literature, about 30 percent, fail to refer to a project's objectives, and where they do they are often too broad to effectively evaluate whether the project successfully achieves the objectives (*Science Paper*). Further, few studies evaluate methodologies and metrics to determine whether objectives were actually achieved.

The Mitigation Rule requires mitigation plans to state project objectives and goals. The Rule requires the mitigation plan to include, "A description of the resource type(s) and amount(s) that will be provided, the method of compensation (i.e., restoration, establishment, enhancement, and/or preservation), and the manner in which the resource functions of the compensatory mitigation project will address the needs of the watershed, ecoregion, physiographic province, or other geographic area of interest." Mitigation SOPs often reiterate these requirements. However, SOPs give little guidance on developing project objectives and generally do not require objectives to tie to mitigation activities, credit determination, performance standards, or monitoring parameters (*Guidelines Paper*).

As we discuss in Chapter 1, we recommend project proponents detail two levels of goals in their mitigation plans: programmatic and project or design goals. Programmatic goals state why the project is being completed from a regulatory or funding driver perspective. For example, example programmatic goals may include providing mitigation credit. Programmatic goals are important in communicating the regulatory/permitting process that will be followed. Design or project goals are also function-based, but focus on the project reach, and must be developed after some form of project assessment has been completed to determine watershed needs and restoration potential of the site. Design goals can be broad, but should state why the project is being completed and what functional problems will be addressed. Example design goals may include (from Harman *et al*. (2012)):

1. "Improve native brook trout habitat." This goal communicates that the purpose of the project is to improve habitat, e.g., riffles, pools, glides, cover, and maybe substrate composition, implying that habitat is degraded. This could apply to habitat for all life stages. This would be confirmed with the assessment. Note that this goal does not state that brook trout populations will be increased; just the habitat.
2. "Increase the biomass of native brook trout." This goal does state that there will be more brook trout after restoration than before and implies that the watershed will support brook trout if the reach-scale problems are fixed. Specific numbers could be indicated here to specify what is meant by 'increase'. Or, perhaps more likely, the desired level of performance would be included in the performance standards.
3. "Reduce sediment supply from eroding streambanks." This goal communicates that the functional problem is an excess of sediment entering the stream channel.

Each project should also include a list of objectives for each goal. Objectives are more tangible than goals and explain how the goals will be achieved. It is preferable for the objectives to be quantifiable. For instance, for goal number 1 above, example objectives might include the following. (Notice that these objectives do not state that channel dimension, pattern, or profile will be changed. In reality, the geometry will change, however, the reason is explained in functional terms.)

1. Improve floodplain connectivity by reducing bank heights from an average of 4 feet to 2 feet. The activity would likely include grading.
2. Improve bed-form diversity by increasing the number of pools per 100 feet from 1 to 5. This would likely include the installation of wood, rock, or meandering to create and maintain the pools.
3. Reduce sediment supply by reducing average bank erosion rates from more than 1 foot/year to less than 0.1 feet/year.

Each project should also include a description of the restoration potential to accompany the goals and objectives. This can help ensure that credit determination adequately reflects the actual restoration potential given the watershed characteristics. It is important to provide a realistic view from the outset of what credits have the potential to be released, provided that the site is effective at improving the identified functions. Restoration potential is the highest level of restoration achievable given the health of the upstream watershed, condition of the project reach, and site constraints (See Harman *et al*. 2012 for more on restoration potential). In order to achieve goal number 1 above (improve native brook trout habitat), for example, the restoration potential is less than that of goal number 2 above (increase biomass of native brook trout). Goal number 1 could have a restoration potential limited to restoring hydraulic and geomorphology functions because the watershed or site constraints will not support biological improvements to a reference condition. For example, the watershed is moderately developed or has point source discharges that are impacting the biology. A restoration project could provide channel stability, reduce sediment supply, improve floodplain connectivity and more; however, the biology will not be significantly improved. Goal number 2 states that more fish, or larger fish, will inhabit the reach after restoration, so the restoration potential extends through the biological functional category. This example might include a highly degraded stream reach downstream from a state or national forest.

CREDIT DETERMINATION

The science of functional assessment continues to develop and methodologies that can link changes in function at the compensation site to credit determination are also under development (*Guidelines Paper*). Functional and condition assessment methodologies are currently applied in several districts (*Practice Paper*) and new methodologies are under development (ASWM 2014).

The incorporation of functional assessment methodologies in credit determination could help establish standardized mechanisms to consistently assess and credit functional lift associated with various mitigation approaches and techniques. Guidelines at the district level could require a clear link between mitigation approaches and/or techniques with identified function-based parameters, including floodplain connectivity, lateral stability, riparian vegetation, and bed-form diversity, which are major drivers of functional lift. There are numerous assessment methods throughout the country that capture some or all of these parameters (Harman *et al*. 2012, Starr *et al*. 2015). This could help apply credits to activities (such as creation of riffle-pools, bank stabilization, floodplain excavation, and tree planting) that yield quantitative changes to function-based parameters, and reduce reliance on the previous categories of dimension, pattern and profile, as these categories do not adequately capture how activities contribute to functional improvement. This level of guidance would maintain flexibility at the watershed and project level.

Credit determination varies by district (*Policy Paper*). In many instances where no guidelines are available, credits are determined based upon a linear-foot basis rather than functional parameters (*Policy Paper*), which is acceptable under the Rule (33 CFR 332.3(f)(1)). Some SOPs provide credit tables that identify mitigation methods associated with different credit ratios based upon the mitigation method (i.e., restoration, preservation, etc.) and other parameters (*Guidelines Paper*). Relatively few SOPs attempt to link functional lift to the amount of credits generated, and where they do, they generally do not incorporate specific methods. Wyoming's SOP instructs applicants to use an assessment method to calculate anticipated benefit, but it does not specify a particular method, instead suggesting multiple potential assessment methods. Other states, such as Pennsylvania, have developed specific protocols for function based aquatic compensation as recently as 2014 (see above and *Guidelines Paper*).

Developing credit determination methods that link mitigation activities to changes in function-based parameters to create credits is critical. To accomplish this linkage, it is recommended that IRTs move beyond attaching credits to changes in dimension, pattern, and profile alone. An ideal change would be linking the credits to changes in floodplain connectivity, bed-form diversity, lateral stability, and riparian vegetation at a minimum. Additional parameters should be added based on landscape settings and restoration potential. For example, stream projects in regions with bottomland hardwood forests might require large woody debris; streams in alluvial valleys might require sinuosity; and urban projects might require runoff and nutrient reduction efforts associated with best management practices installed in conjunction with a stream restoration project.

PERFORMANCE STANDARDS

Performance standards provide a mechanism to understand if projects are meeting the identified goals and objectives. They are observable and measurable physical, chemical and/or biological attributes that are programmatically linked to a credit release schedule and ecologically linked to stream function. The Mitigation Rule states that performance standards must be based on attributes that are objective and verifiable and must also be based on the best available science that can be measured or assessed in a practicable manner. It also states that performance standards may be based on variables or measures of functional capacity described in functional assessment methodologies, measurements of hydrology or other aquatic resource characteristics, and/or comparisons to reference aquatic resources of similar type and landscape position (33§ C.F.R. 332.5(b)).

Some stream mitigation SOPs include few specific examples or requirements for performance standards. In general, performance standards are considered case-by-case and depend on the project at hand. For example, Virginia's stream criteria are "a standard set of Criteria to choose from" and intended to be project-specific (Virginia Mitigation Bank Instrument Template, Exhibit M). The Mobile SOP observes that "[t]here are too many variables that must be addressed for a one-size fits all approach to stream channel restoration" and states that biological and chemical performance standards in particular may vary depending on the nature of the project, so long as they are “practicable, repeatable, and appropriate for implementation in the Regulatory Program” (Mobile SOP, p. 37). Savannah likewise states that the Interagency Review Team will determine which metrics are appropriate on a case-by-case basis. Savannah also lays out monitoring requirements and notes that specific standards depend upon the stream and valley classification.

However, various science-based and measurable performance standards are beginning to be developed for various project characteristics or types of aquatic resources across the country. These new methodologies are designed to clarify expectations and provide mitigation providers with clear guidance on what is expected of a mitigation project. These methodologies are typically more objective and more quantifiable, and focus more on the outcomes of the actions rather than the actions themselves. Wetland examples include:

- The U.S. Army Corps of Engineers St. Paul District has developed performance standards for target hydrology for wetlands (the hydrology necessary to achieve the objectives of a compensation site). The target hydrology performance standards were developed for specific plant communities based on monitoring well data, field observations, scientific literature and other sources. The performance standards for specific wetland plant communities included specifying minimums and maximums for depth, duration and frequency of inundation and/or a water table during the growing season and in the context of antecedent precipitation. Standards are regionalized to account for different plant communities, climatic conditions, etc. Monitoring wells/dataloggers are used to confirm whether performance standards are met (Eggers 2015).
- The U.S. Army Corps of Engineers Mobile District has developed performance standards for pine savannah wetlands. The objective was to develop ecologically based wetland mitigation success criteria for pine savannah wetlands that are objective, measurable, and based on the best available science. The district used current HGM manuals as best available science (RIBITS). The performance standard included 20 indicator species with pictures for easier identification.

Development of national criteria for developing performance standards would enable regulators to better assess whether projects are providing required functional lift. It is important to keep in mind that the purpose of setting performance objectives is to provide criteria so that the success of a project may be measured. Performance objectives should be two-tiered, where the first tier relates to form/structure and the second tier to function. An example of two tiered performance objectives could be (from Ossinger 1999):

- Tier 1 (form/structure)
    - ____acres of wetland restoration (enhancement/creation/etc.).
    - A minimum buffer width of ______ feet around the entire perimeter of the wetland.
- Tier 2 (function)
    - Food chain support.

- Habitat for ______ (Specify a target group such as waterfowl, shorebirds, raptors, anadromous fishes, or amphibians).

When setting functional standards, practitioners should consider what functions they want to restore, enhance, or create early in the planning process. After developing a list of potential functions, then it should be determined which of these should be tied to the evaluation of the project's success. While most projects will require some personal judgment and a unique approach, due to the variability across districts, it is important that personal judgment be based upon actual data and that standardization occur where possible (Ossinger 1999). Ossinger (1999) lists some useful guidelines for writing performance standards, including:

1. use extremely precise and unambiguous language,
2. use measures not action verbs,
3. avoid using fixed numbers except in cases where you have a need to achieve an exact amount,
4. write standards with the intent of exceeding minimum thresholds, and
5. write standards such that they can be achievable and capable of being monitored.

The creation of standardized performance measures would benefit practitioners by providing clarity on how to demonstrate functional improvements and how credits and debits are determined in relation to stream mitigation. General SOPs could identify these standard measures and local districts could adapt them to meet unique local circumstances.

MONITORING

Monitoring is necessary to determine if a project is meeting performance standards. Monitoring reports provide documentation of functional improvement of aquatic resources and the necessary data to evaluate credit release. Effective monitoring also provides an early indication of potential problems and provides the basis for corrective actions. Ideally, these reports identify challenges with project implementation, and how those challenges were addressed through remedial action. It is this adaptive process that allows for the science of stream restoration to continue to evolve to meet the goal of no net loss to aquatic resources. Yet, a Government Accountability Office (GAO) report in 2005 found that while 59 percent of the permit files analyzed contained requirements for monitoring, only 14 percent of those cases had monitoring reports that were received by the Corps (GAO, 2005).

The 2008 Rule emphasizes the importance of monitoring, but is relatively vague on specific requirements, recognizing the diversity of stream resources across the country and leaving it to districts to develop appropriate monitoring for different resources. The Rule states that monitoring should occur for at least five years and suggests that longer monitoring times should be considered for systems with slower development rates such as bogs and forested wetlands (33 C.F.R § 332.6 (b)). The Rule requires that monitoring reports be submitted and that the content and level of detail of monitoring reports should be "commensurate with the scale and scope of the compensatory mitigation project" (33 C.F.R § 332.6 (a)) and should be "sufficient for the district engineer to determine how the compensatory mitigation project is progressing towards meeting its performance standards" (33 C.F.R § 332.6 (c)). The mitigation plan must detail monitoring requirements, including the parameters to be measured and the frequency for submitting monitoring reports, among others (33 C.F.R § 332.6 (a)). In practice, however, reporting requirements can be inconsistent across districts and even within districts over time (*Guidelines Paper*). Since monitoring generally occurs over a 5—10 year period, there is often turnover at the district, practitioner, and other agency level that can create inconsistencies over the project life.

Most district SOPs include requirements for monitoring duration and some include specific monitoring criteria (*Guidelines Paper*). Table 18 identifies some of the most common types of monitoring criteria employed for different levels of restoration (stability, water quality, and biological). Many district SOPs and guidelines require both physical and biological monitoring (*Guidelines and Practice Papers*), but there is a range in the level of detail required. Some districts require specific types of monitoring associated with different levels of restoration. For example, Kentucky includes detailed requirements for both physical and biological monitoring in their guidelines (Kentucky Division of Water SOP, 2007). Plan requirements include: 1) an as-built survey that identifies the longitudinal thalweg profile, stream cross-sections, permanent concrete monuments and a plan view; 2) permanent picture stations of structures and bends that show riparian planting and erosion control measures; 3) riffle and channel pebble counts following the Wolman procedure; 4) bar sampling following the Rosgen procedure; 5) vegetative monitoring of species composition, dominant species, plant survival and invasive species presence; and 6) habitat assessments following the *Rapid Bioassessment Protocols for use in Wadeable Streams and Rivers* (Barbour *et al*. 1999). Biological monitoring is based upon the Kentucky Department for Environmental Protection's *Methods for Assessing Biological Integrity of Surface Waters in Kentucky* that outlines physicochemical monitoring, sampling procedures for benthic algae as an indicator of biological integrity, and phytoplankton sampling procedures (Barbour *et al*. 1999). It then describes procedures for monitoring macroinvertebrates, including a specific section on freshwater mussel sampling. The section on fish community structure includes: sampling methods, how to incorporate the index of biotic integrity, and reporting fish data to demonstrate community structure. The Kentucky monitoring guidelines are more comprehensive than most

***TABLE 18.* Monitoring for each level of restoration**

Stability	Water Quality	Biological
• Channel slope • Valley slope • Cross-sections • In-stream structures • Reference photos • Erosion analysis • Plant survival analysis • Habitat assessment	• Water temperature • Turbidity • pH • Dissolved oxygen • Specific conductivity • Nitrogen and Phosphorous • Sediment loading	• Macroinvertebrate sampling • Invertebrate community index • Plant species diversity • Index of biotic integrity • Vegetative species monitoring (density and percent cover) • Invasive species

districts and demonstrate how monitoring guidelines can relate the evaluation of projects to the restoration potential of a specific mitigation site.

Districts and states should develop more guidance on monitoring criteria and requirements for what must be included in monitoring reports to ensure consistency across projects. Monitoring report requirements should ensure there is sufficient information to determine that the site is meeting performance standards. Requirements could include:

- Progress in addressing watershed goals and impacts to aquatic resources
- Development of standard data formats to facilitate data availability
- Performance standards for project site to meet goals and objectives
- Documentation of functional lift to meet performance standards
    - Baseline, as-built and current data related to performance measures
    - Maps, plans, and as-built designs
    - Photographs documenting change
- Problems and remedial actions taken to address those problems
- Summary of site condition and any conclusions regarding ecological function
- Documentation of quality assurance measure to document use of standard practices

Accessibility of monitoring and design reports is critical. Providing standardized, accurate, transparent, and accessible information in monitoring reports not only can help regulatory agencies better evaluate the effectiveness of specific projects in meeting their goals and objectives, but should also help evaluate the effectiveness of site location in regards to meeting the watershed goals and objectives. This information and analysis is essential to understanding the success of compensatory mitigation programs. In addition, clear monitoring documentation could help further the science of stream mitigation and ensure that practitioners are learning from mistakes and improving the ecological success of stream restoration projects.

One of the challenges associated with monitoring has to do with the inherent conflict between monitoring to determine credit release and monitoring to ensure ecological performance. Ecological performance is tied to achieving the functional lift required to achieve the site-level and watershed goals and objectives of the project. While there are successful examples of stream restoration projects, there are many challenges associated with effectively restoring degraded functional systems to their natural regimes. In order to achieve no net loss of aquatic resource function at the watershed scale, however, stream restoration practitioners and regulators need to learn from past mistakes and identify ways to improve restoration in the future. One of the limitations of evaluating progress in this regard has to do with the programmatic focus of monitoring. Monitoring programs and reports ideally should not only serve the programmatic function of approving credit release and documenting what site level performance standards have been, but also provide the necessary information to assess improvement in the chemical, physical, and biological integrity of the nation’s waters at a larger scale. Monitoring should ultimately link functional lift at the project site to how well projects address the overall functional loss within the watershed. Providing transparent documentation of implementation challenges and remedial action is a key element that has been missing in monitoring.

One way to address this challenge might be to incentivize or provide additional credits where performance standards can be tied to the goals and objectives of the watershed. A few SOPs – such as Kansas, Kentucky, Wyoming, and Virginia – grant additional credit for mitigation work in designated priority watersheds (See Chapter 2). Virginia's Unified Stream Methodology grants an additional 10—30% credit for each stream reach that is conserved/protected to the drainage divide. This "adjustment factor" is an important consideration in mitigation project site selection (USM, p. 26). While it can be a challenge to provide a clear scientific linkage from the project scale to the watershed scale, it is necessary in order to evaluate whether compensation projects are offsetting lost aquatic function in a broader context. A more comprehensive attempt to evaluate project effectiveness not only at the project scale, but also at the watershed scale could also improve our understanding of site selection, service area determination, and credit determination.

PROJECT SUCCESS SHOULD BE TIED TO FUNCTIONAL IMPROVEMENT

Functional lift is used to describe improvements in ecosystem function through compensatory mitigation actions such as restoration. Tying functional improvement to project success can better capture how individual projects contribute to overall watershed goals and needs. The 2008 Rule emphasizes the agencies' desire to increasingly tie decision-making to functional improvement. As stated in the Preamble, "With this rule, we are moving towards greater reliance on functional and condition assessments to quantify credits and debits, instead of surrogates such as acres and linear feet. We believe that more frequent use of such assessment methods will help improve the quality of aquatic resources in the United States." (FR Vol 73, 19601). Currently, states and Districts still rarely employ functional assessment methods for credit determination or for developing performance standards, primarily because few function-based tools are available (*Practice Paper*). However, tying functional assessment methodologies to credit determination, performance standards, and monitoring can help improve ecological success and achieve the goal of replacing lost aquatic resource functions. In this report, we highlight SOPs that have integrated functional or conditional assessment methodologies into debit methodologies (e.g., South Pacific Division, Norfolk, West Virginia) and credit determination methodologies (e.g., Pennsylvania, West Virginia, Charleston), but there are few examples of tying these functional assessment to developing performance standards or monitoring requirements.

Although stream functional assessment methodologies are still relatively rare, there are a number of conditional and functional assessment methodologies that have been developed that are currently being applied across the country to stream permitting and mitigation decision-making and in other contexts. Ten states use functional assessment to assess streams, six additional states are developing functional assessment methodologies, and several more are interested in developing functional assessment tools for streams in the future (ASWM, 2014). For example, as mentioned above, the state of Oregon and the Environmental Protection Agency are developing a rapid function-based assessment method to determine mitigation debits and credits. ASWM's "Report on State Definitions, Jurisdiction and Mitigation Requirements in State Programs for Ephemeral, Intermittent and Perennial Streams in the United States" lists the assessment practices used at the state-level for permitting (e.g., biological, wildlife/fish habitat, water quality/control, physical, hydrological, etc.) and sample assessment guidance documents provided by state agencies (both conditional and functional). The report also provides a state-by-state summary of assessment practices.

Continued investment in the development of functional assessment methodologies is needed to achieve the goal of moving toward a greater reliance on functional and conditioned assessments outlined in the preamble of the Rule. There are resources available to assist in the development of new assessment methodologies. In 2012, Stream Mechanics, EPA, and the U.S. Fish and Wildlife Service released A Function-Based Framework for Stream Assessment and Restoration Projects (Harman *et al*., 2012). The Framework (described above) is not a functional assessment methodology, but can be used to help agencies and other stakeholders create functional assessments or at least function-based assessments that address the suite of parameters most important to the project goals based on the interdependencies of stream functions. Additional resources should also be targeted towards understanding where and how assessment methodologies are being used for credit determination, performance standards, and monitoring and to evaluating whether this leads to improved decision-making, results in more successful compensatory mitigation projects that yield measurable functional improvement, and ultimately improves the quality of aquatic resources in the United States.

PROGRAMS SHOULD BE ADAPTIVE

Corps districts generally recognize the importance of adaptive management for stream compensation projects and incorporate it into compensation guidance, generally in one of two different ways. First, the SOPs and guidance documents of several districts, including Galveston, Little Rock, Los Angeles, Mobile, Norfolk, and Wilmington, require some minimum adaptive management discussion in the mitigation plan. This may be brief and simple, recognizing that the problems that require adaptation often are unforeseeable, but adaptive management must be at least considered in the plan from the outset (*Guidelines Paper*). Adaptive management discussions tend to describe a process for forming an adaptive management plan if the need arose later (*Practice Paper*). Alternatively, a few districts — Fort Worth, New England, and Omaha — require adaptive management if and when a project encounters difficulty, rather than up front in the mitigation plan.

Adaptive management is critical to not only ensure the success of individual projects but also to identify areas for improvement in stream restoration science and mitigation practice. Adaptive management is important for both the active phase of mitigation as well as for long-term management. Adaptive management plans for the active phase of mitigation may include provisions for modifying mitigation activities, monitoring measures, and credits generated. Districts and states sometimes also require that adaptive management plans include procedures that allow for the modification of performance standards. For example, the Detroit District includes the following provision: "Corrective actions may be required if a mitigation site is not fully successful. Describe procedures to allow for modifications of performance standards if the mitigation project has unanticipated changes or time limits cannot be met" (Detroit SOP, p. 24). While credit release is contingent upon meeting performance measures, projects sometimes do not, for a variety of reasons, achieve performance standards. Adaptive management plans can provide provisions for how potential modification to performance standards will affect the number and type of credits generated.

Additional guidance is needed on how to develop adaptive management plans for mitigation projects and how to identify, in advance, potential issues that may arise during construction, monitoring, and long-term management phases. Additional focus on documenting and making available information on the challenges identified through monitoring and remedial actions taken as adaptive management to overcome these challenges would also be valuable.

MITIGATION DATA SHOULD BE PUBLICLY AVAILABLE AND USED TO IMPROVE MITIGATION GUIDANCE

As suggested above, data availability is key to continuously evaluating and improving stream compensatory mitigation programs. The Rule requires that mitigation plans include baseline information (e.g., historic and existing plant communities, historic and existing hydrology, soil conditions, a map showing the locations of the impact and mitigation site(s) or the geographic coordinates for those site(s), and other site characteristics appropriate to the type of resource proposed as compensation on the site (33 § C.F.R. 332.4(c)(5)). This information along with data gathered in permitting and required site monitoring can not only ensure that projects are meeting performance standards and project objectives, but can also help agencies to determine if mitigation techniques and evaluation measures are sufficient to ensure projects are successful and mitigation programs are meeting no net loss of aquatic resource area and function. These data should be made available and accessible so that evaluations of mitigation performance by agency and independent researchers can help improve mitigation guidance and performance.

There has been no consistent approach, methodology or effort at the national scale to assess the performance of mitigation. Data availability is one constraint in designing and implementing such a study. ELI convened a panel of expert wetland scientists to develop a study design to assess the regulatory and ecological outcomes of the three compensatory mitigation mechanisms — mitigation banking, in-lieu fee mitigation, and permittee-responsible mitigation — in a manner that will enable comparisons of the three mechanisms nationwide. This wetland study design methodology, with increased access to data on mitigation projects, could be a model for a related study design that would provide the basis for continued evaluation of stream compensation projects (Fennesy *et al., 2013*).

The Regulatory In lieu fee and Baking Information Tracking System (RIBITS) was developed by the Corps with support from the Environmental Protection Agency, the U.S. Fish and Wildlife Service, the Federal Highway Administration, and NOAA National Marine Fisheries Service to provide better information on mitigation and conservation banking and in-lieu fee programs across the country. RIBITS allows users to access information on the types and number of sites, associated documents, mitigation credit availability, and service areas. Information, such as monitoring and performance data, would be valuable to agency and independent researchers seeking to evaluate how and if projects are meeting performance standards and project objectives, as well as the broader objectives of the 404 Regulatory Program. The Corps and mitigation providers should consider working together to determine how to make the appropriate data available and accessible to researchers.

MITIGATION PROGRAMS SHOULD BE REGULARLY EVALUATED TO ADDRESS GAPS AND SHORTCOMINGS

The implementation and reformation of stream compensation methods will be inadequate without proper and stringent evaluation. The Rule includes little guidance on program evaluation. In-lieu fee (ILF) programs are required to include in the compensation-planning framework "A strategy for periodic evaluation and reporting on the progress of the program in achieving the goals and objectives in paragraph (c)(2)(v) of this section, including a process for revising the planning framework as necessary." (33 § C.R.F. 332.8(c)(2)(x)). The district engineer may audit the records pertaining to the program account. All books, accounts, reports, files, and other records relating to the in-lieu fee program account shall be available at reasonable times for inspection and audit by the district engineer. However, the Rule says little about evaluating or auditing other types of compensatory mitigation.

The execution of random audits of mitigation projects (including permittee responsible, bank, and ILF projects) and programs could encourage continual improvement within the mitigation community and allow the Corps to be more successful at evaluating whether the mitigation program is achieving national goals. Although mitigation banks and ILF programs have generally faced more frequent oversight by the Corps, evaluation at the project level has been historically lacking (GAO, 2005). Ultimately, districts must do a better job at assessing whether or not projects are meeting ecological standards and resulting in any watershed level changes.

CONCLUSION

The goal of compensatory mitigation is to offset impacts to aquatic resources from permitted activities under the Clean Water Act 404 Regulatory Program. The purpose of each component of an effective stream mitigation program identified in this chapter is to better ensure that mitigation projects are in fact restoring the necessary functions to offset permitted impacts. Based on our analysis, we have identified the following recommendations to improve stream mitigation guidelines, practice, and science:

- Site selection should not occur in an ad hoc or opportunistic fashion. The identification of sites should be reflective of science-based reasoning about site potential given the watershed characteristics. Site selection also needs to be clearly linked to restoration potential and functional improvement.

- Districts, states, and other organizations should put substantial effort towards developing guidance on the watershed approach using available watershed plans or other suites of information (e.g., aquatic habitat conservation plans, etc.).
- In the absence of watershed plans, districts should provide criteria by which to evaluate site potential within the watershed context.
- In order for project success or failure to be objectively evaluated, each stream compensation project should state clear and measurable goals and objectives that reflect the restoration potential of the site and the watershed context.
- Project-level goals and objectives should be clearly linked to the watershed goals and objectives.
- It is important that districts clarify how a selected project will contribute to the goals and needs of the watershed based upon specific functional parameters of the larger watershed.
- We recommend project proponents detail two levels of goals in their mitigation plans: programmatic and project or design goals. The project goals should identify linkage to the programmatic goals.
- Each project should include a list of objectives for each goal. Objectives are more tangible than goals and explain how the goals will be achieved. It is preferable for the objectives to be quantifiable.
- Each project should also include a description of the restoration potential to accompany the goals and objectives. This helps ensure that credit determination is appropriate given the watershed limitations and site potential.
- The creation of national criteria for developing performance measures would benefit practitioners by providing clarity on how to demonstrate functional improvements. SOPs could identify these standard criteria and local districts could adapt performance standards to meet unique local circumstances and address watershed needs and goals.
- Developing credit determination methods that link mitigation activities to changes in function-based parameters to create credits is critical. To accomplish this linkage, it is recommended that IRT's move beyond attaching credits to just changes in dimension, pattern, and profile.
- Monitoring and evaluation should ensure that the identified performance measures are met through the application of approaches and techniques employed. If this is not the case, it might be necessary to adapt the approach, techniques, and/or performance measures to ensure that goals and objectives are achieved.
- Monitoring reports should identify challenges and remedial action taken to address those challenges. This is critical to improving stream restoration science and ecological performance.
- Monitoring reports should require information about how project-level improvements tie back into watershed plans and how expectations and limitations during the site selection

phase may have changed throughout implementation.

- Monitoring reports should be required at regular intervals with a consistent process for documentation. This would go a long way to address issues of staff turnover and allow for improved evaluation of program success.
- Programs should be adaptive and districts should include provisions for modifying performance standards when unanticipated changes occur.
- The execution of random audits of mitigation projects (including permittee responsible, bank, and ILF projects) and programs could encourage continual improvement within the mitigation community and allow the Corps to be more successful at evaluating whether the mitigation program is achieving national goals.

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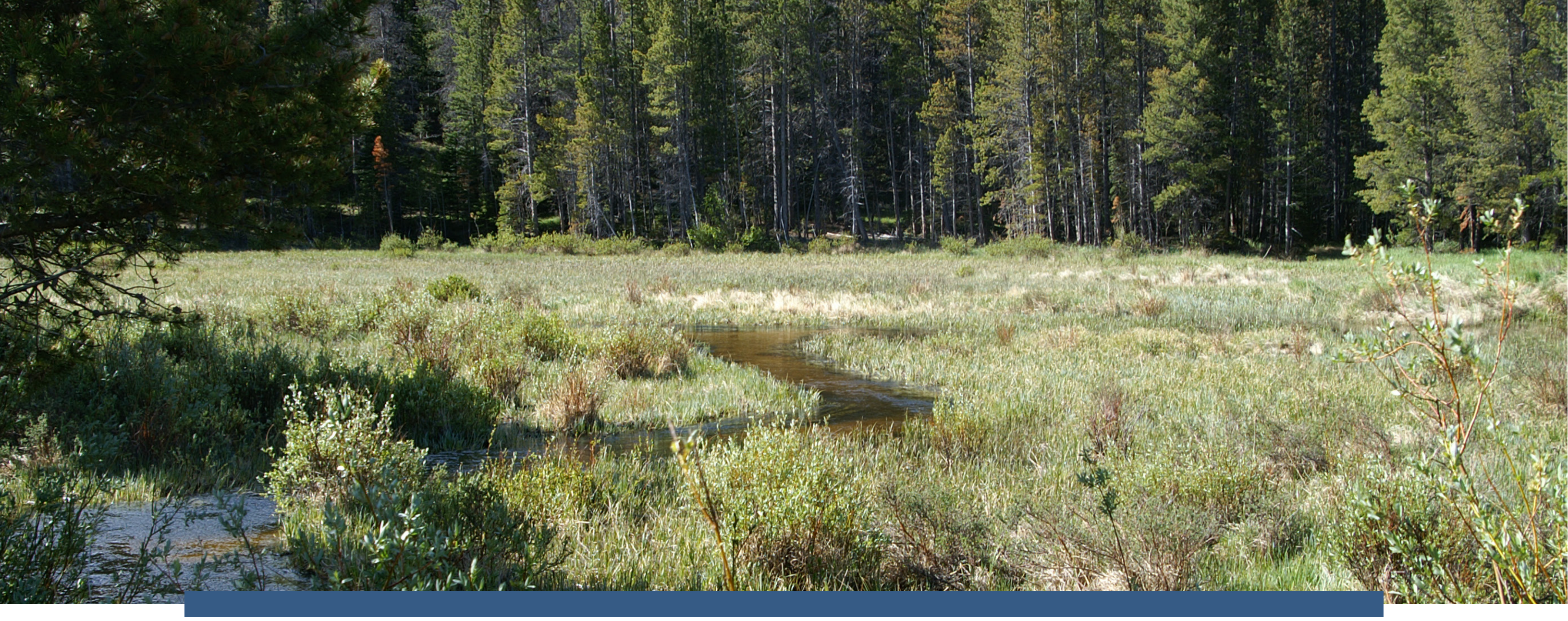

CHAPTER 4: ALIGNING STREAM MITIGATION SCIENCE AND POLICY

(*Adapted from* The Nature Conservancy, Aligning Stream Mitigation Policy with Science and Practice, *Available at* http://www.eli.org/compensatory-mitigation/state-stream-compensatory-mitigation-science-policy-and-practice)

While the 2008 Rule (33 C.F.R. § 325 (2007); 33 C.F.R. § 332 (2008); 40 C.F.R. § 230 (2006); 73 Fed. Reg. 19594 (Apr. 10, 2008)) established much needed provisions designed to improve the outcomes of compensatory mitigation, relatively broad language leaves substantial discretion to district engineers and may cause inconsistency in application across the nation. While creating standardized mitigation guidelines for mitigation programs could help tie mitigation activities to functional improvements in the watershed, this can also be expensive and difficult to determine given the diversity in geography and ecology across the country. However, more guidance on planning, implementation, and monitoring of stream mitigation projects could help providers design projects to maximize watershed benefits and ensure functional improvements.

In this report we have presented the results of a series of research papers describing how current mitigation guidelines relate to the Rule and how those policies align with current mitigation practice and science. Here we conclude with our summary thoughts on current gaps in stream compensation science, practice, and guidelines. These include: 1) integrating functional lift into the mitigation program, 2) more guidance on the watershed approach and linking project goals to watershed goals, 3) need for improved data for site selection, 4) more guidance on monitoring for adaptive management and improving program success, 5) aligning flexibility versus prescribed approaches, and 6) a need to better align regulator and ecological goals.

1) INTEGRATING FUNCTIONAL LIFT

Although clear progress has been made, there are still many challenges to incorporating functional considerations into stream mitigation decision-making. Measuring function and uplift is a challenge; it can be expensive, even cost-prohibitive to do so, and determining uplift in one area is difficult when the rest of the watershed is beyond one's control. Further, currently employed assessment methodologies and other tools are often not as function-based as regulators might hope. Nevertheless, many districts are working to revise their approach to rely more on a function-based approach in the belief that incorporating more functional considerations would improve their methodology. Continued investment in the development of functional assessment methodologies and in evaluating where and how assessment methodologies are being used for credit determination, performance standards, and monitoring are needed to ensure that the goal of no net loss of aquatic resource function is met.

2) THE WATERSHED APPROACH – LINKING PROJECT GOALS TO WATERSHED GOALS

Most districts lack guidelines for developing a watershed approach (*Guidelines Paper*), leaving much discretion to district engineers, especially where no watershed plan is available (*Practice Paper*). The current lack of guidance continues to allow for a project-by-project analysis of mitigation sites and activities that does not address the entire watershed and its needs. As discussed above, the lack of a watershed plan should not, however, preclude the use of available data to identify and evaluate sites within a watershed context. In the absence of a watershed restoration plan, agency guidance could encourage more integrated requirements at the watershed scale. Such guidance could include identification of stream mitigation benefits at a larger scale, such as: water quality, flood attenuation, habitat improvement, recreation, and return on economic investment. Encouraging the identification of these benefits across a larger scale can help achieve maximum functional improvement by prioritizing projects that yield multiple benefits and ultimately increase the overall benefit to watershed goals.

Connecting project-scale functional lift to larger watershed functional improvements can better capture how individual project credits/debits contribute to watershed functional goals and requirements. For example, the benefit of removing a threat through preservation could be associated with functional improvement at the watershed scale that is not currently captured directly through the project site. Or, identifying the relationship of watershed hydrology and localized stream hydraulics could clarify the linkages between compensation projects and the larger watershed functional goals. While there are clear performance measures and methods of measurement for localized stream hydraulics, there are inconsistencies with capturing the larger performance measures associated with watershed hydrology. To demonstrate an understanding of this relationship, projects could identify and attempt to address watershed stressors. The cumulative effects analysis framework developed by the Corps for West Virginia and western Washington (and under development in other parts of the country) provides a way to use available data to track stressors and determine which stressors are most critical in the watershed. This could incorporate land use analysis of the entire watershed that can help establish priorities in regard to stream function of individual projects. There are currently quantification tools in development that include catchment assessments to determine stressors that affect restoration potential but are outside of the practitioner's control (Harman & Jones, 2016).

Guidance from the national or district level could help ensure that watershed needs are effectively incorporated into the compensation process. Project success could benefit from the identification of larger watershed goals, and overall watershed health could be improved through a better understanding of how individual projects contribute to those goals. Further, identifying the linkages between functional improvements of specific projects can not only clarify the establishment of credits/debits, but also clarify individual project contribution to larger watershed goals.

3) SITE SELECTION

A key challenge in implementing the watershed approach is that many compensation sites are still selected based on factors other than ecological considerations. In many cases, sites are selected opportunistically, often based largely on practical and economic considerations (*Practice Paper*). Many districts base site selection requirements on watershed, or sometimes sub-watershed (because of the way the watershed has been defined), boundaries (e.g., HUCs) and often rely on an evaluation of only hydrology and topography when making siting decisions. Even when practitioners attempt to use available watershed plans to identify "hotspots" and other areas where mitigation would be beneficial, sites that are ideal in terms of watershed needs may not be available to acquire or practical to restore (*Practice Paper*). In many cases stream compensation SOPs are not detailed in addressing how the watershed approach should guide site selection (*Practice and Guidelines Papers*). Some SOPs consider site selection at a larger scale by focusing on ecoregion. Considering ecoregions could lead to a more holistic approach to site selection and aligns well with the watershed approach.

To address these issues, districts could incentivize siting based on ecological criteria to encourage the broader use of the watershed approach to mitigation. For example, some districts incentivize mitigation projects that take into account broader watershed concerns by granting additional credits either for projects in priority watersheds or if a watershed approach is utilized (Kentucky Division of Water SOP 2007, Kansas Stream Mitigation Guidance 2010, Wyoming Stream Mitigation Procedure SOP 2013).

4) MONITORING AND EVALUATION TO ENSURE MITIGATION SUCCESS AND PROGRAM IMPROVEMENT

Monitoring the success of mitigation is essential to ensure that the planned functional improvements of a mitigation project are observed in practice. Effective monitoring also provides opportunities for adaptive management, ensuring that mitigation projects are implemented based on the most up-to-date scientific knowledge and understanding of aquatic functions.

Many stream compensation guidance documents, however, fail to outline specific monitoring criteria and associated measurements that will be required of mitigation projects. And, while those that do outline specific criteria generally require physical (abiotic) monitoring, few also require biological (biotic) monitoring. Stream compensation guidelines/SOPs should include more information on the specific and measureable monitoring criteria that will be required of mitigation projects, especially those that go beyond just physical monitoring.

Guidelines should also require that the monitoring criteria tie back to the goals and objectives identified in the mitigation plan (see above) and that monitoring is substantively tied to performance standards. Currently, most SOPs do not explicitly link monitoring and performance standards (*Guidelines Paper*). Better integration of science- and place-based performance measures and monitoring is needed to ensure that project activities are linked to functional lift. Monitoring data availability is also key to continuously evaluating and improving stream compensatory mitigation programs. Data gathered in permitting and required site monitoring can also help agencies to determine if mitigation techniques and evaluation measures are sufficient to ensure projects are successful and mitigation programs are meeting no net loss of aquatic resource area and function. Making these data available and accessible can help improve mitigation guidance and performance.

5) FLEXIBILITY VERSUS PRESCRIBED APPROACHES OR SPECIFIC BEST PRACTICES

While regulations establish many standards for the implementation of compensatory mitigation projects, the language leaves considerable flexibility (*Practice Paper*). Flexibility may be necessary in some areas due to the ecological differences across regions and to allow for innovation, but additional guidance on a number of key components could improve consistency and reliable outcomes (*Practice Paper*). When guidelines lack objective criteria, practitioners may struggle to understand what regulators expect and regulators may struggle to review projects consistently. Standard criteria, templates, and performance measures could result in more consistent products. On the other hand, a lack of flexibility in some program components, performance standards for example, may cause providers to adapt projects to meet standard metrics rather than to restore functions appropriate for the site (Doyle and Shields, 2012).

Though stream compensation SOPs vary, many of them are alike in what they do and do not address. Many SOPs provide guidance on mitigation methods and debit/credit determination and most mention one or more allowable mitigation techniques (although a district may allow the use of a technique as a mitigation action even if the SOP does not explicitly identify that technique as a permissible action). Most state and Corps district stream compensation SOPs also discuss site protection instruments, but do so by reiterating the language in the 2008 Rule. Some topics, however, consistently receive less attention than others. Some of the more complicated and important aspects of stream mitigation policy – the siting of projects, the watershed approach, and performance standards – are also the least well defined in guidelines and left up to review on a case-by-case basis. Further, the staff responsible for such case-by-case review often have relatively little experience and training in stream restoration or mitigation. Monitoring protocols and credit release schedules have also generally received little attention. This is true at both the district and state level, as the Association of State Wetland Managers found that the vast majority of states evaluated success of compensation projects on a case-by-case basis (ASWM, 2014).

More guidance on these topics would improve consistency and aid both regulators and providers in designing sustainable mitigation projects. As discussed above, districts need more explicit guidance on effective methods of mitigation in a given context, and guidelines for application of the watershed approach in order to improve site selection and to adequately protect priority aquatic resources. Regional guidance could be tailored to local ecological conditions and resources.

6) BETTER INTEGRATION OF REGULATORY AND ECOLOGICAL GOALS

The tension between stream restoration in practice and stream restoration guidelines is related to the inherent conflict between meeting ecological performance measures and obtaining credit release. Given the current state of stream restoration science, there is a lot of uncertainty regarding best practices, identifying potential challenges, and implementing remedial measures. Additionally, there is a high level of economic risk on the part of the practitioner, hence the various credit release schedules that attempt to compensate for upfront attainment of milestones and longer-term releases based on achievement of performance measures. Because of these challenges, it is incumbent on both practitioners and regulators to provide a transparent process for credit determination that best reflects the ability of projects to improve ecological functions. In order for projects to truly offset impacts to aquatic resources, the functional lift awarded credits should reflect the functional needs of the watershed. In order for credits to truly reflect lost functions they should not be awarded when the identified functions are not improved. Likewise, monitoring reports should accurately and honestly reflect upon ecological and functional performance, and how individual projects improve the aquatic function within the given watershed or service area.

CONCLUSION

Although some of the gaps identified here will clearly require years of scientific data to address, many of the issues can be addressed within district SOPs or through Regulatory Guidance Letters. As noted above, many of the districts have yet to update their SOPs to bring guidance up to date with the 2008 Rule. Districts can increase compensatory mitigation effectiveness, sustainability, transparency, and consistency by providing clarification on key items discussed in these recommendations. While some variation is expected between districts given the difference in aquatic resources across the nation, Corps and EPA headquarters should assist districts in developing standard language for the gaps highlighted in this paper so stream mitigation is applied more consistently across the nation.

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APPENDIX B: INTERVIEW QUESTIONS

Questions for Corps Respondents

PART 1: General Questions About Stream Mitigation in the District

1. To the extent possible, we would like to gather information on the amount of stream mitigation that is implemented in your district.
    a. Can you estimate the average amount of linear feet of mitigation that is required in your district annually?
    b. Can you estimate the number of stream credits that are purchased in your district annually?
    c. Can you estimate how much is spent on stream restoration in your district annually?
    d. Can you estimate the number of projects carried out in your district annually?
    e. How have these numbers changed over the past 10—15 years?
2. Can you estimate the percentage of compensatory mitigation projects in your district annually that are stream-related?
    a. How have these numbers changed over the past 10—15 years?
3. Does your district allow all four mitigation methods (i.e., preservation, enhancement, restoration, and establishment) for streams?
    a. Do you use the same definitions for these methods as the 2008 federal compensatory mitigation rule?
    b. Does your district prioritize any of the methods? If so, which one(s)?
    c. Which methods are most common? Do any of them predominate?
    d. In what circumstances are preservation or establishment allowed?
4. What types of activities that impact streams require permits?
    a. What kinds of impacts do these activities cause?
    b. How significant are the impacts? (E.g., how many linear feet?)
    c. What is the threshold, in stream length, for requiring mitigation?
    d. In general, what is the ratio of large and small projects?

   e. Are there types of impacts for which mitigation is now required that did not require mitigation 10—15 years ago?

5. Do you have a sense of the average price of credits in your district?

6. Has your district adopted or are you in the process of developing mitigation guidelines specific to streams?

   a. If not, how do you make decisions about stream mitigation?

   b. If you have adopted or are in the process of developing mitigation guidelines for streams, are there particular district guidelines that you used or are using to shape those in your district?

7. Do you have review staff with a background in stream functions?

PART 2: Mitigation Activities – Techniques and Approaches

8. What approaches and techniques can be used to generate stream credits? (For definitions of approaches and techniques, please see page 4.)

   a. Are changes to stream dimension, pattern, and profile required to get credits?

   b. Does your district require natural channel design to be used? If not, is there a preferred restoration approach in your district?

   c. Do you use different criteria for different types of mitigation?

      i. Preservation

      ii. Enhancement

      iii. Restoration

      iv. Establishment

9. Does your district require the same mitigation actions for all types of streams, or do you have different requirements based on stream characteristics (e.g., size, class by order, flow duration – perennial, intermittent, ephemeral)?

   a. Does your district require the use of the Rosgen stream classification system? If not, is it often used by the provider?

10. What level of design do you require for mitigation plans?

a. Do you require engineering drawings? If so, is a Professional Engineer required to seal the drawings?

b. Is an as-built survey of the implemented project required? If so, is it sealed by a Professional Engineer or Professional Land Surveyor?

11. To what extent does your district attempt to match stream mitigation approaches and techniques to:

    a. Impacts at the project site?

    b. Problems in the watershed?

12. Credit/debit determinations:

    a. If your district does not use credit/debit determination tables (example on p. 6): How does your district make credit and debit determinations? Is this done on a case-by-case basis, or do you follow general rules or guidelines?

    b. If your district does use credit/debit determination tables: Does your district generally follow the tables? If not, what other approaches do you take, and why? (E.g., do you sometimes allow credits for mitigation actions that are not included in the credit determination table?)

    c. Are ratios used? If so, are the ratios multiplied by the proposed stream length? Do you use a different ratio for new channel construction versus the existing channel length?

13. How does your district determine buffer credits?

    a. Do you provide different credit levels by buffer width?

    b. Are buffer credits calculated separately from stream credits?

14. Does your district apply assessment methodologies and if so, in what context (and which ones)?

    a. Are the assessment methods rapid? If so, what is the definition of rapid?

    b. Do you also require a detailed assessment once the project is approved (e.g., past the prospectus stage)?

PART 3: Site Selection and the Watershed Approach

15. How does your district implement the watershed approach requirement? How do you define "watershed"?

a. Do you have any watershed plans that you have determined are “appropriate” to guide compensatory mitigation decisions?

    i. If not, are you relying on existing relevant plans and information to guide watershed-based decision making?

    ii. If so, what plans are you relying upon?

b. Does most mitigation occur in the same watershed as impacts? What percent?

16. How do you select mitigation sites? Do you consider HUCs and/or ecoregions in site selection? Are they included in your service area requirements?

PART 4: Performance Standards, Monitoring, and Adaptive Management

17. How does your district determine performance standards?

    a. Do you use assessment methodologies to establish measurable performance standards?

    b. Do the performance standards match or align with the design criteria?

18. How does your district determine what must be monitored, and for how long?

    a. How do the monitoring requirements relate to performance standards?

19. Does your district incorporate adaptive management into stream mitigation policy and practice? If so, how?

PART 5: Final Thoughts

20. What is not covered in your district? Are there any gaps or specific issues that your district is struggling to address? Please explain.

21. Are there others we should talk to (e.g., state agencies, NGOs, mitigation professionals)?

Questions for Other Respondents

PART 1: Your Involvement in Stream Mitigation

1. Please tell us about your involvement in stream mitigation. What role do you play (e.g. sit on IRT, practitioner with X projects, etc.)?

2. How does your agency or organization interact with the Corps?

3. Are you aware of any formal agency stream mitigation guidelines developed for your region?

   a. If so, was your agency or organization involved in development of the guidelines?

4. Do you think that there are gaps in the existing stream mitigation guidelines (if any)? What do you think could be improved?

PART 2: Stream Mitigation Practice

5. Would you say that stream mitigation is (a) expanding rapidly; (b) well established and steady; (c) just getting started; or (d) something else; in your state or region?

6. How would you characterize the level of expertise (e.g., novice, competent, expert) on stream mitigation amongst:

   a. The Corps?
   b. Other federal agencies?
   c. State agencies?
   d. Tribes?
   e. Practitioners?
   f. NGOs?

7. Do you have a sense of how much stream mitigation occurs in the state or region where you work?

8. How has stream mitigation changed over the past 10—15 years (e.g., amount of compensation required, types of projects approved, compensatory mitigation methods available)?

   a. Have you noticed any changes after the 2008 Mitigation Rule?

9. Which stream mitigation methods (i.e., preservation, enhancement, restoration, and establishment/creation) are most common in your experience?

   a. If you work for a state agency: does state law allow all four types of mitigation methods? If not, why are certain methods prohibited?

10. What types of activities that impact streams require permits? What types of impacts are not routinely required to provide offsets?

11. Do you know how much stream mitigation credits cost (per credit and per linear foot)?

    a. Has this price changed in recent years? If so, has it gone up or down?

PART 3: Mitigation Activities – Techniques and Approaches

12. What approaches and techniques do you see/apply most frequently? (For definitions of approaches and techniques, please see p. 4—5.)

    a. Are changes to stream dimension, pattern, and profile common?
    b. Is natural channel design often used? If not, is there another preferred restoration approach?

13. How do stream mitigation actions vary across stream type or characteristics (e.g., flow duration – perennial, intermittent, ephemeral)?

    a. Is the Rosgen stream classification system often used?

14. Do you try to match stream mitigation approaches and techniques to impacts at the project site or problems in the watershed?

15. How are credits and debits determined? Please specify the methodology.

16. How are buffer credits determined?

    a. Do wider buffers get more credits?
    b. Is there a minimum or maximum buffer size?
    c. Are buffer credits calculated separately from stream credits?

17. Are assessment methodologies used?

    a. If so, how are they applied, and in what context?
    b. Are the assessment methods rapid? If so, what is the definition of rapid?

PART 4: Site Selection and the Watershed Approach

18. How are mitigation sites selected? Are HUCs and/or ecoregions considered in site selection?

19. How is the watershed approach applied to stream mitigation?

    a. Are watershed plans available? If so, do you use them?
    b. Does most stream mitigation occur in the same watershed as impacts? What percent?

PART 5: Performance Standards, Monitoring, and Adaptive Management

20. How are performance standards determined?

    a. Do the performance standards match or align with the design criteria/monitoring requirements?

21. How are monitoring requirements (including duration) determined?

22. Is adaptive management incorporated into stream mitigation policy and practice? If so, how?

PART 6: Final Thoughts

What is not covered in current approaches to stream mitigation? Are there any gaps or specific issues that your agency/practice is struggling to address? Please explain.

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