

## **I. INTRODUCTION**

The Estuary Restoration Act of 2000 (amended in 2007) mandated the development of monitoring data standards, which the Estuary Habitat Restoration Council (Council) published in 2003. The Council revised the existing standards to provide additional information and clarify certain requirements, in an effort to ensure that future monitoring plans would more effectively meet the standards. This document provides additional details on defining project goals, objectives, success criteria, and on preparing project evaluations. This document represents the revised monitoring data standards established by the Council.

The Council hopes that the revised standards will promote monitoring and provide standards that restoration practitioners can apply to any estuary restoration project. Post construction monitoring is critical to identify the need for corrective measures to achieve unfulfilled project objectives and evaluate restoration techniques to improve the success of future restoration projects. While not the focus of this document, the Council acknowledges that adaptive management throughout the restoration process is an important component of effective project management.

Throughout this document, the inset boxes provide a project example to illustrate how to apply the standards.

## **II. GOALS, OBJECTIVES, AND SUCCESS CRITERIA**

**Projects are required to have clearly defined project goals, objectives, and success criteria.** We recommend that practitioners collaborate with a diverse set of field-appropriate specialists (e.g., ecologists, botanists, statisticians, economists, resource managers) when developing their monitoring plan to ensure that monitoring questions, parameters, and analyses are appropriate for determining if the goals, objectives, and success criteria have been met.

- A. Goals and Objectives:** Goals should describe the overall purpose of the restoration project. Objectives should represent specific measurable and tangible outcomes for a project. Restoration projects can have one or more goals and objectives depending on the complexity of the project.

### **Wild Bison Tidal Basin Restoration: Goals and Objectives**

The goal of the project is restoring the tidal hydrology and ecological function to a salt marsh.

The objectives of the project are: 1) increasing the tidal stage by 30 percent and 2) creating 60 acres of tidal marsh. The chosen method for achieving the objectives is replacement of an undersized culvert.

- B. Success Criteria:** Project objectives should be the basis for success criteria used to evaluate project performance. Success criteria are required for at least one structural and one functional parameter. Structural habitat characteristics define the physical, chemical, and biological composition of the habitat. Functional habitat characteristics describe ecological processes and services provided by a habitat (Thayer et al., 2003).

**In order to determine if the project is meeting its goals and objectives, practitioners will monitor success criteria for a *five-year* period following the construction of the project.** Practitioners should carefully select success criteria to ensure they are achievable in light of project objectives, project design, and site constraints. When developing the success criteria, it is important to be explicit about the spatial and/or temporal scale over which results are expected.

**Wild Bison Tidal Basin Restoration: Success Criteria**

The structural parameter is monitoring tidal stage to evaluate the objective of increasing the tidal stage. The success criterion is a 30 percent increase in stage following the replacement of the culvert.

The functional parameter is assessing the percent cover of native, herbaceous, and salt marsh vegetation. The success criterion is 75% cover of native salt marsh species in the 60-acre restoration area, five years following construction.

**III. MONITORING QUESTION DEVELOPMENT**

**Restoration practitioners are encouraged to develop a monitoring question.** By developing a monitoring question, restoration practitioners must identify what conditions or parameters are necessary to evaluate whether the project meets its objectives and achieves its success criteria. The monitoring question can be a restatement of the project objectives.

The question should prompt practitioners to consider what sampling locations, frequency and duration, and data analyses are necessary to answer the monitoring question. Practitioners should also consider what constitutes meaningful and measurable change, and develop their monitoring plan to answer the monitoring question using formal, testable hypotheses based on the monitoring question (Roni et al., 2005; Thayer et al., 2003).

**Wild Bison Tidal Basin Restoration: Monitoring Question**

One monitoring question is “Has the tidal stage in the marsh immediately upstream of the replaced culvert changed?” A structural parameter for answering this question is tidal stage.

Another monitoring question is “Did we create a native salt marsh?” A functional parameter for answering this question is percent cover of native salt marsh vegetation.

For each of the questions above, statistical hypothesis testing can define a measureable change. Determination of “no change,” an “increase” (one-sided test), or a “change” (two-sided test) in the identified parameters like tidal stage or percent cover of salt marsh vegetation will help answer the monitoring questions most accurately.

#### **IV. REQUIRED PARAMETERS**

**Baseline and post construction monitoring are required. Parameters must include at least one structural and one functional parameter assessed for five years post construction.** Restoration practitioners should consult relevant monitoring guidance or field-appropriate specialists to identify appropriate parameters and methods for evaluating project success. A few recommended references are Roman et al., 2001; Neckles et al., 2002; Thayer et al., 2003; Collins et al., 2007; and Taylor, 2008.

#### **V. MONITORING DURATION AND FREQUENCY**

Restoration practitioners may assess a suite of parameters, during baseline and post-construction monitoring, to evaluate the overall performance of the project; however, assessment of one structural and one functional parameter is required over five years post construction to fulfill the prescribed success criteria requirement.

- A. Baseline monitoring** provides data to document the habitat conditions prior to restoration. Required parameters allow for the comparison of baseline and post construction conditions, and evaluate success criteria. For more information on the collection and importance of baseline, historical, and reference site data, refer to Thayer et al., 2003.

**The required baseline monitoring should include the parameters chosen to determine project success.** Ideally, practitioners would collect baseline data for several parameters over multiple seasons and years prior to project implementation to allow for a more comprehensive understanding of environmental fluctuations at the project site.

- B. Post construction monitoring** provides data to evaluate the habitat conditions following the restoration. Assessment methods should be the same as those used during baseline monitoring to ensure the data are comparable.

The duration and frequency of post-construction monitoring should be appropriate for the chosen parameters and site conditions. Each parameter should be measured at the most appropriate time of day, month and/or year; for example, according to wildlife activity levels, tidal cycles, migratory patterns, vegetation growing seasons, and other relatively predictable variations.

**Monitoring parameters must be sampled multiple times during the post-construction period including a final sampling event at the end of the five-year period.** Multiple sampling periods allow for a more accurate evaluation of project success and identification of the need for adaptive management. Restoration practitioners are encouraged to continue restoration monitoring beyond the required five-year period.

**ESTUARY HABITAT RESTORATION PROGRAM**  
**Monitoring Data Standards**

**Wild Bison Tidal Basin Restoration: Monitoring**

The following chart contains an example of a salt marsh monitoring sequence. Although the species composition and acreage of habitat are not necessary to evaluate the success criteria, they are necessary to evaluate the overall success of the project. The **Xs** indicate what period the parameters were monitored.

Parameters	Baseline Monitoring			Post Construction Monitoring				
	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3	Period 4	Period 5
Tidal stage	X	X	X	X	X	X	X	X
Percent cover of tidal marsh vegetation	X		X	X		X		X
Species composition	X		X	X		X		X
Acreage of habitat	X		X	X		X		X

**VI. PROJECT EVALUATION**

**At the end of the five-year monitoring period, the required final monitoring report will include an overall project evaluation.** The purpose of the project evaluation is to document the overall project success as defined by the goals, objectives, and success criteria. The evaluation should also present lessons learned on how to improve project planning, implementation, monitoring, and analysis techniques. The results from this evaluation will benefit the science of restoration, and may inform design of future projects with similar goals.

A project evaluation can incorporate numerous components of the restoration effort; however, it must contain the following:

- A. **Project name:** The name of the project listed on the proposal.
- B. **Project description:** A brief description of the project should include the importance of the project and any significant changes in the design and implementation of the proposed project.
- C. **Project goals, objectives, and overall project success:** List the goal(s) and objective(s), and discuss whether they were met. If goals, objectives, or overall project success were not achieved, discuss why and connect this to the lessons learned section.
- D. **Analyses:** Analyze and interpret the quantitative and qualitative monitoring data. Discuss the results in light of the project's success criteria. The analyses may include summary tables and interpretive plots.

## ESTUARY HABITAT RESTORATION PROGRAM

### Monitoring Data Standards

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- E. **Lessons learned:** Describe anything learned during project planning, implementation, monitoring, and analysis that could improve the implementation of future restoration projects. For example, were the goals, objectives, and parameters for measuring success appropriate for the project? What would you change if you did a similar project in the future?
- F. **Informing others:** Although not required, practitioners are encouraged to make project evaluations publicly available. Describe how you plan to share your evaluation with the restoration community. This will help other restoration practitioners learn from your experience.

The following summary is a simplified example of a project evaluation. These sections should be included in a more comprehensive monitoring report.

#### **Wild Bison Tidal Basin Restoration: Project Evaluation**

**Project Name:** Wild Bison Tidal Basin Restoration.

**Project Description:** The project replaced an existing undersized culvert with a larger culvert at a lower elevation to return the natural tidal flow to the tidal basin.

**Project Goals, Objectives, and Overall Success:** The goal of the project was to restore the tidal hydrology to the salt marsh with the associated objective of raising the tidal stage by 30%. Overall, the tidal stage rose by 35% (i.e., structural parameter) due to the increased tidal flow from the enlarged culvert. These changes supported an increase in native, tidal marsh plant species (i.e., functional parameter).

**Analysis:** An analysis of the habitat before and after the installation of the culvert documented creation of 60 acres of salt marsh habitat consisting of 85% cover of native, tidal marsh plants, 5% cover of mudflats, 5% open water, and 5% non-native plant species. This has resulted in a ten-fold increase in nesting bird diversity and a 20-fold increase in invertebrate diversity based on the Shannon-Weaver diversity index.

**Lessons learned:** With limited budgets and staff, leveraging partner resources to continue routine inspections of the culvert is critical to maintain optimal tidal stage for target native salt marsh species into the future. Inspections ensure the culvert is functioning properly and clear of debris, and that invasive species have not returned.

**Informing others:** In addition to making our monitoring reports available on our website, we plan to host several restoration workshops that highlight tidal restoration techniques.

**REFERENCES**

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