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Technical Guide for the Development, Evaluation, and Modification of Wetland Rapid Assessment Methods for the Corps Regulatory Program

Jacob F. Berkowitz, Gabrielle C. L. David, and Kyle Gordon

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Abstract

The US Army Corps of Engineers (Corps) Regulatory Program considers the loss (decrease) and gain (improvement) of wetland functions as part of Clean Water Act Section 404 permitting and compensatory mitigation decisions. To better inform this regulatory decision-making, the Regulatory program needs accurate, transparent, objective, and defensible approaches to assess the function and condition of wetlands. Additionally, wetland assessments must balance the need for objective decision-making with the concurrent need to make Regulatory program decisions in a timely manner. Consequently, it is often necessary to assess wetlands using rapidly attainable proxy measures of ecological function or condition by evaluating a suite of metrics that represent structural and compositional attributes of a wetland. In response, this document describes a set of guidelines to effectively develop, evaluate, and modify wetland assessment methods, specifically for the Corps Regulatory Program.

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Preface

This study was conducted for the Wetlands Regulatory Assistance Program (WRAP) under Project 2022-ERD-0500-002, “Technical Guide for the Development, Evaluation, and Modification of Wetland Rapid Assessment Methods for the Corps Regulatory Program.” The technical monitor was Mr. Kyle Gordon.

The work was performed by the Wetlands and Coastal Ecology Branch of the Ecosystem Evaluation and Engineering Division, US Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL). At the time of publication, Ms. Patty Tolley was branch chief; Mr. Mark Farr was division chief; and Dr. Jennifer Seiter-Moser was the technical director for Civil Works. The deputy director of ERDC-EL was Dr. Brandon Lafferty, and the director was Dr. Edmond Russo.

The content of this report was conceptualized and developed with input from several individuals instrumental to the development of wetland assessment methods over the past four decades. The following commented on a draft version of the report: Mr. Chris Noble (USACE, retired and deceased), Mr. Michael Gilbert (USACE, retired), Dr. Eric Stein (Southern California Coastal Water Research Project), Dr. Siobhan Fennessy (Kenyon College), Dr. William Kleindl (Montana State University), Dr. Thomas Roberts (Tennessee Tech University, Emeritus), Mr. Bill Ainslie (US Environmental Protection Agency), and Dr. Brad Johnson (Johnson Environmental Consulting, LLC).

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1 Introduction

1.1 Background

The Regulatory program requires defensible wetland assessments to (1) characterize a wetland's function or condition, (2) understand the impact of a proposed action to wetland function or condition, and/or (3) inform the development of wetland compensatory mitigation instruments to ensure that appropriate levels of wetland function or condition are achieved. A well designed and executed wetland assessment provides regulatory decision-makers with the resources needed to objectively evaluate alternatives; avoid and minimize impacts; quantify unavoidable impacts; determine mitigation requirements; and monitor the success of mitigation projects.

1.2 Objective

The sections below describe technical guidelines for the development, evaluation, and modification of wetland rapid assessment methods. It outlines nine phases (i.e., elements) that promote technically accurate, science-based, defensible, repeatable, and transparent approaches to wetland rapid assessment. Thus, they provide a template for (1) developing new methods for Regulatory program applications, (2) evaluating methods to determine if they meet Regulatory program requirements (or comparing multiple methodologies), and (3) modifying existing assessment approaches to better meet Regulatory program needs. Wetland rapid assessment methods should utilize the best available methodologies. These guidelines are not intended to overrule or invalidate wetland assessment methods made prior to their publication.

1.3 Approach

The guidelines build upon previously completed work addressing wetland rapid assessment method development and implementation (Bedford and Preston 1988; Barbour et al. 1999; Sparks et al. 2003; USEPA 2004). The guidelines offer a concise examination of major wetland rapid assessment elements tailored to the needs of the Regulatory program and as such, provide the Regulatory community with a decision support tool for working with wetland rapid assessment methods. These guidelines summarize the findings of previously published documents, and do not

replace comprehensive descriptions of wetland assessment method development such as included in Smith et al. (2013).

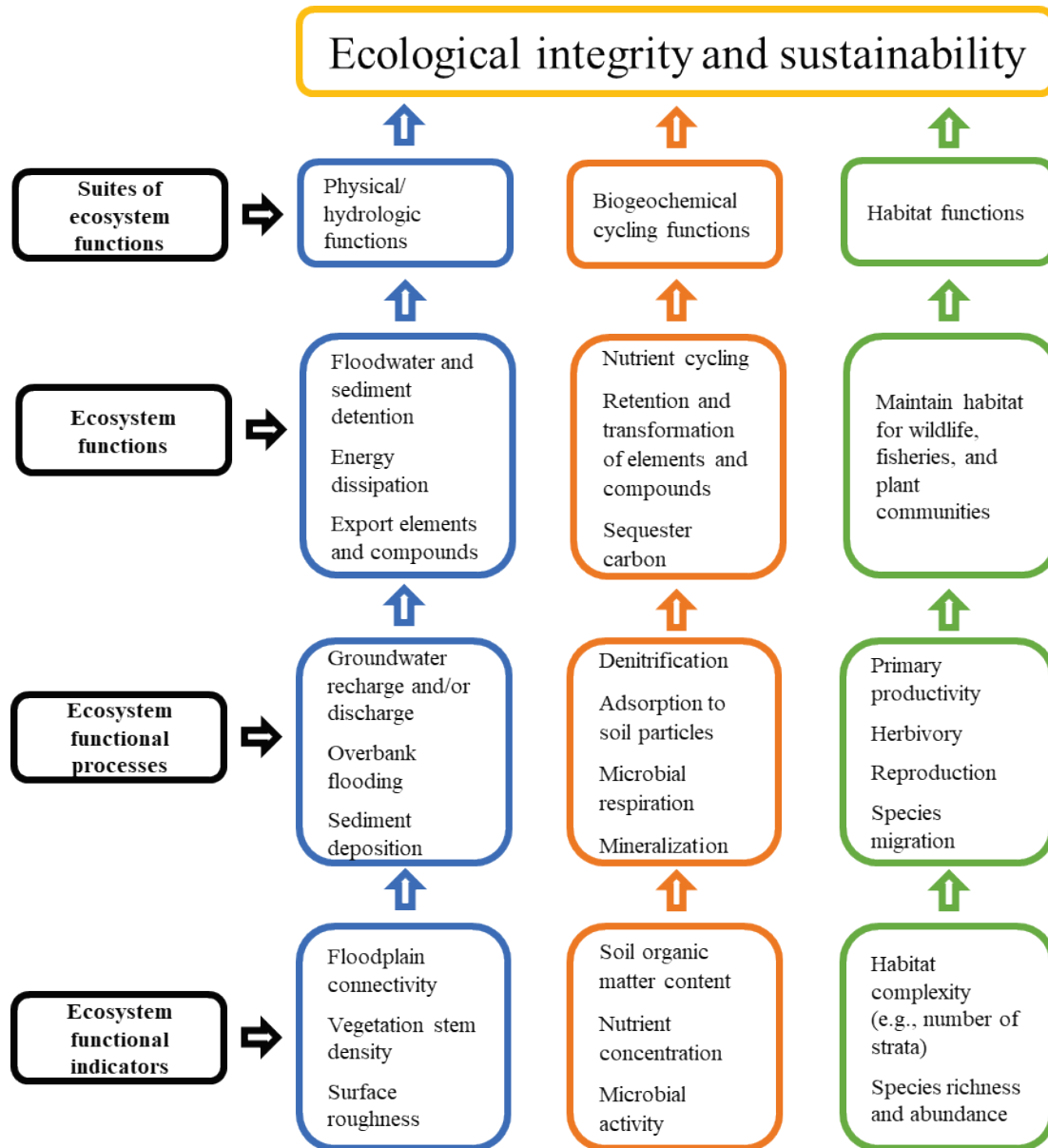
Wetland rapid assessment methods are designed to document wetland function or condition. Wetland functions are defined as the normal activities or actions that take place in an ecosystem, such as the maintenance of habitat for flora and fauna, detention of floodwater and reduction of storm surges, and the biogeochemical cycling of nutrients and other compounds (Novitski et al. 1996). These functions result from complex interactions between the structural components in an ecosystem (e.g., plants, animals, soil, water, and the atmosphere), the surrounding watershed and landscape (e.g., geomorphic setting), and the processes linking these structural components such as overbank flooding, evapotranspiration, chemical transformations, predation, and primary productivity (Smith et al. 1995). In general, ecological functions can be grouped into three broad categories (physical, biogeochemical, and habitat functions) based upon the underlying processes driving the function. These functions work in concert to maintain ecosystem integrity and sustainability, and a hierarchy has been developed to demonstrate the relationship between ecological indicators (or structural elements), processes, functions, and suites of functions (Figure 1; Smith et al. 1995).

Wetland condition has been defined as the relative ability of an ecosystem to support and maintain a community of organisms, which has species composition, diversity, and functional organization comparable to high-quality reference natural resources in the region (Davies and Jackson 2006). Wetland condition is, therefore, the state of the wetland at the time of the assessment, as opposed to a function, which is a process occurring over time (Wardrop et al. 2007). Both wetland function and condition can be altered by natural processes (i.e., vegetation community succession) and anthropogenic alterations and stressors (e.g., logging activities, development of drainage works, placement of fill) (Novitski et al. 1996).

Continued human development pressures resulted in regulation and permitting procedures for activities impacting wetlands (Cole 2006; Ainslie 1994). The need to assess wetland function or condition remains rooted in the objectives of the Federal Water Pollution Control Act of 1972 (Clean Water Act) which sought to maintain and restore the physical, chemical, and biological integrity of the Nation's waters and the "no overall net loss" policies implemented for wetlands during the 1980s

(ASTM 1998; Carletti et al. 2004). The 2008 Mitigation Rule and subsequent regulatory guidance further outlined the requirements for wetland resource compensatory mitigation (USACE and USEPA 2008). Requirements of the 2008 Mitigation Rule include characterization of baseline information for areas impacted by a permitted activity and compensatory mitigation project sites, determination of mitigation credits, the establishment of ecological performance standards, and monitoring of compensatory mitigation projects, all of which rely on the deliberate application of practical, accurate, and defensible wetland assessment tools.

Figure 1. Hierarchy of ecological functions and relationship among ecosystem indicators, ecosystem functional processes, ecosystem functions, and suite of ecosystem functions.



A variety of wetland assessment strategies have been developed with the goal of improving natural resource management, with a special emphasis on the development and implementation of wetland rapid assessment methods (Figure 2; Stein et al. 2009a, 2009b; Wardrop et al. 2007). For example, Fennessy et al. (2007) identified over 40 rapid assessment protocols, and development of additional methodologies continues (Berkowitz et al. 2017). The various rapid wetland assessment approaches in use exhibit a wide variety of characteristics. However, each assessment

method can be described, categorized, and evaluated based on a few key elements (Carletti et al. 2004; Sutula et al. 2006; Stein et al. 2009b).

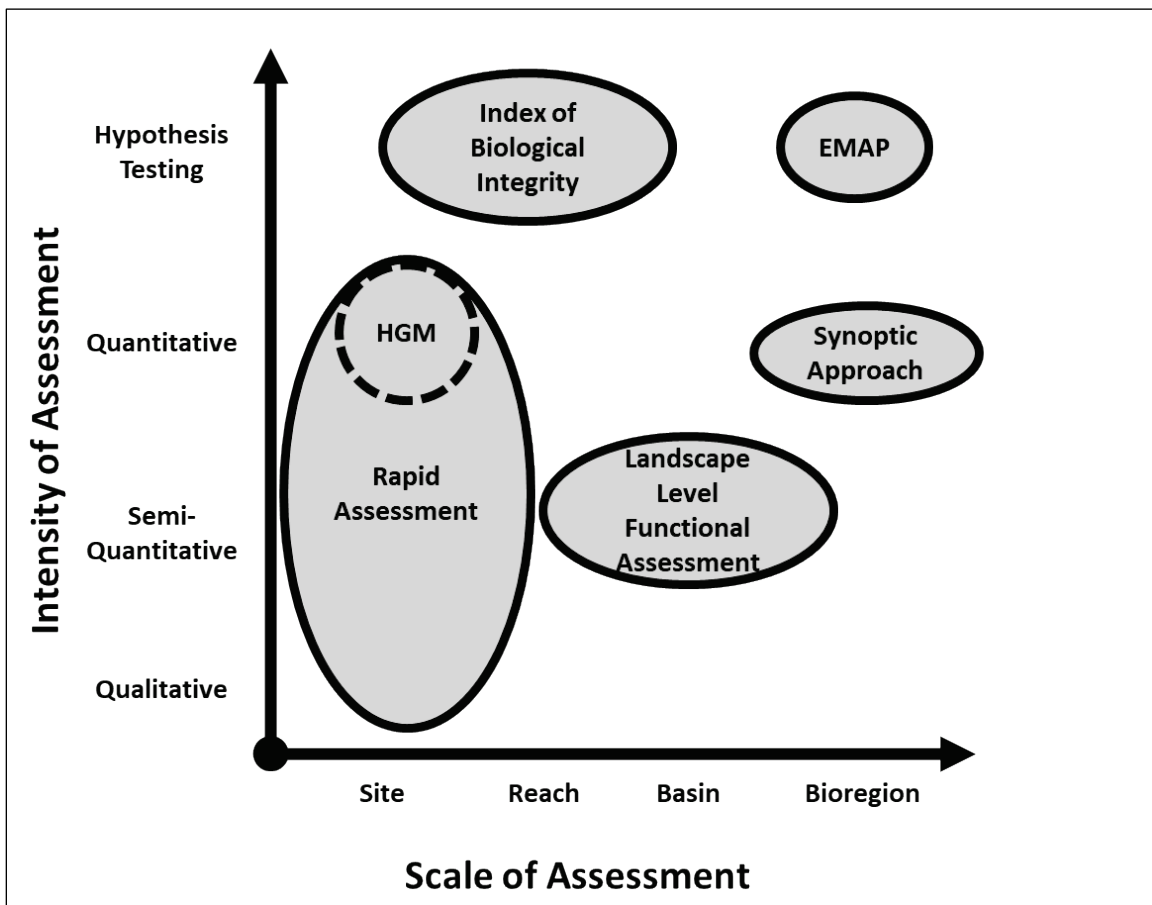
Due to the proliferation of a wide variety of wetland rapid assessment methods across the nation, the Regulatory community requires approaches and tools for evaluating and comparing different methods to select the most appropriate, practical, and defensible methodology for a given application. The guidelines outlined in the subsequent sections (phases 1-9) address this need. Additionally, some methods (i.e., the Hydrogeomorphic Approach) were specifically developed to meet the needs of the Regulatory program under the Clean Water Act, while others were designed for a variety of potential applications. As a result, the guidelines also include information on the development of a new method and the modification of existing methods to improve their utility for Regulatory program applications.

In general, the term “rapid” refers to assessment methods that can be completed in one day or less for a single assessment area (Smith 1995; USEPA 2004). While Sutula et al. (2006) and others make a distinction between methods for addressing ecosystem function and condition, the guidelines outlined herein consider all wetland assessment methodologies that can be accomplished within one day or less to be wetland rapid assessment methods (Figure 2). Wetland rapid assessment methods would fit into EPA level 2 assessment activities described by Kentula (2007) as described herein the following: “rapid methods are composed of indicators of (1) the ecological features of wetlands (e.g., hydrology, plant community, soils); (2) human activities that stress the system and degrade its ecological integrity; or (3) some combination of both.”

Wetland rapid assessment methods systematically aggregate metrics (often described as ecological indicators or variables) that serve as surrogate measures for wetland function or condition into a scoring system. The scoring systems are generally calibrated based upon the highest attainable condition or function observed within a region. However, wetland rapid assessment methods vary widely in the way that data are aggregated, scored, and interpreted. Somerville and Pruitt (2004) point out that assessment strategies and methodologies are driven by project objectives, available time and resources, and the degree of confidence required to reach a decision. The increased use of wetland rapid assessment methods and the observed variety of available

techniques highlight the need for approaches sensitive to ecosystem impacts, executable in a short period of time, remain somewhat insensitive to seasonality, and can be applied by practitioners with a broad range of expertise and have a general understanding of wetland ecology and field data collection techniques (van Dam et al. 1998; Fennessy et al. 1998; 2004; Mack et al. 2000; Berkowitz et al. 2011). Notably, these guidelines are designed to be robust and do not favor any particular assessment methodology (e.g., Hydrogeomorphic Approach, California Rapid Assessment Method), although they recognize some approaches inherently include features that better meet the requirements of the Regulatory program than others.

Figure 2. Distribution of ecological assessment methods with respect to the geographical scale of applicability and the required level of effort (e.g., sampling intensity/frequency). Note that rapid assessment methods vary in intensity from qualitative (e.g., descriptive categorical variables) to quantitative (e.g., measurements, numerical variables). Modified from Sutula et al. (2006). Acronyms include the Hydrogeomorphic Approach (HGM) and the Environmental Monitoring and Assessment Protocol (EMAP).



2 Results and Discussion

The wide variety of wetland rapid assessment methods in use highlights the need for transparent, practicable approaches to evaluate, compare, and contrast different methodologies based upon a publicly available set of guidelines. Additionally, the Regulatory community as well as the public benefit from broadly applicable tools to support the development of new rapid wetland assessment methods and facilitate the deliberate evaluation and modification of existing assessment methods. To achieve these objectives, the guidelines are based upon the following principles, which have been identified in rapid assessment methods successfully utilized in the Regulatory process (Smith et al. 2013; David et al. 2021):

- Well-structured development procedure
- Clear sampling protocol
- Generally, require a site visit to conduct the assessment
- Rapid data collection and analysis
- Application possible throughout the growing season
- Repeatable and confirmable results
- Transparent scoring system
- Data and document management plan
- Defensible outcomes supported by peer-reviewed documentation

To translate these desirable principles into guidelines, nine phases are described below, each related to one or more important aspects of wetland rapid assessment development, evaluation, and modification (Figure 3). The nine phases describe each element and discuss how each can be used to improve method development, evaluation, and modification. In general, all nine phases should be considered when developing a new wetland rapid assessment method or evaluating existing methods. When modifying an existing method to improve its utility in a Regulatory program context, users of these guidelines may need to focus on a subset of the phases. Regardless of the application, documenting the decision-making process, including identifying the objectives, intent, approach, and outcomes of an initiative, is key to ensuring transparency, defensibility, and success. Therefore, a data and document management plan should be incorporated into the process for transparency, improve clarity in how to apply the method in the field and office, as well as reduce the time it takes to collect and evaluate the data (David et al. 2021).

Figure 3. The nine phases used to inform wetland rapid assessment method development, evaluation, and modification.

Phase 1	Interagency, multidisciplinary teams
A multidisciplinary team of experts should develop new assessment methods or modify existing methods. Methods developed by multidisciplinary are preferred over methods that lack this element.	
Phase 2	Clearly defined assessment goals and outputs that align with Regulatory program needs
Wetland rapid assessment methods should clearly identify 1) the purpose of the method and 2) potential applications and intended uses, and produce 3) clear, usable outputs that coincide with Regulatory requirements. Methods with these elements are preferable to those that lack concise goals and outputs.	
Phase 3	Wetland classification
Ecosystem classification based on vegetative, hydrologic, geomorphic, or other characteristics increases the accuracy and repeatability of assessment methods by defining target ecosystems with similar structure and function. Methods with classification enable in-kind and out-of-kind comparisons and are preferred over methods lacking this element.	
Phase 4	Defined geographic extent
The geographic extent of rapid assessment method applications are defined using ecological/geophysical boundaries, or geopolitical areas. Limiting the geographic region improves accuracy and efficiency by accounting for regional differences in climate, floral communities, or other factors. Methods that include this element are preferred.	
Phase 5	Rapid application
Wetland assessment procedures impact Regulatory program efficiency through the time required to execute the procedure. Rapid assessment methods should require no more than one day to complete, and rapid, reliable methods are preferred for Regulatory applications.	
Phase 6	Calibration and metric scaling based on reference data
Properly calibrating wetland rapid assessment methods improves accuracy and applicability. Calibration includes comparing metric scores generated in areas exhibiting reference standard conditions to outputs observed across a gradient of ecosystem disturbances. Calibrated methods are preferred over methods that lack this element.	
Phase 7	Application of numerical data based upon written protocols
Quantitative measurements generate numerical values from continuous, categorical, and discreet data streams. Quantitative data, collected using written protocols improve the accuracy of assessments. Assessment methods utilizing numerical data are preferred over qualitative methodologies.	
Phase 8	Verification of assessment metrics and outcomes
Verifying wetland rapid assessment methods entails checking the logic and sensitivity of the approach to ensure that it is responsive to and generates the appropriate outcomes that would be anticipated across the range of environmental conditions observed within the applicable area. Verified methods are preferred over methods lacking this element.	
Phase 9	Peer review and implementation
Documenting peer review activity improves the usability, applicability, credibility, and quality of wetland rapid assessment methods. Strategic implementation plans should include training and iterative opportunities to modify the method to meet evolving Regulatory program needs. Methods that include these elements are preferred over methods that lack thorough peer review and implementation.	

2.1 Phase 1: Interagency, multidisciplinary teams

2.1.1 Description

Wetland rapid assessment developers and users range from individual practitioners and resource managers to large teams of wetlands experts working together. Clairain (2002) recommends the formation of assessment teams composed of interagency, multidisciplinary wetland experts when developing, evaluating, or modifying wetland assessments. The size and composition of the team affects assessment method outcomes, defensibility, and credibility; with more experienced multidisciplinary teams capable of producing and applying methods across larger geographical areas that contain multiple ecosystem types (Sutula et al. 2006). Multidisciplinary teams can also develop and interpret more refined and detailed methodologies, promoting technical accuracy and applicability. Team members often include federal, state, and local resource agency staff, tribal experts, academics, end users, and other subject matter experts familiar with Regulatory program requirements and the wetland types addressed by the rapid assessment method. The assessment team often includes individuals with expertise in wetland ecology, vegetation, hydrology, soils, field data collection, the Regulatory program, scientific writing, statistics, and other relevant fields.

2.1.2 New method development

Development of new wetland rapid assessment methods should incorporate input from an interagency, multidisciplinary team of experts familiar with the wetland types, functions and/or conditions, and the gradient of impacts within the geographical area of interest. Team members should exhibit expertise in applying rapid assessment techniques, sampling methods and design, statistical analysis, Regulatory program requirements, and knowledge regarding wetland stressors and impacts occurring within the region. The names and professional resumes of all participants should be maintained for documentation purposes.

2.1.3 Evaluating existing methods

Wetland rapid assessment methods developed by an interagency, multidisciplinary team are preferable to those developed by a single individual, agency, or discipline. When comparing multiple methods for project application, those providing documentation of the team's

background and expertise are preferred over methods lacking this element.

2.1.4 Modifying existing methods

An interagency, multidisciplinary team review of the rapid assessment method should be conducted when modifying methods currently in use. The team review should include documentation of the decision-making procedure utilized in method modification. Many modification initiatives focus on (1) the assessment protocol, (2) calibration and scaling of assessment metrics, (3) the geographic extent of applicability, and (4) the interpretation of assessment method results. Changes to the assessment method should be incorporated where appropriate, especially when available data or published literature supports team recommendations, and the proposed changes enhance the accuracy, efficiency, and utility of the rapid assessment method for the Regulatory program. Documentation of changes made to the method, including associated rationale and justification, should be maintained using a data and document management plan to ensure transparency and promote the defensibility of the revised method.

2.2 Phase 2: Clearly defined assessment goals and outputs that align with Regulatory program needs

2.2.1 Description

Wetland rapid assessment methods are developed for a wide array of applications such as characterizing baseline conditions, determining potential impacts under the Clean Water Act permitting process, conducting alternatives analysis, and monitoring ecosystem restoration or compensatory mitigation outcomes over time (Smith et al. 2013; Berkowitz 2019). As a result, some rapid assessment methods are inherently more appropriate for Regulatory program applications. Users must consider the stated objective and purpose of assessment methods to determine its applicability to Regulatory program activities. For example, the Hydrogeomorphic (HGM) approach was specifically designed to support Clean Water Act requirements and has proven effective for a variety of Regulatory program needs (Brinson 1996; Cole 2006; Murray and Klimas 2013).

Wetland rapid assessment methods often indicate whether they are designed to evaluate indicators of ecosystem function or condition (Figure 1; Fennessy et al. 2004). Ecological functions are the physical, chemical, and biological processes that occur in ecosystems (Smith et al. 1995). The HGM has proven to be a rapid and defensible approach to document individual ecosystem functions (e.g., floodwater detention) or general classes of function (e.g., habitat, biogeochemical cycling) (Smith and Klimas 2002; Berkowitz et al. 2011). The 2008 Mitigation Rule defines ecosystem condition as the relative ability of an aquatic resource to support and maintain a community of organisms having a species composition, diversity, and functional organization comparable to reference resource (USACE and USEPA 2008). Wetland rapid assessment methods examining condition include the Ohio Rapid Assessment Method (ORAM) and the California Rapid Assessment Method (CRAM) (CWMW 2012). Many wetland rapid assessment approaches examine a combination of metrics related to both function and condition (Wardrop et al. 2007).

Many wetland rapid assessment methods also identify intended uses and applications. Users must determine if the selected methodology is appropriate for their Regulatory program needs based on its stated uses. Commonly cited applications include quantifying expected impacts of project alternatives, analyzing various mitigation options, prioritizing wetlands for special protection, identifying areas for potential achievement of other goals (e.g., habitat for endangered species), calculation of compensatory mitigation requirements, monitoring of compensatory mitigation projects, or estimation of anticipated functional/conditional lift associated with ecosystem restoration or enhancement actions (Mack 2001).

The outputs or products generated as part of the wetland rapid assessment methods should coincide with Regulatory program requirements and goals, and those requirements often differ with application (National Research Council 2001). For example, if the documentation of existing or baseline wetland function or condition is all the information needed, a simple numerical functional or conditional score likely meets the assessment objectives (Wakeley et al. 2001). Conversely, more complex applications require determining the gain or loss of wetland function/condition, including the anticipated losses likely to be caused by a regulated activity or the improvements in site conditions resulting from compensatory mitigation or restoration projects (USACE and USEPA

1990). These types of assessments require the generation of numerical assessment scores that facilitate calculation of mitigation requirements or credits under both no-action and action alternatives, including procedures accounting for the aerial extent of the activity, the specific wetland type(s) involved, temporal considerations related to patterns of ecological succession, as well as other factors.

Additionally, in cases where multiple wetland functions or conditions are evaluated, some assessment methods combine individual functional or conditional scores into a single value, often using simple averages, the minimum observed value, or another approach (Smith et al. 2013). The generation of a single value simplifies data interpretation and facilitates comparisons among similar wetland types, which may be useful for evaluating alternatives or other tasks (Fennessy et al. 2007). However, combining scores limits specificity and the ability to target individual conditional or functional elements, increases uncertainty, and makes method validation (i.e., determining method accuracy by applying independent measures) more difficult (Wakeley and Smith 2001; Fennessy 2004; Berkowitz and White 2013).

2.2.2 New method development

New wetland rapid assessment methods should clearly identify the objectives of the assessment approach and state how those objectives align with Regulatory program requirements. For example, is the tool designed to determine baseline conditions or to support more complex analysis integrating changes in wetland functions (or conditions) across space and time as a result of project implementation? The outputs generated by the wetland rapid assessment method should be usable in a Regulatory program context, including the capacity to conduct in-kind (and where applicable, out-of-kind) comparisons for the target wetland types evaluated. Assessment method documents should transparently demonstrate how results are determined, including the mathematical formulas and/or multimetric relationships utilized in scoring wetland function and condition.

2.2.3 Evaluating existing methods

When comparing multiple rapid assessment methods, methodologies that clearly indicate how objectives and outputs align with Regulatory program needs are preferable to approaches lacking this element. When absent,

users need to determine the extent to which the assessment method objectives and outputs are appropriate for Regulatory program applications. The rationale and justification for the selection and application of a wetland rapid assessment method should be documented in the description of the project record or elsewhere to promote transparency and the appropriate interpretation of assessment outcomes.

2.2.4 Modifying existing methods

For wetland rapid assessment methods that lack clear linkages between Regulatory program requirements and the objectives and outputs of the methodology, documentation can be developed outlining the intended purpose, intended applications, and practical outputs generated by the assessment method. Documentation should include information regarding the decision-making procedure utilized in method development and focus on whether the assessment method is intended to evaluate ecosystem function or condition and identify suitable applications for the methodology (e.g., determination of project impacts, calculation of mitigation requirements). Additionally, if the purpose or intended applications of an existing assessment method are expanded or modified, documentation concerning the rationale supporting expansion and any data, end user feedback, or other information supporting the decision-making process should be incorporated into wetland rapid assessment methods supporting materials. Increasing the usability of assessment method results may include developing a mechanism for incorporating a spatial dimension to condition or function scores. For example, Smith and Klimas (2002) and other HGM guidebooks generate wetland Functional Capacity Index (FCI) scores on a scale of 0.0 to 1.0. The FCI scores are designed to incorporate a spatial component, when needed, by multiplying the FCI score by the size of the affected area to yield Functional Capacity Unit (FCU) scores (Smith et al. 1995). This approach has proven useful for several Clean Water Act applications across a range of project types, scopes, and time intervals (USACE 2021).

2.3 Phase 3: Wetland classification

2.3.1 Description

Wetland functions and conditions differ across wetland types. As a result, many wetland rapid assessment methods integrate ecosystem classification into the methodology (Brinson 1996). While some wetland

rapid assessment methods do not utilize ecosystem classification (e.g., ORAM), several studies indicate that the classification improves the accuracy and defensibility of assessment approaches (Reppert and Sigleo 1979; Karr and Chu 1997, 2006; Stoddard et al. 2006). Wetlands display variability within the same ecological regions (e.g., forested freshwater riparian floodplains versus tidal marshes in the southeastern Coastal Plain). Classification reduces the effect of variability of different ecosystem types on assessment method outputs. Classification increases the ability to discern differences among individual sites, and aids the selection of appropriate assessment metrics during method development (Stein et al. 2009a; Smith and Klimas 2002). Wetland classification also increases the accuracy and repeatability of assessment methods by defining target ecosystems with similar structure and function, which enables both in-kind and out-of-kind comparisons utilized by Regulatory program (Wharton 1978; Smith et al. 1995). In addition, the stressors that affect ecological function and condition may differ among the various wetland types occurring in a region (Fennessy et al. 2007). Depending on the goals of the wetland rapid assessment method, the classification system used may be broad or narrow (Sutula et al. 2006). Examples of classification systems applied in wetlands include categories based on vegetative characteristics, hydrologic regimes and hydrodynamics, soil features (e.g., mineral or organic), and geomorphic characteristics (Cowardin et al. 1979; Brinson 1993).

2.3.2 New method development

During the development of new wetland rapid assessment methods, development teams should consider opportunities to incorporate ecosystem classification into the approach because classification has been shown to improve assessment accuracy and defensibility. The rationale for selecting a particular classification system should be documented, along with a description of the target ecosystem characteristics (including potential adverse impacts and other stressors) found within the region. Care must be taken to develop a classification system based on sound scientific principles, but is not overly cumbersome, complex, or beyond the expertise of properly trained practitioners. For the purposes of rapid wetland assessment methods, no more than two layers of classification are recommended. For example, Smith and Klimas (2002) classify assessment areas as riverine, depressionnal, flats, and fringe wetlands. A second layer of classification subdivides these wetland types due to differences in how they function (e.g., riverine wetland class is subdivided into riverine

overbank and riverine backwater wetlands). In many cases, wetlands can be effectively classified using a single layer of classification based on readily observable landscape position, hydrodynamics, and/or floral community structure and composition.

2.3.3 Evaluating existing methods

When comparing multiple rapid assessment methods, methodologies that include wetland classification are preferable to approaches lacking this element. When absent, users need to determine the extent to which an assessment method is appropriate for Regulatory program applications, or if the lack of a classification scheme poses a significant challenge to achieving project objectives (e.g., unreliable results, inability to compare within or across wetland types). Considering how the wetland classification scheme influences the assessment method outcomes, and how the outcomes will be applied is another important consideration when evaluating the effects of wetland classification on existing methods.

2.3.4 Modifying existing methods

Wetland assessment approaches currently in use that do not classify wetland types as described above can be modified to integrate a classification scheme into the methodology. Modification should focus on (1) the wetland types observed with the region, (2) the position of target ecosystems within the landscape, (3) what physical drivers (e.g., hydrologic regime, salinity) and structural and biological community factors (e.g., channel morphology, vegetative growth form) distinguish target wetland classes, and (4) how potential stressors differ across wetland types. In some cases, modifications of existing assessment approaches have expanded the ecosystem classes initially addressed with an assessment method, in other instances wetland rapid assessment methods have simplified the classification system to improve usability. Modifications should be accompanied using data collection and published literature supporting the implementation of a wetland classification element or alteration of an existing wetland classification scheme.

2.4 Phase 4: Defined geographic extent

2.4.1 Description

Wetland rapid assessment methods differ in their geographic area of intended application. The geographic extents of intended method

application are defined using ecological or geophysical regions (e.g., watershed, ecoregion, Land Resource Region, Major Land Resource Area) or restricted to one or more geopolitical area (e.g., state, county) (Omernik 1987; USDA 2006; Smith et al. 2013). Limiting the geographic region addressed by an assessment method improves accuracy and efficiency by accounting for regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors affecting wetland functions and conditions (National Research Council 1995; Wakeley 2002).

2.4.2 New method development

Newly developed wetland rapid assessment methods should define the intended geographical extent of the methodology during the development process. The rationale for selecting a particular geographical area should be documented along with a description of the target wetland characteristics found within the region and potential stressors that may adversely affect wetland function or condition. Assessment method developers should attempt to balance the need for a well-defined geographic extent, which improves accuracy by limiting variability, with the need to develop methods that can be applied as broadly as possible without sacrificing quality. Developers should also consider how agency boundaries (USACE District areas of responsibility, EPA regions) can inform the selection of an appropriate geographic extent for assessment method application. Finally, the selected geographic extent will often be influenced by the wetland classification phase described above, because wetland types vary spatially on the landscape and often align with the natural boundaries used to define ecoregions and land resource regions. As a result, developers should work to define the appropriate geographic extent that coincides with the wetland classes (and potential stressors) that require assessment by the Regulatory program.

2.4.3 Evaluating existing methods

When comparing multiple rapid assessment methods or reviewing a method to determine if it is appropriate for Regulatory program application, methodologies that include a clearly defined geographic extent are preferable to approaches lacking this element. In general, methods that define geographic extents using ecologically derived boundaries are preferred over approaches that utilize geopolitical boundaries. However, this element must be considered in the context of the other phases described herein to identify the most appropriate

methodology for a given project or Regulatory program requirement. When absent, users need to determine the extent to which an assessment method is appropriate for application in the region of interest, or if the lack of a defined geographic extent poses a significant challenge to achieving project objectives (e.g., unreliable results, inability to compare results across different areas). Considering how the geographic extent addressed by a wetland rapid assessment method influences how the assessment method and its outcomes will be applied by the Regulatory program is another important consideration when evaluating existing methods.

2.4.4 Modifying existing methods

For wetland rapid assessment methods currently in use that do not define a specific geographic region in which it is to be used, documentation can be developed defining the intended geographic area for assessment method application. Documentation should define the applicable assessment region using geophysical, ecological, or (when necessary) political boundaries and include a rationale supporting the selected boundaries. In some cases, modifications of existing assessment approaches have proven effective for expanding the assessment method beyond the geographical region or ecosystem types originally intended. The expansion of existing geographical ranges should be based upon data collection and published literature supporting the expansion process. Berkowitz et al. (2014) describes a framework for the data-driven expansion of rapid wetland assessment methods.

2.5 Phase 5: Rapid application

2.5.1 Description

Wetland rapid assessment methods can impact Regulatory Program efficiency through the time required to complete the assessment procedure and the amounts and types of data that need to be collected. Approaches necessitating many field measurements or time-consuming analysis are beyond the scope of a wetland rapid assessment. Wetland rapid assessment methods must be usable by staff of different backgrounds, and the methods must be practical and expedient to meet the requirements of the Regulatory program (Stein et al. 2009a, 2009b; Wardrop et al. 2007). Rapid assessment methods (RAMs) should require no more than one day to complete, combining office work and site visits to gather and analyze

information for the assessment (Smith et al. 1995, 2013; Fennessy et al. 2004; van Dam et al. 1998; Mack et al. 2000; Berkowitz et al. 2011). Fennessy et al. (2007) reviewed data from 16 assessment approaches and reported that rapid functional and conditional assessments can effectively be completed in one day or less. Most RAMs provide a written protocol outlining data collection and analysis procedures (data sheets, formulas, surveys) that promote consistent, rapid application.

Large, complex projects may require the completion of multiple wetland rapid assessments, or in some cases, may not be well suited for the application of a rapid assessment. However, wetland rapid assessments have proven successful and efficient for large project applications when properly applied and using care to collect an adequate amount of data. For example, USACE (2021) involved the collection of wetland rapid assessment data at 321 locations during the evaluation of a large Civil Works project occurring across multiple states. Other, more time intensive approaches were deemed impracticable due to the large size of that project, highlighting the utility of rapid wetland assessment methods.

2.5.2 Development of new methods

The development of new wetland rapid assessment methods should require no more than one day per assessment area to complete based upon the application of a clear, written protocol. Documentation demonstrating time requirements should be compiled during method development, field testing, and implementation (Berkowitz et al. 2011). Making documents available and easily accessible will promote rapid application of the method. Under some circumstances (e.g., difficult terrain, highly disturbed or complex areas, inexperienced user) more time may be required to complete the assessment method, or multiple assessments will be required to meet the needs of the Regulatory program.

2.5.3 Evaluating existing methods

When evaluating multiple methods, users should select the best available method that will yield accurate results without requiring an excessive amount of data collection or interpretation. Wetland rapid assessments that can be completed in a day or less while providing accurate and defensible results are preferred over approaches that require additional time to complete.

2.5.4 Modifying existing methods

For wetland rapid assessment methods currently in use that cannot be completed in a day or less, documentation can be modified to demonstrate the time required to apply the assessment method as written, including the amount of time required to complete each component of the assessment protocol. Users can examine the components of the assessment protocol and determine whether redundancy exists within the assessment procedure or whether any steps in the assessment procedure can be modified or eliminated to reduce the amount of time necessary to conduct the assessment to a day or less. Smith et al. (2013) provides guidance on identifying and removing redundant and unnecessary metrics from assessment methods and promoting efficiency while maintaining accuracy. The alteration of assessment protocols should be documented, including the rationale for the changes that are made and, when possible, data demonstrating the effect of those changes on assessment outcomes. In some cases, a wetland rapid assessment method may not be possible or appropriate, and alternative, more intensive methods should be applied (Figure 2; Kentula 2007).

2.6 Phase 6: Calibration and metric scaling based on reference data

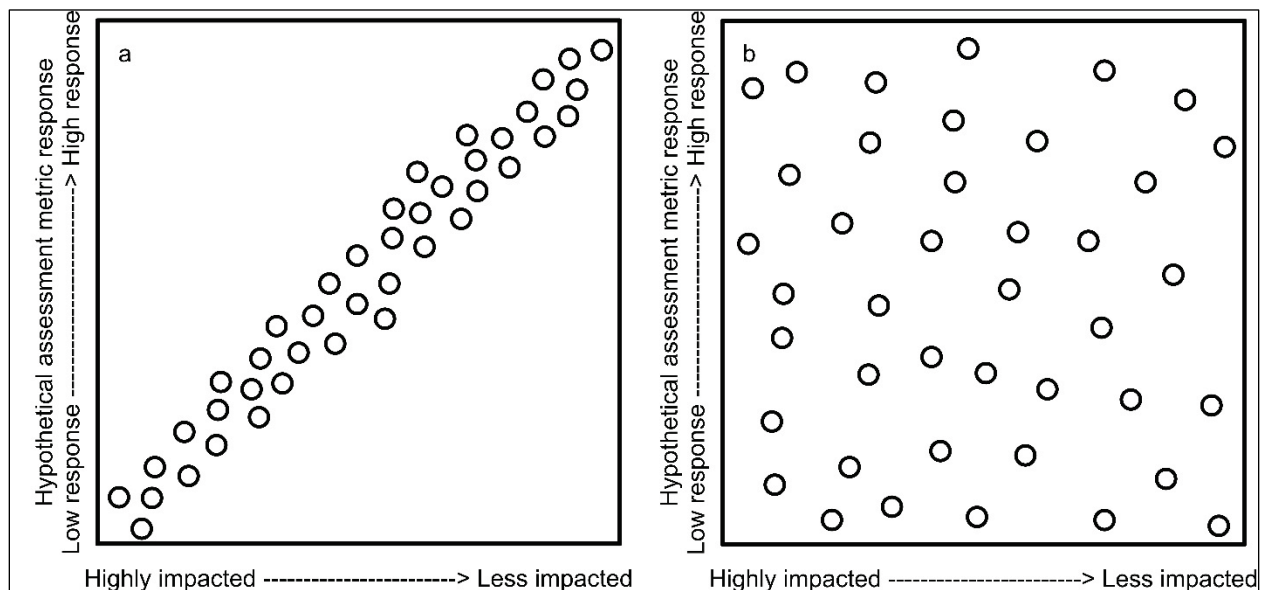
2.6.1 Description

Wetland rapid assessment method calibration provides the standard of comparison used to scale assessment observations and measurements based on the level of condition or function a wetland exhibits. Assessment method calibrations are derived from a combination of available literature and data collected during method development (Smith et al. 2013). The opinions of resource professionals [i.e., best professional judgment (BPJ)] are also often incorporated in the calibration process (USACE 1999). Calibration aids in the selection of assessment metrics (Figure 4) and determines how individual assessment metrics and the overall level of wetland function or condition are scored (Figure 5).

Common calibration approaches include the comparison of assessment method scores with observations made in wetlands exhibiting reference conditions/functions across a gradient of ecosystem disturbances (Hughes et al. 1986; Brinson 1993; Smith et al. 1995; Smith et al. 2013; David et al. 2021). Stoddard et al. (2006) discusses the use of reference sites within a wetland assessment context and highlights how a clearly defined reference

framework is required to properly calibrate assessment methodologies. David et al. (2021) discusses the development of a reference framework and how to compile and evaluate that information within a regulatory context. Whigham (1999) also describes how method calibration based upon reference data and statistical analysis promotes accuracy and efficiency when comparing less impacted, fully functional wetlands to wetlands exhibiting a range of stressors.

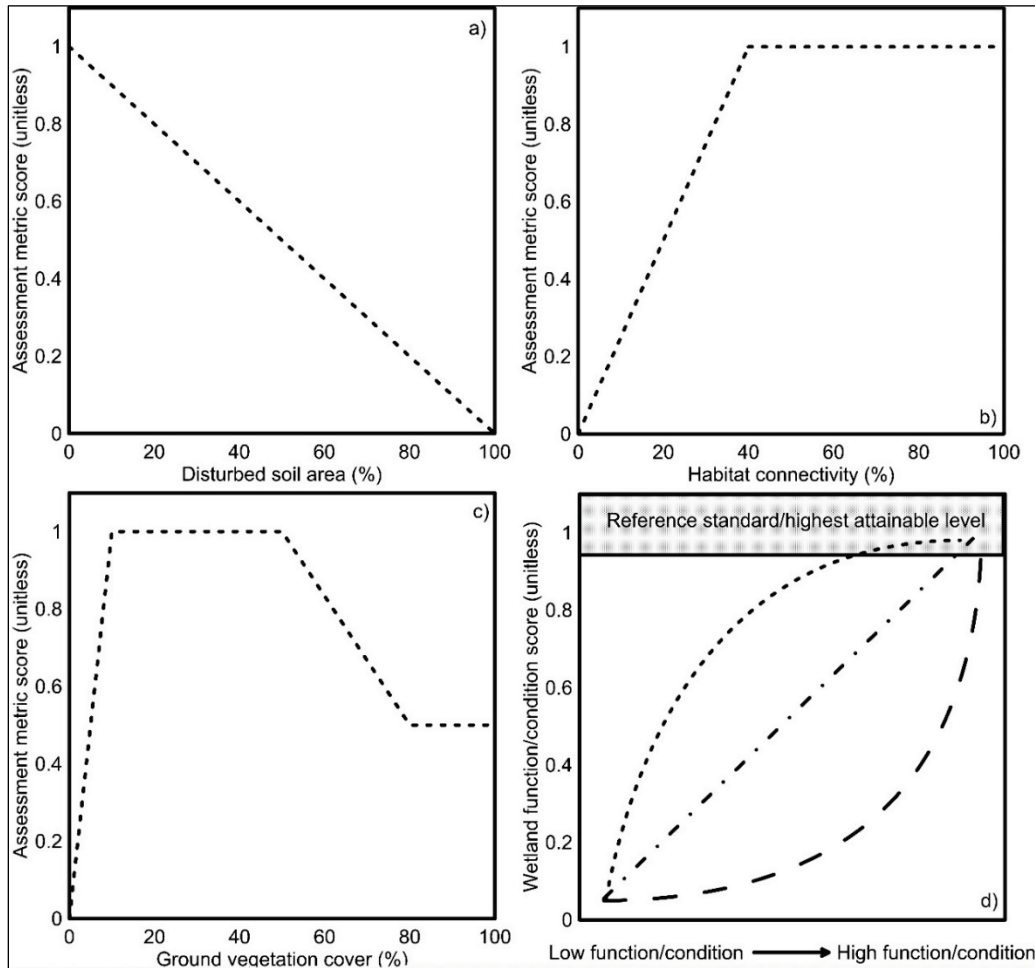
Figure 4. (a) Example of wetland rapid assessment method metric showing a linear response to changes in the degree of disturbance. Note that the figure displays a clear visual relationship between the assessment metrics and site condition. A positive linear example is shown here, but asymptotic, negative linear, or other configurations are possible. (b) Example of an assessment metric that does not respond in a consistent or predictable manner to changes in site function/condition. Based on the observed relationships, the metric depicted in (a) may be useful for inclusion in the assessment method, while the metric in (b) is not appropriate for inclusion. Modified from Smith et al. (2013).



Wetland rapid assessment methods are generally calibrated at two levels. First, individual assessment metrics are calibrated based on their response to a gradient of ecological conditions. For example, individual assessment metrics may increase or decrease linearly across the full observed range of ecological conditions (Figure 5a), exhibit threshold effects that once exceeded no longer respond to changes in ecological conditions (Figure 5b) or display more complex responses to changes in ecological conditions (Figure 5c). At the assessment method level, multiple metrics are combined and calibrated to produce a score reflecting the wetland function or condition being provided relative to regional references. This

entails evaluating different assemblages of individual assessment metrics using empirical equations to yield assessment scores that align with the observed level of function/condition occurring across a range of unaltered and altered wetlands. At the assessment level, careful calibration is needed to ensure that unaltered, fully functional wetlands receive the highest achievable score, and that the assessment outputs accurately reflect the level of impacts or stressors present within wetlands that should receive lower assessment scores. Note that the relationships between wetland function or condition and assessment scores can be linear, exponential, or follow other configurations due to ecological thresholds (e.g., canopy closure) (Figure 5d; Allan 2004). Smith et al. (2013) provides additional guidance on approaches to wetland rapid assessment calibration at both the metric and function/condition level.

Figure 5. Examples of wetland rapid assessment calibration illustrating (a) an assessment metric with a linear response across the observed range of conditions; (b) an assessment metric response displaying a threshold effect; (c) a metric response that increases and decreases around an ideal range of conditions (adapted from Murray and Klimas 2013); and (d) theoretical relationships between the level of wetland function or condition and rapid assessment score.



2.6.2 New method development

Newly developed wetland rapid assessment methods should be calibrated based upon collected and/or published data generated in reference areas exhibiting minimally disturbed function or condition and a gradient of ecosystem disturbances and degradation. Calibration should be used to both select and score individual assessment metrics. Additionally, the entire wetland assessment method should be calibrated by evaluating various empirical equations to ensure that the assessment scores appropriately reflect the range of wetland function or condition observed in the region. Sensitivity analysis and other statistical approaches provide calibration tools to aid in both the selection of individual assessment

metrics and the configuration of the overall scoring system. Documentation should describe the selection and implementation of the calibration process.

2.6.3 Evaluating existing methods

Wetland rapid assessment methods calibrated using data collected in the region are preferred over methods based exclusively on published literature or professional judgement. When comparing multiple methods, assessments that utilize calibration in the selection and scaling of individual assessment metrics are preferred over methods that lack this element. Additionally, wetland rapid assessment approaches that clearly indicate how calibration was used to inform the development of empirical models across a range of wetland function or condition are favored because those approaches yield more accurate and defensible results. Conducting sensitivity analysis or other statistical approaches during the calibration process can help to determine the reliability of a wetland assessment method or identify a preference for an existing assessment methodology.

2.6.4 Modifying existing methods

For wetland assessment methods which were not calibrated based on collected reference data, calibration can be conducted by comparing the responses of individual assessment metrics or assessment scores to data collected at locations exhibiting a range of function or condition. Based on the results of those analyses, the assessment method may require modification, including adjustments to the scaling of individual assessment metrics or the empirical equations used to generate assessment outputs. The decision-making procedure used to calibrate the assessment method should be documented, along with all data and available literature supporting the modifications. In instances where professional judgement forms the basis of the assessment calibration method scoring system, data obtained from field work, monitoring reports, and published literature can be used to improve assessment method accuracy and defensibility. David et al. (2021) discusses how to evaluate data quality when compiling reference data from multiple sources. In many cases, a small amount of calibration data from strategic locations exhibiting the range of function can inform method modification.

2.7 Phase 7: Application of numerical data based upon written protocols

2.7.1 Description

Both numerical (i.e., quantitative) and qualitative metrics have been incorporated into wetland rapid assessment methods. Quantitative data includes measurements and estimates generating numerical values (Berkowitz et al. 2011). For example, wetland assessment protocols often utilize continuous variable measurements such as tree diameter, visual estimates of the percentage of ground vegetation cover, and remotely sensed measurements of a project area characteristics. All of these measures result in the generation of numerical data. Quantitative data also include discrete variables such as counts of vegetation species within a defined area or the number of layers of vegetation (Smith and Klimas 2002). These discrete variables result in the generation of numerical data. Both continuous and discrete numerical variables can be categorized in order to increase efficiency and simplify data interpretation. For example, Murray and Klimas (2013) describe methods for determining the extent of potential ponding as a measure of microtopographic relief. The ponding variable begins with an estimate of the percentage of the assessment area surface having microtopographic depressions and vernal pool sites capable of ponding rainwater, generating numerical data (e.g., 40%). The estimate is based upon either the presence of water immediately following an extended rainy period, or indicators such as water-stained leaves or changes in ground vegetation cover during dry periods. The quantitative, numerical measurement is then translated into a categorical variable (Table 1; 40% ponding yields a metric score of 1.0). This approach is efficient and makes data easy to interpret. This approach also facilitates the production of consistent results among users (Berkowitz et al. 2011). The technique of grouping or categorizing numerical data is widely applied (Daubenmire 1959; Floyd and Anderson 1987) and Fennessy et al. (2004) suggests that categorizing assessment components derived from numerical data dampens variability among users resulting in a more robust methodology.

Table 1. Example of a quantitative metric combined into categorical metric scores for determining ponding in riverine backwater wetlands (adapted from Murray and Klimas 2013).

Assessment metric score	Percentage of potential ponding (microtopographic relief)
1.0	21%-70%
0.7	15%-20% or 70%- 85%
0.4	5%-14% or >85%
0.1	<5%

Qualitative variables commonly employ narrative statements or diagrams, often based on a non-numerical, visual assessments that document the presence or absence of observable ecological stressors. Notably, qualitative variables do not require the measurement of a particular metric and do not generate a numerical value such as the percentage of canopy cover in a study area. Table 2 provides an example of the descriptive categories utilized in the Uniform Mitigation Assessment Methodology (UMAM 2007). In this example, qualitative ratings are solely based on descriptive statements and no numerical data is used to differentiate between categories. Although a number (e.g., a score of 10) is generated based on the narrative descriptions, the approach lacks numerical data supporting the outcome. While, qualitative approaches potentially increase efficiency, they lack sensitivity and result in increased subjectivity (Whigham et al. 1999). Many assessment methods contain a combination of numerical and qualitative elements.

Table 2. Example of qualitative narrative statements applied in determining vegetation and structural habitat (UMAM 2007).

-
- A score of (10) means that the vegetation community and physical structure provide conditions which support an optimal level of function to benefit fish and wildlife utilizing the assessment area as listed in Part I.
 - A score of (7) means that the level of function provided by plant community and physical structure is limited to 70% of the optimal level.
 - A score of (4) means that the level of function provided by the plant community and physical structure is limited to 40% of the optimal level.
 - A score of (0) means that the vegetation communities and structural habitat do not provide functions to benefit fish and wildlife.
-

The type of data collected (i.e., numerical or narrative) dictates the output generated by each wetland rapid assessment. Numerical data is easily translated into wetland rapid assessment method scoring systems because quantitative outputs occur across a continuous or discreet range. For

example, many assessment approaches scale results across ranges of 0.0 and 1.0 (or 0.0 and 100) (Smith and Klimas 2002; Sutula et al. 2006); with zero representing the absence of that function or the lowest level of condition and 1.0 (or 100) representing the highest attainable level of function or condition. Numerical metrics can easily be scaled into these scoring systems. Alternatively, assessments of wetland condition often employ scoring approaches that place a wetland within a continuum from least disturbed (condition similar to a reference standard) to highly disturbed (poor condition). Narrative, qualitative outputs also often describe an ecosystem condition as “Excellent,” “Good,” “Fair,” or “Poor” or as “High,” “Medium,” or “Low,” or apply a grading scale (A = unimpacted; F = highly impacted). These narrative, qualitative descriptions have the advantage of being easily understood by a wide range of stakeholders and are often converted to some numerical proxy (e.g., “Excellent” translates to a score of 1.0). However, Klimas (2008) suggests that utilizing broad narrative and qualitative categories increases user bias, decreasing accuracy and repeatability.

The objectivity of an assessment method impacts outcomes, with more objective measures yielding more repeatable, accurate, and defensible results. For example, measuring the diameter of each tree within a defined area yields accurate and quantitative, repeatable results (Berkowitz et al. 2011). Qualitative data utilized in assessment methods generally rely on narrative statements (e.g., Table 2) or the perceived presence or absence of ecological stressors. Examples of qualitative narrative descriptions can be found in Wardrop et al. (2007), which also incorporated some metrics tied to numerical thresholds (Table 3). While direct measurement of tree diameter or the exceedance of some threshold level leads to more objective results, several of the categories presented in Tables 2 and 3 remain subjective because responses depend on user experience, training, and perception. For example, the statement “Heavy or moderately heavy cover of algal mats” is problematic because what one user considers “heavy or very heavy” may be interpreted as normal and appropriate to another user. As a result, Klimas (2008) notes that although qualitative approaches are designed to be rapid, they often lack sensitivity and potentially decrease accuracy and repeatability.

Table 3. Examples of qualitative narrative descriptors and numerical thresholds used in a rapid wetland rapid assessment method (adapted from Wardrop et al. 2007).

Qualitative narrative descriptors
<ul style="list-style-type: none"> • Excessive density of aquatic plants or algal mats in water column • Excessive deposition or dumping of organic waste • Severe vegetation stress • Obvious increase in concentration of dissolved salts • Excessive herbivory • Heavy or moderately heavy cover of algal mats • Excessively clear water • High concentration of suspended solids in water column • Significant increase in water temperature
Quantifiable numerical thresholds
<ul style="list-style-type: none"> • Dominance (>50% cover) of sediment tolerant vegetation • Dominance (>50% cover) of exotic or invasive plant species • Tree cutting (>50% canopy removed) • Dominance (>50% cover) of nutrient tolerant vegetation

In addition to the advantages of collecting numerical data, the effective and accurate execution of rapid assessment methods also requires clear sampling and analysis protocols. Clearly written, published protocols promote repeatability and allow end users to: determine the type of wetland being assessed (Johnson et al. 2008); define the assessment area (Sutula et al. 2006); collect all required data, including data forms (Noble et al. 2002); conduct data analysis (Stein et al. 2009b); and apply assessment results. The protocol should also identify any temporal assessment application windows, which are periods when the method should or should not be used due to limitations associated with vegetative growth form, seasonal patterns of hydrology, or other factors. Smith et al. (2013) outlines procedures for developing end-user protocols.

Quantitative and qualitative data can both be generated during site visits or using office-based resources (e.g., GIS, aerial photos), and most wetland rapid assessment methods require an onsite field visit (Fennessy et al. 2007). In some cases, site visits are not required to complete the assessment. For example, Berkowitz et al. (2017) developed a wetland rapid assessment that can be applied with or without a site visit due to the remote nature of the assessment area (North Slope of Alaska) and the limited seasonal period when site visits can be conducted. Completing a site visit adds to the amount of time required to complete the assessment, but allows for evaluation of site-specific, quantitative, numerical

measurements (e.g., tree diameter) and increases the precision of the assessment method (Sutula et al. 2006). A site visit also enables direct observation of indicators of aquatic resource function or condition, the verification of data generated from remotely sensed data, and many of the metrics used in rapid assessment methods simply cannot be accurately evaluated using remote sensing techniques.

2.7.2 New method development

The development of new wetland rapid assessment methods should utilize numerical data, develop a detailed written and published protocol, and incorporate a site visit (where possible) during normal application because those elements result in more accurate and defensible assessments in the context of the Regulatory program. Both onsite and offsite measurements should be organized into groups or categories, as appropriate, to promote efficiency and repeatability. A clear, written protocol should provide guidance on applying the method, detailing data collection and analysis, providing examples of how the results can be applied and interpreted, and identifying any temporal assessment windows.

2.7.3 Evaluating existing methods

Rapid wetland assessment methods that utilize numerical variables (linear, discrete, or categorical) linked with quantitative data are preferred over methods that lack this element. Additionally, written protocols clearly meeting requirements of the Regulatory program are preferred over methods lacking a direct link with the program requirements. In general, methodologies that require a site visit are preferred over those based solely on remotely sensed metrics.

2.7.4 Modifying existing methods

In instances where narrative statements or the presence/absence of ecosystem stressors form the basis of the assessment method, quantitative data can be used to improve the accuracy and defensibility of assessment results. In many cases, a small amount of well documented data strategically gathered across reference sites exhibiting a gradient of altered functions or conditions can provide a defensible basis for modifying existing methods (Smith et al. 2013) or for defining the limitations of a given assessment approach for Regulatory program applications. If a wetland rapid assessment method does not include a clear, published

assessment protocol, a protocol can be developed and made publicly available. The protocol should include guidance for applying the method, detail data collection and analysis procedures, provide examples of how the results can be applied and interpreted, and identify any temporal assessment windows associated with method application. Similarly, assessment methods that currently do not require a site visit can be improved by incorporating onsite measures into the existing methodology.

For rapid wetland assessment methods currently in use that do not collect numerical data, documentation can be developed to integrate quantitative measurements into the assessment method. Examples of suitable numeric measures include readily quantifiable aspects of ecosystem structure (e.g., number of strata; extent of microtopographic relief), vegetation community (e.g., species richness, abundance of invasive species); site hydrology (e.g., flood frequency; distance from a water source), and other rapid measures with established relationships to ecological condition or function. The decision-making procedure utilized to select quantitative measures should be documented along with data supporting any modifications made based on the data collected or references cited. When quantitative metrics or field-based measurements are integrated into the assessment method, they should be calibrated as described above.

2.8 Phase 8: Verification of assessment metrics and outcomes

2.8.1 Description

Verification of a wetland rapid assessment method involves evaluating the logic and sensitivity of the methodology (Smith et al. 2013). The goal of verification is to answer the following types of questions. In general, does the assessment perform as envisioned by its developers? Is it sensitive to the types of impacts and stressors that can be expected to occur in the target ecosystem? Do the assessment metrics reflect the relevant attributes and processes occurring within the wetland? Are the empirical equations used to combine assessment metrics appropriate?

The data used for verification should also be evaluated to determine whether the assessment method operates logically, with each assessment metric and the aggregated empirical equations work as intended. To verify the logic of a wetland rapid assessment method, developers apply field data or hypothetical data and evaluate the results and outputs of the assessment. The two basic approaches to testing model logic include

sensitivity analysis and applying the assessment method to sample data sets (Schroeder and Haire 1993; Smith et al. 2013). Notably, verification differs from assessment method validation, which compares rapid assessment method outputs to direct measures of wetland function or condition in a hypothesis testing context (e.g., direct measurement of habitat utilization, stormwater detention, or denitrification; Figure 2).

2.8.2 New method development

Newly developed wetland rapid assessment methods should conduct verification procedures to evaluate the logic and sensitivity of the assessment approach in detecting changes in ecosystem condition or function. Verification should demonstrate that the assessment method operates as intended by developers. Applied together, sample data sets and sensitivity analysis work well to verify wetland rapid assessment methods.

In order to verify methods using sample data sets, the assessment should be applied at sample locations exhibiting a range of wetland functions or conditions. The sample locations should not have been previously used during calibration or other phases discussed herein. Once completed, the data from each individual assessment metric should be compared with the calibrated scoring system to ensure that the metric is responsive to variations in wetland function or condition. The overall assessment output can also be evaluated across a disturbance gradient to ensure that the method is generating assessment scores that are responsive to variations in wetland function or condition and that the empirical assessment equations are operating as intended.

Sensitivity analysis tests the responsiveness of each assessment metric by varying the score of a single metric while keeping all other metrics constant. This is accomplished by evaluating a target assessment metric across a range of intervals (e.g., 0.0, 0.1, 0.5, 1.0) while iteratively keeping the scores for all other assessment metrics at the constant score. Sensitivity analysis identifies assessment metrics that impart a higher impact on assessment scores. Graphing the results of the sensitivity analysis allows for rapid interpretation of the results, denoting which variables are responsive across different metric scores, as well as identifying metrics that exhibit steeper slopes which indicates they have more influence on the assessment outcome. Sensitivity analysis is particularly useful for identifying redundancies among assessment metrics

and can be used as justification for the removal of repetitive or unnecessary variables during the verification process.

2.8.3 Evaluating existing methods

Wetland rapid assessment methods that underwent verification are preferred over approaches that lack this element. In particular, accurate and defensible methods document how the assessment metrics were selected, combined into empirical equations, and tested to ensure that the method is responsive across the observed range of wetland functions or conditions. Methods that conducted sensitivity analysis or applied other statistical approaches to evaluate assessment metrics and outputs are preferred for use for Regulatory program applications.

2.8.4 Modifying existing methods

For wetland rapid assessment methods currently in use that did not undergo verification, developers can conduct verification via one of two methods. First, the responsiveness of the assessment method can be verified through the collection and analysis of field data at locations exhibiting the disturbance gradient of functions and conditions found within the region. The field data should be analyzed to determine whether or not assessment outcomes respond appropriately to changes in function or condition due to natural changes, anthropogenic disturbances, and other stressors. At the most basic level, undergraded natural areas should yield higher assessment scores than wetlands exhibiting a range of alterations. Verification for the modification of existing methods can be conducted as described by Smith et al. (2013) and Noble et al. (2014), which provides examples of sensitivity analysis outcomes utilized in a verification context.

2.9 Phase 9: Peer review and implementation

2.9.1 Description

Many wetland rapid assessment methods undergo independent peer review, and some approaches require independent peer review as part of the method development (Smith et al 2013). Clairain (2002) describes a procedure for distributing assessment methods and supporting materials to peer reviewers and incorporating reviewer recommendations into the assessment approach. The peer review process promotes technical accuracy and defensibility, and encourages stakeholder buy-in through

participation from experts within federal, state, tribal, and local agencies, academia, and the private sector (Federal Register 1997). Proper implementation of wetland rapid assessment methods is essential to promote adoption of the method by practitioners, proper application of the method, and appropriate interpretation of assessment results. A well-executed implementation strategy includes the following: (1) publicly available documentation of the assessment method, (2) a plan for reviewing and updating the assessment method and data management approaches as the need arises, (3) a training plan, (4) distribution of the wetland assessment method to end users, stakeholders, and the public, (5) continuing support, training, and technical assistance to end users, and (6) a documented approach to update the assessment method, training, and data management tools as the need arises (David et al. 2021).

2.9.2 New method development

Development of new wetland rapid assessment methods should incorporate an independent peer review during the development process. The peer review should examine the assessment protocol, calibration and scaling of assessment outcomes, and the application of assessment results (including usability and practicality). Reviewer comments should receive a written response, and changes should be incorporated where appropriate, based on data analysis and where published literature supports modification. Assessment method developers should include a minimum of two peer reviewers with experience concerning wetland rapid assessment techniques, sampling methods, and exhibiting knowledge regarding ecosystem types addressed by the method. Wetland rapid assessment developers should maintain documentation of the peer review process, including the names and credentials of the peer reviewers, and all responses to reviewer comments. New wetland rapid assessment methods should also include a documented long-term implementation strategy and training plan.

2.9.3 Evaluating existing methods

Wetland rapid assessment methods that underwent a transparent peer review process are preferred over methods that did not. When comparing multiple methods, evaluate the available documentation to determine who conducted the peer review and how the comments were addressed. Assessment methods with appropriate peer review are considered more accurate and defensible for Regulatory program applications.

2.9.4 Modifying existing methods

For wetland rapid assessment methods currently in use that did not undergo peer review as described above, independent peer reviews can be conducted. The review should include available information documenting the decision-making procedure utilized in method development and focus on the (1) assessment protocol, (2) calibration and scaling of assessment parameters, and (3) application of assessment method results. Peer review comments should receive a written response. Changes to the assessment method should be incorporated where appropriate, especially when available data and published literature supports reviewer recommendations, and the proposed changes enhance the accuracy, efficiency, and goals of the rapid assessment method. A modified implementation strategy and training plan may be required.

2.10 Flexibility

Wetlands can exhibit a high degree of variability within a given geographic area and across wetland types. As a result, approaches to wetland rapid assessment must allow for flexibility in order to remain robust and practical and be adaptable for other regions or wetland classes. Additionally, this report provides a tool to assist with method development, evaluation, and modification. However, some of the phases described herein may not be applicable or appropriate in all cases. Additionally, the availability of wetland rapid assessment methods does not preclude the application of more intensive assessment methodologies or data collection, such as floral or faunal surveys and monitoring, analysis of water chemistry, Environmental Impact Statements, or hypothesis testing when additional information is needed to meet the requirements of the Regulatory program. Wetland rapid assessment methods should utilize the best available methodologies, and these guidelines are intended to support the development, evaluation, and modification of methodologies to yield the most accurate, consistent, and defensible outcomes possible.

3 Summary

A set of guidelines for developing, evaluating, and modifying wetland rapid assessment methods designed to evaluate the wetland condition or function have been introduced throughout this report.

Each of the nine phases are described, and applications for new method development and the evaluation and modification of existing methods are discussed within the context of the Regulatory program. The guideline phases include the following:

- 1) Interagency, multidisciplinary teams
- 2) Clearly defined assessment goals and outputs that align with Regulatory program needs
- 3) Wetland classification
- 4) Defined geographic extent
- 5) Rapid application, including a site visit
- 6) Calibration and metric scaling based on reference data
- 7) Application of numerical data based upon written protocols
- 8) Verification of assessment metrics and outcomes; and
- 9) Peer review and implementation

Documenting each phase and having a data management plan is encouraged to promote transparency, defensibility, and usability. The guidelines provide a tool to support technically accurate, science-based, defensible, consistent, and transparent approaches to wetland rapid assessment.

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14. ABSTRACT

The US Army Corps of Engineers (Corps) Regulatory Program considers the loss (decrease) and gain (improvement) of wetland functions as part of Clean Water Act Section 404 permitting and compensatory mitigation decisions. To better inform this regulatory decision-making, the Regulatory program needs accurate, transparent, objective, and defensible approaches to assess the function and condition of wetlands. Additionally, wetland assessments must balance the need for objective decision-making with the concurrent need to make Regulatory program decisions in a timely manner. Consequently, it is often necessary to assess wetlands using rapidly attainable proxy measures of ecological function or condition by evaluating a suite of metrics that represent structural and compositional attributes of a wetland. In response, this document describes a set of guidelines to effectively develop, evaluate, and modify wetland assessment methods, specifically for the Corps Regulatory Program.

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