Assessing Stream Mitigation Practice

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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 (Science Paper), 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 have partnered to provide a wide-ranging view of the state of stream compensatory mitigation. In this series of white papers, we examine how stream compensatory mitigation has evolved in policy and practice in the more than seven years since the 2008 Rule, identifying trends, areas for improvement, and best practices. We also examine 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. The white papers in this series 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).

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

- 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 other white papers in this series using the abbreviations shown in parentheses.

Practice Paper

In this paper, we characterize the practice of compensatory stream mitigation and explain how regulators and practitioners are implementing compensatory mitigation rules and procedures in different jurisdictions across the country. It is intended to illustrate the different contexts in which compensatory stream mitigation takes place, trends in the development of compensatory stream mitigation, and variation and similarities among regions. A separate white paper (Guidelines Paper), which analyzes formal guidance and standard operating procedures from around the country, complements the analysis of practice provided here.

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 or standard 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 impact 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 (EPA, Accessed 2016). 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; Hill *et al.*, 2013; 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 released a Regulatory Guidance Letter addressing compensatory mitigation (USACE, 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, 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). Accordingly, the Rule establishes the following policies for streams:

- 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));
- 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)); and
- Require at least five years of monitoring for mitigation projects, or longer for certain slow-developing resources (73 Fed. Reg. 19597).

Although these 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 disproportionate regulatory risk (that is, risk that the required mitigation may not adequately offset permitted aquatic resource impacts) (BenDor and Riggsbee, 2011). Some 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). 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).

METHODOLOGY

Over several months in mid-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 1). 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 2). 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.

Table 1: Corps Districts Interviewed
• Fort Worth • Galveston • Little Rock • Los Angeles • Mobile • New England • Norfolk • Omaha • Portland • Seattle • St. Louis • Wilmington

Interview questions (Appendix A) covered a range of topics. First, questions addressed the extent and evolution of stream compensatory mitigation in each interviewee's region, including the amount of compensatory mitigation required, 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, 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.

Table 2: Other State and Federal Agencies Interviewed
• 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) • U.S. Fish and Wildlife Service (FWS) • 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.

RESULTS

I. General Trends and Context of Mitigation

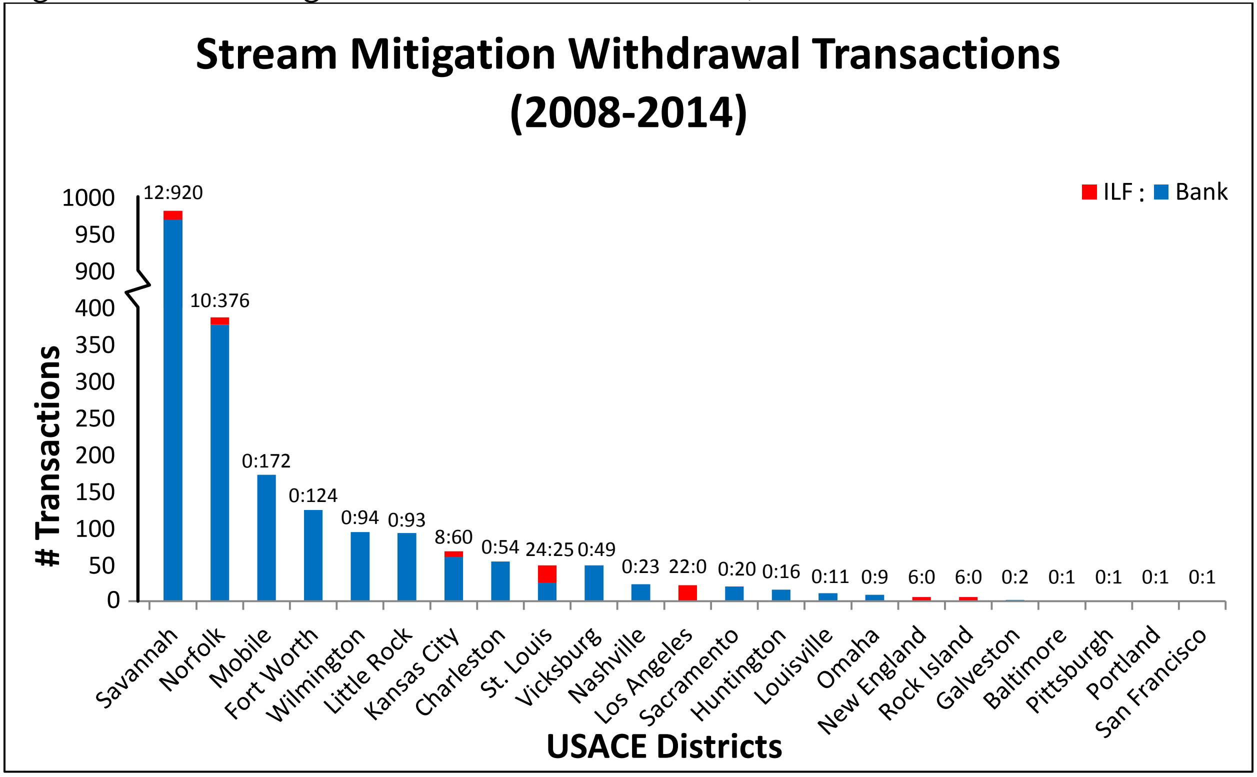
A. Regional Variation

Although stream mitigation is a well-established and high-volume endeavor in some areas of the country, agencies in other regions are only just beginning to require that permit applicants offset impacts to streams with stream compensation projects, rather than wetland projects. Regions also vary in whether permittee-responsible mitigation, banks, or in-lieu fee (ILF) programs predominate in generating credits.

Nationwide data on compensation is incomplete and difficult to obtain, as other scholars have remarked (BenDor *et al.*, 2009), but nonetheless data collected from the Corps' Regulatory In-lieu fee and Bank Information Tracking System (RIBITS) provide some sense of the number of ILF and mitigation bank transactions (separate instances of credits generated or withdrawn), the volume of stream mitigation occurring (measured by number of linear feet of compensation associated with withdrawn credits), and the prevalence of mitigation banks versus ILF programs across districts (USACE, RIBITS, Accessed 2015). Because RIBITS does not track permittee-responsible mitigation, the data present only an incomplete picture of the stream compensatory mitigation market.

RIBITS includes data on both the release of credits to banks and ILF programs (that is, credit generated) and the withdrawal of credits from banks and ILF programs to permit applicants. Between 2010 and 2014, mitigation banks and in-lieu fee credit programs accounted for just over half (52%) of all wetland and stream compensatory mitigation authorizations (USACE, Institute for Water Resources, 2015). We have limited our data set to the number of credit withdrawals from banks and ILF programs from 2008 to 2014 in order to capture transactions after the issuance of the 2008 Rule. We report data on the number and total linear feet of stream compensation transactions during this period. Because the number of linear feet per credit varies among and within districts, it is difficult to use number of credits to compare the amount of on-the-ground compensation taking place across the country. In addition, some states use area rather than linear feet to measure stream compensation. However, in many cases districts have reported a number of linear feet associated with released or withdrawn credits. We report data on the number of linear feet of stream compensation associated with credit withdrawals during this time period. As a result, our results exclude transactions that were recorded as credits only as well as those recorded as acres instead of linear feet. Thus, the data underestimate the actual extent of mitigation that took place.

Figure 1: Stream Mitigation Withdrawal Transactions, 2008-2014



Data showing withdrawal transactions from 2008-2014 for each Corps district with available bank or ILF data in RIBITS. Red bars or segments indicate withdrawal transactions for ILF programs. Blue bars indicate withdrawal transactions for mitigation banks. Numbers on bars represent the number of ILF and Bank transactions, respectively. *Data is not complete because some districts do not upload complete data to RIBITS. For example, Wilmington data excludes NCEEP credit transactions.

According to the RIBITS data, Savannah and Norfolk were the districts with the highest number of total transactions (Figure 1). Similarly, the most linear feet of mitigation takes place in the South Atlantic and North Atlantic Corps divisions (Figure 2). Mobile, Fort Worth, and Wilmington were the next largest districts in terms of number of stream mitigation withdrawal transactions, although the data for some districts is incomplete in RIBITS. For example, the numbers for Wilmington exclude the substantial amount of stream compensation overseen by NCEEP, the North Carolina ILF program (75,000 to 100,000 linear feet per year, according to our interviewee), because the NCEEP compensation sites and associated credit transaction data have not been entered in RIBITS.[2]

[2] The U.S. Army Corps of Engineers Headquarters and Institute for Water Resources are working with districts to update ILF data in RIBITS.

Figure 2: Mitigation Types Comprising Stream Compensatory Mitigation Provided by Mitigation Banks and In-Lieu Fee Projects

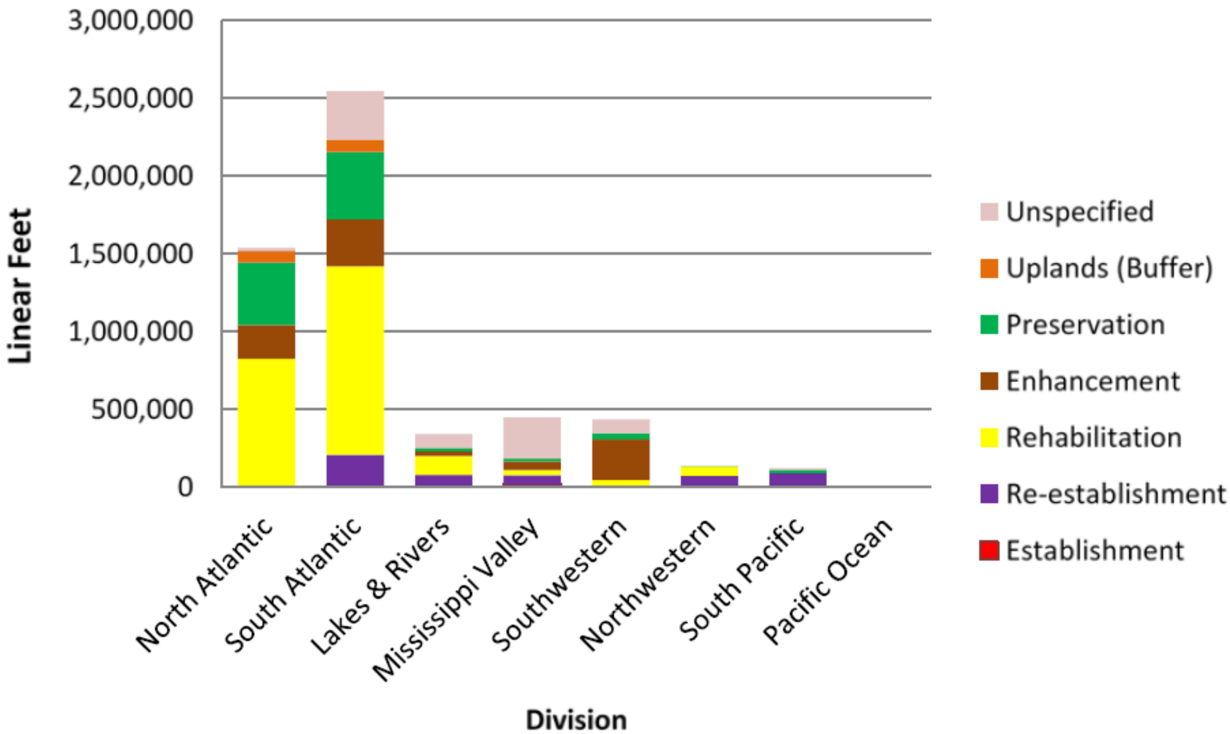


Figure showing linear feet of stream compensatory mitigation as provided by banks and ILF programs for each Corps division by mitigation type as of 2014 using data in RIBITS. Figure reproduced from USACE, Institute for Water Resources, 2015.

Nationally, the data made available through RIBITS indicate that much more compensatory stream mitigation is carried out through mitigation banks than through ILF programs. However, stream ILF mitigation predominated in the Los Angeles, New England, and Rock Island districts. St. Louis, Kansas City, Norfolk, and Savannah had a modest amount of ILF mitigation. Note again that a lack of data on permittee-responsible compensation presents an incomplete picture of the distribution of all compensatory mitigation. Western districts had much less stream compensation, measured by linear feet, than districts in the East. In total, according to the RIBITS data, the equivalent of 1.97 million linear feet of compensation credits were released for sale from banks and ILF programs, and 857,050 linear feet were withdrawn to satisfy compensation requirements, between 2008 and 2013.

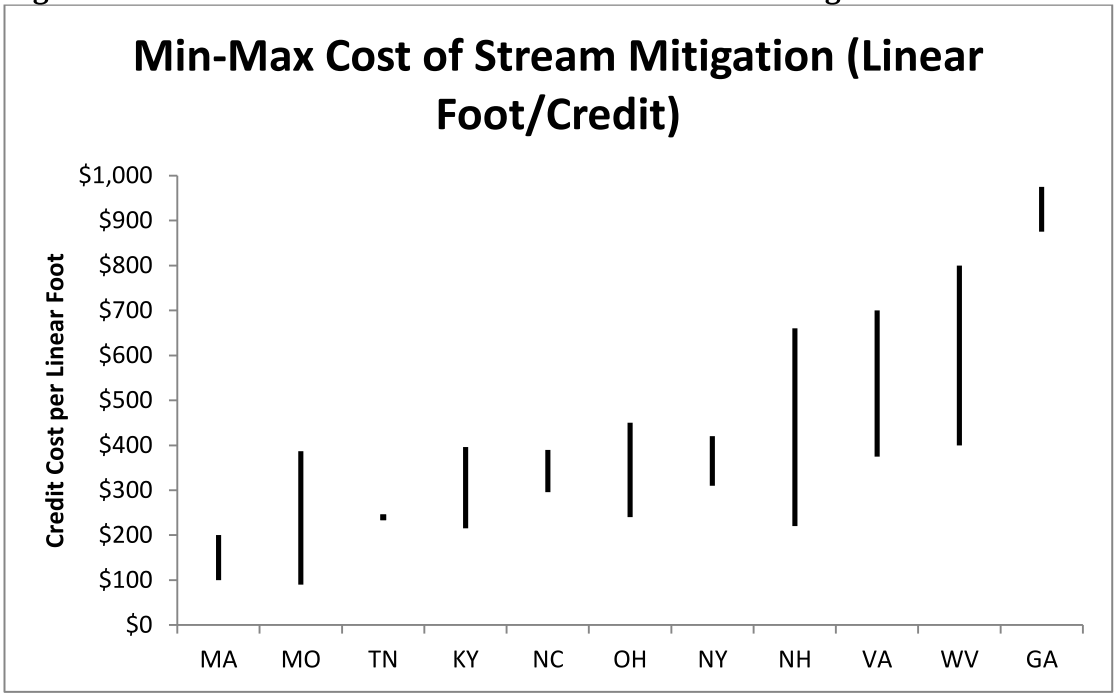
The results from our interviews showed similar trends. The Southeast in general, including North Carolina, Georgia, Kentucky and Virginia (and also Tennessee, Mississippi, and Alabama), has a relatively long history with stream compensatory mitigation. According to the NCEEP respondent, the stream compensation market has been robust in North Carolina for some time. North Carolina began providing compensatory mitigation for impacts to steams in the mid-1990s through NCEEP; today the program oversees between 75,000 and 100,000 linear feet of stream compensation annually, with 90 percent of its $40-50 million annual budget going to stream compensation. Likewise, the VDEQ respondent observed that Virginia has had an active stream compensatory mitigation market for over a decade.

Stream compensatory mitigation also has been a growing practice in the Pacific Northwest for about 15 years, according to a NOAA respondent based in Washington, though historically mitigation demand in the region has often been due to requirements under the Endangered Species Act or state regulatory programs and not due to the Clean Water Act. However, few stream banks exist in the Portland district, and no banks or in-lieu fee programs in the Seattle district currently have stream credits. At the state level, Washington has had a stream mitigation program for decades under a state statute.

Outside the Southeast and Pacific Northwest and a few additional areas, stream compensatory mitigation markets are generally a more recent development. Mid-Atlantic states like Maryland and Pennsylvania are much newer arrivals to stream compensation than states just to the south. According to a practitioner at the FWS, Maryland has had no stream compensatory mitigation banking projects to date. Elsewhere, stream mitigation in Montana is also just getting off the ground, says a former board member of Montana Aquatic Resources Services (MARS), a nonprofit compensatory mitigation organization that operates a statewide in-lieu fee program.

The monetary value — both the cost and price of credits — of stream compensatory mitigation in each district varies no less widely, depending on the availability of stream credits, the accounting procedures used to convert linear feet of stream impact or mitigation into stream credits, and other factors. Most of the districts with whom we spoke were unable to estimate the price of stream compensation credits in their district. For those districts that were able to report, credit prices varied widely (though the meaning of credits is not directly comparable across states or districts). One way to estimate stream compensation costs is to use ILF credit prices. Figure 3 shows the minimum and maximum estimated cost of ILF stream mitigation credits by state for those programs that reported credit prices in cost per linear foot in their instruments or other documents. Interviewees also reported a large variation in credit prices. In the Los Angeles district, our interviewee reported credits are priced at as much as $180,000, but in Little Rock the price is far lower, just $40 per credit, as reported by our interviewee. The cost of generating stream credits is equally hard to estimate.

Figure 3: Minimum and Maximum Cost of ILF Stream Mitigation Credits



ILF Stream Mitigation Credit Prices based on public ILF program fee schedules compiled by IWR.
*Oregon estimates excluded due to different unit of measure ($42,339-$81,599 per acre as calculated by OHW width * length).

B. Local Sources of Demand for Compensatory Stream Mitigation

Although the types of projects commonly requiring stream compensatory mitigation are generally similar across the country, they do vary geographically and fluctuate over time as industry and economic forces shift. Our interviews provided some information on the types of permitted impacts or other contributing factors that drive compensatory stream mitigation across the country.

Table 3: Dominant Stream Impacts Requiring Compensatory Mitigation as Reported by Respondents

Activity	**Where Impacts are Common**
Transportation (bridges, culverts, crossings)	New England, Norfolk, Los Angeles, Omaha, Portland, Seattle, Wilmington
Commercial/residential development	Fort Worth, Los Angeles, Norfolk, Portland, Seattle, St. Louis, Wilmington
Oil & gas/fracking	Fort Worth (until 4-5 years ago); Little Rock
Sand and gravel mining	Missouri
Floodplain obstructions (*e.g.*, levees)	Missouri
Flood control	Los Angeles
Industrial	Norfolk, Los Angeles

Across districts, transportation and development projects were the most frequently cited activities requiring compensatory stream mitigation. Beyond that, cited impacts were more regionally specific. Norfolk and Los Angeles mentioned industrial projects, whereas Fort Worth and Little Rock cited oil or gas development and fracking, and Missouri mentioned sand and gravel mining and floodplain obstructions like levees. Los Angeles also cited flood control projects. While Section 404 drives the majority of the permitting for these activities in most areas of the country, impacts to endangered and threatened fish drive most of the stream compensation projects in the Pacific Northwest, according to respondents from NOAA and a consultant we interviewed.

Development activities affect streams in a variety of ways, and impacts may vary by stream type. The installation of riprap, for instance, can impede vegetation establishment and sediment deposition, while bank stabilization and impoundments can alter flows and reduce or change aquatic habitat. Activities such as bank stabilization frequently result in partial, rather than complete, loss of stream function. The Fort Worth Corps pointed out that commercial and residential development often impact ephemeral and intermittent streams, rather than perennial streams.

We also sought to characterize the general size (in linear feet) of permitted stream impacts. Generally, respondents reported that smaller projects predominate, though Fort Worth, for example, reported larger projects of more than 6,000 feet and impacts can be much larger in other states (e.g., impacts associated with mining projects). Interviewees differed on what constitutes "small," however. Many districts considered impacts of fifty to a few hundred feet "small." Norfolk considers any project involving less than 2,000 linear feet "smaller" and may fall under 1 or more State Program General Permits (SPGP). Seattle considered anything over 400 linear feet to be a large project. St. Louis "closely evaluates" any impact over 100 linear feet.

We also sought to determine whether Corps districts have a threshold above which they require compensatory mitigation for impacts to streams (Table 4). Several districts, including Little Rock, Fort Worth, Norfolk, and Omaha (only for projects in Montana), have a 300-foot minimum threshold for requiring mitigation. Losses below 300 feet are often non-reporting under Nationwide Permits (NWPs). Losses above this threshold would require reporting and submittal of notifications (e.g., pre-construction notification).

By contrast, 100 and 150 feet are the minimums for requiring mitigation in St. Louis and Wilmington, respectively. New England, Portland, and Seattle decide whether a project requires compensatory mitigation on a case-by-case basis, though New England stated that it would prefer a more specific standard. In the Seattle district, many projects require compensatory mitigation even if they are small because of Endangered Species Act requirements. Mobile reported that all unavoidable impacts require compensatory mitigation, regardless of the size of the impact.

Table 4: Minimum Threshold for Requiring Mitigation	
District	**Linear feet or area**
Fort Worth	300 (typically)
Galveston	Depends on permit type
Little Rock	300
Los Angeles	1/10 acre, approx., but varies case-by-case
Mobile	Mitigate all impacts
New England	No threshold
Norfolk	300 (typically)
Omaha	300 in Montana; elsewhere 300-500 feet
Portland	No threshold; case-by-case; projects <50 feet may not require mitigation
Seattle	No threshold; case-by-case (though Endangered Species Act often requires mitigation)
St. Louis	100 (typically); road crossings treated differently
Wilmington	150 (typically)

C. Growth of Stream Mitigation

Since 2001, the number of stream credit transactions and the amount of stream mitigation credits has steadily increased, with a substantial uptick since 2008 (USACE, Institute for Water Resources, 2015). Interviewees generally agreed that the stream compensatory mitigation market is expanding in their region, both in absolute terms and relative to the wetland compensation market. New Hampshire did not require stream compensation before 2010, when it adopted stream mitigation rules. Virginia's stream compensatory mitigation market has grown over the past decade as stream restoration science has developed. VDEQ and the Norfolk Corps District produced their Unified Stream Methodology (USM) to assist in stream assessment and state and federal permitting throughout Virginia (USACE, Norfolk District, and VDEQ, 2007). In the Galveston district, the Corps has seen an "explosion" in stream compensatory mitigation since the 2008 Rule, and district staff in Fort Worth, Little Rock, Los Angeles, and Omaha also reported increases since then.

According to our interviewees, stream mitigation has made up about 80 percent of all compensatory mitigation in the Little Rock district in recent years, and more than half of the compensatory mitigation in Norfolk and Wilmington (Table 5). In other regions, the proportion of stream compensation relative to wetland compensation is still modest: 10 percent in St. Louis, 30 percent in Seattle. The Portland district is just beginning to require stream compensation.

Table 5: Reported (based on interviews) Percent of Compensatory Mitigation Projects that are Stream-Related	
District	**Stream mitigation percentage** (approximate)
Galveston	15-20%
Little Rock	80%
Los Angeles	>50% (90% in 2012)
Norfolk	>50%
Seattle	30%
St. Louis	10%
Wilmington	50-75%

Our interviews suggest that no single factor accounts for the rise in stream compensatory mitigation markets. National and local economic trends strongly influence the demand for compensatory mitigation in some areas: Wilmington and Little Rock observed that the recession resulted in fewer compensation projects taking place over the last several years, and Little Rock noted that, with the economic recovery, the compensation market was again growing. A post-2008 boom in the Illinois coal industry caused substantial stream impacts requiring compensation in the St. Louis district. Similarly, fracking in the Fayetteville Shale of Arkansas increased required stream compensation in the Little Rock district.

The 2002 nationwide permits also created a relative shift to stream compensation in some districts. In 2000 and 2002, stream compensatory mitigation (and setting aside a riparian area if a stream is on the project site) began to be considered as appropriate mitigation in the NWP Program. Los Angeles stated that the increasing stringency of nationwide permits had encouraged people to avoid more wetland impacts, so wetland compensation has decreased as the relative percentage of stream mitigation has grown. Similarly, the Norfolk District observed that nationwide permits issued in the early 2000s, particularly the 2002 nationwide permit 39, caused their office to start focusing on stream compensation separately from wetlands compensation, though they were already moving in that direction. Before these nationwide permits were issued, most of the compensation projects approved in the Norfolk district were wetlands projects, and the amount of mitigation required was generally based on the acreage of impacts. Nationwide permit 39 prompted the Norfolk district to measure stream impacts in linear feet and credit stream projects separately from wetlands. Little Rock's respondent also noted that compensation is required for more stream projects now because nationwide permits are stricter. Likewise, according to the interviewee from the St. Louis district, both the requirements of and the thresholds for the nationwide permits have become increasingly strict over time.

Respondents from the Fort Worth, Galveston, Little Rock, and Omaha districts attributed at least some of the rise in stream compensatory mitigation — both regulators requiring stream mitigation and banks providing it — to the 2008 Rule. The 2012 NWPs also more explicitly endorsed stream mitigation as acceptable compensatory mitigation (especially for surface coal mining activities). A staff member at the WDFW also reported a general increase in bank and ILF program proposals after the 2008 Rule. This corresponds with the growth in the number of mitigation banks providing stream mitigation credits, which has more than doubled since 2008 (USACE, Institute for Water Resources, 2015).

On the other hand, some respondents, including practitioners, state and federal agencies, and NGOs, saw little change in the amount of stream compensatory mitigation required after the finalization of the 2008 Rule. In Virginia, for example, the development of the USM had a much more substantial impact than the Rule did. The USM, by providing clarity, substantially improved the implementation of stream compensatory mitigation in Virginia, and therefore had a more significant impact than the 2008 Rule in the state according to respondents. The NHDES respondent thought the expansion in their state was independent of the 2008 Rule. However, according to data in RIBITS the number of bank & ILF projects providing stream credits more than doubled since issuance of the mitigation rule (from 51 to 113 bank & ILF sites). The rule may not be causative but there appears to be a correlation.

II. Stream Mitigation in Practice

A. Methods of Mitigation

Although the 2008 Rule allows four compensatory mitigation methods — preservation, enhancement, restoration, and establishment — the regulations establish a preference for restoration activities (33 C.F.R. § 332.3(a)(2)). Written Corps policies on stream mitigation generally authorize all four compensatory mitigation methods identified in the federal regulations. Many of these policies do not have a stated preference for any particular strategy, but a good number do state a preference for restoration over establishment (Guidelines Paper). Many of the districts we interviewed said they do prioritize or incentivize restoration or both restoration and enhancement for streams. Districts almost uniformly either disfavor or prohibit establishment as a compensatory mitigation method for streams, citing concerns about its efficacy. This is also consistent with the 2008 mitigation rule provision that states that streams are difficult-to-replace resources (USACE-EPA 2008). All of the districts we interviewed used the same definitions for each method as those included in the 2008 Rule.

Districts prohibiting or avoiding stream establishment

- Galveston (not allowed)
- Little Rock (generally not allowed)
- Mobile (generally not allowed, will allow relocation)
- New England (not allowed)
- Norfolk (not allowed)
- Omaha (generally not allowed, some short distance relocation)
- Seattle (generally not allowed, will allow relocation)
- Wilmington (not allowed in practice)

Districts permitting all four methods

- St. Louis
- Portland
- Los Angeles

Districts allowing preservation in conjunction with restoration/enhancement

- Galveston
- Fort Worth
- Norfolk
- Omaha

Districts generally discouraging preservation

- Seattle
- Mobile

Districts where preservation is common

- New England

As might be expected given these practices, stream restoration and enhancement projects generally predominate over establishment and preservation. Although it is common for stream mitigation projects, especially bank and ILF projects to include a combination of restoration, preservation, and enhancement components. Although enhancement and restoration may be the most common types of projects, the Los Angeles district and the VDEQ observed that preservation tends to account for a larger area or length than other methods, because large areas must be preserved to achieve the same number of credits as a smaller restoration or enhancement project. Wilmington noted that although restoration is most common in their district, because the credit ratios are better for restoration projects than for other methods, enhancement is increasingly popular because people are trying to minimize on-site impacts and take a lighter approach to compensation. Another interpretation could be that stream enhancement (establishment of riparian buffers, bank stabilization, etc.) is far less expensive to design and implement than full channel restoration. In the Chesapeake Bay area, banks generally prefer preservation and enhancement because they are more cost-effective, but permitting authorities emphasize restoration, according to a practitioner from the region. In the Galveston district, restoration projects are divided into reestablishment and rehabilitation. The district incentivizes reestablishment in their credit calculations.

Most, but not all, districts apply different criteria for each mitigation method, allowing each under different circumstances and often granting differing credit amounts for preservation, restoration, or enhancement. The Mobile district requires documentation of the channel condition and monitoring to ensure the condition remains constant for preservation projects, while enhancement or restoration projects require additional documentation of both the reference streams and design stream. Fort Worth, on the other hand, reported that they used the Texas Rapid Assessment Method (TXRAM) to determine credits for all mitigation methods and so apply the same criteria to each (USACE, 2010). Wilmington generally makes case-by-case determinations about when different mitigation methods are appropriate. Little Rock has not laid out any specific requirements for each mitigation method. Portland uses essentially the same criteria for enhancement and restoration, the only two mitigation methods generally allowed by the district.

Many stream compensation SOPs have stated limitations on preservation, allowing it only under certain circumstances or in conjunction with restoration or enhancement (Guidelines Paper). When districts do allow preservation, they reported (and their policies state) that they typically do so according to the five factors set out in the 2008 Rule:

> "(1) The resources to be preserved provide important physical, chemical, or biological functions for the watershed;
> (2) The resources to be preserved contribute significantly to the ecological sustainability of the watershed. In determining the contribution of those resources to the ecological sustainability of the watershed, the district engineer must use appropriate quantitative assessment tools, where available;
> (3) Preservation is determined by the district engineer to be appropriate and practicable;
> (4) The resources are under threat of destruction or adverse modifications; and
> (5) The preserved site will be permanently protected through an appropriate real estate or other legal instrument (e.g., easement, title transfer to state resource agency or land trust)." (33 C.F.R. § 332.3(h)(1)).

The 2008 Rule's provision that compensation for difficult to replace resources, such as streams, should be provided through in kind rehabilitation, enhancement, or preservation, if practicable (33 C.F.R. § 332.3(e)(3)) is also a factor in bolstering preference for preservation.

Galveston allows preservation only under certain conditions, such as when the stream is well established, is basically pristine, and has buffers. Mobile allows preservation only for riparian buffers. Wilmington follows the five factors of the 2008 Rule, but also has a separate preservation policy that provides preferences and requirements, like a preference for conservation easements for site protection, as well as model language for conservation easements, restrictive covenants, and declarations of restrictions (USACE, Wilmington District, 2003). Both Norfolk and Omaha said they would more likely consider preservation if it was proposed in conjunction with either enhancement or restoration.

Establishment is considered on a case-by-case basis, at least in Fort Worth and Los Angeles. Los Angeles considers the sensitivity of the uplands area when deciding whether to approve an establishment project. The Mobile district allows Priority 1 channel restoration or relocating a stream segment. Priority 1 Restoration is defined as "stream channel restoration that involves the re-establishment of a channel on the original floodplain, using a relic channel or constructing a new channel" (U.S. Army Corps of Engineers, Mobile District, *Compensatory Stream Mitigation Standard Operating Procedures and Guidelines, SAM-2011-317-MBM*, p.10).

B. Stream Restoration Approaches

We identified five restoration approaches currently in use across the country:

Table 6: Approaches to Stream Mitigation

Approach	Description
Natural Channel Design	Also called the Rosgen Geomorphic Design Methodology. This approach includes eight phases ranging from restoration objectives and watershed assessment to design and monitoring. It primarily focuses on creating or maintaining a bankfull channel with floodplain/floodprone area access that does not aggrade or degrade over time. Design tools include hydraulic geometry relationships, bankfull regional curves, reference reach ratios, sediment transport calculations, and more (NRCS, 2007a).
Regenerative Design	There are two types of Regenerative Design Approaches: Step Pool Storm Conveyance (SPSC) and Floodplain Weirs. SPSC is typically used to convert ephemeral stormwater flow to subsurface flow through the use of step-pool channels and sand seepage berms. Floodplain weirs are used in perennial streams to create stream/wetland systems to reduce energy and improve water chemistry (Anne Arundel County, 2012).
Valley Restoration	This approach is primarily applied in regions with legacy sediments and small headwater systems with low sediment supply, but it has also been applied in larger watersheds with sediment supply. The design methodology includes reconnecting stream/wetland systems to the original valley and groundwater sources, typically through floodplain excavation. The channels are much smaller than bankfull channels. Sediment sinks are used to remove sediment in larger watersheds with sediment supply.

Analytical	This approach uses physically based equations, including continuity, hydraulic resistance, and sediment transport, to design the riffle dimension. The primary result is a channel stability curve that predicts riffle depth and average channel slope for a range of channel widths. Other empirically based methods are generally used to design meander geometry and bed-form profiles (NRCS, 2007b, c).
Process Based	The purpose of process-based restoration is to re-establish normal rates and magnitudes of physical, chemical, and biological processes. This approach provides broad guidelines about design goals and steps and then points to specific techniques that can be used to manipulate stream processes and channel forms (WDFW, 2012).

Interviewees were asked which stream restoration approaches, as defined earlier, were used in their district (Table 7). Their responses revealed clear trends and commonalities in approaches to stream restoration. Natural Channel Design is the dominant approach to stream mitigation employed across the country. The use of NCD is also required and or encouraged in several formal district and state policies (Guidelines Paper).

Table 7: Districts Applying Restoration Approaches

Approach	**Districts**
Natural Channel Design	Fort Worth, Little Rock, Mobile, New England, Norfolk, Seattle, St. Louis, Wilmington
Regenerative	New England, Wilmington (under consideration)
Valley Restoration	None
Process-Based	Seattle
Analytical	Seattle, Wilmington

Natural Channel Design is generally a preferred compensation approach in many places across the country. In the Norfolk district, for example, NCD may be combined with other mitigation approaches, on a case-by-case basis. In Little Rock and Seattle districts, it is required under some circumstances. In Fort Worth, St. Louis, and Wilmington, NCD is preferred, but not required. New England stated that they prefer to see NCD or the regenerative approach used for in-channel work. In other locations, Los Angeles, for example, NCD is uncommon. The Missouri respondent emphasized that NCD, which Rosgen developed for use in the Rocky Mountains, does not necessarily translate well to other regions and can be applied too mechanically.

Other restoration approaches are used in some locations, but far less commonly than NCD. The regenerative approach is used in New England, and is under consideration in Wilmington, where they have received plans for a few projects that intend to use it. Norfolk, on the other hand, does not allow use of the regenerative approach to generate credits. The VDEQ sees some analytical work in Virginia, and both the Seattle and Wilmington districts allow the use of the analytical approach, or elements of it, for mitigation. The Seattle respondents reported that they see projects using the Process-Based approach as well.

Other districts tend to be flexible in what they allow in terms of project design, incorporating elements from two or more approaches. Los Angeles stated that any compensatory mitigation approach that can provide ecological lift could generate credits. Similarly, the Chesapeake Bay area practitioner we interviewed observed that practitioners will often start with their preferred approach (typically Natural Channel Design) and then incorporate other elements as appropriate, depending on the site.

C. Techniques

Most respondents did not identify specific mitigation techniques that they permitted or used in compensation work, and techniques varied among those that did. We define techniques as discrete activities, such as buffer reestablishment or bioengineering, that generally serve a specific purpose as part of the broader goal of stream restoration. Based on a literature review and our prior experience, we identified 22 restoration techniques: agricultural best management practices (BMPs), bio-engineering, buffer establishment, controlled burning, creation of floodplain habitats, culvert removal, dam removal, engineered logjams, fencing, fish passage structures, floodplain connectivity, floodplain grading, groundwater dams, in-stream structures, levee removal, large woody debris placement, remeandering of a straightened channel, removal of invasive species, riparian re-vegetation, sediment removal, stormwater BMPs, and substrate addition (Figure 1 and Table 3). We distinguished a range of stream mitigation purposes for which these techniques are commonly used. Each technique 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.

The Portland district said it did not require any particular techniques to generate stream credits. In St. Louis, removal of concrete low-water crossings, which form dams, is a common in-stream mitigation technique. The MDC said it used a variety of techniques. Washington said common techniques were the addition of large woody material, riparian buffer reestablishment, and off-channel habitat reestablishment. One practitioner stated that the techniques they used depended on the project at hand.

D. Changes to Dimension, Pattern, and Profile

Most respondents reported that changes to stream dimension, pattern, and profile were common in compensatory mitigation work (Table 8). Both NOAA and the Washington state respondent noted that compensation projects often involve remeandering or changing a straightened stream. According to interviewees from the districts, changes to stream dimension, pattern, and profile are required for credits in Fort Worth and Seattle. However, the WDFW pointed out that if a stream is in a fairly natural state already, though, they probably will not make pattern, dimension, and profile changes and will look at other options. In Fort Worth, these changes, along with some degree of functional lift, are required for in-stream credits. Several districts, including Los Angeles, Mobile, and Norfolk, often require pattern, dimension, and profile changes for restoration. Los Angeles explained that these changes are required for rehabilitation, restoration, or establishment. However, in general, their primary focus is on improving function and condition. Changes to dimension, pattern, and profile are generally not required for enhancement projects in the district. Galveston and St. Louis, on the other hand, do not require such changes, and Omaha requires them only if a project exceeds a certain threshold of linear feet or risks causing flooding. The MDC reported that they try to avoid dimension changes.

Table 8: Changes to Stream Pattern, Dimension, and Profile as Reported by Respondents	
Policy	**Districts**
Pattern, profile, dimension changes required	Fort Worth, Seattle, Wilmington (usually)
" " changes required sometimes	Little Rock, Los Angeles, Mobile, Norfolk, Omaha
" " changes not required	Galveston, New England, Portland, St. Louis

E. Stream Classification

Regulators tend to classify streams according to several different factors. Most commonly, districts, including Little Rock, Fort Worth, and St. Louis, among others, break down stream types by duration of flow, into perennial, intermittent, and ephemeral streams. But other districts take different approaches. The Wilmington district, for instance, focuses more on functional differences in determining mitigation requirements than whether a stream is perennial or intermittent. Additionally, the North Carolina Stream Assessment Methodology has a classification based on size, location, and other factors related to anticipated stream function. New England does not differentiate between stream types. In formal policy documents, some states have developed or borrowed other stream classification systems for calculating credits and debits (Guidelines Paper).

In many Corps districts, mitigation requirements vary by stream classification. Galveston noted, for example, that a biological assessment would be unnecessary for an ephemeral stream. Mobile sets different buffer requirements depending on whether a stream is perennial, intermittent, or ephemeral. The Wilmington district treats perennial and intermittent streams essentially alike, as does Norfolk, but Wilmington generally did not consider ephemeral streams jurisdictional. Though the Corps does not grant credits for ephemeral stream work in North Carolina, NCEEP has a pilot program to use regenerative stormwater conveyance on ephemeral streams. One practitioner also indicated that work on ephemeral or intermittent streams often receives less credit than work on perennial streams, but there is a movement to eliminate distinctions among how the different stream categories are treated.

Beyond categorizing streams solely by duration of flow, many respondents said they used the Rosgen stream classification system. Fort Worth, Little Rock, Galveston, Mobile, Norfolk, Portland, Omaha, Seattle, and Wilmington said they saw the Rosgen classification system frequently, as did the EPA and FWS respondents and multiple practitioners. State respondents in New Hampshire and Virginia also see the Rosgen classification often. Respondents from the Seattle and Portland districts suggested that because so many people are well-versed in the Rosgen classification method, it serves as a useful default.

However, responses indicated that the Rosgen classification system is less favored in other parts of the country. The NOAA respondent pointed out, and the WDFW respondent agreed, that Rosgen classification is less commonly used in the West. The Los Angeles district reported that they see Rosgen classification only occasionally. The Missouri respondent stated that they do not use Rosgen classification method because it is poorly suited for the state's streams. In the view of NCEEP, Rosgen classification serves some purposes, but is too often overused and misused in the state, and the Wilmington Corps thought it has been less used in recent years. The practitioner in the Chesapeake Bay cited academic consensus that a move away from the Rosgen classification system is overdue.

In Oregon, regulatory interagency partners (Oregon Department of State Lands, U.S EPA Region 10, Portland District) working to develop a stream mitigation framework to implement the 2008 Final Compensatory Mitigation Rule and a 2009 state rule requiring non-wetland compensatory mitigation, identified a stream classification system and a rapid, function-based assessment method as primary needs to develop and implement a stream mitigation program. The EPA developed a GIS-based Stream Classification System for Oregon (Nadeau et al. 2012) which provides information at the local hydrologic unit and integrated watershed scale, including parameters such as aquifer and soil permeability, floodplain presence, and erodibility. A subset of classification system parameters were used to identify seventeen stream types for Oregon, assigned state-wide to the local hydrologic unit scale. Stream type and classification data, together with stream flow duration categories and other site level information, inform anticipated stream function and supply data included in the rapid, site-level function-based assessment method also nearing completion (Stream Function Assessment Method). Oregon's stream classification system, including stream types, will soon be publically available as an interactive web-based tool.

Factors other than stream type also play a role when determining mitigation activities. Omaha considers the importance of the resource, the type of stream, and other factors when determining mitigation requirements. The Wilmington district also considers stream function in deciding what mitigation is required. Mitigation activities in North Carolina also often vary between mountain streams and coastal streams, according to one practitioner. Seattle and Portland determine appropriate mitigation actions on a case-by-case basis. Both federal and state respondents in Washington stated that the main distinction in the state is the presence or absence of fish, which means, as the NOAA respondent observed, that most work is done on perennial streams.

F. Design Requirements

The level of detail and design required for mitigation plans is also roughly consistent among Corps districts. Most districts (Fort Worth, Galveston, Mobile, St. Louis, Seattle) require about 60 percent design initially, although Los Angeles requires just 30 percent in some cases. Some districts, including Fort Worth, Mobile, and Portland, require a complete or nearly complete plan before approval or before activity begins. Other districts have a less standardized approach: Norfolk requires a more complete design for bigger projects, and Little Rock sees a variety of completeness levels. Neither Omaha nor Portland specified a particular level at submission, but both stated that a complete plan is needed before a permit can issue. In general, Corps districts recognized that plans might be modified throughout the review process.

Many districts require an engineering drawing, especially for bigger projects, but they generally did not demand the seal of a Professional Engineer. Seattle requires sealed engineering drawings from bank projects only. Norfolk noted that drawings typically are sealed, although it is not mandatory. Almost all the districts require an as-built survey, but generally did not require a Professional Engineer or Land Surveyor's seal.

G. Location of Compensatory Mitigation and Defining Service Areas

The 2008 Rule states that, in general, "the required compensatory mitigation should be located within the same watershed as the impact site" (33 C.F.R. § 332.3(b)). Most regulators indicated that most, or nearly all, compensation takes place in the same watershed as impacts, though they may define watershed in different ways (Table 9). 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 of a watershed. In many districts, including Galveston, Los Angeles, Mobile, and some states within New England and Omaha, a watershed is equivalent to an 8-digit Hydrologic Unit Code (HUC). Los Angeles will also occasionally use a smaller HUC-10 definition. Within Maine, the New England district uses bioregions, and they use the larger HUC-6 area in Vermont.

Table 9: Estimated Amount of Mitigation Occurring in the Same Watershed as Impacts (using each district’s watershed definitions)

Corps District	**Percent of mitigation**
Galveston	90%
Los Angeles	More than 75%
New England	Close to 100%
Norfolk	All (same or adjacent HUC-8 in the same river basin and physiographic province)
Omaha	99%
Portland	More than 50%
Seattle	Close to 100%
St. Louis	95%
Wilmington	95%

Accordingly, in both policy and practice, many districts use HUCs to define bank service areas and limit the distance between impacts and permittee-responsible mitigation, though ecoregions are also used in some regions (Guidelines Paper). Los Angeles, Wilmington, Fort Worth, and the NHDES use HUCs, as well as ecoregions, to define service areas. Fort Worth, for example, uses HUC-8s and Level III Ecoregions as part of its Texas service area requirements, and it applies the same guidelines to siting permittee-responsible mitigation projects. The NHDES respondent observed that most of their mitigation is not only in the same HUC-8, but also in the same HUC-10 as the impact site. South Carolina requires compensation sites to be located within the same HUC-8 or adjacent ecoregion as the impact site, according to the Environmental Banc & Exchange (EBX) respondent. Some districts consider areas larger than HUC-8s in some circumstances: the Little Rock district, for example, authorizes mitigation banks with a primary service area of two HUC-8s, and Omaha looks at regions slightly larger than a HUC-8 for certain projects, particularly long, linear projects. Portland typically uses a larger, 6-digit HUC area to define service areas east of the Cascades.

Washington State (Seattle district) and the State of Missouri (Portions of Kansas City, Little Rock, Memphis, Rock island, and St. Louise districts) use their own watershed categorization systems to limit service areas and define watersheds. Washington uses Water Resource Inventory Areas (Washington State Department of Ecology, Accessed 2016). Missouri uses both priority watersheds—those that have a particular attribute such as sport fishing value, biological diversity, or threatened and endangered species—and Ecological Drainage Units

(EDUs), which are similar to a HUC-8 in size and incorporate both biotic and abiotic factors (University of Missouri, Accessed 2016). Missouri has ten large EDUs and three smaller ones.

H. Site Selection for Stream Mitigation

Districts rely on a variety of considerations in reviewing stream compensatory mitigation sites. Some districts rely on, or are developing, formal site selection guidance. Los Angeles, for example, is in the process of developing site selection guidance. The Norfolk district has an established site selection document, and it is currently under revision. Seattle uses joint EPA, Corps, and Washington Ecology site selection guidance (Hruby *et al.*, 2009). Other districts do not have formal policies, but rely on a range of information when making site selection decisions. Little Rock, for example, considers site gradient, bank viability, distance from impact site, and preservation of unusual flora and fauna, as well as comments from the Interagency Review Team (IRT) when evaluating sites. When assessing bank locations, the Mobile district also considers competition and permit loads within the watershed area, to assess demand for mitigation credits in the region.

Practitioners told us they consider a range of factors and criteria when making stream site selection decisions. A practitioner from Wildlands Engineering said he has three to five staffers who work on site selection. They consider several factors when evaluating locations, including priority watersheds, natural heritage sites, species of concern, land cover, stream size, and presence or absence of cattle (excluding cattle is an easy, effective technique). His company also relies on state watershed plans that identify “hotspots” and other areas where compensation projects would be useful. Another practitioner, based in the Chesapeake Bay region, explained that his company increasingly focused on watershed plans rather than HUCs or ecoregions in site selection and that municipal separate storm sewer systems and TMDLs are increasingly driving mitigation projects. The Virginia ILF programs’ compensation planning framework (part of the ILF instrument that is used to guide how they select, secure, and implement mitigation activities) considers TMDLs, among a range of other criteria, when evaluating sites.

Respondents in a variety of roles consistently emphasized the opportunistic nature of mitigation site selection, as well as the tension between practical, economic considerations and watershed needs. The Portland district respondent, for example, said they would like to develop more strategic site selection that considers not only permittee convenience, but also the need for stream function replacement, and they are working to encourage banks to locate to where they provide the most benefit to the watershed. Many respondents emphasized that permittees are rarely able 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 approve the site. This type of opportunistic site selection can also be true for mitigation banks and ILF programs. As the EPA respondent explained, a farmer or other landowner may reach out to a mitigation-banking consultant and suggest using their land for a project. In his view, mitigation banks often consider HUCs and ecoregions in selecting sites only if many other projects are already underway in an area, though he noted that HUCs or ecoregions are part of most state and district site selection requirements in his region. Economic considerations are also important factors in site selection. Permittees generally want to minimize mitigation costs, noted the New England Corps district, and a practitioner said profitability is a factor in selecting appropriate compensation sites.

I. Watershed Approach

Although the districts are working to implement the watershed approach, their progress has been uneven. In general, written stream mitigation policies 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). In practice, the Galveston district said, their coastal location makes their work very watershed-focused, and they rely on watershed plans from NGOs to identify functions to target. The Little Rock district tries to use a watershed approach, but their analysis is mostly subjective and they lack comprehensive watershed plans. Seattle has a focus on broader watershed issues; issuing site selection guidelines for using a watershed approach in 2009 (Hruby *et. al*, 2009). Los Angeles and Omaha both mentioned that benefits to the watershed could justify allowing out-of-kind mitigation projects in some cases. Norfolk will consider watershed needs and encourage stormwater work or low-impact development on a project-specific basis, particularly in urban watersheds. Mobile reported that it does not match mitigation to watershed problems function for function, in part because their role is limited to approving projects rather than proposing them.

An oft-cited impediment to implementing a comprehensive watershed approach was the lack of watershed plans for the region. 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)). Both state and federal respondents, from EPA's Region 4 to the NHDES to the Little Rock Corps district mentioned that watershed plans were often unavailable and that this held back their efforts to fully embrace the watershed approach.

In some areas watershed plans were more complete, particularly at the state level. The St. Louis district noted that Missouri has a watershed inventory assessment for 60 out of 67 of its HUC-8 regions. Wilmington said appropriate watershed plans are written into the ILF program instrument. The Washington State Department of Ecology has studied the watersheds across most of the state. In Galveston, NGOs are a common source of watershed plans. Corps districts often rely on plans from the state level, or from NGOs or other federal agencies—whatever is available. For example, the Corps is currently involved in drafting plans for the Colorado Front Range area, in collaboration with other organizations, according to the Omaha respondent. Table 10 provides examples of watershed plans that originate from a variety of sources. The Watershed Approach Handbook, by The Environmental Law Institute and The Nature Conservancy, discusses the watershed approach in detail and describes numerous examples of watershed plans that can be used in the context of compensatory mitigation (ELI and TNC, 2014).

Table 10: Types and Examples of Watershed Plans

Type	**Example**
Endangered Species Act Habitat Conservation Plans	Etowah Habitat Conservation Plan
Flood Management Plans	New Hampshire Flood Protection Tool
Special Area Management Plans	Rhode Island Salt Pond Special Area Management Plan

State Watershed Plan	North Carolina Ecosystem Enhancement Program's Local Watershed Plans
State Wildlife Conservation Plans	Idaho Wetland Conservation Prioritization Plan
USACE Watershed Assessments	The Monongahela River Watershed Assessment
Water quality standards and implementation plans	Maryland Water Resource Registry

Districts are seeking ways to implement a watershed approach in spite of the absence of watershed plans, though they vary in their methods. The practice in Wilmington differs between banks and ILF programs: whereas watershed plans are not required of banks, ILF programs have a comprehensive watershed planning process to target and develop plans for local watersheds. Likewise, in Seattle and in New England, the Corps applies the watershed approach differently depending on whether the compensation is accomplished through a bank, an ILF program, or permittee-responsible mitigation. Permittee-responsible mitigation projects in New England generally do not consider watershed needs in siting and design. Seattle requires a detailed watershed plan from mitigation banks, and a similar analysis from ILF programs.

State agencies are also focusing on watersheds, with varying levels of experience and success. In Missouri, the watershed approach is "the basis for their work;" in New Hampshire, by contrast, the watershed approach is not really used. North Carolina is working toward a more functional, rather than spatial, watershed approach, to be more consistent with the 2008 Rule. NCEEP develops its own watershed plans, but also relies on plans developed by municipalities or conservation groups that meet NCEEP standards. One practitioner and former regulator 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.

Although most districts require or encourage mitigation projects to consider broader watershed problems, or at least strive to do so, fewer districts require that mitigation providers attempt to match the choice of mitigation activities to the particular impacts at a project site. Several districts (Little Rock, Fort Worth, Los Angeles, New England, Seattle, and Omaha) said they consider project site impacts to at least some degree. But these districts generally agreed that broader watershed issues have more weight than particular project impacts. Seattle does try to link mitigation to project site impacts, but they are shifting to a broader focus on the watershed. New England said they try to focus on improvements to stream function overall, as did Portland, and take into account where compensation would be most viable. Fort Worth observed that if there are functional issues from the project at the impact site that need to be addressed, then the compensation project should address it on-site, if possible. Mobile, Wilmington, and St. Louis, on the other hand, avoid examining projects at such a granular level. Mobile observed that they try to look more broadly at the ecosystem level to avoid fragmented, incomplete projects. State respondents from Virginia and North Carolina reported that they do not tailor compensatory mitigation approaches and techniques to impacts at the permitted project site, though they do attempt to match the compensation to problems in the watershed. WDFW pointed out that they prefer compensation that benefits the affected fish species, whether the project is on- or off-site, and New Hampshire said they do consider impacts at the permitted project site.

Practitioners try to incorporate broader watershed considerations into their work, although they generally do not try to match compensation to specific impacts at the project site.

One practitioner observed that they try to match compensatory mitigation approaches to watershed problems, but noted that most restoration takes place on a smaller scale. Another pointed out that addressing watershed issues in urban areas, where water quality is a bigger problem, is a challenge. Respondents from both EPA and FWS observed that the projects they see typically do not match techniques and approaches to watershed issues. In the view of the FWS practitioner, projects generally look at watershed conditions, but fail to consider how functions at their site are affected by those conditions.

J. Credit/Debit Determination

Many written Corps district stream mitigation policies include specific methods for calculating mitigation debits and credits (Guidelines Paper). In practice, several districts use or have developed assessment methodologies to support debit and credit determination. Fort Worth uses TXRAM to calculate credits. The methodology allows district staff to determine credits based on the results of the conditional assessment of a mitigation site and debits based on the baseline condition of the impact site. Norfolk uses the USM to support credit and debit determination. As the VDEQ respondent explained, the USM incorporates a conditional assessment of four parameters—channel stability, 100-foot riparian buffers, in-stream habitat, and anthropogenic channel alterations—that are combined into a condition index score. An impact compensation requirement (debit) is calculated based on the length and type of impact and USM score. Compensatory mitigation (credit) is calculated with different ratios depending on the type of mitigation activity and the anticipated improvement in stream quality, with potential extra credit for additional efforts, such as entire watershed protection, threatened and endangered species habitat protection, and permanent exclusion of livestock (if present), according to the VDEQ.

Other districts use interactive worksheets to calculate the number of credits that a given project will generate or make credit determinations on a case-by-case basis (for more detail and additional examples, see Guidelines Paper). Nebraska and Montana both use interactive worksheets to calculate credits, but the interactive version is only available upon request from the Corps. Seattle and Portland determine credits for a mitigation project on a case-by-case basis. Portland provides general guidelines based on comparison to similar mitigation projects and is considering this issue in guidance currently under development. Although multiple respondents described using mitigation ratios as a less current approach, they are used to at least some degree in New England, Los Angeles, the Dakotas, St. Louis and Wilmington.

State respondents likewise used different methods to assess debits or credits. Missouri uses the Missouri Stream Mitigation Method (used by the 5 Corps districts in Missouri), a joint federal-state procedure for the regulation and oversight of compensatory mitigation in the state (USACE *et al.*, 2013). For ILF programs, the MDC uses a two-part worksheet with separate sections for in-channel work and riparian work to calculate credits. Virginia uses the USM, as described above, to determine compensation requirements and credits. Maryland and Washington lack guidelines or protocols and take a case-by-case approach for determining debits and credits. North Carolina grants credits based on ratios for linear feet of activity, with restoration work earning credits at a 1:1 ratio (i.e., 1 linear foot = 1 credit), enhancement at a 1.5, 2, or 3 to 1 ratio, and preservation at 10:1 ratio (i.e., 10 linear feet = 1 credit).

K. Stream credits from buffers

Most districts we interviewed calculate stream credits from buffer areas separately from stream credits associated with in-stream work, with the exception of New England, Wilmington, and some states within the Omaha district. However, most districts consider credits generated from buffers as stream credits, not as a separate credit classification. In North Carolina, the Corps and the state calculate buffer credits differently: the Wilmington district counts buffer credits as a percentage of stream credits, but the state counts buffer credits separately.

Districts use a variety of approaches to calculate buffer credits (Guidelines Paper). Fort Worth uses TXRAM, as it does for stream credits. Seattle will occasionally grant credit for buffers directly when the existing buffer at a compensation site is adequate and the applicant proposes to enhance or expand the buffer, but it generally awards credit for buffers indirectly. That is, under Washington state's functional wetlands tool, buffers contribute to the overall functioning of an aquatic resource and therefore to its categorization as a higher or lower-quality wetland (Washington State Department of Ecology *et al.*, 2006). When buffers are expanded or improved as part of a compensatory mitigation project, they contribute to an improved wetland category (and therefore to more credit), but the buffers are not separate "buffer credits." The same concept applies to compensatory stream mitigation, though Washington lacks a functional tool for streams. However, the Seattle district remarked that eventually, the state will move toward buffer credits. In Portland and Wilmington, buffer credits are given on a case-by-case basis, though Wilmington has draft buffer credit guidance.

Respondents generally agreed that wider buffers should receive more credits, at least up to a point. Table 11 provides examples of minimum and maximum buffer widths. The Fort Worth district is in the process of determining just how many credits should be allowed and establishing a maximum buffer width. In Norfolk, New England, Los Angeles, St. Louis, and other districts, the amount of buffer credits granted varies by width. The VDEQ observed that although the USM states that any proposed buffer beyond 200 feet requires approval, in practice 300 feet is the maximum. In addition, the first 100 feet of buffer generally generates the most credit, with less credit granted for additional feet of buffer. In Missouri's policy, a table establishes increasing benefit values for each additional 25 feet of buffer from 50 up to 300 feet, with the benefit varying depending on whether the buffer is restored, enhanced, or merely preserved (USACE *et al.*, 2013). The Chesapeake Bay area practitioner observed that the mitigation community is moving toward granting wider buffers more credits if they are integrated with the stream. According to Missouri, the IRT has changed its approach to buffer credits in their region, generally giving no credits for buffers beyond 300 feet and reducing the number of credits given for buffers overall.

Table 11: Minimum and Maximum Buffer Width (per streambank)

District	Minimum Buffer Width (feet)	Max (feet)
Fort Worth	25 (ephemeral) 50 (intermittent) 100 (perennial)	
Galveston	100 (or at least 20 per side, with a total width of 200)	
Little Rock	25	100
Los Angeles		300

New England	100	250
Norfolk	100 (narrower buffers may be considered, but will not receive full credit)	300 (in practice)
Wilmington	50 (piedmont/coastal plain) 30 (mountain)	

L. Stream Performance Standards

Many districts said they take a case-by-case approach to developing performance standards, and few had detailed performance standard guidelines or examples in their written policies (Guidelines Paper). In the New England, Portland, Seattle, and St. Louis districts there is no standardized approach, and interviewees told us that regulators rely on earlier similar projects to develop performance standards for new projects. Seattle also relies on Washington's 2006 interagency wetlands mitigation guidance. Los Angeles, having recognized substantial variation in permit conditions, established uniform performance standards that serve as a toolbox for project managers, including a table that shows the applicable performance standard types (USACE, South Pacific Division, 2012). Galveston considers several factors, based on the hydrology and hydraulics of the stream and buffer, when developing performance standards. Specifically, they look at stream stability, diversity and richness of vegetation, and erosion.

Many districts that had a preferred assessment method used it in designing performance standards, including Fort Worth, Galveston, Los Angeles, Mobile, Omaha, and Wilmington. Mitigation project proposals in the Mobile district, for example, must be accompanied by a data sheet indicating stream condition for the existing stream, the stream as designed, and a reference stream. In Mobile, performance standards are developed based on the design criteria and the reference stream parameters (USACE, Mobile District, Appendix B and C, 2012). Wilmington's new draft guidance discusses performance standards in much more detail than previous documents, and the district is attempting to tie standards more tightly to function and uplift. However, the Wilmington respondent acknowledged that doing so is resource-intensive and difficult, because of the challenges of defining success.

Almost without exception, Corps districts try to align performance standards with design criteria, even if they are not always completely successful. This is generally done to ensure the mitigation provider holds the responsibility for developing the right design to meet performance standards. However, linking performance standards to meeting the design criteria can place risk on the agency for understanding that the design will achieve the desired performance. If performance standards are set based on the desired outcome in terms of function or condition, then the design criteria may be less important and the risk in developing the right design to meet the performance standards stays with the mitigation provider. The Mobile district representative explained that district staff develops performance standards based on the reference reach and the design data. Wilmington attempts to connect performance standards to criteria like bank height ratio, but will not necessarily require providers to measure sinuosity or similar factors. New England observed that whereas design criteria are specific and physical, performance standards may be ecological, making it difficult to align the two concepts. Fort Worth noted that their relative inexperience with stream compensatory mitigation presents a challenge in developing performance standards. In the experience of the FWS respondent, several projects have fallen short of connecting performance standards with design criteria. This may not be surprising, given that project design and ecological performance have not been strongly linked. More recently, however, there is a movement away from form-based restoration practices towards process-based restoration practices in much of the scientific literature concerning stream restoration.

At the state level, performance standards are typically established in cooperation with the Corps, and several states said they develop performance standards on a case-by-case basis. The North Carolina respondent remarked that the process the Corps employs to develop performance standards takes an oversimplified view of streams, making it very difficult to apply more complex design criteria. In the view of one practitioner, ad hoc approaches to performance standards permit undesirable inconsistency between projects. Another practitioner, from the Chesapeake Bay region, observed that performance standards have until recently overemphasized structural stability, and that they are just now realizing the importance of biology, including water quality and biota. By contrast, another practitioner in a different region found that standards were too focused on biology, at the expense of design considerations and hydrology.

M. Stream Assessment Methodologies

Districts and states are increasingly developing formal stream assessment methodologies to assess the condition or function of streams, to serve as the basis of credit/debit determination, and to facilitate oversight of compensatory mitigation. Most of the assessment methodologies in use are condition assessments, rather than functional assessments. Assessment methodologies serve several purposes, but, where used, are most commonly employed to determine current conditions and functions of impact sites, mitigation sites, and reference sites, as well as the projected value of restoration work. The EPA respondent observed that assessments typically demonstrate site impairment prior to mitigation; problems arise when they are used to show project success, he said, because the methodologies generally lack objective standards. Galveston uses assessment methodologies at impact sites to determine debits. In North Carolina, the North Carolina Stream Assessment Method (NCSAM) is used only on the permitting side, not by the NCEEP. New Hampshire has a stream assessment methodology and protocol that helps determine bankfull width, geomorphic form, and erosion occurrence. It also helps prioritize crossings and determine what a site should look like. One practitioner told us that he uses assessment methodologies during watershed assessments; similarly, a Chesapeake Bay area practitioner said assessments can reveal when existing resources are not high quality and there is room for improvements to the stream.

Corps districts tend to use assessment methodologies developed for their district or states within their district. For example, Fort Worth uses TXRAM, Norfolk uses the USM (a conditional assessment), and Los Angeles uses the California Rapid Assessment Method. St. Louis has incorporated elements of various methodologies into condition criteria for its own methodology to assess stream function, but it does not have one standalone method. Little Rock's respondent pointed out that, although their SOP characterizes their assessment method as functional, it is a conditional approach in practice. Omaha's approach differs by state, but in Wyoming they use a visual method. Assessment methods, when available, are used to develop performance standards. Seattle has not yet developed stream assessment methods. The Portland district has developed a stream assessment method, but it is not yet used in practice. The District does use the state Oregon Rapid Wetland Assessment Protocol for wetland projects.

The time required for assessment varies substantially across the country (Table 12). The Portland district and the WDFW have assessments that take one to two days, whereas the

Wilmington and Los Angeles districts, and the New Hampshire and Virginia state agencies, employ rapid assessments, which require under half a day to complete. Several districts expressly endorsed the merits of rapid assessment (Fort Worth, Wilmington, Little Rock). Some respondents outside the Corps—from EPA and North Carolina—said that many rapid assessment methodologies were overly quick and prioritized speed over quality or objective criteria (for instance, the NCEEP respondent and a practitioner who works in North Carolina suggested the NCSAM may be too quick and superficial to be useful in a mitigation context). Districts vary on whether they require a more detailed assessment after project approval. Fort Worth, Galveston, and Mobile typically do, but Norfolk, Portland, and Seattle do not.

Table 12: Reported Time (based on interviews) Required for Assessment of a Reach

District or state agency	Estimated Time
Los Angeles	< half-day
Wilmington	15 minutes
New Hampshire DES	3-4 hours
Virginia DEQ	15 minutes per reach
Washington DFW	1 day

N. Monitoring

District SOPs typically impose a required minimum monitoring period — usually five years, occasionally more — and then mandate additional monitoring until the performance standards are met (Guidelines Paper). In practice, most Corps districts reported requiring a minimum of 5 years of monitoring. Others, including Mobile, Norfolk, and Omaha, require 10 years under certain circumstances. Wilmington and Savannah districts generally require seven years of monitoring. The length of additional monitoring may vary depending on the site, project complexity, and the severity of concerns about the project's success. In New England, credits may be released after the site is stable, which may be less than five years. One mitigation provider felt that long-delayed credit releases could harm a project's economic viability. The substance of monitoring requirements is often determined on a project-specific basis, and some districts, like Little Rock, assign one of several standardized levels of monitoring requirements to each project.

Our respondents generally agreed that, for most districts, monitoring requirements were closely aligned with performance standards. One practitioner observed that monitoring requirements are sometimes more strict than performance standards, which is consistent with our policy review, as well as scholarship indicating that districts sometimes require monitoring for criteria, particularly chemical or biological indicators, that are not part of performance standards (Doyle *et al.*, 2013). The analysis of written policies also indicated that monitoring for physical criteria was more common than for biological criteria (Guidelines Paper). Another practitioner remarked that although water quality monitoring is not currently a common requirement, it is becoming more common.

O. Adaptive Management

Corps districts 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. 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 are often unforeseeable, but adaptive management must be at least considered in the plan from the outset. EPA Region 4's respondent observed that the adaptive management discussion tends to describe a process for forming an adaptive management plan if the need arose later. 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. New England's post-construction assessment requirements can be considered part of a programmatic adaptive measure. The final assessment (often conducted by an independent party) evaluates how the project compares with permitted requirements, resources and resource conditions, problems encountered and how they were addressed, regulatory practices that may have affected project implementation, and suggestions for improvement (USACE, New England District Compensatory Mitigation Guidance, 2010).

DISCUSSION

The practice of stream compensatory mitigation remains in flux and current science on stream restoration should be used to make improvements to stream compensatory mitigation practices to achieve better ecological performance. Stream compensation has gradually become a truly nationwide activity, though its implementation may look very different in different parts of the country. The development of state and Corps policies governing stream assessment and compensation requirements is growing. Thirteen states have formalized state stream mitigation programs (ASWM, 2014), and at least 32 stream mitigation guidance documents and policies have been developed by states and Corps districts across the country (Guidelines Paper). While regulators and practitioners have made serious strides, they still grapple with the complex challenges of incorporating watershed and functional considerations into their work.

Regulators Learn from Each Other's Practices

Expanding demand for the availability of stream compensatory mitigation credits has encouraged state and federal regulatory agencies to search for restoration approaches that they can adapt to their own circumstances. Corps districts with less stream mitigation experience often have turned to other districts for guidance when developing guidelines. For example, Little Rock looked initially to Mobile when drafting their original guidelines, and then looked to Wilmington, Mobile, Savannah, and Charleston when they updated the document. The New England district also relied on districts covering South Carolina, Virginia, and Missouri. Mobile's initial standard operating procedures were based on those of Savannah. Omaha also adapted methods from eastern districts to their purposes.

Effects of the 2008 Rule on Stream Mitigation Unclear

Many interviewees thought the 2008 Rule had galvanized stream compensatory mitigation in areas where it was not previously well-established, often focusing attention on stream functions and the watershed approach. In fact, according to RIBITS data, the number of mitigation banks providing stream credits has more than doubled from 2008 to the present (USACE, Institute for Water Resources, 2015). The EBX respondent suggested that the Rule sparked stream compensatory mitigation in the many regions where it was not already happening. The NHDES staff member said she had not observed any substantial changes to stream compensation in her state, but EPA and the Corps were more involved in mitigation projects after the Rule. According to a practitioner and former regulator, the 2008 Rule gave regulators authority to deny a proposal where compensation was too distant from project impacts, and encouraged regulators and practitioners to look at ecosystems and stream functions when making compensation decisions. Another ILF provider emphasized that the 2008 Rule boosted mitigation banks by establishing a clear preference for banks over ILF programs (33 C.F.R. § 332.3(b)), and also speculated that the new requirement that all mitigation plans include a long-term management plan and long-term management funding could prove significant, but it is too soon to tell (33 C.F.R. § 332.4(c)(11)).

However, some respondents, particularly those in regions where stream mitigation predated the 2008 Rule, questioned the Rule's impact. Mitigation practitioners almost uniformly said they have seen few changes as a result of the rule. This may not be surprising, given that, for the most part, the 2008 rule codified existing practices, while placing more emphasis on ecological outcomes and allowing for regional variability. One respondent remarked that stream mitigation practice is still surprisingly diverse across the United States even after the 2008 Rule. For example, the respondent noted that Kentucky's rules differ greatly from those of Ohio, even though they both fall within the Louisville Corps district. State practitioners in Virginia and Washington also did not see substantial changes post-rule. The EPA respondent observed that although post-Rule Corps guidance often refers to the 2008 Rule, the gap between the rule's intent and facts on the ground is still substantial, particularly with regard to objective standards.

In many regards, it may be too soon to tell what impact the rule has had on stream compensatory mitigation. The Los Angeles Corps district, for example, mentioned the need to update their monitoring guidelines in light of the Rule and explained that it took a few years after 2008 just to absorb and understand the rule. At least one respondent thought the Rule might also have negative consequences. For example, the Rule's preference for mitigation banks and new requirements for ILF programs had disrupted previously effective programs and burdened them with additional requirements. However, the new requirements will ensure that ILF programs provide the compensatory mitigation they commit to providing. One state respondent noted that although the approval process has gotten more predictable for banks, the Corps has become much less flexible and cooperative, and decision-making has slowed.

Mitigation is More Rigorous

Many respondents agreed that for multiple reasons, stream compensatory mitigation is both more common than it was ten to fifteen years ago and more rigorous in application. Several respondents noted that stream compensation projects that may have been routinely approved a decade ago would not be approved now. According to a former regulator and practitioner, the Los Angeles district did significant training for its staff and increased mitigation ratios after the Rule. Both the Little Rock and St. Louis districts observed that nationwide permits are increasingly strict, and the threshold for notification is lower, so compensation has been required for more projects. The trend toward increasing rigor in stream compensatory mitigation can also be attributed to a better understanding of stream science and other external factors. The Portland district requires more mitigation in part because of better knowledge of species and their requirements. The Seattle district mentioned that they scrutinize culvert projects more closely in recent years because of a lawsuit between tribes and the state over salmon.

Need for Training and Technical Resources

Even as stream mitigation matures, respondents noted that regulators often lack stream-specific technical expertise and experience and have limited opportunities for training. Multiple Corps districts said they lacked staff with a background in stream functions, and several reported that their staff acquired much of their knowledge through on-the-job training and experience. A common observation was that regulators had related experience, particularly in biology, but lacked engineering backgrounds. The St. Louis Corps pointed out that while many of their staff are biologists, no one has a strong background in stream functions. Similarly, Portland had lots of fisheries experts and one geomorphology expert, but few with significant background in stream functions. Little Rock reported a mix of experience, from ecology to biology to engineering. The Mobile district stated that the entire regulatory staff had had numerous stream courses and training and that they had one staff member who has been working on stream mitigation since 2000, who reviews all applications along with a colleague. Seattle, Galveston, and Little Rock districts cited the need for more training and experience for regulators. A few practitioners suggested that agency staff often have limited technical background and that offices are understaffed.

Many respondents reported that although those involved in stream compensatory mitigation had a basic understanding of stream mitigation science and practice, additional stream-specific expertise was still needed. A 2014 analysis of state stream mitigation policies pointed out a similar lack at the state level (ASWM, 2014). The FWS practitioner noted that Maryland had many biologists but not enough experienced engineers. Practitioners in the region, he observed, have some experience, but tend to repeat the same design template for different sites. Another practitioner echoed this, noting that practitioners in the region display a range of expertise in stream mitigation practice, from novice to competent.

Trading Simplicity for Standardization

Interviewees disagreed on the need for more detailed, objective guidance and procedures. Regulators at the state and federal level often said they sought more detailed, objective procedures for stream mitigation to ensure consistent and reliable results. As the EPA Region 4 respondent explained, when guidelines lack objective criteria, both practitioners and regulators struggle because practitioners cannot understand what regulators expect, and regulators cannot review projects consistently. Site assessment in particular, he said, should be more objective and even prescriptive. Similarly, the FWS practitioner called for standardized, specific guidelines, though he pointed out that more flexibility would be acceptable for voluntary restoration. The Little Rock district respondent observed that his district could get more consistent products if they developed standard criteria, templates, and performance measures. According to the Fort Worth district, their 2011 stream mitigation guidelines were driven in part by mitigation bankers' desire for a more standardized process. The NHDES staff member said that their current guidelines were insufficiently detailed, providing only a basic framework for stream project design without details on prioritizing mitigation methods, project design, or determining success. The WDFW respondent called for more consistent methodology on determining credits and debits.

In contrast, at least one practitioner said excessively complex guidance was counterproductive. He remarked that when every site is different, working through strict, detailed guidelines is unhelpful, particularly for more experienced practitioners. Another practitioner noted that simpler functional assessments are often better, as more complex assessments may be too far out in front of the science. On the other hand, he pointed out that a completely ad hoc approach undermines certainty. For practitioners, he emphasized, simplicity is invaluable.

Moving Toward More Effective Assessment Approaches

Although clear progress has been made, the challenge of incorporating functional considerations into stream mitigation was a consistent theme among respondents. For example, assessment methodologies and other tools are often not as function-based as regulators might hope. In fact, many of the districts we spoke with lacked a functional stream assessment tool. Little Rock and Wilmington both acknowledged that their assessment methods are more conditional than functional. The Fort Worth respondent made the same observation about TXRAM, although he pointed out that a functional assessment would take much more time. Neither district in the Pacific Northwest has a functional assessment method, although Portland is developing one.

Several districts have recognized the importance of a functional approach to stream mitigation decision-making and are designing better methods to achieve it. The challenge is actually to develop more effective assessment methodologies whether they are functional or conditional approaches. As one practitioner and former regulator observed, the 2008 Rule's emphasis on the watershed approach has forced people to consider stream functions and ecosystems more carefully. The Portland district emphasized that they try to match mitigation approaches to both site impacts and watershed problems to maximize functional improvement, and New England said they prioritize the overall improvement of stream function. Wilmington is currently revising its mitigation guidance, and its draft version attempts to tie both performance standards and monitoring requirements more closely to functional and conditional improvements. However, the Wilmington district staff member observed that measuring function and uplift is a challenge on two fronts: 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 control. The NCSAM is actually a conditional assessment that considers the effect of stressors on resource condition. Those stressors can affect condition and functioning. Similarly, the Little Rock respondent is currently working on performance standards, relying on a function-based approach (Harman *et al.*, 2012). The Norfolk staff member observed that any revisions to their USM will make it a more functional approach, and the VDEQ respondent agreed that incorporating more functional considerations would improve the methodology.

Some states are following suit in incorporating functional considerations into their mitigation work. Oregon is working on a new functional assessment, as described above. Similarly, the NCEEP is revising their watershed approach in a more functional direction, to comport better with the 2008 Rule.

Practitioners acknowledged the complexity and difficulty a functional approach to stream mitigation entails. One practitioner cautioned against overreliance on functional approaches: in his view, science tends to lag behind mitigation techniques, and it may not be possible to accurately evaluate improvements. By contrast, another practitioner encouraged stream mitigation to focus on functional lift despite the added complexity it entails.

Gaps in Existing Practice and Policy

Beyond these overarching issues, districts identified challenges specific to their district that they seek to address. Several districts pointed out relatively modest updates and changes that would improve their stream mitigation program, rather than wholesale changes. Seattle and New

England both mentioned that they lacked an assessment methodology; New England said that although one for wetlands was in the works, a stream assessment methodology was not yet on the horizon. Wilmington is increasingly focused on long-term management challenges, because they have growing numbers of closed-out sites. Norfolk said they needed to modify the USM and update their 2010 mitigation bank instrument template, but emphasized that what was needed at this point were "tweaks" rather than an update of the science. Los Angeles stated that their monitoring guidelines need updating to account for the 2008 Rule (the latest revision of Los Angeles's monitoring guidelines was released in January 2015). For Seattle, coordination between the entities involved and integration of Clean Water Act requirements with Endangered Species Act requirements is an ongoing challenge.

Respondents outside of the Corps also differed on what gaps existed in current stream mitigation policy and practice. For instance, the NOAA respondent emphasized the insufficiently small scale of projects. Missouri and New Hampshire both identified changes from the Corps that would help them — Missouri urged the Corps to improve consistency in regulating and mitigating impacts, and New Hampshire said stream mitigation guidelines from the Corps would aid their efforts. Targeting invasive species is a priority for the VDEQ.

Some practitioners identified more big-picture challenges in stream mitigation. One practitioner, for instance, said agencies should better integrate stream mitigation with wetland mitigation. According to the EBX practitioner, a clear definition and understanding of long-term stewardship will help address recurring issues in stream mitigation.

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APPENDIX A: 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.