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Addressing Well and Field Infrastructure Siting Challenges in the Wetlands and Streams of the Haynesville, Marcellus, Utica and Eagle Ford Shale Plays

Russell F. Krauss, SPE, Resource Environmental Solutions, LLC

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Abstract

As U.S. shale play activities move from appraisal to production phase, it is increasingly difficult for surface operations to avoid impacts to environmentally sensitive wetlands and streams. Many shale plays are located in areas more visible to the general public than ever before in the history of domestic onshore oil and gas field development. Shale play development for oil, natural gas and natural gas liquids, has therefore resulted in increased scrutiny by agencies causing successful operators to be more proactive in the siting of wells and associated field infrastructure including access roads, flowlines, and gathering systems. Complex regulatory regimes must be navigated by producers and operators in each shale play and, although operating under standardized Federal regulations, are required to address the preferences of each regulatory agency, and in many cases, individual regulators themselves.

Working under new rules since 2008, regulatory agencies require offsets for unavoidable impacts to wetlands and streams to occur in the watershed where the impacts will occur. With limited mitigation acreage available in areas where surface rights are locked up by landowners and operators, and the increased visibility of environmental risk and liability from field operations, the need for proactive, creative wetland and stream mitigation solutions is self-evident.

In the Pennsylvania Marcellus Shale, streams need to be crossed every 2,000 feet, often needing both a state and Federal permit. In the Louisiana Haynesvlle Shale, every fifth well pad typically requires a permit under Section 404 of the Clean Water Act. In the Eagle Ford shale, what is now an access road was once a dry streambed, which potentially should have been permitted, if indeed it was not.

A multitude of functional assessment methodologies are employed by regulatory agencies to assess project-related impacts on habitat functions and values. Even within a single shale play, these methods abound. Only through proactive understanding of complex regulatory regimes in each shale play can operators, producers and infrastructure providers plan for solutions early in their project life cycle, to eliminate operational risk and control their own destiny with regard to managing risk and operational liability in these environmentally sensitive areas.

Introduction and Statement of Theory

To most efficiently conduct hydrocarbon extraction activities, oil and gas producers need flat drilling pads as the basis for executing operations. These pads are most often located and spaced according to selections made by geologists relative to optimal recovery of oil and gas resources. Drilling sites are thusly selected using base maps as guides without consideration of surface development constraints, often only discovered when the future drilling location is surveyed.

For U.S. onshore operations, while it may not be difficult to identify the ideal drilling site, it may be costly and time consuming to obtain appropriate environmental permits enabling these activities. As field development operations grow to include go-to-market networks of flowlines, gathering lines and pipelines, more surface encumbrances need to be taken into consideration. Finally, all field operations require access to the drilling site. Access roads enabling site access are often part of the construction plan. Proactive identification of land-derived encumbrances enables a knowledge base of potential unavoidable impacts that need assessment and require permits and ecological offsets.

Surface operations must take into account and plan for obstacles in the way of streamlined process. These obstacles include unavoidable surface impacts to wetlands, streams and habitats encountered prior to and during operations. Operators and producers and their contractors must abide by the laws and regulations of the land, which include a formalized regime to address surface impacts: Avoid impacts, Minimize impacts if any at all, Compensate for unavoidable impacts (Krauss, 2009).

Overall, hydrocarbon producers and infrastructure developers do an excellent job of avoiding and minimizing impacts, especially when there is a wide berth on which to develop an asset base. U.S. onshore shale plays may occur within sight of the general public and in many cases in urban areas, rather than more remote, unseen areas for conventional play development. Visibility means scrutiny. Scrutiny means regulatory awareness and increased public interaction. Operators can prepare for and address these operational risks and liabilities by planning ahead to quantify surface impacts and being proactive with regulators in avoiding, minimizing and ultimately compensating for unavoidable project-related impacts. These efforts make knowns out of unknowns and directly improve operational efficiency.

Problem and Situation Analysis

Surface impacts from field operations have been described in detail by this author in the context of the Louisiana Haynesville Shale in SPE 141949 (Krauss, 2011). Unavoidable surface impacts from drilling pads and associated field infrastructure are required to be permitted under the proper authorities of federal and state laws and regulations. To operate in areas where waters of the United States, including wetlands and streams, are impacted, permits are authorized under the Clean Water Act, Section 404 and the Rivers and Harbors Act, Section 10 and administered by the U.S. Army Corps of Engineers (Corps). While compliance is the Corps' pervue, enforcement is the domain of the U.S. Environmental Protection Agency (EPA). State agencies also have their own requirements. Operators must understand the regulatory regime within which they operate. Table 1 below illustrates the typical regulatory agencies by shale play.

Table 1. Typical Regulators of Wetlands and Streams in Four Shale Plays

	Haynesville/Louisiana	Marcellus/Pennsylvania	Utica/Ohio	Eagle Ford/Texas
Federal	US Army Corps of Engineers: Vicksburg District	US Army Corps of Engineers: Pittsburgh, Baltimore Districts	US Army Corps of Engineers: Pittsburgh, Huntington Districts	US Army Corps of Engineers: Galveston, Fort Worth Districts
	US EPA Region 6	US EPA Region 3	US EPA Region 5	US EPA Region 6
	US Fish & Wildlife Service Region 4	US Fish & Wildlife Service Region 5	US Fish & Wildlife Service Region 3	US Fish & Wildlife Service Region 2
State	Louisiana Department of Environmental Quality (LA DEQ)	Pennsylvania Department of Environmental Protection (PADEP)	Ohio Environmental Protection Agency (Ohio EPA)	Texas Commission on Environmental Quality (TCEQ)
	Louisiana Department of Wildlife and Fisheries (LDWF)	Pennsylvania Game Commission		Texas Parks and Wildlife Department (TPWD)
	Louisiana Department of Natural Resources (LA DNR)	Pennsylvania Fish and Boat Commission		Texas General Land Office (GLO)
		Pennsylvania Department of Conservation and Natural Resources (PA DCNR)		

Surface Impact Assessment and Offset Determination

Operators directly benefit from developing relationships with the agencies that regulate their operations. Each agency that regulates and permits operations in wetlands and streams has a process and mechanism used to both quantify these unavoidable, project-related impacts and quantify appropriate compensatory mitigation to offset these impacts. (Federal Register, 2008) These mechanisms are termed "functional assessment methods" and are developed and promulgated by the civilian staff, usually comprised of biologists rather than engineers or geotechnicians, of the U.S. Army Corps of Engineers.

The Corps recognizes the Hydrogeomorphic (HGM) Approach as a guide to understanding impacts to Waters of the United States. The HGM Approach is a collection of concepts and methods for developing functional indices, and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in the region. (US Army Corps of Engineers ERDC, 2010) HGM has been extended to include ecosystems in addition to wetlands including streams and other aquatic ecosystems. HGM operates by employing indicators of community structure and process, aggregated into simple logic models, to indirectly reflect functionality. As a result, disturbance regimes are observed and measured within an ecosystem.

The 38 Corps Districts in the United States each employ HGM as appropriate to local ecosystems. Regional guidebooks for assessing wetland functions and values are published by the Corps' Engineer Research Development Center (ERDC). Within each district, however, individual regulators have the flexibility to assess project-related impacts and ecological offsets required as compensatory mitigation for these impacts using HGM, or any other suitable method, including simple ratios and even best professional judgment. All assessment methods result in a quantified determination of impacts to the waters of the United States. Should compensatory mitigation be required to offset unavoidable impacts to comply with permit conditions, the regulator turns to an assessment method to determine how best to achieve "no net loss" of wetland and streams as required by Executive Order 11990. A summary of the assessment methods applied for the each four shale plays discussed herein is shown in Table 2 below.

Table 2. Functional Assessment Methods Applied to Quantify Impacts to Waters of the United States

Play	State	Wetlands	Streams
Haynesville	Louisiana	Vicksburg District: Charleston Method	Little Rock District Stream Assessment Method
Marcellus	Pennsylvania	Ratio and Level 2 Wetland Rapid Assessment Protocol	Ratio and Level 1, Level 2 Riverine Rapid Assessment Protocol
Utica	Ohio	Ratio	Ratio and Huntington/Pittsburgh Approaches
Eagle Ford	Texas	Fort Worth District: TXRAM, Galveston District: HGMi	Fort Worth: Ratios, TXRAM Galveston: Interim Stream Assessment SOP

These assessment methods are current as of the date of this paper. Each Corps District, and indeed each individual regulator, may choose to employ the method deemed by that individual as appropriate and practicable for impact assessment. The corresponding compensatory mitigation offsets for any of these impacts are also calculated using like assessment methods. For these reasons, operators in shale plays must keep apprised of regulatory change to properly tally potential costs from projects with unavoidable impacts. Oil and gas development has occurred in the United States since 1859 while the Final Rule on Compensatory Mitigation for Losses of Aquatic Resources was only published in April 2008.

Haynesville Shale

The Haynesville Shale covers a 4.3 million acre play area in northwest Louisiana and northeast Texas (EIA, 2012). Over 1.4 million acres have been unitized in Louisiana, as seen over time in Figures 1, 2, and 3 below (LA DNR, 2011). Each figure also shows the wetlands in the play area, as over 23% of the Louisiana part of the play occurs in wetlands (USFWS, 2012). A 404 permit is typically required for every 5th well pad and its supporting infrastructure. Compensatory mitigation is very often required to offset these unavoidable impacts, especially as pad sizes grow to accommodate application of new multi-well pads. Details of assessment methods employed in the Haynesville by the Vicksburg Corps District and associated agencies are covered in SPE 141949.

Figure 1. Jan-2010 Play Snapshot

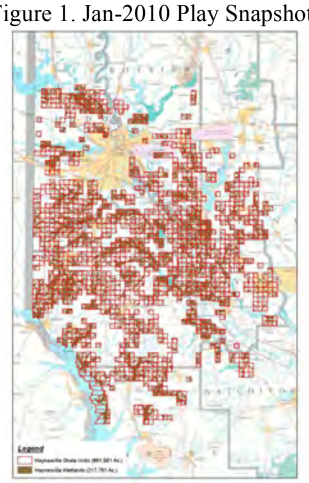


Figure 2. Nov-2010 Play Snapshot

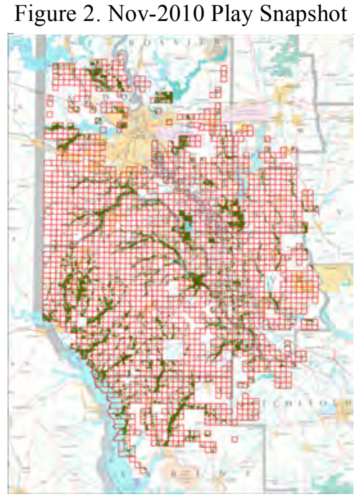


Figure 3. Nov-2011 Play Snapshot

Marcellus Shale

The aerial extent of the Marcellus shale spans some 60,882,397 acres (EIA, 2012) and more than 16,000,000 acres have been leased for hydrocarbon development (Hart Energy, 2012). Within Pennsylvania, the play area covers 21,204,120 acres (EIA, 2012). Wetlands are abundant in the northeast tier of the Commonwealth's play area with over 681,697 wetland acres identified via satellite imagery (USFWS, 2012). Water resources from exceptional and high value streams and their tributaries total 64,098 miles distributed among 20 watersheds (NHD, 2012). The aerial extents of Pennsylvania Marcellus wetlands and streams are shown in Figures 4 and 5, respectively, below.

Figure 4. PA Marcellus Wetlands

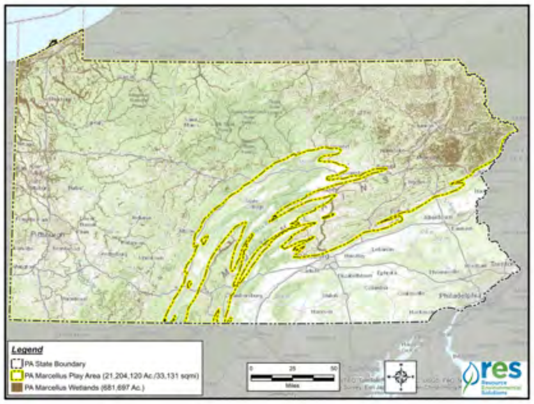
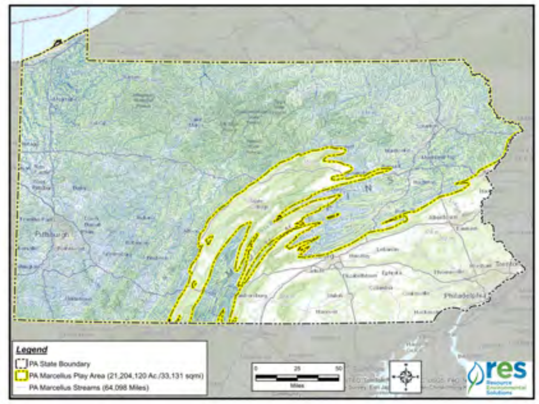


Figure 5. PA Marcellus Streams



Well sites are not permitted to be constructed in the wetlands of Pennsylvania; it is not possible to obtain a permit for this purpose due to state regulations under Chapter 102 and 105 of PA State Code (Pennsylvania Code, Title 25).

The abundance of flowing natural waters results in projects with linear features required to obtain a permit to cross a stream nearly every 2,000 feet. Unlike the Haynesville Shale in Louisiana, impacts to wetlands and streams of the Marcellus Shale in Pennsylvania are regulated by State agencies in conjunction with the Corps rather than with the Corps District leading the permitting process directly. Stream impacts are permitted under the procedures set forth by Chapter 105 of PA Code and the Clean Water Act Section 404. On July 1, 2011, the Corps issued the Pennsylvania Special Programmatic General Permit-4 (PASPGP-4). The PASPGP is a Clean Water Act, Section 404 permit which can be authorized by the Pennsylvania Department of Environmental Protection (PADEP) and county conservation districts for minor activities (crossings) in wetlands, streams, rivers, and other waters without additional review by the Corps. Unlike the Haynesville Shale in Louisiana, impacts to wetlands and streams of the Marcellus Shale in Pennsylvania are regulated by State agencies in conjunction with the Corps rather than with the Corps District leading the permitting process directly.

The PASPGP-4 contains key changes that impact linear projects ranging natural gas pipelines to water and sewer pipelines to electrical transmission, cable television, and telephone lines. Permit applicants must supply the locations for the start and end points along with each proposed crossing as well as the total cumulative impacts needed to complete the entire project. These are used to determine the activity category of the impact. For example, if the cumulative impact for the entire project is greater than 1 acre of jurisdictional waters or 250 linear feet of streams, then the entire project will be a Category III activity and will be reviewed by the Corps, in addition to State agencies.

The PASPGP-4 includes clarification on the calculation of linear footage of stream impact. The linear footage of stream impact is now to be measured from the top of bank to the top of the opposite bank and from the upstream to downstream limits of work. The linear footage of stream impact will be the greater of these two measurements. As such, linear project rights-of-way (ROW) will typically be the basis of calculations used to determine the linear footage of stream impacts for midstream pipeline projects. PADEP permits for impacts at water crossings that are larger than those considered in PASPGP-4 include PA Chapter 105 applications of a General Permit or Joint Permit.

During 2011 and 2012, the PADEP worked to update its assessment methods and approaches. The PADEP sought to establish a standardized process for determining aquatic resource compensation requirements and simultaneously establish a standardized process for determining the potential value of proposed aquatic resource compensation projects such as wetland and stream mitigation banks. The protocol is intended for use in determining functional compensation requirements for projects affecting streams and rivers, floodways and floodplains, wetlands and open bodies of water, such as lakes and reservoirs that require authorization from the PADEP and USACE regulatory programs. (Goerman, Krauss, et al, 2013)

This protocol, the Pennsylvania Function Based Aquatic Resource Compensation Protocol, is applied to authorized activities permitted via Title 25 PA Code Chapter 102 (as related to riparian buffers), and Chapters 105 and 106 and ensures compliance with the Final Rule. (PADEP, 2012)

The Pennsylvania Function Based Aquatic Resource Compensation Protocol includes the Pennsylvania Riverine Condition Level 2

Rapid Assessment Protocol. It was developed to evaluate a proposed project's effect on the basic functions that comprise the riparian ecotone and to ensure that adequate compensation is provided to offset those effects. The primary modification made to the widely adopted, original Unified Stream Methodology (USM, 2007) reflects the approach that the PADEP has taken to establish a riverine resource's condition using a riparian ecotone. Riparian ecotones are a three-dimensional space of interaction that includes terrestrial and aquatic ecosystems, which extend down into the groundwater, up above the vegetative canopy, outward across the floodplain, up the near-slopes that drain water, laterally into the terrestrial ecosystem, and along the watercourse at a variable width. The riparian ecotone includes the 100-year floodplain and 100 feet landward along the valley, where as obvious slumps or landslides are added with a 45-foot band around their edge, as adapted from Verry et al (Verry, 2004).

This rapid condition assessment approach was developed to incorporate components of the riparian ecotone concept while balancing the cost of information gathering requirements. The purpose of the protocol is to describe a methodology for consistently and rapidly assessing the condition of the riparian ecotone. The individual indexes used to establish the overall Riparian Ecotone Condition Index (RECI) are as follows and will be detailed in forthcoming Rapid Assessment Protocol procedures:

- Channel/Floodplain Condition Index
- Riparian Vegetation Condition Index
- Riparian Zone of Influence Condition Index
- In-stream Habitat Condition Index
- Channel Alteration Condition Index

These indices and assessment methods are currently being adopted across the Commonwealth as impacts occur over time in each of the 20 watersheds managed jointly by the PADEP and the Corps.

Utica Shale

If the topography of the Marcellus Shale is largely dominated by the Appalachian Mountains, the geomorphology of the 10 million acres of the Utica Shale in Ohio (EIA, 2012) is caused by glaciation events that created the Great Lakes. Thusly, Ohio's wetlands are sparse (USFWS, 2012) and even termed "isolated" by the Ohio EPA. As in Pennsylvania, impacts to wetlands are regulated by the state, in Ohio by the Ohio EPA via Ohio Code Chapter 6111. Impacts to wetlands are assessed by the number of acres impacted and ecological offsets determined using ratios applied by the regulator. Ratios of offsets to impacts vary from 1.5:1 to 3:1 depending on the type of wetland impacted, forested or non-forested, the spatial proximity of the offset to the impact and the ecological offset habitat type being in-kind or out-of-kind with respect to the impacted habitat. There is no visible application of an HGM approach yet in Ohio.

While wetlands are isolated, streams dominate the surface landscape with some 41,400 stream miles measured within the play area boundary (NHD, 2012). Both the Ohio EPA and the Buffalo and Huntington Corps Districts regulate these streams, waters of the United States. Ohio rivers get special protection under the Rivers and Harbors Act of 1899, as they are navigable waterways with boat and barge traffic. The Huntington Corps office so regularly permits energy projects for hydrocarbon and coal resources that their Energy Resources division office provides guidance on which assessment method to apply and also helps coordinate complex project impact assessment and compensatory mitigation guidance. At present, it is early days of Utica Shale field development history. Savvy operators will now begin to plan for potential future impacts. Figures 6 and 7 provide satellite image-derived views of wetlands and streams respectively within Utica Shale play area within Ohio.

Figure 6. Ohio Utica Wetlands

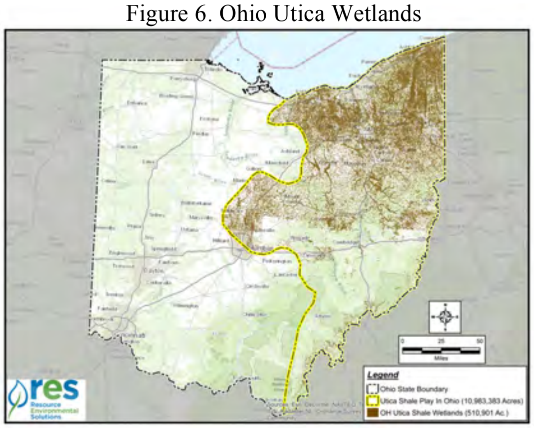
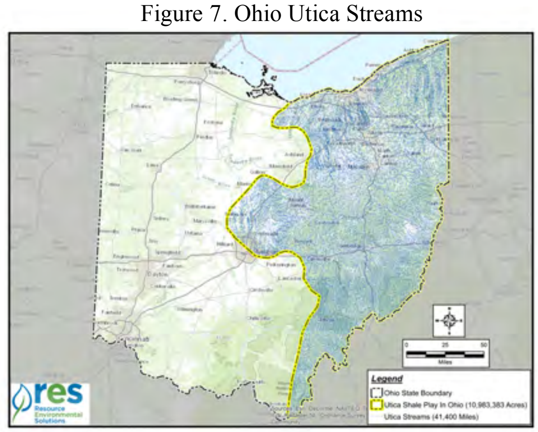


Figure 7. Ohio Utica Streams



Eagle Ford Shale

The Eagle Ford Shale will reveal abundant hydrocarbon resources over the life of the play. In its early days yet, 4,300 wells have been permitted and over 1,300 completed as of mid-July, 2012 (RRC, 2012). The leased area exceeds 5 million acres across 24 counties (Hart Energy, 2012). The area is hot and dry. Or is it? Figure 8 below denotes the 218,000 acres of wetlands measured within the play boundaries (USFWS, 2012). At a glance of the figure, it is easy to avoid these areas. Figure 9, however, shows the 22,125 miles of streams the federal government has extracted from satellite imagery and compiled into the National Hydrographic Database (NHD, 2012). This swath of streams is under the regulatory jurisdiction of both the Galveston and Fort Worth Corps Districts.

The Fort Worth Corps jurisdiction predominates the Eagle Ford Shale area. So concerned are the District regulators about compliance with Clean Water Act permitting that they issued a Public Notice on December 6, 2012. Entitled the "U.S. Army Corps of Engineers Fort Worth District Regulatory Role in Activities Associated with Oil and Natural Gas Production and Development of Class II Injection Wells and Pipelines," the notice verifies that what land seems to be "dry" may indeed be "wet" and therefore may require permitting. Specifically, "Waters of the U.S. are defined in 33 CFR 328 and may include lakes, rivers, streams (ephemeral, intermittent, perennial), mudflats, vegetated shallows, ditches, ponds, and wetlands. While some rivers, streams, lakes and wetlands are clearly jurisdictional waters, in many instances, the USACE can only make the determination of whether an aquatic resource is a water of the U.S. after a site-specific analysis. The presence of drought conditions in no way diminishes the extent and location of federal jurisdiction with respect to waters of the U.S., i.e. just because an area may appear as dry land, does not mean that it is no longer regulated under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act."

Figure 8. Texas Eagle Ford Wetlands

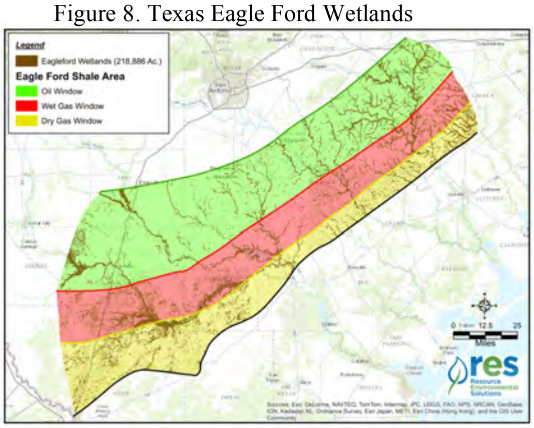
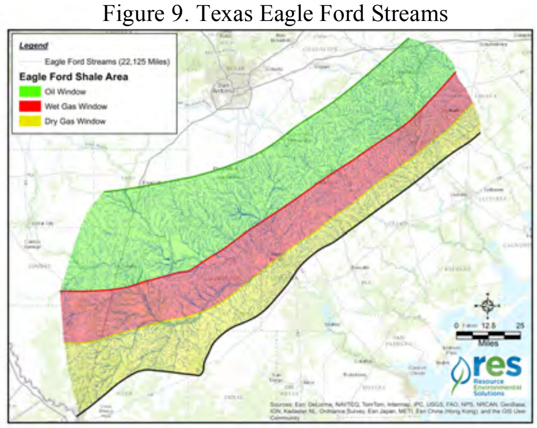


Figure 9. Texas Eagle Ford Streams



For impacts to wetlands, the Galveston District applies the interim Hydrogeomorphic Method (HGMi or iHGM) in four versions to address the forested and herbaceous, riverine and lacustrine habitat variations observed along the Texas gulf coast and extending inland. In 2012, the Galveston District began to utilize the Interim SWG Stream Condition Assessment Standard Operating Procedure. The SOP has three components – a stream assessment tool, a procedure for assessing stream impacts, and a level 1, 2, and 3 stream assessment compensation evaluation procedure. (Galveston Corps, 2012).

The Fort Worth District introduced the Texas Rapid Assessment Method (TXRAM) for both wetlands and stream assessments in 2011 and began its formal use in 2012. While the application of the assessment method may be rapid, like HGMi, TXRAM requires detailed field sampling and verification for proper application. As in Ohio, the Ratio Method also is a tool utilized by the Fort Worth District.

Summary

Shale play operators develop their assets in environments with variable regulatory regimes. Navigating these agencies and their changing requirements and methods of assessing field operations requires proactive, thoughtful engagement by operator personnel and their supporting team members. Many of the assessment methods employed by Corps Districts are published at the Corps public website Regional In Lieu Fee and Banking Information Tracking System (RIBITS) at https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:2:228101192685212. The State-specific assessment methods are available from individual agencies.

Use of one assessment method or another to quantify unavoidable project-related impacts results in real costs to be borne by field operators requiring permits under the Clean Water Act's Section 404 and otherwise as described here. The Society of Wetland Scientists considered one such project under multiple assessment methods. Table 3 highlights useful results of this study, using $20,000 per mitigation acre as a baseline for price comparison. (Krauss and Stahman, 2012)

Table 3. Comparison of Assessment Methods on Single Wetland Fill Project

District	Assessment Method	Ratio: Offsets to Impacts*	Cost per Impact Acre**
Vicksburg	Charleston Method	3.6:1	$72,000
New Orleans	Modified Charleston Method	2.4:1	$48,000
Galveston	HGMi	0.7:1	$15,000
Fort Worth	TXRAM	0.6:1	$12,000

*Based on results of typical bottomland hardwood wetland impact/mitigation scenario comparison conducted by Society of Wetland Scientists Functional Assessment Workshop, National Wetlands Research Center, Lafayette, Louisiana.
**Assumes $20,000 per mitigation acre.

When impacts from a single project are assessed using various functional assessment methods, the results are highly variable, and costs of compensatory mitigation can also vary widely. To consider this project in terms of a well pad, assume that a well pad covers 5 acres and the project is in a wetland. These unavoidable project costs must be borne prior to obtaining a permit and are often not part of an AFE. Improper permitting exacerbates these costs as after-the-fact penalties and enforcement actions add multipliers onto the ratios of required ecological offsets for each acre of impact.

Upfront planning with knowledge captured and applied about the regulatory regimes that govern field development activities can result in real project cost savings. Unavoidable project risks are then properly assessed and liabilities identified and transferred yielding what all developers seek in their business – compliance with regulations and predictability in operations.

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