CBP/TRS-327-19

Nontidal Wetland Creation, Rehabilitation and Enhancement

Recommendations of the Wetland Expert Panel for the nitrogen, phosphorus and sediment effectiveness estimates for nontidal wetland best management practices (BMPs)

DRAFT for CBP partnership review and feedback:
July 10, 2019
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Chesapeake Bay Program
Science. Restoration. Partnership.

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Cover Image: Chesapeake Bay Program

Executive Summary

The Wetland Workgroup approved the formation of this expert panel to evaluate the effectiveness of nontidal wetland best management practices (BMPs) to reduce loads of nitrogen, phosphorus and sediment to the Chesapeake Bay. This panel was formed to expand on the CBP-approved report by a previous Wetland Expert Panel that clarified the wetland restoration BMP and established two nontidal wetland land uses in the Phase 6 Chesapeake Bay Watershed Model (WEP, 2016).

The current panel first convened in November 2017 and deliberated its approach and recommendations over the subsequent months. This report describes the panel's recommendations for review, feedback and approval under the Chesapeake Bay Program's *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*, or "BMP Review Protocol."

The panel's recommended efficiency values for nitrogen, phosphorus and sediment are summarized in Table ES-1. As described in sections 4 and 5 of this report, the panel considered multiple lines of reasoning to arrive at these recommended estimates, including: multiple conceptual models; an updated literature review; an expert elicitation survey of panel members, and; functional assessment data of created and natural wetlands.

Table ES-1. Summary of removal efficiencies for nontidal wetland creation, rehabilitation and enhancement

Wetland BMP Type	TN (%)	TP (%)	TSS (%)
Restoration[1]	42	40	31
Creation	30	33	27
Rehabilitation	16	22	19
Enhancement	Not recommended		

[1] The wetland restoration efficiencies are provided for reference and the values are from WEP (2016).

The expert panel worked diligently to articulate BMP efficiencies for wetland creation, rehabilitation and enhancement with respect to the available literature and the CBP-approved wetland restoration BMP. As with wetland restoration, the recommended wetland creation BMP is simulated as a land use change that also reduces upland loads using the above efficiency value. The recommended wetland rehabilitation BMP is not a land use change, but the efficiency is applied to upland land uses. Further details for how the BMPs will be reported for progress runs and simulated in the Watershed Model are provided in Appendix B. As explained in section 5, the panel recommends that wetland enhancement should not be a BMP for purposes of achieving nutrient and sediment reduction targets under the TMDL, as simulated in the Watershed Model.

Contents [will be updated in final version]

Appendices

Appendix G – Expert Elicitation Survey Round 2 Questions and Results
Appendix H – Application of the Riparia Database Analysis to Estimate TN, TP and TSS Efficiencies
Appendix I – Compilation of partnership feedback and responses on the draft report
Appendix J – Panel minutes

List of Tables **[will be updated in final version]**

List of Figures **[will be updated in final version]**

Introduction

The modern history of human activities across a 64,000 square mile watershed has dramatically shifted the ecosystem structure of the Chesapeake Bay, thus leading to the decline of many iconic ~~species, including submerged aquatic vegetation, blue crabs, and oysters. Declines are due largely to habitat loss and degradation across the entire Bay watershed.~~species and habitats, including blue crabs, submerged aquatic vegetation, wetlands and oyster beds. In 2014, the Chesapeake Bay Program (CBP) partnership committed to the fundamental goal of restoring the Bay ecosystem health in the Chesapeake Bay ~~Restoration~~ Watershed Agreement.

Commented [HJ1]: Per Chris Spaur, USACE

The CBP partnership, a multi-agency partnership led by the six Bay states and the District of Columbia, identified healthy wetlands as a critical element of a restored Bay watershed. Since colonialization, more than 70 percent of historic wetlands were lost by drainage or infill. During the 18th and 19th Centuries the extensive construction of mill dams, combined with agricultural cultivation practices of the time, led to extensive deposition of legacy sediment, particularly in floodplain areas of the Piedmont region within the CBW. Substantial historic floodplain wetlands were lost by burial under this legacy sediment. Most of ~~these~~ the drainage impacts occurred during the twentieth century, when the vital role of wetlands for providing water quality and habitat benefits remained undervalued, and the demands of regional (and global) population growth, combined with modern technology and public works ditch and drainage projects, led to rapid agricultural and urban intensification. The most extensive losses from active ditching and filling occurred in the Coastal Plain, where proximity to water and highly tillable lands naturally led to a concentration of human activities. The ~~Chesapeake Bay~~2014 ~~Restoration~~ Watershed Agreement acknowledged the significance of these losses by establishing wetland restoration as a fundamental objective to a more comprehensive Bay watershed restoration goal. Partners committed to "create or reestablish 85,000 acres of tidal and nontidal wetlands and enhance the function of an additional 150,000 acres of degraded wetlands by 2025." These targets represent approximately 10 percent of the original wetland extent across the region. Identified management strategies include wetland restoration, rehabilitation, enhancement, and creation. Importantly, conservation of existing wetlands (approximately 2 million acres) also is essential to achieving the Bay Program's broader restoration goals.

Commented [HJ2]: Revisions in this para. Per Chris Spaur, USACE and PA DEP.

There are two spatial scales at which decision-makers require guidance for advancing the CBP's wetlands goal. First, the Chesapeake Bay Total Maximum Daily Load (TMDL) requires state agencies and their local partners to detail watershed implementation plans (WIPs) for achieving the regulated nutrient and sediment load reduction targets. Planning agencies must outline the type and extent of best management practice (BMP) implementation intended to meet the reduction targets. Local and state decision making will reflect an assessment of opportunity as well as cost. ~~At this scale, costs and benefits of individual practices likely will not be as significant as evaluating progress toward regional goals (e.g. load reduction targets).~~ The expected cumulative benefits of wetland management are therefore compared to other BMPs and with consideration to other planning priorities. Ideal decision support would include an inventory of wetland management opportunities that details hydrologic function, current condition assessment, expected water quality and habitat benefits, and cost. However, this information is not necessarily available in all cases. Generally, managers should consider where in the project area (e.g., county or watershed) BMP practices can provide the greatest overall benefits.

Commented [HJ3]: Per Chris Spaur, USACE

At the field-scale, restoration managers working with landowners must ~~first~~ consider current site conditions and the cause of degradation to identify appropriate locations and techniques for wetland management. ~~In addition to~~Further, the techniques applied to a wetland BMP ~~if selected as a practice~~ (e.g., levee breach~~-~~, ditch plugs, and landscape grading), should consider design specifications such as the number, size, area, and timing of interventions ~~also must be considered~~to ~~-~~carefully ~~to maximize the~~ target~~ed~~ and optimize wetland ecosystem services. While a simple intervention, such as a levee breach to restore floodplain hydrology can be used, frequently a combination of techniques, including revegetation, invasive species control, and soil remediation or enhancement, are used to achieve a more holistic restoration. In developing these designs, restoration managers must work with landowners to address additional concerns including maintenance requirements and costs. Collectively, all these factors will influence the techniques incorporated into wetland BMP design, which in turn, will impact the potential water quality improvement at the site.

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The reporting of wetland acreage restored or created will be important for tracking progress toward CBP's broader restoration goals. To receive credit toward the established wetland and water quality targets, implemented site-scale designs must be inventoried and evaluated by state and local municipalities for reporting to the CBP. Ideally, this accounting system will account for a range of wetland management actions. Accordingly, CBP state and local municipalities need guidance to classify the field technique(s) applied as one of the four established CBP wetland management categories (i.e., restoration, rehabilitation, enhancement, or creation).

In 2016, the CBP partnership approved recommendations from a Wetland Expert Panel to define a wetland land use and four categories of BMPs as part of the Phase 6 Chesapeake Bay Watershed Model (CBWM). Currently, natural wetlands are assigned the lowest land use loading rate, equal to the forest land use in the Phase 6 CBWM, while pollutant load reductions were approved for the wetland restoration BMP. However, three of the four categories – creation, enhancement and rehabilitation – required further evaluation. The 2016 Panel recommended a follow-up panel to evaluate these additional BMP techniques for inclusion in the CBP watershed model and also encouraged the partnership to review the current modeling framework to evaluate more fully the retention benefits associated with natural wetlands.

1. Charge and membership of the expert panel

The Chesapeake Bay Program's Wetland Workgroup approved the charge for the current panel in June 2017. Through its Cooperative Agreement with the Chesapeake Bay Program office (CBPO), Virginia Tech selected the proposal submitted by the Center for Watershed Protection that identified expert panelists and a statement of work to fulfill the charge by the Wetland Workgroup. Following some adjustments in response to feedback from the CBP partnership, the panel membership listed in Table 1 was approved by the Wetland Workgroup in September 2017. The panel convened for its first conference call in November 2017 and met 14 times via conference call and twice in-person from November 2017 through June 2019.

Commented [HJ5]: Editor's Note: the following table was not titled in error and therefore subsequent table references are off by +1. Since multiple comments refer to table numbers of the July 10 draft report, we are not adding the label at this time to reduce confusion during the partnership review/approval period.

Panelist	Affiliation
Neely L. Law, PhD, Panel Chair	The Center for Watershed Protection

Kathleen Boomer, PhD	Foundation for Food and Agriculture Research (formerly with The Nature Conservancy)
Jeanne Christie	Christie Consulting Services LLC (formerly with Association of State Wetland Managers)
Greg Noe, PhD	U.S. Geological Survey
Erin MacLaughlin	Maryland DNR
Solange Filoso, PhD	Chesapeake Biological Lab
Denise Wardrop, PhD, PE	Penn State
Scott Jackson	University of Massachusetts
Steve Strano	NRCS
Rob Roseen, PhD, PE, D.WRE	Waterstone Engineering
Ralph Spagnolo	EPA Region 3

The full panel charge and scope of work is included as Appendix A. As with the previous Wetland Expert Panel that concluded in 2016 (described below), this current panel and report are focused on voluntary wetland activities that can be tracked and reported toward TMDL progress. Compensatory wetland mitigation is outside the purview of this panel and is not creditable for Chesapeake Bay TMDL purposes.

Commented [HJ6]: Inserted for clarification, per PA DEP comments

1.1. Additional context for the expert panel – Summary of Previous Wetland Expert Panel (WEP)

A Wetlands Expert Panel (WEP) was convened in 2014 to provide recommendations on how natural wetlands and implementation of wetland BMPs should be represented in the Phase 6 Chesapeake Bay Watershed Model (CBWM). This panel provided recommendations to the Chesapeake Bay Program in a 2016 report (WEP, 2016). The panel recognized that natural wetlands provide important water quality and habitat benefits and that restored wetlands are designed to reestablish natural wetland function. The panel also unanimously agreed that wetland water quality benefits strongly depend upon wetland type, which is greatly influenced by a site's hydrogeologic setting and its hydrologic connectivity to upgradient sources of nutrients and sediments. Results of a literature review were consistent with other meta-analyses indicating that wetlands have highly variable capacity to protect regional water quality by sequestering excess nutrients and sediment. Reported differences were attributed not only to site-specific conditions of a wetland but also the connectivity to up-gradient contaminant sources. Consequently, the WEP (2016) developed a simplified framework to estimate expected retention benefits based on location and expected wetland setting and retention capacity. First, information about the physiographic setting and its influence on the distribution of wetlands and wetland types, as well as hydrologic connectivity were considered to estimate the typical acreage of intensive human activity in a wetland's local contributing area, as a basis for estimating typical nutrient and sediment loads. Second, retention efficiencies were prescribed to represent degradation in wetland environments, based on measurements reported in peer-reviewed literature, including natural and restored wetlands, within and outside of the Chesapeake Bay watershed in both floodplain and non-floodplain landscape settings (see Table 9, in WEP 2016). Because of the large variability in reported retention estimates, and as only a few of these studies provided enough information to stratify data based on location or wetland condition, mean values of these data were used as the prescribed average, annual retention rates of Total Nitrogen (TN), Total Phosphorus (TP) and Total Suspended Solids (TSS) (42%, 40% and 31%, respectively). The wetland restoration BMP, as a land use change, also received additional load reductions that account for the treatment of upland area loads. The WEP (2016) recommendations were consistent with the Chesapeake Bay Program credit framework, which in general uses a ratio of upland acres treated to BMP area to quantify this additional load reduction. Importantly, the WEP (2016) recommendations explicitly did not consider wetland condition or the consequences of different wetland management strategies, including creation, rehabilitation and enhancement. The watershed model currently assumes rehabilitation, creation and enhancement wetland management practices have equal potential (i.e., ratio of 1:1) to provide regional water quality benefits.

2. Natural Wetlands in the Phase 6 Watershed Model

The Phase 6 Watershed Model (Figure 1) is a management tool designed to simulate the effect of jurisdictions' management actions on nutrient and sediment loads delivered to the Bay. An integrated estuarine model then simulates water quality responses based on predicted watershed discharge. Time series data of land uses, BMP implementation, animal populations and other factors are simulated in the Model history and the Model is calibrated to monitored loads from River Input Monitoring (RIM) stations from 1985-2014. Thanks to the efforts of the previous WEP, nontidal wetlands were included as a land use in the Phase 6 CBWM, which means that acres of wetlands through time were included in the calibration. Nutrient and sediment loading rates for these wetlands the same as forests were applied. Also similar to forest land cover, additional retention capacity was implicitly captured through the calibration process.

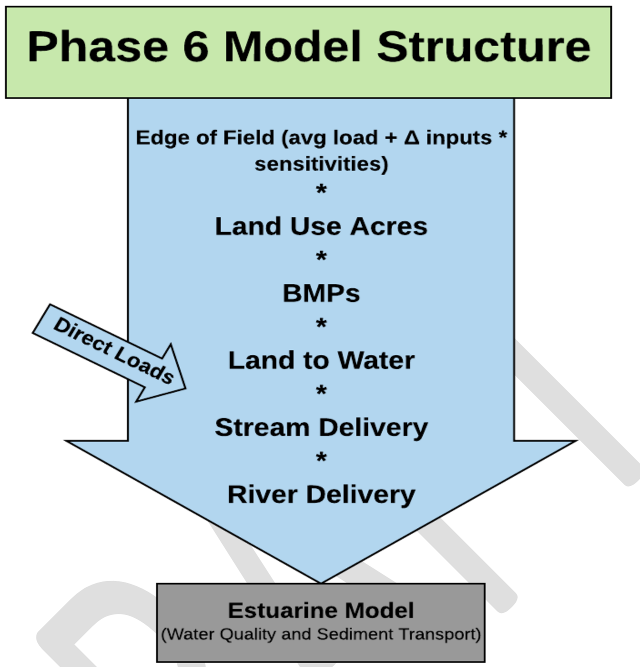

Figure 1. Overall structure of the Phase 6 Chesapeake Bay Watershed Model

Land-to-water factors

As stated in the Phase 6 CBWM documentation, land-to-water (L2W) factors "account for spatial differences in loads due to physical watershed characteristics. L2W factors do not add or subtract to the loads over the entire Chesapeake Bay watershed, but instead represent the spatial variance of nutrient transport." SPARROW (SPAtially Referenced Regressions On Watershed attributes) modeling by USGS sought to explain the spatial variance of nutrient transport and the specific details are described in Chapter 7 of the CBWM documentation. For purposes here, it should be noted that the CBP modeling team explained to the previous WEP that L2W factors accounted for the effect of existing wetlands in the landscape. The panel's report reflected this point and supported future research into the matter (page 47, WEP 2016):

> "…While the land-to-water factors in the Phase 6 Watershed Model are understood to implicitly capture the effect of existing wetlands in the landscape through the model calibration, the partnership may wish to apply a distinct factor in the model to account for the retention and treatment effects of existing wetlands. Their inclusion as land uses will be a basis for potentially simulating their contribution in the future. Though the Panel was unable to make a recommendation for a distinct loading rate or retention factor for existing wetlands at this time

due to a dearth of science on wetland load contributions, it is recommended that future research using SPARROW or other tools be used to inform the partnership in the future."

To reiterate, L2W factors do not change the overall loads, but they reflect variability based on landscape characteristics. The factors used in the SPARROW modeling to establish L2W factors for nitrogen and phosphorus are summarized in Table 1.

Table 1 - Summary of factors used to inform land-to-water factors for Nitrogen and Phosphorus

Nitrogen	**Phosphorus**
Mean EVI (enhanced vegetation index)*	Soil erodibility*
Mean soil available water capacity	% well-drained soils
Groundwater recharge	% area in Coastal Plain*
Piedmont carbonate	Mean annual precipitation*
* Dropped from final calculation of L2W factors as the land uses account for vegetation	*Dropped from final calculation of L2W factors because sensitivities and Δinputs already account for these factors (see Figure 1)

L2W factors can also be understood as "delivery variation factors" or DVFs, as described in Chapter 7 of the CBWM documentation. As noted above, there is no effect on overall loads, because the L2W factors were centered on an average of 1.0. They were broken into the four global land use categories (developed, cropland, pasture, natural) and calculated for Nitrogen (N) and Phosphorus (P) at the land-river-segment scale. For N, the DVF ranged from approximately 0.42 to 2.3 for the Natural category; for P it ranged from 0.6 to 1.18 for Natural (wetland land uses are part of the Natural category).

Ultimately, while the retention or removal of nutrients or sediments by existing natural wetlands are not explicitly accounted for in the Model the same way that N, P and sediment may be retained by a wetland BMP, any removal or loss of wetlands will increase delivered loads in the Model, as every other simulated land use has a higher loading rate, except Forest, which is equal to wetlands. Additionally, if natural wetlands are lost, then it is reasonable to expect that monitored loads will not decrease as expected due to management actions, which will increase the level of effort needed to meet water quality standards. If there is available science to explicitly simulate wetlands as part of the L2W factors, it could be incorporated in future iterations of the CBWM, but this panel did not have the data or resources to address that research need on its own.

Phase 6 Wetland Land Uses

Nontidal wetlands have two land uses in the Watershed Model based on the WEP (2016) recommendations. Tidal wetlands are represented in the Estuarine Model and do not have a land use in the Watershed Model. The appropriate excerpt from Chapter 5 of the Model Documentation describing wetlands in the Phase 6 land use dataset is copied here for accuracy:

> The National Wetlands Inventory (NWI) served as the starting point for defining the universe of mapped wetlands. In all areas outside Virginia, the Chesapeake Conservancy and University of Vermont mapped additional emergent wetlands if visible in the NAIP imagery and they adjusted the boundaries of NWI wetlands if it were obvious that they have changed (e.g., a former wetland which is now covered by a house and lawn). In Pennsylvania, additional wetlands were

mapped by the Upper Susquehanna Coalition and University of Vermont. County-wide wetlands were mapped using an object-based image analysis (OBIA) which combined regression models of hydrogeologic variables with LIDAR-derived terrain variables, high resolution aerial imagery, and land cover data. Woody wetlands were predicted by landscape wetness, surface elevation, climate, and poorly drained soils. Emergent wetlands were predicted by landscape wetness, topographic dissection, landscape roughness, and forest cover. A full description is contained in Appendix 5.X: A LiDAR-aided hydrogeologic modeling and object-based wetland mapping approach for Pennsylvania.

Tidal wetlands were classified using three methods: 1) identifying all wetlands classified as marine and estuarine wetland systems (E2EM, ESFO, W2SS) according to the NWI Wetlands and Deepwater Habitats Classification chart (https://www.fws.gov/wetlands/Documents/Wetlands-and-Deepwater-HabitatsClassification-chart.pdf); 2) identifying palustrine wetlands with water regime modifiers associated with tidal hydrological conditions (e.g., saltwater tidal or freshwater tidal: PEM, PFO, PSS); 3) identifying wetlands that could be influenced by tidal characteristics/processes by having an elevation less than or equal to 2 meters above sea level according to the Bay elevation apparent in the 10m-resolution National Elevation Dataset (Ator et al. 2003).

Floodplain wetlands were mapped by first creating a map of floodplains based on Federal Emergency Management Agency's (FEMA) Digital Flood Insurance Rate Maps in the National Flood Hazard Layer and Natural Resources Conservation Service's (NRCS) Soil Survey Geographic database (SSURGO). The primary soil attributes used to identify potential floodplains include: flooding frequency (annual probability > 1%), fluvial origins (e.g., fluvents, fluventic aquicambids, fluvaquents), and floodplain geomorphic characteristics (e.g., floodplains, floodplain steps, floodplain playa), and presence of water.

All NWI and other mapped wetlands that did not qualify as tidal or floodplain wetlands were classified as "other". Most of these would be considered isolated and/or headwater wetlands.

Based on the draft-final Phase 6 Watershed Model, there are approximately 1.3 million acres of the two nontidal wetland land uses throughout the Bay watershed (approximately 3 percent of the 64,000 mi^2 watershed area). In comparison, there are approximately 1.6 million acres of impervious surfaces (roads, buildings and other), 2.6 million acres of turf grass land uses,[1] 2 million acres of pasture, and 4 million acres of (non-hay) cropland.[2]

3. Definitions and terms used in the report

Best Management Practice (BMP): For purposes here, a BMP is a management action or conservation practice as defined by the Chesapeake Bay Program (CBP), e.g., Wetland Restoration, Wetland Creation, Wetland Rehabilitation and Wetland Enhancement. Definitions of wetland BMPs are provided in Table 2.

[1] Acreage of impervious surfaces and turfgrass do not include tree canopy over impervious or tree canopy over turfgrass.

[2] Base conditions report downloaded from CAST for 2013 Progress with Allocation Air. Accessed Nov. 9, 2017.

Constructed (stormwater) wetland: Engineered shallow marsh areas that are designed and constructed to treat stormwater. These often incorporate small permanent pools and/or extended detention storage to achieve the full water quality volume treatment. A wetland for stormwater purposes in developed areas should be reported under the existing CBP-approved urban BMP "Wet Ponds and Wetlands" or as a stormwater treatment component of a retrofit or performance standard project. In an agriculture context, constructed wetland structures that treat or capture barnyard runoff as part of a treatment train may be eligible under the Agricultural Stormwater Management BMP.

Degraded wetland: The term "degraded" can be subjective based on the focus of the assessment. For purposes of this report, "degraded wetland" refers to a wetland area where impacts to hydrology, soils, or vegetation impede the wetland's ability to function. Assessment methods can be used to determine whether a particular resource is degraded, based on the chosen threshold(s). Best professional judgment may also be used to identify degraded resources in situations where appropriate assessment methods are not available. The assessment may not be limited to water quality. Specific thresholds or assessment methods are outside the scope of this panel and will be set based on the applicable local, state or federal guidance or regulations. An example wetland conditions assessment is provided in Section 6 of the report as part of qualifying conditions.

Efficiency (Net): A net efficiency, or "lift" is defined to express the percent improvement in nutrient and sediment reduction provided by a wetland BMP. The net efficiency is defined by the difference in the output nutrient and sediment loads pre- and post-treatment and expressed as a percentage. (see Appendix D for a more complete description).

Net Improvement: Similar definition as net efficiency.

Post-Treatment Efficiency: The difference in inflow and outflow pollutant load or concentrations of a BMP after construction or implementation of the practice is complete. Typically, this efficiency is based on surface measurements, however groundwater loads may impact the overall performance of a BMP as well.

Practice: A general reference to a management action or conservation practice (i.e., not CBP-specific).

Pre-Treatment Efficiency (Baseline or Existing Condition): The difference in inflow and outflow pollutant load or concentrations of an existing natural wetland, whether the wetland is fully functional or degraded. Typically, this efficiency is based on surface measurements; however, groundwater loads may impact the overall performance of a BMP as well.

Technique: Design strategies used to restore, create, rehabilitate, or enhance wetland conditions, typically as an intervention or action that alters the hydrology, vegetation or soils. One or more techniques may be applied as part of a single BMP. While techniques may be implemented individually as a basic approach to address a singular component of a wetland for enhancement, more frequently they will be implemented collectively as a more comprehensive approach to restore wetland structure and functions. Section 6 of the report provides more detail discussion of techniques used to implement wetland BMPs.

Wetland BMPs – see Table 2 for definitions applicable to the scope of the WEP. Additional information to further distinguish amongst the wetland BMP types is provided in Section 6.

4. Methods, Results and Key Findings to Inform the Development of Recommendations for Wetland Rehabilitation, Enhancement and Creation BMPs

The panel recognized the limitations of traditional literature reviews to evaluate wetland water quality benefits as highlighted by WEP (2016), and therefore, the panel explored a variety of methods to build on the previous panel's work as well as leverage and integrate the expertise provided by the current panel. A 'multiple lines of evidence' approach to build consensus was adopted by the current panel that considered the strengths and comparability of results from the following methods. These included: 1) a preliminary conceptual modeling exercise to direct data synthesis and interpretation; 2) a literature review to build on the data developed by the first WEP; 3) a follow-up conceptual modeling exercise to integrate and advance findings from the literature review and early discussions; 4) an expert elicitation to derive retention efficiencies based on a synthesis of panelists' expert-based estimates and 5) analysis of the Riparia Reference Wetland Database (Brooks et al., 2016) in the Commonwealth of Pennsylvania. Individually, no singular method provided a definitive result or consensus to quantify the water quality benefits of wetland BMPs. Rather, these approaches provided an opportunity to examine wetlands from a variety of different perspectives to either validate results or examine why results diverged from a general expectation or trend.

The information presented in this Section summarizes the development of a body of knowledge and information that informed the Panel's deliberations. The key findings provide a summary of salient discussion points to advance new, or build upon existing lines of evidence.

Table 2. CBP definitions of wetland best management practices and summary of decision ruled currently used in the CBP TMDL accounting framework.

BMP Category /Applicable NRCS Practice Standard	**CBP Definition (for Phase 6 CBWM)**	**CBP will count the BMP acres as…**	**Operational Definitions**
Restoration	Re-establish The manipulation of the physical, chemical, or biological characteristics of a site with the	Acreage gain *(toward Watershed Agreement outcome of 85,000 acre*	• No wetland currently exists • Hydric soils present • "Prior converted"

Table 2. CBP definitions of wetland best management practices and summary of decision ruled currently used in the CBP TMDL accounting framework.			
BMP Category /Applicable NRCS Practice Standard	**CBP Definition (for Phase 6 CBWM)**	**CBP will count the BMP acres as...**	**Operational Definitions**
Applicable NRCS Practice 657	goal of returning natural/historic functions to a former wetland.	*wetland gain <u>and</u> in Phase 6 annual progress runs)*	• **Result**: Wetland acreage and functional gain
Creation Applicable NRCS Practice 658	Establish (or Create) The manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist at a site.	Acreage gain *(toward Watershed Agreement outcome of 85,000 acre wetland gain <u>and</u> in Phase 6 progress runs)*	• No wetland currently exists • Hydric soils not present • **Result**: Wetland acreage and functional gain
Enhancement Applicable NRCS Practice 659	Enhance The manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve a specific function(s).	Function gain *(toward 150,000 acre outcome <u>and</u> Phase 6 annual progress runs)*	• Wetland present • Some functions may be suboptimal • **Result**: Gain in wetland function
Rehabilitation May include some NRCS Code 657 practices.[3]	Rehabilitate The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded wetland.	Function gain *(toward 150,000 acre outcome <u>and</u> Phase 6 annual progress runs)*	• Wetland present • Wetland conditions/functions degraded • **Result**: Gain in wetland function

Conceptual Modeling, Part I

The panel initially engaged in a series of discussions to develop conceptual models that describe the water quality benefits provided by restored, created, rehabilitated, and enhanced wetlands. <u>The panel recognized other benefits provided by wetlands and wetland practices, and the tradeoffs that may occur but these are not reflected in the conceptual model(s) presented.</u> Conceptual models "capture essential system components, relationships and their dynamics and provide a vehicle for building common understanding of complex modeling systems among researchers and stakeholders" (Liu *et al.*, 2008).

[3] *Rehabilitated wetlands are a type of restoration according to NRCS definition.*

When effectively applied, sharing non-software based, abstract descriptions of system dynamics through conceptual modeling can guide more informed data analyses than traditional approaches. The panel attempted to use conceptual modeling exercises to communicate ideas or hypotheses that might explain the wide range of water quality benefits reported in the wetlands literature. This approach was intended to capture expert insights as to the controlling factors that primarily influence wetland function (i.e., account for structural uncertainty), to provide a relative understanding of the different wetland BMP water quality performance, and to provide guidance on how best to expand and interpret the literature database.

As a starting point, the panel reviewed a conceptual model presented in Kreiling et al (2018) relating wetland condition to both disturbance and stream condition (Figure 2). The authors highlighted a threshold effect on wetland condition and the difficulty of restoring wetlands to their full functioning natural state. The panel explored whether Kreiling's model could be modified to capture key factors driving water quality benefits of different wetland conditions, including natural and restored wetlands, as well as created, rehabilitated, and enhanced wetlands. Figure 2 illustrates a set of hypotheses discussed using this conceptual model. For example, the panel considered the relative capacity of different wetland BMPs to provide water quality benefits as compared to a natural wetland. In general, it was hypothesized that restored wetlands have the greatest potential to provide water quality benefits comparable to natural wetlands, whereas created wetlands had the least potential. Rehabilitated and enhanced wetlands were believed to provide moderated benefits in comparison to the two other types of wetlands. Further, this conceptual model presented hypotheses how source loadings (i.e., source connection, watershed condition) and existing site conditions (i.e., level of disturbance) may affect wetland performance. Shared hypotheses discussed with the WEP included the following: 1) wetland BMPs cannot provide the same water quality benefits as natural wetlands, even in a similar state of degradation; 2) restored and rehabilitated wetlands have greater potential than enhanced or created wetlands to provide targeted water quality benefits; 3) wetland ecosystem functions are highest along undisturbed stream reaches in naturally vegetated catchments; however, 4) wetlands situated in catchments with more intensive human activities (e.g., agriculture) likely have greater potential to provide targeted water quality benefits because of connectivity to sources of excess nutrients and sediment.

Commented [HJ7]: Editor's note: We are aware of some lingering formatting issues (e.g., caption to Figure 2 overlapping with the image, inconsistent spacing, etc.). These formatting changes will have ripple effects and will be corrected in the final-approved version of the report following partnership approval.

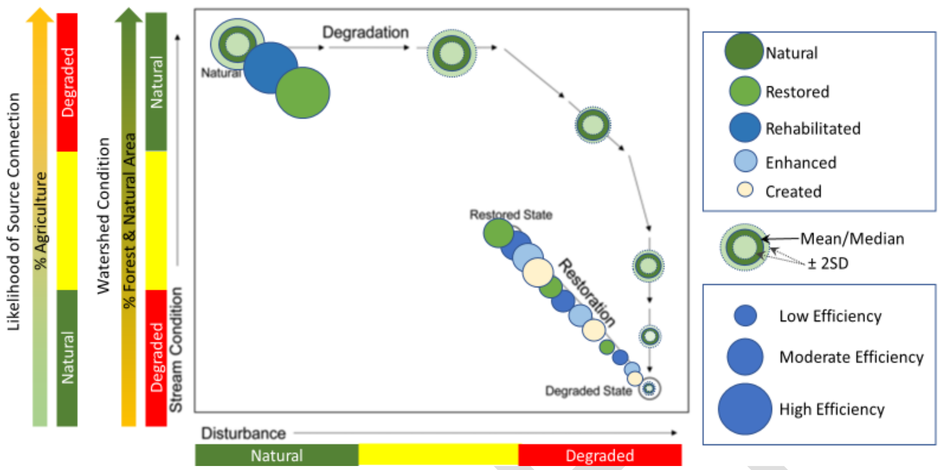

Figure 2 Example conceptual model shared with the panel to illustrate the relative performance of different wetland BMPs based on Kreiling et al (2018).

Key Findings

- The panel acknowledged the need to incorporate the performance of natural and restored wetlands to provide context for the evaluation of the other wetland BMPs.
- General agreement amongst the panel that a relative ranking of wetland BMPs may be valid, however, the conceptual model and literature reviewed was insufficient to reach consensus amongst the panel on a ranking amongst wetland restoration, creation, rehabilitation and enhancement; wetland enhancement was identified as the BMP to provide least net water quality benefit while natural, high-functioning, wetlands would provide the greatest benefit.
- The panel was not able to utilize the Kreiling model or modifications of it as a basis for advancing the panel's charge, in part, because they could not identify key drivers or more explicit processes affecting wetland water quality benefits as depicted by the conceptual model(s) along with supporting data that may be needed to more fully develop them
- The exercise was complicated by acknowledging wetland assessments reflect a wide range of concerns beyond water quality benefits (e.g., plant species diversity, carbon sequestration, water storage, flood protection, and wildlife habitat).

Literature Review

The Panel expanded and added to the literature review database developed by the WEP (2016) panel to summarize the data reported into different types of wetlands. The panel attempted to expand the existing database by identifying additional published observations of water quality benefits provided by restored and natural wetlands and extracting information that may help to differentiate amongst the wetland BMP types. Eight additional studies were added to the database. Appendix E provides a summary of the literature review database and key findings. Similar to the conclusions drawn by the WEP (2016), traditional statistical analyses indicated there is insufficient information in the reviewed literature to differentiate efficiencies amongst the different wetland BMP types. However, there was sufficient information to separate natural wetlands from wetland BMPs. These data were added to the database provided by WEP (2016) and the resulting distribution of TN, TP and TSS percent load reductions for all wetlands – natural and BMP. The summary includes studies reporting both concentrations and loads; however, the majority of the studies are based on loads that accounts for flow and concentrations entering and leaving wetlands[4].

Key Findings

- Since the WEP (2016) literature review was completed, several published meta-analyses (e.g. Land et al 2016) highlighted broader challenges to understanding the wide variation in water quality benefits. For example, wetland BMP definitions were inconsistent across different publications and also challenging to classify according BMP definitions used by NRCS and the Bay program. While a few studies may identify the type of wetland BMP, its operational definition with respect to the techniques used for the project made it often unclear. Variability in the design specifications further complicated comparisons across those studies which provided similar descriptions of restoration techniques. The CBP definitions are predominantly based on the federal (EPA/USACE) definitions for compensatory mitigation with some minor differences
  - Given the wide variety of monitoring methods and site settings, panel members found it difficult to align published wetland BMP descriptions with CBP or NRCS wetland BMP types. Often specific techniques were reported (e.g., levee excavations) without adequate description of pre-existing conditions or surrounding watershed conditions.
  - Comprehensive (i.e., holistic) wetland restorations that address hydrologic impacts and enhance hydric soil and vegetation composition were found to be more effective than simple or singular restoration techniques.

The eight studies were used to update Table 9 in the WEP (2016) report and are presented in Table 3 and Table 4~~Table 4~~ .

[4] A review of the database finds that the percent reductions from the studies reporting concentrations were similar to the load reductions reported in other studies, so they were included in the overall summary.

Table 3. Summary of literature review to update removal efficiencies for wetlands (n= number of studies). This is an update to Table 9 in WEP (2016).

Wetland Type	Vegetation Type	TN (% reduction)	TP (% reduction)	TSS (% reduction)
Headwater/Depressional	All	31.0 (10)	18.8 (16)	28.3 (6)
Floodplain	All	43.8 (22)	26.2 (15)	37.1 (11)
All, except constructed	Forest, mixed, and unknown	34.1 (21)	44.4 (45)	37.3 (11)
All, except constructed	Emergent	38.8 (22)	18.6 (16)	29.7 (8)
All	All	37.7 (57)	37.6 (88)	43.6 (24)
Chesapeake Bay only	All	26.0 (12)	23.9 (14)	24.4 (8)
All, except constructed	All	40.7 (40)	37.6 (61)	34.1 (19)

The data from the literature were further analyzed to separate retention efficiencies for natural and wetland BMPs; constructed wetlands were not included. A summary is provided in Table 4~~Table 4~~.

Table 4. Average Retention Efficiencies (%) for Natural and Wetland BMPs from the Literature Review, (n= number of studies).

Wetland Type	TN % (n)	TP % (n)	TSS % (n)
Natural wetlands	45 (15)	42 (17)	n/a
Wetland BMPs	39 (21)	42 (46)	43 (12)

Conceptual Modeling, Part II

Continued discussions to capture the P~~p~~anel's understanding of factors affecting wetland water quality provisions resulted in a set of more detailed conceptual models to describe how or which bio-physical factors predominantly influence a wetland's water quality function. While~~,~~ these conceptual models did not explicitly consider any specific wetland classification system (i.e., HGM, Cowardin), factors common to these classifications may be reflected in the models discussed by the Panel (e.g., landscape position, hydrology, vegetation, soils). In contrast to the Kreiling-based model discussion, which focused on comparing retention among wetland BMP sites ~~in relation~~relative to stream and catchment conditions, this conversation focused on the mechanisms and conditions driving wetland capacity to provide water quality benefits. The summary of these hypotheses is~~are~~ outlined below, and graphical representations are included in Appendix F. A common thread throughout these discussions ~~focused on~~was the combined effects of a wetland's *capacity* and *opportunity*, which ~~that~~ drive the functional potential of a wetland's~~'~~ water quality benefit. *Capacity* refers to the condition of the wetland (characteristics and size), whereas *opportunity* acknowledges the importance of location, ~~-~~including existing/surrounding site conditions (e.g. presence/absence of a wetland, existing land use/loadings). Each of these ~~Both of these~~

Commented [HJ8]: Extensive clarifying edits and formatting changes to this sub-section in response to Tess Thompson and Chris Spaur, with some specific edits from Chris Spaur also identified below.

overarching ~~[~~components~~]~~ influence a wetland's hydrology, soil, ~~and~~ vegetation condition, and ~~characteristics indicative of~~ biogeochemical functioning.

It is important to emphasize that these hypotheses represent potential explanations to the wide variability in observed water quality benefits (i.e., TN, TP, and TSS retention), and not current paradigms in wetland science. These ~~are~~ statements are not conclusions drawn by the P~~p~~anel, rather ~~those that~~they have emerged based on review of the literature and ~~p~~Panel discussions. Like the Kreiling model-based discussion, this conversation revealed contrasting ideas among expert panelists to explain wetland function and uncertainties. ~~The multiple hypotheses share along with the lack of consensus emphasized the limitations of current available data and publications. Nor are t~~Further, ~~T~~these hypotheses are not completely independent, which can complicate efforts to define a singular conceptual model or framework. ~~Results from this discussion emphasized a need to promote interdisciplinary, collaborative studies across institutions to refine our understanding of wetland ecosystem services across the Bay watershed.~~ ~~Further~~Additionally, ~~T~~the Panel ~~did~~ recognized and supported that the water quality benefits of a wetland are a function of ~~wetland~~ hydrology, soils, and vegetation that may act singularly or in combination to affect the retention of nutrients and sediment. Results from this discussion emphasized a need to promote interdisciplinary, collaborative studies across institutions to refine our understanding of wetland ecosystem services across the Bay watershed.

Emerging Hypotheses to Explain Variability in Wetland TN, TP, and TSS Retention Capacity:

Emerging Hypotheses Set 1: Wetland Condition (Capacity)

~~**Wetland condition (capacity)**: These~~ This set of hypotheses explores how the extent of direct alteration ~~and mitigation~~ of site conditions ~~primarily~~ influences wetland water quality functions. The framework or context to evaluate the water quality functions of wetlands ~~effects~~ determines the relative improvement by the BMPs, as noted by the ~~first two~~ hypotheses described below. For example, the first two hypotheses suggest that the water quality function of a wetland ~~relies~~can either rely on ~~on~~: 1) the presence of a (pre)existing wetland, ~~,~~ or 2) ~~in contrast,~~ the techniques implemented to optimize wetland function— ~~–,~~ irrespective of pre-existing wetland presence or conditions ~~–, may drive the water quality benefits provided by wetland~~. The literature reviewed by the P~~p~~anel and WEP (2016) is inconclusive to ~~fully~~ support ~~either~~any ~~hypothesis~~of the following hypotheses fully at this time.

1. *Natural Wetlands Maximize WQ Benefits*

   ~~:~~ Natural wetlands have the greatest capacity to provide water quality benefits. Rehabilitated wetlands designed to manipulate natural wetlands may achieve comparable water quality benefits, especially over time (years) when natural ecosystem processes can reestablish. Enhanced wetlands designed solely to improve water quality benefits may increase nutrient and sediment retention, though perhaps not as much as rehabilitated wetlands designed to restore wetlands more holistically. It is also hypothesized that ~~C~~created wetlands are least likely to provide improvement in ~~d~~ water quality benefits, with the assumption~~ing~~ that the implementation of techniques are insufficient ~~alone~~~~location is not positioned~~ to promote~~allow~~ the development of sustained natural wetland processes ~~(else wetlands would have occurred at that location historically)~~.

2. *Optimally Designed Wetland BMPs Maximize WQ Benefits*
~~:~~ Because of the opportunity to improve natural processes through engineering, wetland BMPs may provide more effective nutrient and sediment retention compared to natural wetlands. However, these benefits may come at a cost to other targeted ecosystem benefits (e.g., preservation or enhanced establishment of rare wetland species) or be more singularly focused on water quality.

3. *Hydrologic Alteration is the Primary Influence on Wetland WQ Benefits*
~~:~~ Hydrology is the master variable affecting soil development and the establishment ~~an~~and subsequent ~~d~~ maintenance of wetland plant communities. ~~The extent of hydrologic~~Hydrologic alteration ~~primarily~~ most notably influences wetland interception and retention capacity~~, and restoring~~. Restoring a system's hydrology alone ~~ultimately~~ will ultimately improve nutrient and sediment retention capacity by facilitating the reestablishment of natural wetland soil biogeochemistry and hydrophytic vegetation dynamics (i.e., field-of-dreams hypothesis (Hilderbrand *et al.*, 2014)).

Commented [HJ9]: Per Chris Spaur

4. *Complexity of Biophysical Conditions is the Primary Influence on Wetland WQ Benefits*
~~:~~ Multiple factors interactively influence wetland biogeochemistry and their ~~provision~~ resulting~~of~~ water quality benefits. Restoration designs must consider the extent of hydrologic alteration, soil compaction and oxidation, soil organic content, and loss of wetland vegetation to achieve maximum water quality function. Simple, form-based restoration typically "do[es] not achieve long-term project objectives with […] success" due largely "to the failure of most projects to take hydrology and natural processes into account." Successful restoration ~~and provision of water quality benefits~~ requires a holistic approach that addresses all aspects of human impacts on a system.

Commented [HJ10]: Per Chris Spaur

Emerging Hypotheses Set 2: Wetland Location (Opportunity)

~~**Wetland Location (opportunity):**~~ The location of a wetland largely determines wetland functions due to controls on hydrology and connectivity to contaminant sources (i.e., sources of excess nutrients and sediments).

1. *Hydrogeologic Setting is the Primary Influence on Wetland WQ Benefits*
~~:~~ Variation in source waters and source water chemistry due to watershed position (e.g., headwater versus floodplain wetlands) and physiographic province (e.g., Ridge and Valley versus Coastal Plain), are the primarily influences on wetland function~~s~~ and the potential benefits of wetland BMPs to CBP water quality targets. The landscape setting ultimately influences hydroperiod characteristics. Further, biogeochemical functions cannot be determined without consideration of hydro-chemical characteristics of source waters, including the dissolved mineral content, pH, and redox condition of the wetland soils, as well as nutrient and suspended sediment loads.

2. *Hydrologic ~~-~~C~~c~~onnectivity to U~~u~~p-G~~g~~radient N~~n~~utrient and S~~s~~ediment S~~s~~ources is the Primary Influence on Wetland WQ Benefits*

~~:~~Wetlands down-gradient from intensive land use activities that generate high volumes of excess nutrient and sediment loads have a greater ~~capacity~~ opportunity to provide water quality benefits to regional waterways.

Commented [HJ11]: Per Chris Spaur

Expert Elicitation

While the earlier discussions provided opportunities for the panel to review peer-reviewed publications in the context of this panel's charge and to gain understanding of each other's perspective, there remained a great deal of uncertainty regarding how best to quantify and assign efficiencies to the different type of wetland BMPs. Given the limited availability of data to distinguish amongst the BMP types and the currently assigned efficiencies for wetland restoration BMPs, the panel used expert elicitation strategies to estimate the retention parameters based on integration of expertise from all panel members. Expert elicitation provides a scientifically-defensible method to solicit answers to questions in the absence of data based on the collective responses from experts in the field of study (Hemming et al 2018; Speirs-Bridge et al 2010).

This process is suitable for the panel as insufficient data is available to evaluate the three wetland BMPs (creation, rehabilitation, and enhancement) or conformity amongst the Panel to generate a framework or organizational principles to use available data. The purpose of the expert elicitation process was to solicit expert judgement to quantify the relative, average annual effectiveness for three wetland BMPs (creation, rehabilitation and enhancement) for TN, TP and TSS. The responses to the survey questions provided information to assess the degree or level of certainty or agreement associated with the responses. Expert judgement is based on an individual's knowledge, skills and/or experience related to wetlands, both natural or as a best management practice. The wetland restoration BMP and natural wetlands were included in the expert elicitation survey to provide a complete, relative assessment of all the wetland BMPs. However, it was communicated to the Panel that the current operational definitions for natural wetlands or wetland restoration BMP would not change as result of this process or part of the expert panel recommendations.

The expert elicitation survey included two rounds of surveys, with a review of the first round of survey results to clarify understanding of the questions that may affect an individual's response. The survey was re-issued with a revised wording and format of the questions to improve clarity and understanding of the questions and how the survey results would be used. Specifically, the second survey added questions that would enable results to define (quantify) a post-construction wetland BMP efficiency and a net improvement efficiency using both pre- and post-construction values. The results of the Round 2 Expert Elicitation survey were used to determine the percent efficiency pollutant load reductions, as a net efficiency or lift, for the four wetland BMPs: restoration, creation, rehabilitation and enhancement. A coefficient of variation, COV, was used to describe the relative measure of variation amongst the individual responses. The range in percent efficiency reductions (low and high estimates provided by the panel members) were adjusted by the confidence reported. Questions for the pollutant reduction performance of undisturbed, high-functioning natural wetlands and the wetland restoration BMP were included to provide context for the three other wetland BMPs, allowing for a relative ranking. The results provided for natural wetlands and the wetland restoration BMP would not be included as part of the Panel's recommendations on efficiency reductions, nor revise the wetland land use loading rates. However, recommendations may be provided as part of future research or management decisions for consideration by the Chesapeake Bay Program.

The complete results from the second round of surveys questions is provided in Appendix G.

Key Findings:

- There was greatest agreement amongst panel members for the post-treatment efficiencies for the four wetland BMPs compared to the pre-treatment condition.
- The survey responses showed a consistent relative ranking for the wetland BMPs for the pre- and post-treatment conditions for TN and TSS. The ordinal ranking for the BMPs post-treatment were similar. The EE found that the efficiency values for the post-construction wetland enhancement BMP had the greatest pollutant removal efficiency, and wetland restoration BMP had the lowest, followed by wetland creation. This ordinal ranking followed the assumption that sites for wetland rehabilitation and enhancement had some level of nutrient and sediment removal as an existing, or baseline, e.g., hydric soils or vegetation. Therefore, the implementation of management actions/techniques added, or improved this function exceeding sites where no wetland currently existed.
- The ordinal ranking for the wetland BMPs reversed when the baseline condition of the wetland BMP site was considered to determine a net improvement efficiency. That is, the largest improvement in water quality function of wetland occurred for restoration and creation as it was assumed that little to no water quality benefits existed at the site prior to implementation (i.e., the biggest 'lift' occurred) (see Appendix D for additional description of net improvement efficiency).
- A summary of the Round 2 EE results is provided in Table 5.

Commented [HJ12]: Per Chris Spaur

Table 5. Wetland BMP TN, TP and TSS Efficiency Values Based on Round 2 Expert Elicitation Survey Results.

		Efficiency (%), expressed as a net improvement or "lift"		
Parameter	BMP Type[1]	Mean (%)	COV[2]	Adapted Range[3] (%)
TN	Restoration	32	0.48	0.9 – 57.6
	Creation	29.8	0.64	9.1 – 59.9
	Rehabilitation	21.0	0.55	-5.5 – 50.7
	Enhancement	17.5	0.85	-14.5 – 47.1
TP	Restoration	23.5	0.64	-11.0 – 49.0
	Creation	27.0	0.63	0.6 – 56.0
	Rehabilitation	22.8	0.50	-12.8 – 50.5
	Enhancement	25.6	0.80	-18.4 – 49.5
Sediment	Restoration	34.5	0.68	-3.6 – 49.0
	Creation	32.5	0.69	0.9 – 54.4
	Rehabilitation	20.8	0.63	-2.3 – 45.8
	Enhancement	17.3	0.93	-10.5 – 45.6

[1] The values for the wetland restoration BMP are the existing efficiencies as recommended by WEP(2016) and provided for context.

[2] COV is the coefficient of variation is used to describe the relative measure of variation amongst the individual responses

3 The adapted range takes into account the confidence associated with individual responses

Riparia Database Analysis

In support of the WEP process, data from Riparia (a research center located in the Department of Geography, Penn State University) was used to assess the relative water quality functional performance of a collection of natural and created wetlands across the Commonwealth of Pennsylvania. The Riparia Reference Wetland Database (Brooks et al., 2016) consists of 222 natural wetland sites that were originally established during the period of 1993-2003; many have been re-sampled on a 10-year interval since then. The uses of the dataset, background on its formation, and definitions of terms can be found in Brooks et al., 2016. The Pennsylvania Created Wetlands Dataset is the result of a research project by Naomi Gebo, and the majority of the sites (72) in the database are detailed in Gebo and Brooks, 2012; this study compared created wetland sites to the natural wetlands contained in the aforementioned database (additional sites were subsequently added to the database). Both datasets contain values across three sampling protocols, termed Level 1, 2, and 3. Level 1 is a Landscape Assessment, which utilizes digital geospatial data to give a rough approximation of expected condition of the site based on these parameters. Level 2 is termed a Rapid Assessment and supplements the Level 1 assessment with a short field visit that obtains data on the presence of various stressors of the site (e.g., evidence of eutrophication, sedimentation, invasive plants) and buffer characteristics. Level 3 involves a detailed field assessment that obtains information required to estimate various condition indicators (e.g. Floristic Quality Assessment Index, a plant-based Index of Biotic Integrity) and a suite of Hydrogeomorphic (HGM) Functional Assessments. Characteristics of the datasets are presented in Table 6.

Table 6. Datasets used in the Riparia analysis.

Database	Classification System	Ecoregions	Level 1 Landscape Assessment	Level 2 Stressor Checklist and Buffer Characterization	Level 3 Intensive Condition and HGM Functional Assessment	Comments
PA Reference Sites (n=222)	HGM	Ridge & Valley; Appalachian Plateau, Unglaciated; Appalachian Plateau, Glaciated; Piedmont	Available	Available	Available	Includes **Reference Standard sites** in each category of ecoregion/HGM class. Sampled 1993-2003, with some sites re-sampled on a decade interval
PA Created Wetlands (n=107)	HGM	Ridge & Valley; Appalachian Plateau,Unglaciated; Appalachian Plateau, Glaciated; Piedmont	Available	Available	Available	Sampled in 2007/2008; sites ranged in age from 3 to 17 years since construction

The analysis for the WEP focused on three major HGM classes of wetlands, according to Brinson (1993). These included: Riverine (wetlands located along 4th order or greater streams/rivers), Headwater (wetlands occurring in the riparian areas on up to 3rd order streams), and Isolated Depressions. Fringing wetlands (those wetlands located on lakes and ponds) are excluded from the analysis because they occur primarily in highly-managed settings, e.g., farm ponds or recreational lakes, and thus do not generally represent naturally-occurring wetlands.

Reference, Reference Standard, and Created

The PA Reference Sites are composed of natural wetlands that cover the full range of condition and level of anthropogenic disturbance. A subset of sites are designated as Reference Standard. Reference Standard refers to conditions at the least, or minimally, impacted sites, thereby providing the potential to develop a quantitative description of the best available chemical, physical, and biological conditions in the wetland resource given the current state of the landscape. This conceptual framework and family of definitions is adaptable to any wetland type in any geographic setting; for example, a Reference Standard can be developed for Riverine wetlands in the Piedmont ecoregion.

Water Quality Functions

The analysis focused on the HGM Functional Models described in Gebo and Brooks (2012). The analysis focused on the water quality functions that include functional models F5, F6, F7 as shown in Table 7. The functional model scores provide a relative measure of function, rather than absolute. The scores range from a value of 0 to 1, where 0 represents the absence of that function and 1 would indicate that the function is at the maximal level for that wetland type.

Table 7. HGM Functional Models (from Gebo and Brooks 2012)

Function Number	Function Name	HGM Class
Hydrologic Functions		
1	Energy Dissipation/Short-term Surface Water Detention	Headwater Floodplain, Mainstem Floodplain, Slope
2	Long-term Surface Water Storage	Headwater Floodplain, Mainstem Floodplain
3	Maintain Characteristic Hydrology	Depression, Fringing, Slope
Biogeochemical Functions		
5	Removal of Imported Inorganic Nitrogen	Depression, Fringing, Headwater Floodplain, Mainstem Floodplain, Slope
6	Solute Adsorption Capacity	Depression, Fringing, Headwater Floodplain, Mainstem Floodplain, Slope
7	Retention of Inorganic Particulates	Fringing, Headwater Floodplain, Mainstem Floodplain, Slope
8	Export of Organic Carbon	Depression, Fringing, Headwater Floodplain, Mainstem Floodplain, Slope
Biodiversity Functions		
9	Maintain Characteristic Native Plant Community Composition	Depression, Fringing, Headwater Floodplain, Mainstem Floodplain, Slope
10	Maintain Characteristic Detrital Biomass	Depression, Fringing, Headwater Floodplain, Mainstem Floodplain, Slope
11	Vertebrate Community Structure and Composition	Depression, Fringing, Headwater Floodplain, Mainstem Floodplain, Slope

Application of the HGM Functional Model Scores

A method was developed to apply the HGM functional model scores using the Headwaters setting as the default values, combined with the updated literature review values (see Table 4Table 4) to estimate TN, TP and TSS efficiencies for the different wetland BMPs. See Appendix H for a complete description of the method and results.

To facilitate this analysis, a set of assumptions was applied.

1. It was assumed that the scores for the Reference wetlands in the Riparia database are representative of post-construction BMP wetland conditions for restoration and rehabilitation. Both of these wetland BMPs have similar outcomes according to the Chesapeake Bay definitions, where a restoration and rehabilitated wetland should result in the return or repair of wetland functions similar to a historic or natural wetland, respectively. As such, Table 8 presents the following wetland conditions assigned for the purposes of method development.

Table 8. Wetland condition assigned to wetlands in the Riparia database.

Wetland type	Description	Condition
Reference Standard	Existing wetlands in forested settings	Natural, undisturbed wetland
Reference	Existing wetlands in agricultural or urban settings	Approximate water quality functions of a restored or rehabilitated wetland
Created	Created wetlands	Created wetlands

2. Regardless of the method, the core data used are the mean HGM function model scores (0-1) represented by each wetland type.
3. The results using the Headwater Wetlands is used as a first approximation.
4. A net efficiency definition (Appendix D) is used. Where it is assumed that a restoration and created wetland have a pre-treatment of "0" as there is no wetland present. For the Pre-BMP Condition for Rehabilitation, it is assumed that the score is equivalent to the 10^{th} percentile for Reference Wetlands. A sensitivity analysis and professional judgement was used to determine the 10^{th} percentile.
5. Table 9 provides a summary of the data used for the Headwater wetlands using the HGM functional models and Riparia dataset.

Table 9. Mean Scores from the HGM Functional Assessment Models for Headwater Wetlands for Each Wetland Type

Wetland Type	**Wetland BMP State Represented**	**Scores (Headwater Wetlands)**		
		F5. Inorganic Nitrogen[2]	**F6. Solute Adsorption[2]**	**F7. Inorganic Particulates**
Reference	Post-BMP for Rehabilitation and Restoration	0.56	0.51	0.50
Created	Created	0.42	0.41	0.38
10th percentile for Reference Wetlands[1]	Pre-BMP Condition for Rehabilitation	0.41	0.24	0.24

[1] This value is estimated assuming a normal distribution, and the mean and standard deviation provided for each score.
[2] F5 and F6 refer to forms of ~~nutrients which are a subset of~~ TN or TP, which are likely bioavailable forms.

The scores from the HGM Functional Models (the HGM scores) were used to represent the ratio of performance for each wetland condition, then multiplied by the efficiency for wetland BMPs for TN, TP and TSS from the literature (Table 4~~Table 4~~). The resulting scaling Factors (see Table 6 in Appendix H) begin to indicate the relative condition for each wetland state. The scaling factors (F) were then be used to estimate a composite or average factor for each chemical parameter. Since each score represents a different wetland function, TN, TP and TSS are represented using different HGM function model scores, as follows:

- TN is the average of F5 (Inorganic Nitrogen Retention) and F7 (Inorganic Particulate Retention)
- TP is the average of F6 (Solute Adsorption) and F7 (Inorganic Particulate Retention)
- TSS is F7 (Inorganic Particulate Retention)

The resulting efficiencies are presented in Table 10 where the “lift” represent the net improvement or efficiency of the wetland BMP. It is important to note that the values presented in the table for wetland restoration are only applied for the purposes of the method and not recommended for the wetland restoration BMP in the Phase 6 Watershed Model. Values for the wetland enhancement BMP are not provided, given the recommendation by the Panel to exclude this BMP as an eligible management action for nutrient reductions for the Chesapeake Bay TMDL (see Section 5 of this report).

Table 10. Estimated Wetlands Efficiencies Using Scaling Factors for Wetland Creation and Rehabilitation.

	Wetland BMP Efficiency	***Parameter***		
		TN	***TP***	***TSS***
Restoration **(not the same as the numbers in the model)** Mean from our literature review database	*Pre-Restoration*	0%	0%	0%
	Post-Restoration	39%	42%	43%
	Lift	39%	42%	43%
Creation	*Pre-Creation*	0%	0%	0%
	Post-Creation Riparia Scaling of restored efficiency (ratio of Created to Reference)	30%	33%	35%
	Lift:	**30%**	**33%**	**35%**
Rehabilitation	*Pre-Rehabilitation Riparia Scaling (ratio of 10th percentile Reference to Mean of Reference)*	23%	20%	20%
	Post-Rehabilitation	39%	42%	43%
	Lift	**16%**	**22%**	**23%**

5. Recommendations for Nontidal wetland BMPs in the Phase 6 Watershed Model & Qualifying Conditions

The following recommendations are proposed to account for effects of wetland management strategy implementation and to refine the CBP6 TMDL modeling framework. The recommendations are based on a synthesis of the different approaches this panel explored to define and quantify wetland water quality benefits.

Wetland Enhancement

The panel recommends that wetland enhancement should not be a BMP for purposes of achieving nutrient and sediment reduction targets under the TMDL, as simulated in the Watershed Model. The panel noted that wetland enhancement occurs to one or a few functions from a range of wetland functions. Typical enhancement projects are often not focused on water quality functions like nutrients or sediment retention. In some instances, management or treatment options associated with wetland enhancement could have an adverse impact on water quality, even though the intervention has a desirable outcome. For example, *Phragmites australis* control to enhance habitat value may reduce nutrient and sediment trapping as discussed by Bansal et al. (2019) that summarize the range of ecological services and disservices by this invasive plant. The panel agreed that the definition of wetland enhancement does not guarantee either a focus or effect on improved water quality benefits.

Commented [HJ13]: Added in response to Chris Spaur

Further, the definition of enhancement may vary by jurisdiction or practitioner and presents challenges to adequately distinguish between wetland enhancement and rehabilitation BMPs in the literature. For example, invasive species management may be considered either enhancement or rehabilitation, depending on the degree and goals of the project. The Chesapeake Bay Program definition of a wetland enhancement BMP infers that the baseline condition is a relatively functional wetland (i.e., not a degraded wetland). The panel acknowledges there is ambiguity between wetland rehabilitation and wetland enhancement. The main consideration is that wetland rehabilitation is likely to address the wetland's degraded condition, whereas wetland enhancement may occur on wetlands that are generally considered functional. As such, it is this panel's professional judgment that wetlands that cannot reasonably be considered "degraded" by applicable thresholds and methods should not be targeted for management actions for nutrient and sediment reduction.

The panel further agreed that even when a wetland enhancement project is specifically designed to improve water quality, this could potentially be achieved at a detriment to habitat or other wetland functions. Such negative impacts to other functions may occur even if the project is designed and implemented properly, with oversight and permitting. The panel sees no practical methods for safeguarding against these potential losses in function, concluding that the most logical path is to remove the incentive for wetland enhancement as a BMP for nutrients and sediment reductions. Furthermore, the panel agrees that non-degraded wetlands should not be candidates for management actions if the sole purpose of those actions is nutrient or sediment reductions.

Finally, while the panel is not recommending wetland enhancement for TN, TP, or TSS benefits in the Watershed Model, this is not a judgment or disparagement of wetland enhancement as a practice. Indeed, wetland enhancement as a practice might be valuable for a number of management purposes, such as habitat for key species or control of invasive species. The panel acknowledges these potential benefits and encourages stakeholders to continue implementation of enhancement based on local or state needs and goals, but not as a tool to achieve nutrient and sediment targets under the TMDL. The other wetland BMPs (restoration, creation and rehabilitation) are still available to contribute to nutrient and sediment reduction targets.

Pollutant Removal Efficiencies Recommended for Wetland Creation and Rehabilitation

The panel reviewed the combined results of the literature review, expert elicitation and Riparia database method for TN, TP and TSS and provide the recommended pollutant removal efficiencies shown in Table 11 for wetland creation, rehabilitation and enhancement. The recommended values are based on a review of multiple data analyses as no single method or approach provided adequate information, nor garnered consensus amongst the panel on its own. The efficiency values represent a 'lift' in pollutant removal from the wetland BMP to reflect the pre-existing and post-treatment condition of the wetland, consistent with the efficiency definition adopted by the panel. An efficiency reduction for enhancement is not recommended given the panel's rationale provided in the previous section.

Table 11. Recommended pollutant removal efficiencies for wetland creation, rehabilitation and enhancement (expressed as a percent).

Wetland BMP Type	TN (%)	TP (%)	TSS (%)
Restoration[1]	42	40	31
Creation	30	33	27
Rehabilitation	16	22	19
Enhancement	Not recommended		

[1] The wetland restoration efficiencies are provided for reference and the values are from WEP (2016).

The recommended values are based on the criteria that the percent pollutant reduction for the wetland restoration BMP was set by the previous WEP and that there is a relative ranking of the wetland BMPs based on best professional judgement. Consequently, the wetland efficiencies (as “lift”) for creation and rehabilitation would be less than restoration, and rehabilitation would be less than creation. The panel did recognize that site-specific and design considerations for wetland creation may result in a higher load reduction compared to a restoration BMP, however, the panel also acknowledged that the preexisting condition of a wetland restoration site may have greater potential for long-term sustainability.

A summary of the data used to inform the panel’s recommendations is provided in Table 12. These results show the literature review, in general, provides higher efficiency values compared to the other two methods and the numbers established by WEP 2016 for the wetland restoration BMP. The Expert Elicitation results were similar to the results from Riparia database analyses for all three parameters. The panel recommended the efficiency numbers provided by the Riparia database be used, given the similarities with the Expert Elicitation results. Upon further evaluation of the literature review, the recommendation for TSS reduction required an additional decision point. The results in the literature review were heavily influenced by just a few studies and it was determined the average value from all publications reporting a TSS load reduction would be more representative (i.e., 36%) and was applied to the Riparia database analyses. That is, the 36% value was used to adjust the value in the Riparia database analysis from 35% to 27% as shown in Table 10.

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Table 12. Summary of pollutant removal efficiencies from multiple sources.

Wetland BMP Type	TN (%)	TP (%)	TSS (%)	Source	Note
Wetland BMPs	39	32	43[1]	Literature Review	Unable to differentiate amongst the different BMP types (see Table 4Table 4)
Creation	29.8	27	32.5	Expert Elicitation	Results from "Round 2" survey and represents "net efficiency" or "lift" (see Table 5)
Rehabilitation	21	22.8	20.8		
Creation	30	33	35	Riparia database analyses	See Table 10 Table 10
Rehabilitation	16	22	23		

[1] *The average TSS percent reduction from all studies in the literature review databased is 36%*

Upland Treated Acres

The panel was unable to reach consensus to apply the upland treated ratios recommended by the WEP (2016) for the wetland restoration BMP to the rehabilitation and creation wetland BMPs. The panel acknowledged the significance of landscape position and the influence of hydrologic connectivity and upland sources areas on the water quality function of BMPs. Many of the conceptual models discussed by the panel included these elements. However, similar to the challenges to quantify an efficiency value to differentiate amongst the wetland BMPs, the dearth of data to support the upland treated acres by the nine physiographic areas challenged the Panel to agree with the ratios recommended by the WEP (2016). The panel investigated data reported in the Riparia dataset along with a wetland database for the Nanticoke Watershed in Maryland and found insufficient information to support or build on the WEP (2016), or define alternative ratios to distinguish the performance of a wetland based on its location within the Chesapeake Bay watershed. Therefore, it is recommended by the Panel to report the drainage area of the wetland BMP as part of the water quality benefit (credit). If a drainage area for the wetland creation or rehabilitation BMP is not reported to the State agency, a default ratio will be applied for reporting to the Chesapeake Bay Program. A default 1:1 ratio will be applied to non-floodplain wetland creation and rehabilitation BMPs and a 1.5:1 for floodplain wetland creation and rehabilitation BMPs in acknowledgement of the influence of landscape position (flatter topography, lower in drainage area) and hydrological connectivity to upland sources on retention efficiency of a wetland. The Panel further recommends an upper limit for reported upland acres treated of 4:1 for non-floodplain wetland creation and rehabilitation and 6:1 for these wetland BMPs in the floodplain. These are the maximum ratios recommended by the WEP (2016).

5.1 Qualifying Conditions

The statements and procedures outlined in this Expert Panel Report are intended to supplement existing jurisdictional requirements, where established. The qualifying conditions do not affect any jurisdictional regulatory and other legal requirements. Each project should be assessed based on federal, state, and local regulatory requirements, according to best professional judgments in the field, and supported by benchmarks presented in state and federal guidance documents. It is recommended that wetland delineation should be conducted by a qualified professional in accordance with the USACE 1987 Wetland Delineation Manual (USACE, 1987) and applicable Regional Supplements for all potential Restoration or Rehabilitation projects (https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/).

In general, the intended outcome for all wetlands BMPs should result in a sustainable, functioning wetland that requires minimal, long-term intervention. It is recognized that site visits and maintenance are necessary in the initial years following installation to ensure the project's success. The location, to include consideration of hydrologic connectivity and landscape position, is central to achieving this outcome. The panel acknowledges that a single intervention is often not sufficient given the complex hydrologic, vegetation and soil processes and factors affecting the water quality performance of a wetland. The long-term success of wetland creation and rehabilitation may include monitoring, maintenance, remedial actions, and an adaptative management plan. In particular, successful vegetative management may potentially take multiple years.

The following list of qualifying conditions is not intended to be exhaustive, but rather to provide the following basic guidance:

- It is the intention of the panel that wetland BMP projects only earn nutrient and sediment reductions if they are implemented at appropriate sites which improve the ecological function of a wetland or a non-wetland site where a created wetland BMP is implemented.
- Negatively impacting the functions and/or values of existing wetland systems and high-quality or rare non-wetland ecosystems should not be pursued.
- Changing the functions of existing high-quality wetlands should not be pursued.
- Wetland BMPs should adhere to all federal, state, and local permit requirements and regulations pertaining to jurisdictional wetlands.
- All BMPs should avoid adverse impacts to watercourses or wetlands.
- BMP locations should be chosen to ensure hydrology is sufficient for long-term sustainability of the wetland.
- An assessment of pre- and post BMP conditions should document the identification of the appropriate wetland BMP and find that post-construction, the hydrologic, vegetation, and soil conditions exist for a functioning wetland. General guidance to evaluate the pre- and post BMP conditions is provided below.

- Wetland BMPs in agricultural areas should be designed to promote nutrient and sediment retention to the extent practical.

Guidance to Assess Pre- and Post- Wetland BMP Conditions

An existing conditions assessment of the proposed BMP wetland site will help to determine the BMP most applicable for water quality credit. Figure 3 provides a basic decision framework to identify the eligibility for the different wetland BMPs. This decision framework is based on the existing site conditions as determined in part by the Chesapeake Bay Program wetland definitions and the panel's expert judgment and field experience. For example, a key distinction between wetland restoration or creation wetland BMPs and wetland rehabilitation or enhancement is the presence or absence of an existing wetland. It is expected that the outcome of all management actions will result in hydrologic, vegetation and soil conditions that support a functioning wetland to provide water quality benefit.

The pre-BMP condition is central to determine the eligibility of the type of wetland BMP credit. The project goals and techniques implemented will vary depending on the existing conditions and type of wetland BMP, as shown in Table 13. The list of techniques is provided for example purposes and not intended to be an exhaustive list of all techniques that may be applied in a wetland BMP project. However, all post-BMP wetlands need to have hydric soils, sustainable wetland hydrology, and a dominance of hydrophytic vegetation, in line with the definition of a wetland (U.S. Army Corps of Engineers, 1987, p 9).

> *"Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."*

According to the 1987 USACE Wetland Delineation Manual, evidence of a minimum of one positive wetland indicator from each parameter (hydrology, soil, and vegetation) must be found in order to make a positive wetland determination.

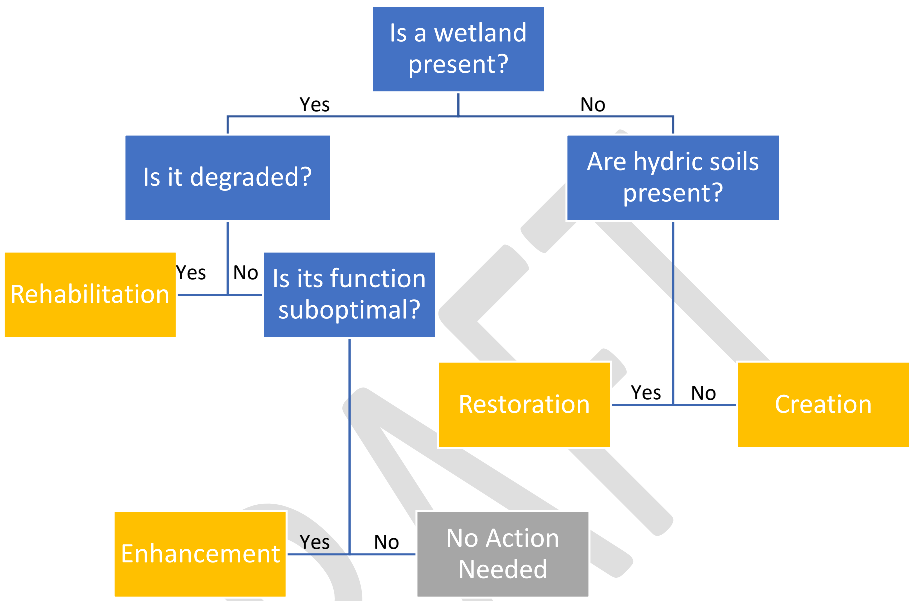

Figure 3. Wetland BMP determination based on existing conditions

Table 13. Wetland BMPs and example techniques to address the hydrologic, vegetation and soil conditions of a wetland post construction.

Wetland Techniques Matrix[1,2]

BMP type	Number of Components Typically Addressed	Wetland Components					
		Hydrology		Vegetation		Soils	
		Goal	Typical Techniques	Goal	Typical Techniques	Goal	Typical Techniques
Restoration	2-3	Reestablish wetland hydrology	• Legacy Sediment Removal • Ditch Fills / Ditch Plugs • ~~Ditch Plugs~~ • Tile Drain Plugs or Breaking Tile Drains • Berm Creation or Modification • Addition of Microtopography	Reestablish a functioning native plant community	• Planting • Seeding • Invasive Species Management • Manage Excessive Wildlife Browse • Livestock Fencing	Reestablish functioning hydric soils	• Fill Removal • Legacy Sediment Removal • Excavation • Decompaction • Organic Matter Addition
Creation	All 3	Establish and maintain wetland hydrology	• Berm Creation or Modification • Excavation • Water Control Structures*4 • Creation of Microtopography	Establish and maintain a wetland plant community	• Planting • Seeding • Invasive Species Management • Manage Excessive Wildlife Browse • Livestock Fencing	Establish wetland soils conditions	• Decompaction • Addition of soil • Organic Matter Addition • Soil Amendment
Rehabilitation	1-2	Modify current hydrology to repair degraded hydrologic conditions.	• Ditch Fills and Ditch Plugs • Regrading Ditch or Watercourse Banks • Levee Breach • Berm Creation or Modification • Addition or Enhancement of Microtopography	Supplement and improve existing plant community to reflect a reference community	• Planting • Seeding • Invasive Species Management • Manage Excessive Wildlife Browse • Livestock Fencing • Forest Management	Amend soils to support a functioning wetland	• Decompaction • Organic Matter Addition • Soil Amendment

Enhancement[3]	1	Improve Hydrologic Function	• Berm Modification • Microtopography/ Addition of Pools and/or Hummocks	Supplement and improve existing plant community to reflect a reference community	• Planting • Seeding • Invasive Species Management • Manage Excessive Wildlife Browse • Livestock Fencing	Enhance existing wetland soils	• Organic Matter Addition • Soil Amendment

1: Derived from Expert Elicitation, the 4/25/18 Strawman Common Wetland and specific inputs from panel members. The techniques provided in the table are included as examples and not intended to be an exhaustive nor complete list.
2: Represents typical techniques; other options may be used to achieve the same goals.
3: Although Hydrology and Soils goals and practices are identified, Enhancement typically focuses on a singular component, and modifying a functioning wetland could have potential negative ecological impacts.
4: Use of water control structures may create concerns as they typically require ongoing maintenance and may have impacts to other resources.

6. Accountability Mechanisms

The accountability mechanisms for wetland creation and rehabilitation practices are similar to wetland restoration practices. These practices must be accounted for and verified for credit toward Chesapeake Bay water quality goals. The Panel recommends the following reporting and verification protocols for wetland BMP projects, consistent with existing CBP wetland BMP verification guidance:

1. Initial verification – The installing agency must confirm that the proposed practice was installed to design specifications, is hydrologically stable and vegetatively stable, and all erosion and sediment control measures have been removed. It is recommended that the installing agencies use an assessment method to identify the applicable wetland BMP eligible for credit (see Qualifying Conditions for recommendations to include a pre- and post-conditions assessment).

   All jurisdictions have or will have verification protocols for reporting wetlands BMPs. Protocols must be based on Chesapeake Bay Program (CBP) guidance. Outreach to practitioners will be necessary to ensure that additional qualifying practices are reported. In addition, CBP will have to ensure that reporting databases contain appropriate fields to receive data on the new BMPs, distinct from other wetland BMPs.

2. Recordkeeping – The installing agency must keep records of all wetland BMP projects.

3. Reporting and duration of credit – Once a year, the NEIEN coordinator for each state will compile this information and submit it to Chesapeake Bay Program.

4. Tracking
   a. The following 8 fields are requested from the state contacts every year:
      i. Field 1: County
      ii. Field 2: HUC-10
      iii. Field 3: Is the project on Federal Land?
      iv. Field 4: Prior landuse
      v. Field 5: Wetland drainage area (acres)
      vi. Field 6: Project Partners
      vii. Field 7: Completion date
      viii. Field 8: Gains in acres (by wetland type: nontidal emergent, nontidal shrub, nontidal forested, nontidal other, tidal)
         1. Gains – Reestablishment (i.e. Wetland Restoration)
         2. Gains – Establishment (i.e. Wetland)
         3. Functional gains – Rehabilitation (i.e. Wetland Rehabilitation)
         4. Protection – Long-term (i.e. applied toward Watershed Agreement protection outcome)
         5. Protection – Short-term (i.e. applied toward Watershed Agreement protection outcome)

b. NEIEN has been updated for Phase 6 to reflect the four categories of wetland BMPs that are now available as defined by this panel and future panel(s). It will accept and distinguish Wetland Restoration and Wetland Creation as acreage gains and; Wetland Enhancement and Wetland Rehabilitation as functional gains. State databases must also be updated to accommodate the enhancement and rehabilitation entries.

5. Ongoing verification – Verification is required to ensure that the wetland BMP projects are performing as designed. The installing agency should confirm that the project was built according to plans (as-built survey was completed). Monitoring of vegetation, hydrology, and soil should be completed for the first three - five years of the project. Native vegetation species cover, invasive species, and wetland indicator status should be recorded. Invasive species should be managed early to prevent further invasion. Hydrology or indicators of hydrology should be recorded, as well as indicators of hydric soils (per the Army Corps of Engineers Wetland Delineation Manual and Regional Supplements). After 5 years, annual observations are recommended to document the continued success of the project. However, if on-site observations are not possible, other methods can be used as a proxy. The Chesapeake Bay Program BMP Verification guidance states the following:

    Onsite monitoring within the three years following construction is recommended. For any long-term monitoring, use of aerial or satellite imagery for remote observations is highly recommended for verification of wetland BMPs; remote observations can indicate encroachment of agricultural activities, clearing, and tree removal. Any issues or concerns with projects implemented on private lands are typically reported by the landowner to the installing agency and addressed as needed.

Commented [HJ14]: Per Chris Spaur

Wetland restoration, creation, rehabilitation and construction projects are reported to CBP either as stormwater BMPs or Ag BMPs/Voluntary restoration. The flow chart shown in Figure 4 (as shown in WEP, 2016) was developed to help practitioners and agency personnel determine how to correctly report wetland acres. Wetland restoration practices that would receive the recommended Phase 6 BMP efficiency values described in this report would fall under the Tidal and Nontidal portions of Figure 4; though as noted in the diagram there are other practices (e.g., shoreline management) that are covered through other BMPs as defined by the CBP.

Existing BMP verification guidance for wetlands is available online as part of the CBP's adopted BMP Verification Framework at: http://www.chesapeakebay.net/about/programs/bmp/verification_guidance

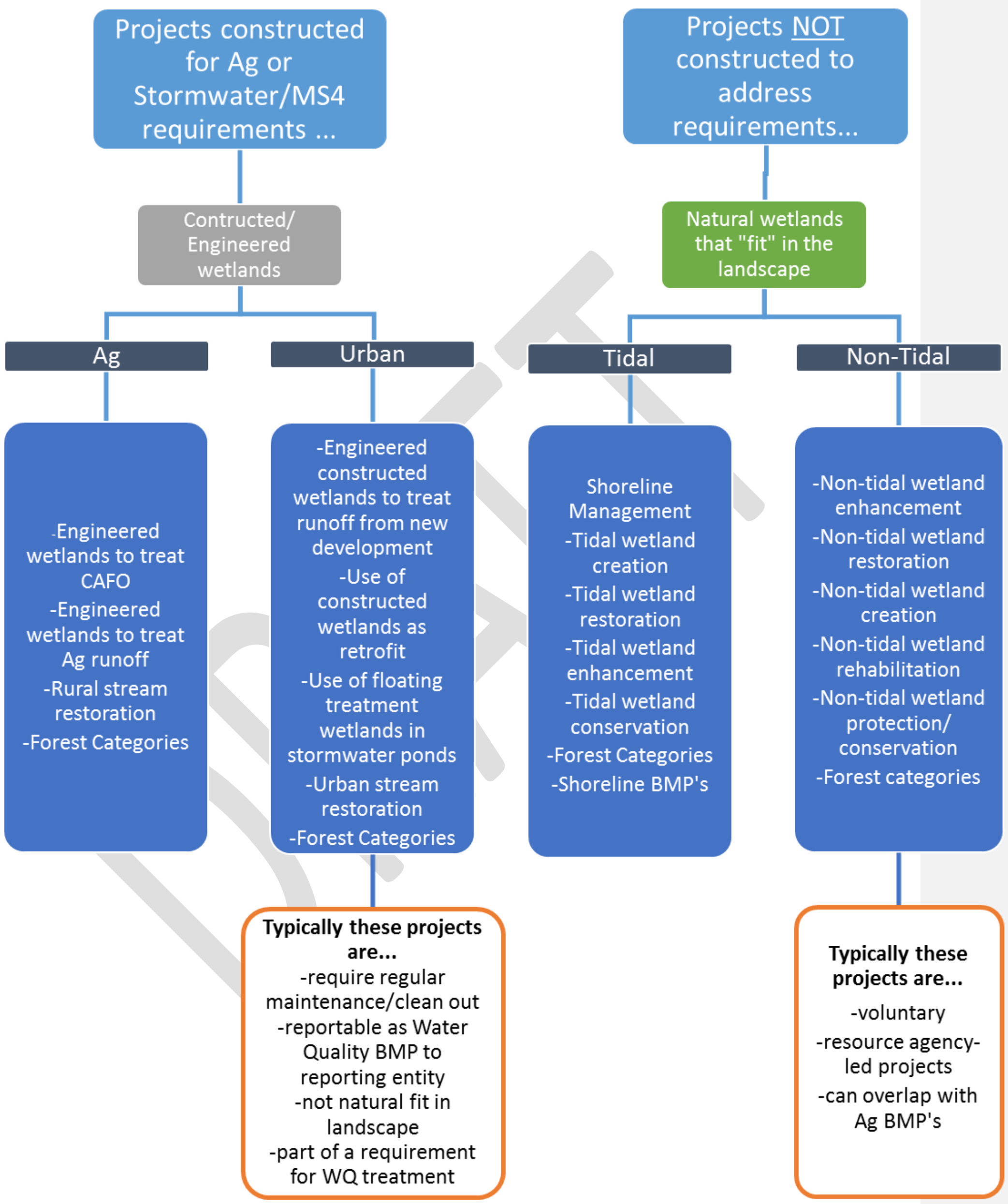

Figure 4. Wetland BMP Reporting Matrix

7. Unintended Consequences

Wetlands provide a vital function to the health and sustainability of the Chesapeake Bay and its watershed. The Chesapeake Bay Agreement acknowledges the significant habitat and water quality benefits provided by wetlands. Wetlands also provide key recreational opportunities and economic value for fishing, hunting and crabbing industry. The conservation of both nontidal and tidal wetlands ~~will~~ could also have a critical role to mitigate the effects of sea level rise in coastal areas. The benefits provided by wetlands need to be safeguarded to ensure their long-term sustainability within the Chesapeake Bay watershed – through the protection and conservation of existing, functioning wetlands along with management actions that increase the acreage and function of wetlands through the implementation of wetland BMPS (e.g. wetland restoration, creation and rehabilitation). The Panel provides a set of issues to ensure these benefits are maintained and achieved with future management actions.

Commented [HJ15]: Per Chris Spaur

- The restoration, creation and rehabilitation of wetlands can not only achieve water quality outcomes and wetland acreage gains sought by the Bay Agreement but could also provide a significant benefit to local water resources and increase and improve habitat within the Bay watershed for a variety of species. However, there are also potential unintended adverse impacts.
- Similar to WEP (2016), the panel asserts the need to identify appropriate sites for wetland BMPs that avoid impact to or alteration of high-quality wetlands. Changing the structure and function of existing high-quality or rare wetland systems should be avoided due to potential unintended adverse impacts and tradeoffs.
- As indicated in Section 5, by removing enhancement as a potential BMP, the potential for unintended consequences of impacting fully functioning and high quality wetlands should be somewhat reduced.
- The potential to improve nutrient and sediment function of wetland should not overlook or take priority over other functions provided by the wetland; tradeoffs of functions should generally be avoided. Mindful consideration and evaluation by wetland professionals/practitioners is needed
- The location of management actions to implement wetland BMPs should be targeted where the need for water quality may be most beneficial; areas of high pollutant loadings/export.
- Avoid double counting of wetlands created in the floodplain for water quality credit from the implementation of stream restoration projects that reconnect streams to the floodplain (see Protocol 3 in Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects). It is recommended that the acreage of wetland created from such stream restoration effort be tracked and reported to the relevant State agency, and subsequently the Chesapeake Bay Program as part of the Agreement Outcomes.

8. Future Research and Management Needs

The recommendations provided by the Panel build on the work from the WEP (2106). The collective effort of these panels provided recommendations that reflect a comprehensive review and discussion of the relevant science and conceptual models to provide the best estimates for nutrient and sediment retention benefits of wetland BMPs for the Chesapeake Bay Watershed. The implementation of the WEP (2016) recommendations and the findings of this panel highlights a continued need to evaluate and quantify the water quality benefits of both natural wetlands and wetland BMPs and likely tradeoffs that result from management actions. The following recommendations are as follows:

- Continued need for research to understand the performance of the different wetland BMPs and how the techniques specifically affect water quality function of wetlands. This will likely require long-term research efforts given that climatic and seasonal patterns significantly affect wetland performance.
- Currently, very limited information is provided to States (reporting is primarily wetland acreage.) Information to track and report wetlands BMPs is needed, including the type of wetland BMP along with drainage area. This is integral to report progress on Agreement Outcomes.
- An accounting framework is recommended to distinguish between high functioning natural wetlands and existing wetlands that are degraded and eligible as a BMP. The implementation of the Phase 6 Watershed Model accounted for existing wetlands with the acreage provided by existing databases (i.e., NWI). There is no condition assessment associated with the mapped wetlands and therefore all acres of natural wetland acreage in the model receive the same land use loading rate.
- It is expected that high-functioning natural wetlands provide multiple benefits to the Chesapeake Bay watershed. Whereas, the water quality function of these wetlands may not be optimal, given the trade-offs with other functions, it is important to incentivize, account or recognize in some way the value of these wetlands to the overall health of the Chesapeake Bay and its ecosystem.
- Review and evaluation of how future versions of the Model may provide an improved representation of natural wetlands as a land use along with wetlands for water quality improvement. Reiterating a recommendation from the WEP (2016), it is recommended that future research using SPARROW or other tools be used to inform the partnership in the future about loading rates or retention factors more representative of wetlands' water quality function.

Commented [HJ16]: Will consider new bullet point after follow-up with Chris Spaur comment re: recent applicable STAC workshops

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