APPENDIX Q: MONITORING AND ADAPTIVE MANAGEMENT PLAN

Neuse River Basin Integrated Feasibility Report and Environmental Assessment Monitoring and Adaptive Management Plan

Contents

1.0 Introduction

This document outlines the feasibility level monitoring and adaptive management plan for Neuse River Basin Feasibility Study and Environmental Assessment. The Project Delivery Team developed this monitoring and adaptive management plan to identify and describe the monitoring and adaptive management activities proposed for the project and estimates their cost and duration. This plan will be further developed in the preconstruction, engineering, and design (PED) phase as specific design details are made available.

The resulting project adaptive management plan for the Neuse River Basin Feasibility Study and Environmental Assessment describes and justifies whether adaptive management is needed in relation to the proposed project management alternatives identified in the Feasibility Study. The plan also identifies how adaptive management would be conducted for the Neuse River Basin Feasibility Study and Environmental Assessment. The developed plan outlines how the results of the project-specific monitoring program would be used to adaptively manage the project, including specification of conditions that will define project success.

This Neuse River Basin Feasibility Study and Environmental Assessment reflect a level of detail consistent with the project Feasibility Study. The primary intent of this Monitoring and Adaptive Management Plan is to develop monitoring and adaptive management actions appropriate for the project's restoration goals and objectives. The specified management actions permit estimation of the adaptive management program costs and duration for the Neuse River Basin Ecosystem Restoration.

This plan is based on currently available data and information developed during plan formulation as part of the feasibility study. Uncertainties remain concerning the exact project features, monitoring elements, and adaptive management opportunities. Components of the monitoring and adaptive management plan, including costs, were estimated using currently available information. Uncertainties will be addressed in preconstruction, engineering, and design (PED), and a detailed monitoring and adaptive management plan, including a detailed cost breakdown, will be drafted by the Adaptive Management Planning Team and PDT as a component of the design document.

2.0 Authority and Purpose

Per Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007), feasibility studies for ecosystem restoration are required to include a plan for monitoring the success of the ecosystem restoration. "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be need to attain project benefits." Section 2039 also directs that a Contingency Plan (Adaptive Management Plan) be developed for all ecosystem restoration projects.

3.0 Management and Restoration Actions

The PDT performed a thorough plan formulation process to identify potential management measures and restoration actions that address the project objectives. Many alternatives were considered, evaluated, and screened in producing a final array of alternatives. The PDT subsequently identified a tentatively selected plan (TSP) which included the following components:

1. Modifying low-head dam on Little River near Goldsboro
2. Kinston East Wetland Restoration complex
3. Stabilizing Gum Thicket Creek and Cedar Creek
4. Restoring oyster reef habitat

4.0 Objectives of Project to be Measured through Monitoring

According to the CECW-PB Memo dated 31 August 2009, "Monitoring includes the systemic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits." The restoration objectives are summarized below. An effective monitoring program will be required to determine if the project outcomes are consistent with original project objectives. These project objectives are summarized below:

- Improve anadromous fish access to Little River.
- Restore degraded floodplain forested wetlands.
- Restore estuarine shoreline marsh and shallow water habitat.
- Provide additional oyster sanctuary reefs.

5.0 Risk and Uncertainties

Adaptive management provides a coherent process for making decisions in the face of uncertainty. Scientific uncertainties and technological challenges are inherent with any large-scale ecosystem restoration project. The team used experience from previous projects i.e expanding on and referencing successful similar work completed by the USACE Wilmington District and others on adjacent/nearby stream or shoreline segments or oyster reef, to identify possible risks and decrease uncertainty in plan formulation. No measures in the TSP are believed to be burdened by significant risk or uncertainty regarding the eventual success of the proposed habitats. Significant risk would be avoided by proper design, appropriate site selection, and correct seasonal timing of biotic applications.

Below is a list of remaining risks and uncertainties associated with the proposed plan:

Risks

- Unusual wind and weather conditions during construction could produce damaging waves, causing flood or drought, alter wind driven hydrology, exacerbate low DO conditions and change normal current and larval distribution patterns. Aberrations from normal conditions could affect plant and oyster establishment and survival.
- Sites will be posted preclude unauthorized vehicle access or oyster harvest; however, the potential remains that anthropogenic damage could occur.

Uncertainties

- Is expected that sufficient quantities of oyster larvae will be are present at proposed reef sites for colonization/oyster recruitment of the newly placed reef structures, as a result, the plan does not include the placement of seeded cultch. There is however uncertainty regarding this expectation. If monitoring shows that natural recruitment has not occurred, an adaptive management measure to apply seeded spat on shell will be implemented.
- Additionally, potential climate change issues, such as sea level rise are significant scientific uncertainties for all coastal projects. These issues were incorporated in the plan formulation process and will be monitored by gathering data on water levels, salinities, and land elevation. These data will inform adaptive management actions, but future climate change projections remain highly uncertain at this time.

6.0 Rationale for Adaptive Management

The primary incentive for implementing adaptive management is to increase the likelihood of achieving desired project outcomes given the identified uncertainties. Adaptive management provides an organized, coherent, and documented process that suggests management actions in relation to measured project performance compared to desired project outcomes. Adaptive management establishes the critical feedback among project monitoring and informed project management, and learning through reduced uncertainty.

Several questions were considered to determine if adaptive management should be applied to the Neuse River Basin Project:

1) Is the ecosystem to be restored sufficiently understood in terms of hydrology and/or ecology, and can project outcomes be accurately predicted given recognized natural and anthropogenic stressors?
2) Can the most effective project design and/or operation to achieve project goals and objectives be readily identified?
3) Are the measures of this restoration project's performance well understood and agreed upon by all parties?
4) Can project management actions be adjusted in relation to monitoring results?

A 'NO' answer to questions 1-3 and a "YES" answer to question 4 qualifies the project as a candidate that could benefit from adaptive management. These questions were asked for each

component of the Neuse Plan; only the oyster component received a "no" for one of the 1st three question (#2) and a "yes" for the 4th and therefore met the requirement for AM.

Relative to the #2 question, there is uncertainty remaining as to whether or not adequate oyster will be present in the estuary at proposed reef sites to assure natural recruitment. If natural recruitment does not occur as predicted, an adaptive management measure to apply seeded spat on shell would be needed.

7.0 Monitoring for Adaptive Management

Oyster Reef Restoration

Proposed Plan. Construct 10 acres of sustainable oyster reef top habitat supporting 80 acres of reef and adjacent service area.

Recruitment monitoring will occur annually for the first 5 years. Methods will be consistent with NCDMF sanctuary sampling methods to the degree practical. The information obtained will be compared to the previous year's sampling results from the restoration site and annual state sanctuary Indexes as available. The following information will be collected for each sample

- Length x Width x Height of rock (mm)
- Number of live and dead oysters
    - 3 size classes spat, sublegal and legal size oysters
- Height of each alive and dead (box) oyster. (Size distribution)

Success Criteria and Adaptive Management Measures

Success Criteria. Successful recruitment will be identified when all 3 size class are present with each class well represented.

Adaptive Management Trigger. If monitoring shows that spat settlement is not adequate (less that 50 spat per m^2) for two consecutive years, spat on shell will be applied during the following reproductive season.

Monitoring. Methods will be consistent with NC Division of Marine Fisheries oyster sampling methods to the degree practical. The information obtained will be compared to the previous year's sampling results from the restoration site and annual state sanctuary Indexes as available. Faunal utilization of the site will be assessed by qualitative methods. An annual monitoring report will be prepared and coordinated with interested parties.

The following additional information will be collected for each sample

- Organisms found attached to rock and extent (fouling)
    - Barnacles, mussels, tunicates, bryozoans, sponges, limpets, etc.
    - Recorded as percent coverage using 7 graded scale (1, 5, 10, 25, 50, 75, 100)
- Presence and number of predators

- Oyster drills, crabs, etc.

8.0 Additional Monitoring of Objectives to Determine Project Success

Oyster Reef Restoration

Structural Persistence. A bathymetric survey of the reef site identifying significant project features will be made upon completion (year 1), which will document base conditions and construction compliance. A comparison survey will also be made at the end of the monitoring period (year 5) to determine structural persistence of project components. The extent of reef will be mapped and quantified.

> ***Success Criteria.*** Neuse River Reef Sanctuaries will be considered successful if at the end of 5 years, the average reef top area (elevations greater than 2 ft above the adjacent river bottom) for all sanctuary reefs is at least 75 percent of the average reef top area for all sanctuary reefs for the as built condition.

Biological Persistence. Biological sampling would be conducted annually for the first 5 Years and also at Year 10. Monitoring would include collection of Class B stones and/or Quadrate Samples by Divers at each project sanctuary and an associated nearby reference reef. Three randomly selected target areas per reef top would be evaluated by collection and analysis of 3 samples each, on an annual basis between years 1- 5 and 10.

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    - Barnacles, mussels, tunicates, bryozoans, sponges, limpets, etc.
    - Recorded as percent coverage using 7 graded scale (1, 5, 10, 25, 50, 75, 100).
- Presence and number of predators
    - Oyster drills, crabs, etc.

> ***Success Criteria.*** Neuse River reef sanctuaries will be considered successful if at the end of 5 years, attachment organisms are abundant and predators are few.

Kinston East Wetland Complex

Proposed Plan. Fill material would be excavated on 14.5 ac of land to approximately match the elevation of the adjacent bottomland hardwood forest (4 ft) allowing high Neuse River flows to flood the area. This measure would restore 14.5 ac of bottomland hardwood forest. The site will be initially planted in grasses. Because the site is located adjacent to mature forest it expected to naturally revegetate with appropriate tree species, without additional planting.

Structural Persistence. A topographic survey of the restoration area will be made upon completion (year 1) as a requirement of the construction contract, which will document base conditions and construction compliance. A comparison monitoring survey will be made at the end of the monitoring period (year 5).

> ***Success Criteria.*** The site will be considered persistent if at least 80 percent of the restored area remains at or below elevations appropriate to support wetlands.

Biological Persistence. Vegetative monitoring would be conducted by plot sampling that is generally consistent with methods for sampling vegetation as described in *A Standard Operating Procedures Manual for the Coast-Wide Reference Monitoring System-Wetlands* (Folse et.al 2008). Monitoring would be conducted annually for the first 5 years and then in years 7 and 10.

Large trees and shrubs (>5 cm DBH) would be counted and measured in three 20m x 20m plots that would be randomly placed along a diagonal transect located across the restoration site. Within each plot, all woody shrubs and trees (saplings and seedlings) >5 cm DBH will be identified to the species level, counted, and their height measured. Diameter at breast height measurements shall be taken for shrubs and saplings of adequate height.

Trees and shrub seedlings and saplings would be counted in at least nine 6m x 6m plots nested (3 each) within the three larger plots. Within each plot, all woody shrubs and trees (saplings and seedlings) <5 cm diameter at breast height (DBH) will be identified to the species level, counted, and their height measured. DBH measurements shall be taken for shrubs and saplings of adequate height.

Herbaceous coverage would be assessed within three 2m x 2m plots nested within each of the $6m^2$ plots. Species composition and cover for each station would be determined using visual estimates of cover following the Braun-Blanquet cover scale (Mueller-Dombois and Ellenburg 1974). Estimates of total percent cover in the plot and percent cover by individual species will be determined.

> ***Success Criteria.*** Targets for tree density and diversity will be developed considering counts made in an adjacent reference area using methods described above. Target species would be selected from a list of dominate species located in the reference site. The forested wetland would be considered successful when, at or after year 10, at least 80

percent of the target density (number of tree species established) and coverage (trees/acre) has been established.

Gum Thicket Cedar Creek

Rock sills approximately 4,500 ft-long at Gum Thicket Creek and 6,700 ft-long at Cedar Creek would be built at distances of up to 90 ft offshore. Constructing the rock sill and replacing eroded sediment landward of the sill would create new marsh after initial planting with *Spartina* species to create a *living shoreline* consisting of planted and open-water areas.

Structural Persistence. A topographic survey of the restoration area will be made during PED, and upon completion (year 1) as a requirement of the construction contract, which will document pre and post project conditions, and construction compliance. A comparison monitoring survey will be made at the end of the monitoring period (year 5).

> ***Success Criteria.*** The site will be considered persistent if at year 5 at least 75 percent of the restored wetland area remains within the range of elevations appropriate to support wetland habitats and shorelines remain seaward of the area where existing wetlands are being protected.

Biological Persistence. Vegetative monitoring would be conducted by plot sampling that is generally consistent with methods for sampling vegetation as described in *A Standard Operating Procedures Manual for the Coast-Wide Reference Monitoring System-Wetlands (*Folse et.al 2008). Monitoring would be conducted annually for 5 years.

Marsh cover would be assessed within a minimum of two hundred 1m x 1m quadrates. Species composition and cover for each station would be determined using visual estimates of cover following the Braun-Blanquet (B-B) cover scale (Mueller-Dombois and Ellenburg 1974) Estimates of Frequency of Occurrence of vegetate samples, total percent cover and percent cover by individual species per plot, and for Gum Thicket and Cedar Creek will be determined. Invasion by exotic non-native plants such as Phragmites will also be assessed.

Plots will be identified in the field by GPS from random points generated by GIS. GPS will also be used to establish the location of the shoreline during each monitoring year.

> ***Success Criteria.*** Targets for Average B-B cover will be developed considering counts made in an adjacent reference area using methods described above. The marsh would be considered successful when the site is generally vegetated along its entire length, where Frequency of Occurrence for vegetated quadrates is at least 80 percent, and average B-B value for percent total cover is no less than 1 increment below the B-B target.

Little River Dam near Goldsboro

Modification of Little River Dam near Goldsboro will include removal of approximately 20-ft section of the existing 100-ft-wide, 4-ft-high concrete dam. Either a hydraulic gate or a stop log structure would be installed within the 20-ft opening. The gate in the existing dam would remain open during the anadromous fish migration season (i.e., about January to May). Only during low-flow conditions (i.e., July to September) would Goldsboro close the gate to use the upstream secondary water intake structure. The PDT estimates fish passage efficiency for the measure to be 99 percent.

Structural Persistence. The up/down river connection would be monitored by visual inspection annually for 5 years to assure that hydrologic connectivity remains intact.

> ***Success Criteria***. The connection would be considered successful when the removed dam section is generally un-obscured for two consecutive monitoring events.

9.0 Cost Estimate

Monitoring Component	**Estimated Total Cost (10 years)**
Oyster Reef Restoration	$457,000
Kinston East Wetland Complex	$144,000
Gum Thicket Cedar Creek	$150,000
Little River Dam Removal	$10,000
10 year total monitoring cost	$741,000
Adaptive Management	**Estimated Total Cost (10 years)**
Oyster Reef Restoration	$450,000

10.0 References

Folse, T.M., J.L. West, M.K. Hymel, J.P. Troutman, L.A. Sharp, D. Weifenbach, T. McGinnis, and L.B. Rodrigue 2008. A standard operating procedures manual for the Coast-wide Reference Monitoring System-Wetlands— Methods for site establishment, data collection, and quality assurance/quality control: Baton Rouge, LA., Louisiana Coastal Protection and Restoration Authority, Office of Coastal Protection and Restoration, 191 p.

Mueller-Dombois, D., and H. Ellenberg. (1974). "Aims and Methods of Vegetation Ecology." John Wiley and Sons, New York.

Water Resources Development Act 2007. Pub.L. 110-114.