NAVFAC
Naval Facilities Engineering Command

ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

USER'S GUIDE
UG-2061-ENV

GUIDANCE FOR HABITAT RESTORATION MONITORING: FRAMEWORK FOR MONITORING PLAN DEVELOPMENT AND IMPLEMENTATION

Prepared by

NAVFAC Risk Assessment Workgroup
and
Argonne National Lab

August 2004

Approved for public release; distribution is unlimited.

GUIDANCE FOR HABITAT RESTORATION MONITORING:

FRAMEWORK FOR MONITORING PLAN DEVELOPMENT AND IMPLEMENTATION

Naval Facilities Engineering Command
Washington, D.C.

prepared by

Environmental Assessment Division
Argonne National Laboratory

for the

Naval Facilities Engineering Command
Risk Assessment Working Group

August 2004

(This page intentionally blank.)

EXECUTIVE SUMMARY

This guidance document presents a framework for developing and implementing technically defensible monitoring plans for habitat restoration projects associated with Department of Navy (Navy) Installation Restoration Program (IRP) sites undergoing remediation in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This guidance is also applicable to sites where habitat restoration activities are being considered to address natural resource injuries that may have occurred as a result of past or ongoing Navy activities.

The purpose of this guidance is to:

1. Provide a framework for the development and implementation of scientifically defensible monitoring plans for habitat restoration projects,

2. Facilitate consistency of monitoring of habitat restoration projects across the Navy IRP, and

3. Establish procedures for identifying decision criteria regarding habitat restoration success and cessation of further monitoring.

This guidance presents a six-step framework for developing and documenting a habitat restoration monitoring plan. This framework, which is fully consistent with U.S. Environmental Protection Agency guidance on monitoring plan development, includes identification of monitoring objectives and the development of monitoring hypotheses to focus the monitoring plan, and the development of exit criteria that include action levels and alternative actions for terminating or continuing the restoration project and/or its monitoring program.

This guidance is not intended to specify the scale, complexity, protocols, data needs, or investigation methods for meeting the needs of site-specific restoration monitoring. Rather, it presents a framework that can be used to develop and implement scientifically defensible and appropriate monitoring plans for habitat restoration projects being conducted under the Navy's IRP. Within the framework, Steps 1 through 3 document the logic and rationale of the monitoring program by developing monitoring objectives that are directly related to the objectives of the restoration project. These steps also develop decision rules that will support site management decisions related to the success of the restoration project and its associated monitoring program. Steps 4 through 6 focus data needs and data collection and analysis methods on directly supporting the monitoring objectives, decision rules, and subsequent management decisions. The framework is iterative and allows for the evaluation of the monitoring data as they are generated, thus supporting adaptive management of the restoration project and its monitoring program.

(This page intentionally blank.)

CONTENTS

EXECUTIVE SUMMARY iii

LIST OF EXAMPLES, FIGURES, AND TABLES viii

LIST OF ACRONYMS AND ABBREVIATIONS xi

INTRODUCTION: GUIDANCE FOR HABITAT RESTORATION MONITORING Intro-1

Purpose Intro-1
Overview of Monitoring Intro-2
Habitat Restoration-Specific Monitoring Issues Intro-3
Habitat Restoration Monitoring Plan Development Intro-4
Use of the Data Quality Objectives Process Intro-4
Stakeholder Input Intro-6

STEP 1 IDENTIFY RESTORATION MONITORING OBJECTIVES 1-1

1.1 Examination of the Habitat Restoration Project 1-1
1.1.1 Identify the Restoration Objectives and Endpoints 1-2
1.1.2 Identify the Restoration Approach 1-2
1.1.3 Stakeholder Involvement 1-3
1.2 Identification of Monitoring Objectives 1-3
1.3 Scientific Management Decision Point 1-3

STEP 2 DEVELOP MONITORING PLAN HYPOTHESES 2-1

2.1 Monitoring Hypotheses 2-1
2.2 Monitoring Conceptual Models 2-3
2.3 Stakeholder Involvement 2-3
2.4 Scientific Management Decision Point 2-4

STEP 3 FORMULATE MONITORING DECISION RULES 3-1

3.1 Restoration Monitoring Decision Rules 3-1
3.2 Development of Preliminary Decision Rules 3-2
3.2.1 Action Levels 3-2
3.2.2 Alternative Actions 3-3
3.2.3 Multiple Decision Rules 3-3
3.2.4 Development of Final Decision Rules 3-4
3.3 Temporal Considerations Regarding Restoration Success 3-4
3.4 Stakeholder Involvement 3-6
3.5 Scientific Management Decision Point 3-6

CONTENTS (Cont.)

STEP 4 DESIGN THE MONITORING PLAN 4-1

4.1 Identification of Data Needs 4-1
4.1.1 Expected Outcome of the Habitat Restoration Project 4-3
4.1.2 Previous Site Conditions and Reference Sites 4-4
4.1.3 Data Characteristics 4-5
4.2 Determination of Monitoring Boundaries 4-5
4.3 Selection of Data Collection and Analysis Methods 4-6
4.3.1 Data Collection Methods 4-8
4.3.2 Data Analysis Methods 4-9
4.3.2.1 Descriptive and Inferential Statistics 4-10
4.3.2.2 Trend Analysis 4-10
4.3.3 Uncertainty Analysis 4-11
4.4 Finalization of the Monitoring Plan Design 4-11
4.4.1 Optimizing the Monitoring Study Design 4-12
4.4.2 Finalizing the Decision Rules 4-12
4.4.3 Adaptive Management Considerations 4-14
4.5 Preparation of a Monitoring Quality Assurance Project Plan 4-14
4.6 Scientific Management Decision Point 4-15

STEP 5 COLLECT DATA AND CHARACTERIZE RESULTS 5-1

5.1 Data Collection and Analysis 5-1
5.2 Continued Optimization of the Monitoring Plan 5-2
5.3 Evaluation of Analytical Results 5-2
5.3.1 Relationship of the Results to the Habitat Restoration Monitoring Hypotheses 5-4
5.3.2 Data Adherence to the Data Quality Objectives 5-5
5.3.3 Data Support of the Decision Rules 5-5
5.4 Addressing Data Deviations from the Monitoring DQOs 5-6
5.4.1 Natural Variability 5-6
5.4.2 Evaluating the Habitat Restoration Project 5-7
5.4.3 Evaluating Implementation of the Monitoring Plan 5-8
5.5 Revising the Monitoring Plan 5-9

STEP 6 MANAGEMENT DECISION 6-1

6.1 General Management Decisions 6-1
6.1.1 Monitoring Results Indicate Habitat Restoration Is Successful 6-2
6.1.2 Monitoring Results Indicate Habitat Restoration Is Trending toward Success 6-2
6.1.3 Monitoring Results Indicate Habitat Restoration Is Unsuccessful 6-4

CONTENTS (Cont.)

6.2 Documentation and Scientific Management Decision Point 6-4
6.2.1 Interim Annual Monitoring Reports 6-5
6.2.2 Final Monitoring Report — Conclude Habitat Restoration 6-5
6.2.3 Final Monitoring Report — Continue Habitat Restoration and Monitoring 6-6
6.2.4 Final Monitoring Report — Revise the Habitat Restoration Project 6-7

7 REFERENCES 7-1

APPENDIX A: CASE STUDY A-1

LIST OF EXAMPLES, FIGURES, AND TABLES

List of Examples

1 Integration of Data Quality Objectives into the Development of a Monitoring Plan for Verifying the Success of a Hypothetical Prairie Restoration Project Intro-7

1.1 Potential Monitoring Objectives for Different Restoration Projects 1-4

2.1 Monitoring Conceptual Model for a Wetland Restoration Project 2-4

3.1 Preliminary Decision Rules for a Terrestrial Habitat Restoration Project 3-3

3.2 Preliminary Decision Rules for a Wetland Restoration Project 3-5

List of Figures

1 Six-Step Process for Developing and Implementing a Habitat Restoration Monitoring Plan Intro-5

5.1 Decision Path during Monitoring Implementation and Data Collection and Analysis 5-3

6.1 Monitoring Outcome Management Decision Path 6-3

List of Tables

4.1 General Physical Data Categories Commonly Considered for Monitoring Success of Habitat Restoration Projects 4-2

4.2 General Chemical Data Categories Commonly Considered for Monitoring Habitat Mitigation Projects 4-2

4.3 General Biological Data Categories Commonly Considered for Monitoring Habitat Mitigation Projects 4-3

4.4 Relative Response Times for Observing Changes in General Categories of Potential Chemical Monitoring Data 4-7

4.5 Relative Response Times for Observing Changes in General Categories of Potential Biological Monitoring Data 4-7

LIST OF EXAMPLES, FIGURES, AND TABLES (Cont.)

4.6 Relative Response Times for Observing Changes in General Categories of Potential Physical Monitoring Data..... 4-8

4.7 Advantages and Limitations of Some Commonly Used Monitoring Data Collection Methods..... 4-13

6.1 Monitoring and Management Decision Documentation..... 6-5

(This page intentionally blank.)

LIST OF ACRONYMS AND ABBREVIATIONS

BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DQO	data quality objective
GIS	geographic information system
IRP	Installation Restoration Program
m	meter(s)
NOAA	National Oceanic and Atmospheric Administration
NRT	Natural Resource Trustee
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RPM	Remedial Project Manager
SER	Society for Ecological Restoration
SMDP	Scientific Management Decision Point
U.S. EPA	United States Environmental Protection Agency

(This page intentionally blank.)

INTRODUCTION: GUIDANCE FOR HABITAT RESTORATION MONITORING

PURPOSE

This guidance document presents a framework for developing and implementing technically defensible and appropriate monitoring plans for habitat restoration projects associated with Department of the Navy (Navy) Installation Restoration Program (IRP) sites undergoing remediation in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). It is also applicable to sites that are implementing habitat restoration activities to address natural resource injuries that may have occurred as a result of past or ongoing Navy activities. It is directed to the site managers (Remedial Project Managers [RPMs]) who are responsible for managing removal and remedial site activities and their support staff. The purpose of this guidance is to:

1. Provide a framework for the development and implementation of scientifically defensible monitoring plans for habitat restoration projects,

2. Facilitate consistency of monitoring of habitat restoration projects across the Navy IRP, and

3. Establish procedures for identifying decision criteria regarding habitat restoration success and cessation of further monitoring.

Habitat Restoration

In this guidance, habitat restoration refers to the process of establishing a habitat that resembles a natural condition and provides for habitat conditions that are improved over prerestoration conditions.

The framework described in this document is intended solely as guidance. This guidance is not a regulation itself, nor does it change or is a substitute for any existing or future provisions and regulations. Because of site-specific circumstances, the framework and associated guidelines provided in this document may not apply to all situations under which Navy habitat restoration activities are being conducted. Thus, the RPM is free to deviate from this guidance as deemed necessary under a particular situation. However, application of this guidance to the development of habitat restoration monitoring plans is expected to provide overall benefits to the restoration project, in particular, and, in general, to the overall remediation project.

The United States Environmental Protection Agency (U.S. EPA) has recently prepared interim guidance (U.S. EPA 2004) for developing and implementing monitoring plans at hazardous waste sites. The monitoring framework presented in that guidance describes a process that can be adapted to monitor remedy effectiveness, compliance, and restoration activities. The monitoring design and implementation framework presented in this Navy guidance is fully consistent and compatible with U.S. EPA monitoring guidance.

This guidance document is not intended to specify the scale, complexity, protocols, data needs, or investigation methods for meeting the needs of site-specific restoration monitoring. Rather, it presents a framework that can be used to develop and implement scientifically defensible and appropriate monitoring plans for habitat restoration projects being conducted under the Navy's IRP.

OVERVIEW OF MONITORING

Monitoring may be defined as the collection and analysis of environmental data (biological, chemical, and/or physical) over a sufficient period of time and frequency to determine the status and/or trend in one or more environmental parameters or characteristics toward meeting a management objective (Elizinga et al. 1998). On the basis of this definition, monitoring is driven by management objectives and is implemented within a management context.

Focus of Habitat Restoration Monitoring

- Evaluation of restoration effectiveness.
- Compliance with regulatory requirements.
- Guidance of restoration activities to enhance success potential.

Contingent upon the nature of the site, the focus of the restoration monitoring will depend directly on the specific restoration activity and its associated objectives. In general, restoration monitoring will have one overarching objective, namely, documenting restoration effectiveness. Another monitoring objective, equally if not more important, is that of guiding restoration activities to enhance overall restoration success. In most cases, monitoring should not produce a "snapshot in time" measurement, but rather should involve repeated sampling over time in order to define the trends in the parameters of interest relative to clearly defined management objectives. In some cases, restoration monitoring may have the additional objective of demonstrating regulatory compliance.

The data generated during monitoring will, in general, point toward one of three conclusions related to restoration success that will be used to support a management decision regarding the restoration project. First, the monitoring results may indicate that the restoration has been successful, and the management decision may be to terminate monitoring and further restoration activities. Second, the monitoring data may indicate that the restoration is trending toward success. In this case, the decision may be to continue the restoration and its monitoring, continue restoration but reduce the frequency of monitoring, or to conclude that the restoration has been successful and terminate further restoration and monitoring. Finally, the monitoring data may be equivocal, show no restoration success (e.g., fail to attain the desired restoration goal), or show a slight trend toward success. The management decision in this case may be to evaluate both the restoration project and the Monitoring Plan to determine what factors may be responsible for the observed results, and revise the restoration project and/or the Monitoring Plan accordingly. Such management decisions may be made throughout the monitoring period as monitoring data are generated and interpreted.

HABITAT RESTORATION-SPECIFIC MONITORING ISSUES

Monitoring for habitat restoration will be quite different from the monitoring associated with determining the site remediation success, especially from a temporal perspective. For a remediation project, monitoring will likely focus on environmental parameters related directly to the contaminants of concern. For example, remediation success will often be based on monitoring data showing that an environmental contaminant level has been reduced to a target concentration, that the spatial extent of contamination has been reduced, and/or that contaminant migration has been controlled. Depending on the type of remedy (groundwater treatment, soil excavation, or landfill capping), the success of the remediation project will be relatively straightforward to ascertain and may be relatively quickly achieved.

At habitat restoration sites, the monitoring design will be affected not only by the physical, chemical, and biological nature of the site, but also by the natural variability of ecological parameters and unpredictable time frames for desired habitat responses to occur. Restoration sites can be expected to have a much greater degree of uncontrollable variability and unpredictability with regard to the target habitat conditions and may require considerably greater time (decades) for the preferred habitat condition to be achieved. In contrast to an engineered remediation project, project staff cannot control many restoration-related site parameters.

Once the initial restoration activities have been implemented (such as planting or stocking of desired species, exotic species removal, or physical construction), the determination of restoration success often moves into a "wait-and-see" approach for some aspects of the restoration. Subsequent restoration activities typically occur in direct response to the observed changes in the monitored habitat parameters and professional judgment. Observed changes may occur for a variety of reasons. Biota from outside the restoration site may move into the site and become established, while plant species in a seed bank may not germinate for a year or more following initial placement into the restoration site. Alternately, previously uncommon biota within a site may spread throughout the site. Finally, environmental conditions may change as the new habitat "ages," affecting which species can best use the restored site at any particular point in time (a natural ecological process known as succession).

In each of these situations, the time frame needed to observe a change may be several years. The time frame may vary, not only as a function of the type of restoration project being implemented, but also on the basis of the site-specific environmental and biological conditions of the site, regardless of the restoration project itself. Because of the temporal aspects of ecological change in habitats, actual restoration success may require many years (decades or more) to demonstrate. Thus, monitoring programs for determining restoration success may be more difficult than programs designed for demonstrating remediation success. In such cases, the monitoring objectives may be directed more to showing a trend toward the desired habitat condition rather than the determination that the desired condition has been attained.

HABITAT RESTORATION MONITORING PLAN DEVELOPMENT

This guidance document presents a six-step process (Figure 1) that can be used to develop clear-cut restoration monitoring objectives; develop scientifically defensible study designs and data interpretation methods; and support management decisions based on decision criteria for continuing, revising, or concluding monitoring and site activities. This guidance does not provide details on individual data collection methods, statistical analyses, or other data collection and analysis aspects of monitoring. Rather, it focuses on the components critical to developing a monitoring plan for restoration projects with clearly identified and appropriate objectives, methods, and decision criteria.

At the conclusion of each of the steps of the monitoring framework, a scientific management decision point (SMDP) occurs. These SMDPs serve as points in the process where decisions are made with regard to Monitoring Plan objectives, hypotheses, study design, and, ultimately, the management decision. Depending on the specific step in the process, documentation of the SMDP in a formal deliverable may or may not be appropriate. The Monitoring Plan should include the quality assurance (QA) and quality control (QC) policies and procedures needed to achieve the monitoring objectives.

Monitoring Framework Scientific Management Decision Points

Step 1:	Monitoring objectives.
Step 2:	Monitoring hypotheses, questions, and conceptual site models.
Step 3:	Preliminary decision rules.
Step 4:	Monitoring Quality Assurance Project Plan.
Step 5:	Revisions to monitoring implementation.
Step 6:	Decision document.

The development of a restoration monitoring plan may go through one or more iterations, especially involving Steps 2 through 4. For example, development of the Monitoring Implementation Plan may show that using the restoration monitoring hypotheses and decision rules developed in Steps 2 and 3 may result in a monitoring plan that is too expensive or too difficult to implement. In this case, one should return to Step 2 and see if the current hypotheses can be revised, or alternative monitoring hypotheses and decision rules can be developed that would allow development of an appropriate monitoring plan.

USE OF THE DATA QUALITY OBJECTIVES PROCESS

The six-step process for developing restoration monitoring plans presented in this guidance is fully consistent with recent U.S. EPA monitoring guidance (U.S. EPA 2004) and relies heavily on the use of the data quality objective (DQO) process (U.S. EPA 2000a). The DQOs identify (1) when and where to collect samples, (2) the number of samples to be collected, (3) how the samples should be analyzed, (4) the analytical performance criteria that need to be met, (5) how the results should be interpreted relative to the monitoring objectives, (6) the practical constraints for collecting the samples, and (7) the level of uncertainty that is acceptable to the decision maker with regard to making a management decision about the restoration.

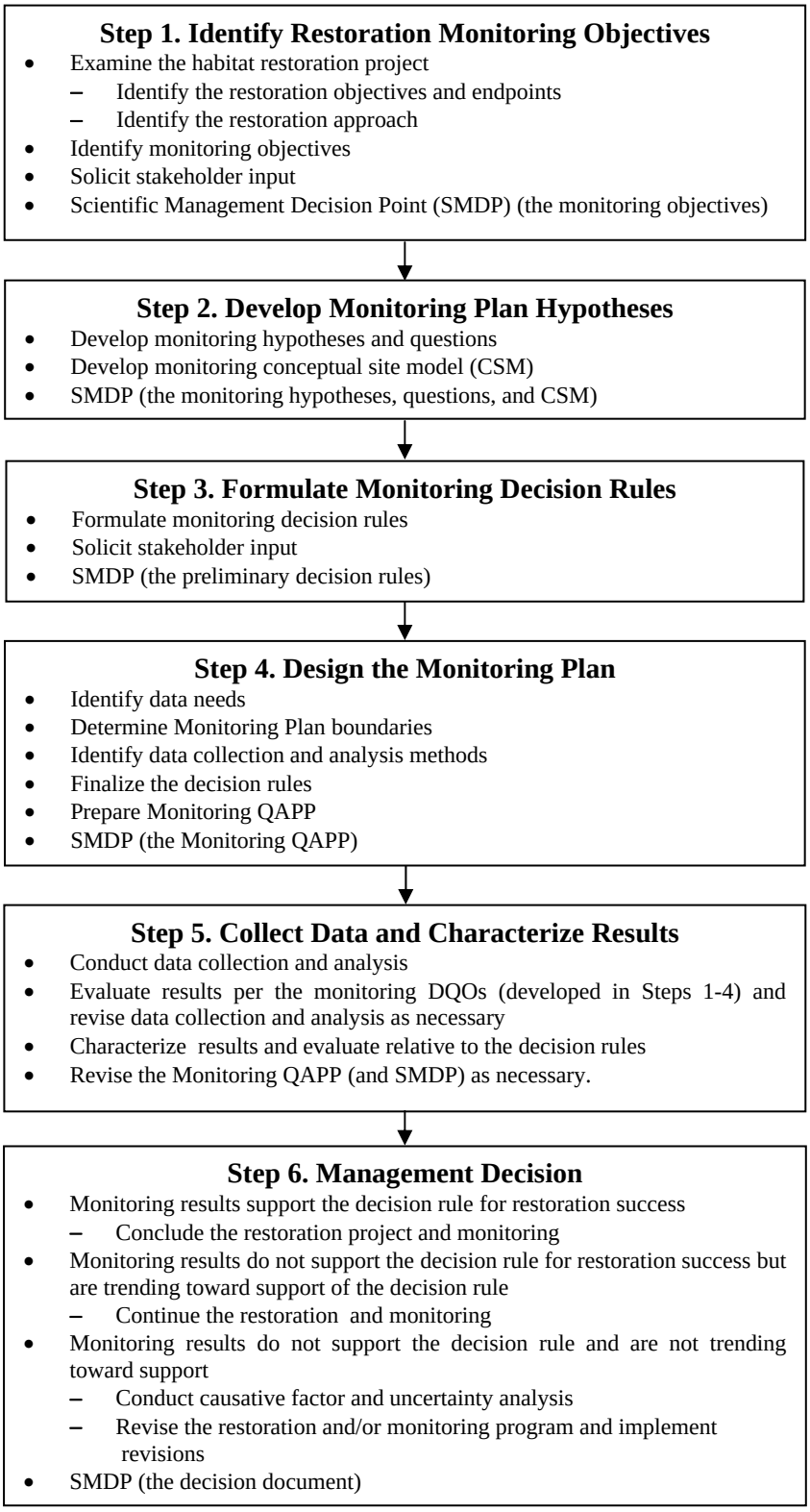


FIGURE 1 Six-Step Process for Developing and Implementing a Habitat Restoration Monitoring Plan

The DQO Process

1. State the problem.
2. Identify the decision.
3. Identify input to the decision.
4. Define the study boundaries.
5. Develop a decision rule.
6. Specify limits on the decision errors.
7. Optimize the design for obtaining data.

Use of the DQO process in the development of the restoration monitoring plan will serve to focus the Monitoring Plan on a clear action-oriented decision and help ensure that decisions are made with a desired level of confidence in the results. The DQO process consists of seven sequential steps that lead to the development of an optimized data collection plan, and the output of each step serves as input for the next step (U.S. EPA 2000a). The process may be iterative, with the output of one step resulting in reconsideration of earlier steps. Example 1 illustrates how the DQO process may be integrated with the restoration monitoring plan development framework for a hypothetical habitat restoration project.

STAKEHOLDER INPUT

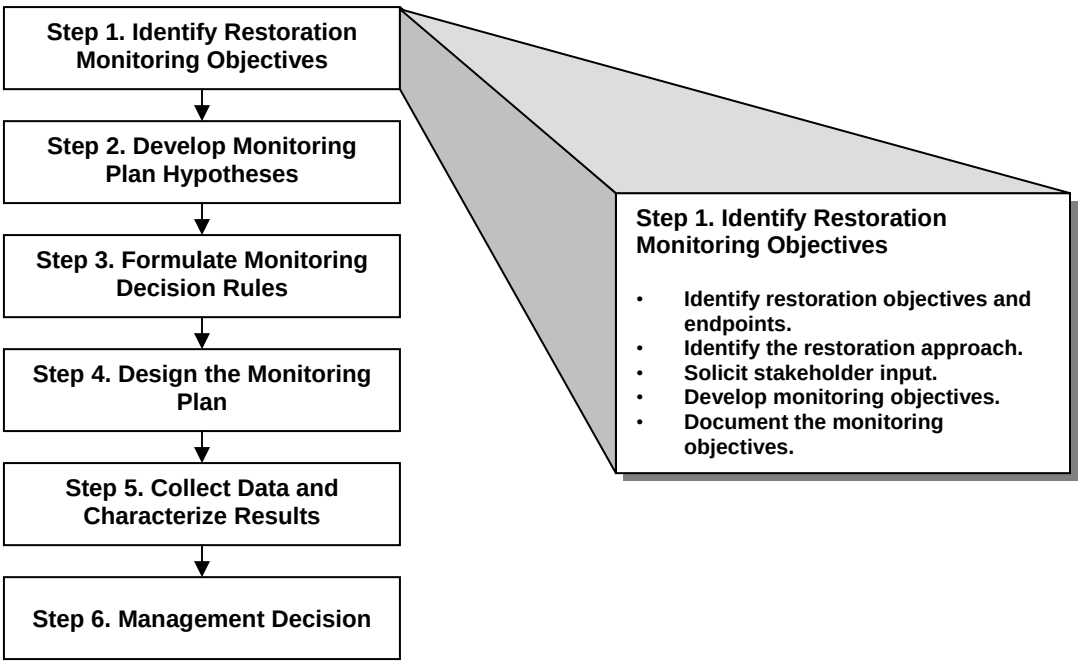
Development of the restoration monitoring plan should include the early involvement of appropriate stakeholder such as regulators, Natural Resource Trustees (NRTs), and the public. Early involvement during development of the Monitoring Plan serves to identify stakeholder issues and concerns before the monitoring objectives, decision rules, and study design are finalized and implemented. During stakeholder involvement, it is important to keep in mind that the Navy is the lead decision maker for the restoration project and for the development of its associated monitoring program. While the intent of such early involvement is to take stakeholder opinions into consideration and thus limit future disagreements regarding the specific design of the Monitoring Plan and thereby avoid project delays and increased costs, it may not be possible for the Navy to meet all stakeholder expectations for restoration and monitoring.

EXAMPLE 1 Integration of Data Quality Objectives into the Development of a Monitoring Plan for Verifying the Success of a Hypothetical Prairie Restoration Project

Monitoring Framework Step	Associated DQO Step	Habitat Restoration Project
Step 1. Identify Restoration Monitoring Objectives	**Step 1. State the Problem.** Summarize the problem that will require new environmental data (the monitoring hypothesis).	A 50-acre former landfill site was selected for restoration to prairie. The Monitoring Plan objective is to determine when the restoration activities have successfully restored the 50-acre site to acceptable prairie habitat.
Step 2. Develop Monitoring Plan Hypotheses		Through planting, controlled burns, and herbicide application, a prairie habitat will be established within 7 years. Native plant species typical of this prairie habitat will compose >50%, and exotic species will compose <10% of the vegetative cover of the restored site.
Step 3. Formulate Monitoring Decision Rules	**Step 2. Identify the Decision.** Identify the decision that requires new data to address the problem.	The decision, identified as a preliminary decision rule, is that *If* restoration is shown to be successful, *then* restoration and monitoring will be terminated. *If* success is not indicated, *then* the decision will be to continue restoration and monitoring.
Step 4. Design the Monitoring Plan	**Step 3. Identify Input to the Decision.** Identify information needed to support the decision; specify new data needs.	Needed data include plant community species composition and the contribution of native and exotic vegetation to the total vegetative cover of the restored site.
	Step 4. Define the Study Boundaries. Specify the spatial and temporal aspects of the environmental media or endpoints that the data must represent to support the decision.	Monitoring will be limited to the 50-acre restoration area; data collection will occur yearly in late summer-early autumn for the next 7 years.
	Step 5. Develop a Decision Rule. Develop a logical "*if...then…*" statement that defines the conditions that would cause the decision maker to choose among alternative decisions.	Finalize the decision rule as: *If* the plant community includes 40 native species, with 7 native species composing >50% and nonnative species composing <10% of the vegetative cover of the site, *then* restoration will be considered successful and restoration and monitoring can be stopped. *If* these conditions are not met, *then* determine causative factors, revise restoration and/or monitoring, and implement.
	Step 6. Specify Limits on Decision Error. Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.	Reducing data uncertainty will be based on a sample size considered representative of the restoration site. Randomly placed transects with a minimum 15-m spacing interval and with plant survey locations spaced at 10-m intervals along each transect will be considered to adequately represent the restoration site.
	Step 7. Optimize the Design for Obtaining Data. Identify the most resource-effective sampling and analysis design for generating data needed to satisfy the DQOs.	Identify appropriate sampling methods, develop sampling design, and prepare the Monitoring Implementation Plan.
Step 5. Collect Data and Characterize Results	Implement design optimized in Step 7.	Implement data collection and analyze data as they are collected.
Step 6. Management Decision	DQO Steps 2 and 5.	Evaluate monitoring results and make a management decision based on the decision rules.

(This page intentionally blank.)

STEP 1 IDENTIFY RESTORATION MONITORING OBJECTIVES



Development of the restoration monitoring plan should begin with the identification of monitoring objectives that are directly related to the expected outcome of the habitat restoration project (i.e., creation of new habitat, mitigation of wetland function, restoration of a native plant community). In general, the restoration monitoring objectives can be placed into one of the following categories:

- Demonstration of the establishment of a particular habitat type;
- Demonstration of the attainment of a specified amount of habitat; or
- Demonstration of compliance with a habitat-based regulatory requirement (i.e., required wetland replacement to meet Clean Water Act permit requirements).

The monitoring objectives most applicable to a particular habitat restoration project will be determined by the nature of the restoration itself. In some cases, a variety of monitoring objectives may be needed at a single restoration site.

1.1 EXAMINATION OF THE HABITAT RESTORATION PROJECT

The identification of monitoring objectives will be based on the examination of the restoration project, which will help to identify physical, chemical, and/or ecological parameters

that could be used in developing the Monitoring Plan study design. Examination of the restoration project should focus on:

- The expected outcome of the habitat restoration project (what is the restoration intended to accomplish and what are the specific biological or environmental parameters expected to be affected by the restoration?) and

- The restoration approach (how is the restoration expected to meet its intended objectives?).

In addition to aiding in the development of monitoring objectives, information regarding the expected outcome of the restoration project, its endpoints, and its approach will also be useful in the development of monitoring decision rules (see Section 3) and in the design of specific monitoring studies (see Section 4). The time frame for implementation and completion of the habitat restoration should be identified to provide temporal bounds to the monitoring objectives and subsequent monitoring studies.

1.1.1 Identify the Restoration Objectives and Endpoints

Each habitat restoration project will have a unique set of biological endpoints (and related physical and chemical endpoints) that are associated with (or related to) the restoration objectives and are the target of the restoration activity. These endpoints should be considered in developing the monitoring objectives. For example, the target endpoints for a grassland restoration project may be a specified level of plant species diversity or a specific community structure, while the target endpoint for a wetland restoration project may be a specified areal amount of wetland coverage. For the former example, the monitoring objective would likely be related to demonstrating attainment of the target species diversity or community structure. For the latter example, the monitoring objectives would be related to demonstrating attainment of the specified areal extent of wetland habitat.

Restoration Endpoints

Restoration endpoints are the biological, chemical, and/or physical parameters that are the target of the restoration activity. Examples include:

- A target plant community structure.
- A minimum level of fish production.
- A specific amount of artificial reef.
- A specified flooding regime.

1.1.2 Identify the Restoration Approach

The restoration approach defines how the restoration is expected to attain its desired outcome and relates the restoration endpoints to the restoration objectives. For example, at a wetland restoration project the restoration objective might be to mitigate past impacts to the wetland community, with the restoration targeting plant community structure and species composition. The mode of action of the restoration may be the establishment of a specific wetland community type through the use of controlled burns and herbicide application to reduce or eliminate exotic and undesirable vegetation, and active planting to establish desired wetland

plant species. Monitoring objectives related to this mode of action may focus on demonstrating the reduction or elimination of exotic vegetation as well as the establishment of the desired native wetland vegetation.

Restoration Approach

The restoration approach refers to the mode of action by which the restoration is expected to be accomplished and may include:

- Vegetation planting.
- Fish stocking.
- Artificial reefs.
- Passageways to enhance fish access to existing habitats.
- Exotic species removal.

1.1.3 Stakeholder Involvement

The Navy is the lead decision maker for the restoration project and for the development of its associated monitoring program. Because habitat restoration projects will typically be of high interest to NRTs, and probably other parties, it is important that interested stakeholders be involved during the identification of the restoration outcome and approach. Such groups have probably played some role in the development of the restoration project, including the identification of the restoration methods and outcome.

1.2 IDENTIFICATION OF MONITORING OBJECTIVES

The ultimate purpose of the restoration monitoring program is to demonstrate that the desired restoration outcome has been, or is being, met and to thus support a management decision regarding project success and termination. Once information regarding the restoration objectives and approach has been examined, one or more restoration-specific monitoring objectives can be identified. These objectives should be developed to specifically evaluate restoration success relative to the stated objectives of the restoration activity. The focus of the monitoring objectives relative to the restoration objectives and mode of action should be clearly stated. Example 1.1 presents potential monitoring objectives of different types of restoration activities.

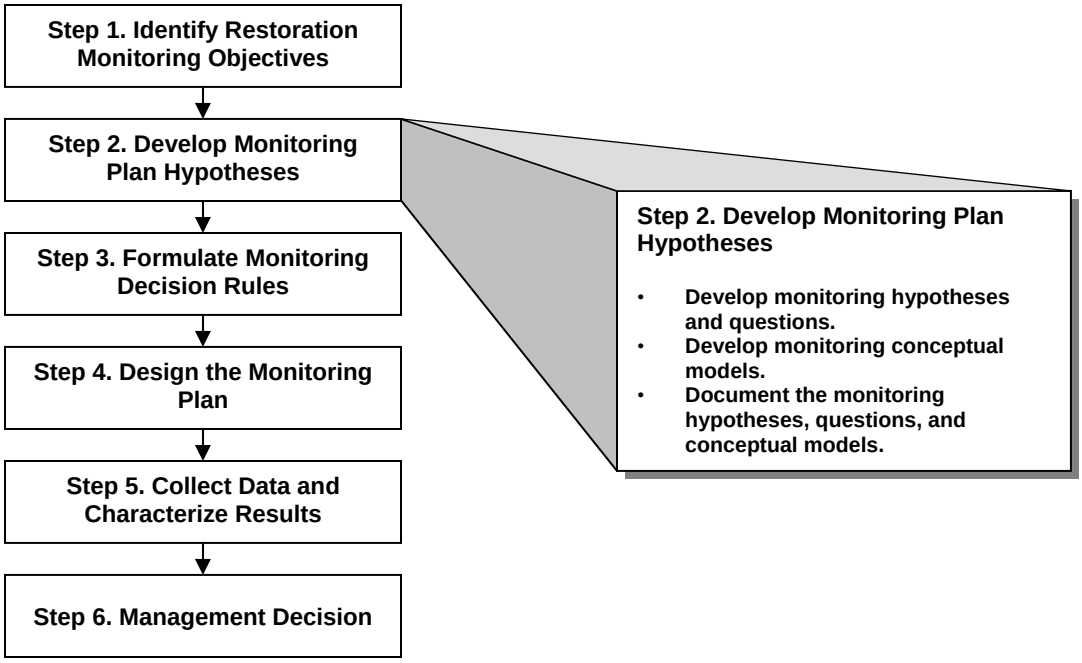
1.3 SCIENTIFIC MANAGEMENT DECISION POINT

Once the initial monitoring objectives have been identified, the decision identifying the restoration project monitoring objectives should be documented. While a formal deliverable is not necessary, the monitoring objectives, including the rationale supporting the selection of the objectives and any discussions with stakeholders, should be recorded as a memorandum or letter to file.

EXAMPLE 1.1 Potential Monitoring Objectives for Different Restoration Projects

Restoration Project	Restoration Approach	Monitoring Objectives
Grassland restoration to provide habitat for upland birds.	Use prescribed burns to reduce or eliminate exotic vegetation and establish, through active planting, food and cover crops required by selected upland bird species.	Demonstrate the successful restoration of upland bird habitat by the establishment of a plant community that can support upland bird populations.
Wetland creation to provide waterfowl habitat.	Contour terrain to support desired hydrologic regime followed by planting wetland vegetation.	Demonstrate the successful creation of waterfowl nesting habitat through the creation of wetland that can be used by waterfowl.
Stream channel restoration to return salmonid spawning to past levels.	Restore substrate composition to create suitable spawning habitat for selected trout species.	Demonstrate the successful creation of suitable trout spawning habitat through the creation of gravel bars with appropriate substrate characteristics.

STEP 2 DEVELOP MONITORING PLAN HYPOTHESES



The next step in developing the restoration monitoring plan involves the development of monitoring hypotheses, which serve to focus the Monitoring Plan, its decision criteria, and thus the overall and specific monitoring design. These hypotheses will be developed from the monitoring objectives developed in Step 1. The monitoring hypotheses can be incorporated into a monitoring conceptual model that describes the assumed relationships between the restoration activity and the expected environmental responses. The development of monitoring hypotheses and a monitoring conceptual model is analogous to Step 1 of the DQO process (*State the Problem*). Rather than stating a *problem* that requires new environmental data, a *desired outcome* is stated that will require new data to verify attainment of that outcome.

Monitoring Hypotheses and Questions

Monitoring Hypotheses: Statements on how the restoration project is expected to reach its objectives.

Monitoring Questions: Questions that link the expected restoration outcome with specific restoration project activities and measurable habitat characteristics.

2.1 MONITORING HYPOTHESES

The Monitoring Plan presents the approach to be implemented in order to answer one or more monitoring questions related to the success of the restoration project. Specifically included in the plan are the data collection and analysis methods needed to adequately answer these questions and determine project success. Consequently, the outcome of the monitoring will aid in

management decisions regarding the continuation, modification, or termination of the restoration project and/or its associated monitoring.

The monitoring questions are based on specific hypotheses regarding the expected outcome of the restoration project and its associated activities. Development of these monitoring hypotheses is analogous to the problem formulation step of the DQO process. For most habitat restoration projects, the hypotheses will be statements on how the restoration project is expected to reach its stated objectives with regard to specific measurable characteristics of the habitat. The associated monitoring questions will directly link the restoration objectives with the measurable characteristics.

For example, implementation of a remediation project may have required the elimination of a mature deciduous forest habitat. To mitigate the loss of habitat, nearby fallow fields will be planted with a number of tree species native to the deciduous forest to reestablish a native forest community. A simple monitoring hypothesis associated with this restoration activity could be stated as: "By planting nearby fields with native tree species and allowing for natural colonization from nearby woodlots, a forest habitat comparable to that impacted will be established as a result of the restoration project." An associated monitoring question could be: "Have the native plant community structure and species diversity been restored to a desired level?" In this example, the Monitoring Plan would focus on the collection and analysis of vegetation data appropriate for a determination of diversity and dominance of the forest plant community.

In this simple example, success of the restoration project is linked only to the establishment of a plant community similar in structure and species diversity to that of the impacted habitat. Note that this example does not include a temporal component. However, habitat restoration projects with the goals of establishing stable and mature habitats may require many years to reach a preferred level of success, particularly if the characteristic species are slow to mature and reproduce. This would likely be the case in the above example of the restoration of a mature forest community, which may take 50 years or more to establish. However, the development of certain habitat conditions during the monitoring period may indicate that the restoration activity is progressing toward the ultimate goal along an acceptable path. In this case, further monitoring may be deemed unnecessary once the desired plant community has been established (but before the mature community has developed).

Restoration monitoring hypotheses and associated monitoring questions may include statements regarding not only ecological parameters but also physical ones, such as hydrology and soil structure. For example, a remediation project may have required soil removal that resulted in the destruction of a freshwater marsh. To compensate for the loss of wetland functions, a restoration project was implemented that included grading the impacted area to topographic contours that would provide for a suitable hydrologic regime, along with planting of native wetland vegetation to reestablish the wetland plant community. For this example, the restoration monitoring hypothesis may be stated as:

> The topography of the disturbed area will be contoured to provide a hydrologic regime that can support the formation of saturated (hydric) soils and that is conducive to the establishment of wetland vegetation. Native wetland vegetation will be planted within the newly contoured areas, which will lead to the establishment of a stable wetland plant community comparable to that of the wetland before it was impacted.

In this example, the monitoring objective may be to evaluate the success of the restoration project in reestablishing a desired wetland plant community. Subsequent monitoring questions could include:

1. Has the hydrology been restored to a desired level (including areal extent of hydric soils)?;

2. Are the soils developing hydric characteristics?; and

3. Have wetland plant community structure and species diversity been restored to a desired level, indicating the development of the site toward a future stable wetland?

The Monitoring Plan, in this example, would focus on the collection and analysis of hydrologic, soil, and vegetation data appropriate for a determination of wetland area, as well as wetland plant species diversity and community structure, and colonization by native and nonnative species.

2.2 MONITORING CONCEPTUAL MODELS

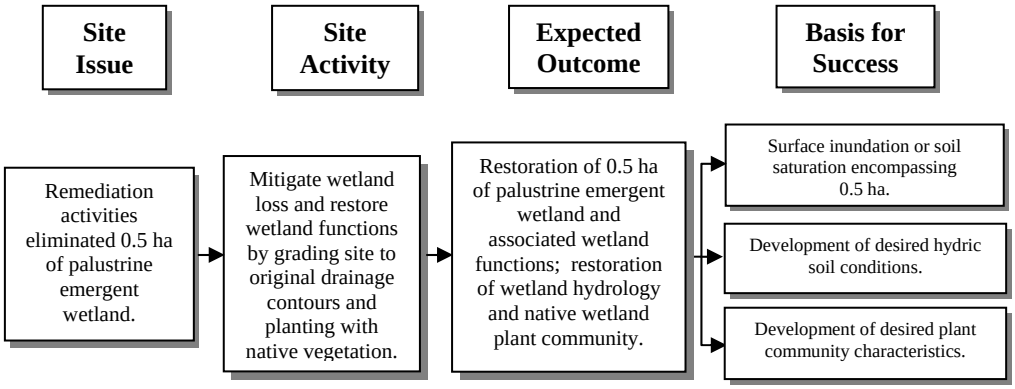
Development of the restoration monitoring plan may be aided by the use of a restoration monitoring conceptual model. The conceptual model will consist of one or more restoration hypotheses that identify the relationships between the restoration activity and its expected outcome (Example 2.1). The model does not need to be highly detailed or describe all aspects of the restoration activity and its expected outcome. The model should include descriptions of the assumptions, objectives, and expected outcome of the restoration activity. These descriptions, subsequently, will serve as a basis for determining restoration success and play an important role in identifying the monitoring decision criteria, data needs, and collection methods.

2.3 STAKEHOLDER INVOLVEMENT

Stakeholders should be involved, to the extent appropriate, in the development of the remediation hypotheses, monitoring questions, and conceptual model. As previously discussed, it is very likely that NRTs, regulators, and/or the public had some degree of input into the original decision for implementing a habitat restoration project. While the Navy is the decision maker for the monitoring program, the involvement of appropriate stakeholders in this step of the monitoring framework will serve to identify any differences of opinion in the expected outcome

EXAMPLE 2.1 Monitoring Conceptual Model for a Wetland Restoration Project

This example illustrates a monitoring conceptual model, a monitoring hypothesis, and associated monitoring questions for a habitat restoration project implemented to mitigate the loss of wetlands as a result of a remediation project. The monitoring objectives for this activity would be to evaluate the effectiveness of the mitigation activity in restoring wetland hydrology, soils, and plant communities, and determining whether and when restoration should stop, continue, or be revisited and possibly revised.



Restoration Monitoring Hypothesis: Soil remediation resulted in the loss of wetland habitat. To mitigate the habitat loss, the site will be graded to provide hydrologic conditions needed to support a wetland community, and annual planting of native wetland vegetation will be used to reestablish the plant community and restore previous wetland functions within 5 years.

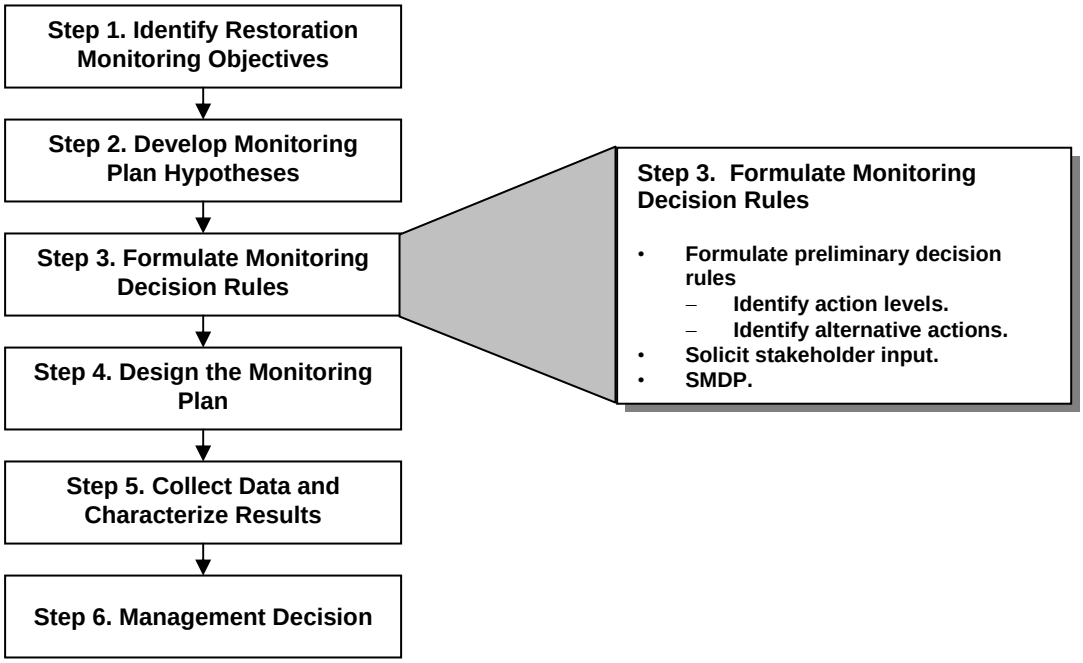
Monitoring Questions:
1. Have hydrological conditions been restored to a desired level or condition?
2. Have the desired hydric soil conditions been attained?
3. Has a desired wetland plant community been established?

of the restoration project and in the restoration approach. Early identification of stakeholder issues or concerns will aid in the development of a restoration monitoring conceptual model that will limit future disagreements regarding the design of the Monitoring Plan.

2.4 SCIENTIFIC MANAGEMENT DECISION POINT

The outcome of this step of the monitoring framework (Step 2, Figure 1) will be one or more restoration hypotheses, associated monitoring questions specific to the restoration project, and a conceptual model identifying the relationships between the restoration activity and its expected outcome. The hypotheses and related conceptual model comprise the SMDP for this step. The purpose of the SMDP is to document a decision regarding monitoring hypotheses, questions, and the conceptual model. Any subsequent changes to these items should be agreed upon by the Navy and applicable stakeholders. While a formal deliverable is not necessary, the SMDP should be recorded as a memorandum or letter to file.

STEP 3 FORMULATE MONITORING DECISION RULES



With the development of the monitoring conceptual model, the monitoring objectives have been identified, and restoration hypotheses and associated monitoring questions have been developed. The next step in developing the restoration monitoring plan is the establishment of the monitoring decision rules (Step 3, Figure 1). These decision rules identify the criteria for deciding whether to continue, cease, or modify the habitat restoration and/or monitoring activities.

3.1 RESTORATION MONITORING DECISION RULES

Monitoring Decision Rules

Statements that establish the criteria for deciding whether or not the restoration objectives have been met, and thus whether or not to continue, cease, or modify the restoration and/or monitoring activities.

The monitoring decision rules are analogous to the decision rules of the DQO process (Example 1) and take the form of "if...then..." statements that establish the criteria for making a choice between specific alternative actions. Data collected during monitoring are analyzed and evaluated with regard to how well the decision rules are met, and the results of these evaluations are used to determine the success of the restoration in relation to its objectives. The final determination of success of the habitat restoration project will be based on the decision rules, thus linking the restoration hypotheses and monitoring questions with the restoration objectives and monitoring results.

Formulation of the monitoring decision rules consists of two steps. First, preliminary decision rules relate, in general terms, the expected restoration objectives and monitoring results to a decision for continuing or ending the restoration activity and monitoring. Next, as the specific monitoring study design is developed (in Step 4 of the monitoring design framework [Figure 1]), the preliminary decision rules are refined to specifically relate to the monitoring studies and anticipated results, to identify specific measurable parameters and target parameter values, and to identify under what conditions a specific alternative action would be implemented.

3.2 DEVELOPMENT OF PRELIMINARY DECISION RULES

In general, there should be four main elements to each monitoring decision rule:

- The restoration parameter of interest,
- The expected outcome of the restoration activity,
- An action level (the level at which a monitoring decision will be made), and
- Alternative actions (the monitoring decision choices for the specified action level).

The preliminary decision rules should be stated in general terms with regard to these elements. At this step in the development of the restoration monitoring plan, the preliminary decision rule does not identify specific bounds for the action level, such as a specific plant community structure or level of habitat use by wildlife, or specific time frames within which restoration success is expected. Such details will be developed during the specific design of the Monitoring Plan and incorporated into the final decision rules. Example 3.1 illustrates the form and content of preliminary decision rules for a hypothetical terrestrial habitat restoration project.

3.2.1 Action Levels

Preliminary Action Levels

An action level is the threshold value that provides the criterion for choosing between alternative actions. For a restoration monitoring program, the preliminary action level will be a general value or condition of the monitored parameter.

The monitoring decision rules must specify the action level for each restoration parameter (or combination of parameters) that is monitored. These action levels are often referred to as success criteria or performance standards and specify the target level of the measured parameter. Success criteria must be carefully selected so that if the criteria have been met, as evidenced by analysis of the data collected during monitoring, there should be certainty that the mitigation objectives were achieved. The monitoring decision rules must also specify the restoration and/or monitoring actions to be taken whether the success criteria are met or not.

EXAMPLE 3.1
Preliminary Decision Rules for a Terrestrial Habitat Restoration Project

A habitat restoration project was developed to restore a previously impacted woodlot to a 10-acre savannah with an understory plant community similar to that of undisturbed regional savannah habitats. The project involves the use of controlled burns, mechanical and chemical removal of exotic vegetation, and planting native vegetation to reach these objectives. The preliminary monitoring decision rule may be stated as:

1. "*If* the monitoring results indicate that a savannah habitat with an understory plant community of a desired structure and diversity has been established, *then* the restoration will be considered to have reached its objectives and no further restoration or monitoring will be necessary. *If* the savannah and desired understory plant community have not been established, *then* controlled burns, exotic species removal, and native planting should continue."

In this example, the preliminary decision rule identifies: (1) the parameter of interest (a savannah habitat with a desired understory plant community), (2) the site activities (controlled burns, exotic plant removal, and planting), (3) the action level that will serve as the basis for a decision (a desired understory plant community structure and diversity), and (4) the alternative actions (conclude or continue restoration and monitoring).

3.2.2 Alternative Actions

Once the action levels (success criteria) have been identified, alternative actions must be developed. These identify the options from which the decision maker will choose with regard to the restoration activity. In general, these choices will be that:

- The restoration has been successful and further restoration and monitoring are not necessary;
- The restoration has not yet reached its desired outcome but is proceeding toward success, and thus the restoration and associated monitoring should continue; and
- The restoration has not been successful and is not trending toward the desired outcome, and causative factors should be evaluated and the restoration (and monitoring) revised accordingly or stopped.

3.2.3 Multiple Decision Rules

Depending on the nature of the restoration project and its monitoring objectives, a number of monitoring decision rules may be required (Example 3.2). If the monitoring study design includes the collection of several types of dissimilar data (e.g., community structure, species diversity, and areal coverage by preferred species), the analysis of these dissimilar results may produce conflicting results. In such cases, the interpretation of dissimilar data with respect to one another should be predetermined and incorporated into the alternative actions.

3.2.4 Development of Final Decision Rules

Development of the final decision rules will involve refinement of the parameters of interest, the action levels, and possibly the alternative actions identified by the preliminary decision rules. Because the final decision rules will focus on one or more measurable aspects of the restoration project and thus will be directly related to the type of monitoring data to be collected, the refinement of the preliminary monitoring decision rules will occur in Step 4 during the design of the Monitoring Plan when specific data needs and collection and analysis methods are identified (Step 4, Figure 1).

3.3 TEMPORAL CONSIDERATIONS REGARDING RESTORATION SUCCESS

Decision rules associated with remediation activities support management decisions that generally are made within a relatively short period of time (e.g., 5 to 10 years, depending on the nature of the selected remedy). However, natural communities typically require much longer periods of time to develop into mature communities with associated species assemblages and habitat functions. Many native plant species are long-lived and require a number of years to reach maturity, while the complex relationships among vegetation, wildlife, micro- and macroinvertebrate biota, and other habitat components (both biotic and abiotic) require relatively long periods of time to develop (e.g., 20 years or more). Some habitats, such as mature forest, may require many decades to develop the attributes considered to be indicative of the mature habitat. Thus, attainment of a desired restoration objective may not be fully discernable for a length of time acceptable to project management, regulators, or other stakeholders.

Habitats (both natural and at restoration sites) generally develop through a continuous process of community succession, wherein there is a gradual change in both the composition of species and environmental conditions toward a mature habitat type. For example, while planting at a restoration site may introduce desired species into the site, the site will most likely also support and/or be colonized by a variety of other native and exotic plant species. As these species interact with one another and the environment over time, they will influence subsequent changes in the plant community at the site, which in turn will determine ultimate success or failure of the restoration activity. In some cases, the desired species may not become fully established until years later, when site conditions have changed sufficiently enough to support the desired plant community.

Because habitats may require very long periods of time (decades or more) to reach a restoration objective, it may be warranted to include decision rules that consider temporal trends in key habitat components that may be early indicators of restoration success. Examples include:

- Increasing abundance of desired species,
- Establishment of desired physical conditions such as hydric soils or water quality, and
- Increasing areal coverage by target species.

EXAMPLE 3.2
Preliminary Decision Rules for a Wetland Restoration Project

To mitigate the loss of a wetland following site remediation, a restoration project was designed to reestablish the wetland plant community. The restoration project includes: (1) soil grading to provide topographic contours that will result in a suitable hydrologic regime and promote development of anaerobic hydric soils, and (2) planting with native wetland vegetation. In this project, success of the wetland vegetation planting will be strongly dependant on the establishment of appropriate hydrology and hydric soils. If wetland hydrology and hydric soils are not sufficiently established, the planting of wetland vegetation will not be successful. For this example, the first preliminary monitoring decision rule may be stated as: "*If* the monitoring results indicate that the hydrology has been restored to a desired level, and soils are developing the desired hydric characteristics, *then* the contouring has been successful. *If* hydric soils are not developing, *then* additional hydrologic manipulation may be necessary." For this decision rule, the parameter of interest is hydric soil, the site activity is hydrological manipulation via surface contouring, the action level is the development of hydric soils, and the alternative actions are to continue with the planned restoration activities (including plant community monitoring) or revisit establishing appropriate hydrological conditions.

A second preliminary decision rule, related to the success of the vegetation planting, may be stated as: "*If* the desired native plant community structure and species diversity have been attained, *then* the wetland restoration will be considered to have reached its objectives and no further restoration or monitoring will be necessary. *If* the desired plant community structure and diversity have not been attained, *then* planting of native species should continue." For this decision rule, the parameter of interest is the native wetland plant community, the site activity is the planting of native wetland vegetation, the action level is the establishment of a desired plant community, and the alternative actions are termination of the restoration and monitoring activities or continue planting and monitoring.

A habitat progression toward the desired condition may also be strongly influenced by the natural climatic variability at the restoration site. This variability can be short or long term; be completely out of the control of the restoration team; and may affect the nature, extent, and timeliness of both desirable (establishment of a target species) and undesirable (the invasion of undesirable species) ecological responses. For example, an extended period of drought may greatly retard, set back, or even prevent establishment of a desired plant species or community, or result in reduced water levels and affect spawning in a restored aquatic habitat.

Temporal Considerations

- Community succession rates.
- Species-specific reproduction and colonization rates.
- Effects of natural climatic variability.
- Multiple decision criteria with different time lines for success.

Temporal considerations may also be important when there are multiple decision rules for a restoration project. In Example 3.2, two different action levels are identified: the development of hydric soils and the establishment of a desired plant community, with the latter being dependent on the former. In this example, hydric soils will be present before the desired plant community becomes established, although establishment of the plant community will likely begin as the hydric soils become present. Thus, these action levels temporally overlap with regard to their initiation but differ with regard to time for attainment.

Because of the temporal aspects in community succession and the potential effects of climatic variability, it may not be possible to develop monitoring decision criteria based solely on the desired final outcome of the restoration project. For restoration projects where the attainment of a desired habitat type will proceed through community succession and could be significantly affected by climatic conditions, development of the monitoring decision rules should consider temporal trends in habitat parameters that may indicate successful early development toward the target habitat. Additional information on temporal considerations and trend analysis for determining restoration success is presented in Sections 5 and 6 of this guidance.

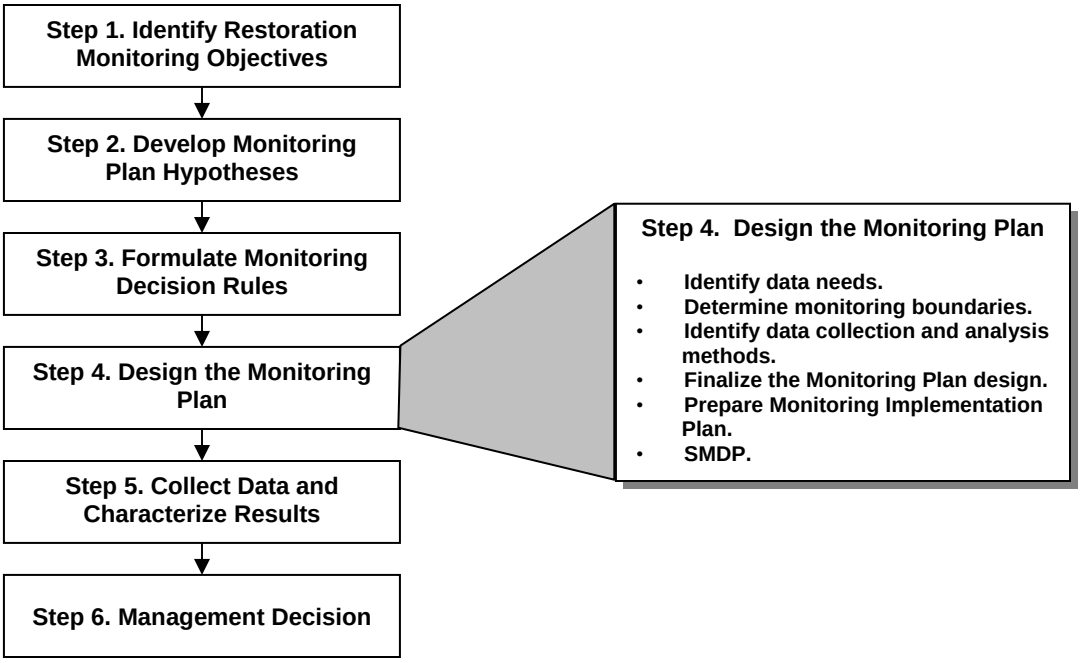
3.4 STAKEHOLDER INVOLVEMENT

To the extent practicable, appropriate stakeholders should be brought into the process of developing the decision rules. In some cases, the stakeholders may have extensive experience in habitat restoration and may provide valuable input into the decision rules, especially the action levels. However, with the exception of habitat restoration projects being conducted to satisfy regulatory permit requirements, the Navy is the lead decision maker for the restoration project and for the development of the associated monitoring program. However, input from appropriate stakeholders may identify issues or concerns related to the success criteria and alternative actions. Early knowledge of such concerns may allow for the development of decision rules that meet the Navy's needs and satisfy stakeholder concerns, thereby reducing the likelihood of future project delays.

3.5 SCIENTIFIC MANAGEMENT DECISION POINT

At the conclusion of Step 3, one or more preliminary monitoring decision rules have been developed. These decision rules define, in general terms, the conditions that allow the decision maker to choose among alternative actions related to the monitoring program and the restoration project. These preliminary decision rules represent the SMDPs for Step 3. While a formal deliverable for the SMDP is not necessary, the preliminary decision rules, as well as any input from or communication with appropriate stakeholders, should be formally recorded as a memorandum or letter to file. Because the final decision rules are completed in the next step during development of the study design, they are included with the SMDP for that activity.

STEP 4 DESIGN THE MONITORING PLAN



The preliminary monitoring decision rules developed in Step 3 are based on the monitoring objectives, hypotheses, questions, and conceptual models previously developed in Steps 1 and 2, and will be used to support a management decision regarding the success or failure of the habitat restoration project. In Step 4, the data needed to address the monitoring hypotheses and questions are identified, and a monitoring plan is developed that identifies the data collection and analysis methods and associated QA/QC requirements. The previously developed preliminary decision rules will also be finalized in this step. Step 4 concludes with a monitoring implementation plan that documents the monitoring activities that will be conducted to meet the monitoring objectives and support a management decision regarding the success or failure of the restoration project.

4.1 IDENTIFICATION OF DATA NEEDS

A variety of data may be necessary to test the restoration monitoring hypotheses, answer the monitoring questions, and ultimately to support a management decision regarding habitat restoration success or failure. These data may be physical (Table 4.1), chemical (Table 4.2), and/or biological in nature (Table 4.3), depending on the hypotheses and questions, and on the decisions to be made. Factors to consider when identifying data needs should include the following:

- Anticipated outcome of the habitat restoration project,
- Preliminary monitoring decision rules,

TABLE 4.1 General Physical Data Categories Commonly Considered for Monitoring Success of Habitat Restoration Projects

	Monitoring Variable							
Habitat Type	Surface Water	Groundwater	Hydro-dynamics	Turbidity	Temperature	Soil or Substrate	Geomorphology	Area
Freshwater wetlands	X	X	X	X	X	X		X
Estuarine wetlands	X		X			X	X	X
Coastal wetlands	X		X			X	X	X
SAV[a]				X		X		X
Artificial reef						X		
Stream	X		X	X	X	X	X	
Bottomland forest	X	X	X			X		X
Upland forest						X		X
Grassland						X		X

[a] SAV = submerged aquatic vegetation.

TABLE 4.2 General Chemical Data Categories Commonly Considered for Monitoring Habitat Mitigation Projects[a]

	Monitoring Variable				
Habitat Type	Water Quality	pH	REDOX	DO	Salinity
Freshwater wetlands	X	X	X	X	
Estuarine wetlands	X		X	X	X
Coastal wetlands	X		X	X	X
SAV					
Artificial reef					
Stream				X	
Bottomland forest	X	X	X	X	
Upland forest	X				
Grassland					

[a] Abbreviations: DO = dissolved oxygen; REDOX = reduction/oxidation; SAV = submerged aquatic vegetation.

TABLE 4.3 General Biological Data Categories Commonly Considered for Monitoring Habitat Mitigation Projects

	Monitoring Variable					
Habitat Type	Species Composition	Species Density	Vegetation Cover	Fish and Wildlife Use	Biomass	Abundance of Native and Exotic Vegetation
Freshwater wetlands	X	X	X	X	X	X
Estuarine wetlands	X	X	X	X	X	X
Coastal wetlands	X	X	X	X	X	X
SAV[a]	X	X	X	X	X	
Artificial reef	X	X		X		
Stream	X	X		X		
Bottomland forest	X	X	X	X	X	X
Upland forest	X	X	X	X	X	X
Grassland	X	X	X	X	X	X

[a] SAV = submerged aquatic vegetation.

- Data characteristics,
- Availability of data from the restoration site prior to the habitat disturbance, and
- Availability of a reference site.

In cases where a habitat mitigation project is being conducted to fulfill the conditions of a permit issued by a natural resource agency, the permit may contain specific data requirements. Guidelines for habitat mitigation and monitoring issued by permitting agencies also often include data collection recommendations.

4.1.1 Expected Outcome of the Habitat Restoration Project

By considering the expected outcome of the restoration project, the monitoring team can identify the specific chemical, physical, and/or biological parameters expected to be targeted or affected by the project. These parameters can serve as the starting point for identifying the habitat restoration monitoring data needs. For example, terrestrial and wetland restoration projects focus on the establishment of a specific type and extent of plant community, and affect the presence, abundance, diversity, and cover of plant species at the site. In these projects, the monitoring data will be related to one or more of these biological parameters.

Alternately, restoration projects such as a wetland restoration will also affect the physical environment at the site, and hydrologic data or data relating to soil characteristics may be needed. Monitoring for a freshwater wetland may require data related to the seasonal hydrologic

regime (such as surface water depth and depth to groundwater) to determine adequate hydrology across the proposed wetland area. Monitoring of tidal wetlands, however, may require measurements of the extent of high tides and low tides, and salinity may be measured in estuarine wetlands.

4.1.2 Previous Site Conditions and Reference Sites

The decision criteria may be based on a desired, predetermined condition, such as a permit-specified aerial coverage, a habitat type, or a water quality parameter. In such cases, restoration success may be measured against a specific, prescribed condition. Alternately, the objectives of the restoration project may be to restore a habitat to either a previous condition or to a condition that is comparable to a similar habitat in the area.

Reference Sites

A reference site is a relatively undisturbed habitat of the type targeted by a habitat restoration project. The site supports plant and animal communities of the type desired to be established at the restoration site. The reference site may provide physical, chemical, and biological data that can be compared to the restoration site to evaluate restoration success.

For example, if a high-quality mature deciduous forest is eliminated by a construction project, data collected prior to clearing of the area may be useful in establishing decision criteria for mitigation of the impact. For impacted sites for which little data are available or are degraded by site conditions, restoration success may be based on the degree of similarity to a reference site. Reference sites are habitats that reflect a relatively undisturbed condition for the type of habitat that is the objective of the restoration project. Reference sites are typically located in the same ecological region and in a similar landscape setting as the restoration site. Although they are generally not pristine sites, the ecological conditions found at reference sites reflect the types and quality of natural communities that can be supported under the conditions present within the region.

Data from reference sites can also indicate natural variability in habitat parameters, particularly if the reference site is monitored along with the mitigation site and changes occur because of regional effects, such as weather patterns. The use of reference sites in developing a habitat restoration project and establishing goals, objectives, and decision criteria is recommended by numerous agencies and organizations associated with habitat restoration or creation (Clewell et al. 2000; Society of Wetland Scientists 2001; USACE 2001; SER 2002; U.S. EPA 2002, 2003; NOAA undated).

4.1.3 Data Characteristics

Data Characteristics

Data characteristics describe the nature and type of the needed data. These may include:

- Level of taxonomic detail (i.e., species, genus, or family).
- Species diversity.
- Abundance (of a desired species).
- Environmental concentration (e.g., concentration of a water quality parameter).

Data characteristics refer to the nature and type of the data, such as a detection level or a taxonomic level. For example, a monitoring plan to determine the success of a prairie restoration may require the collection of abundance data for a variety of species, or may focus on the abundance of only a single indicator species. Suppose data from previous studies indicated a plant community of about 100 species in the undisturbed prairie habitat. In this example, success of the prairie restoration may be based on the establishment of a minimum number of those species (e.g., the presence of at least 80 of the previously identified 100 species). Alternatively, success may be based on the abundance of a smaller subset of species that are considered indicators of desired species associations. In this example, the specific data characteristics are dependent on the restoration and its desired outcome (i.e., establishment of a desired plant community), the monitoring objectives (i.e., determine whether the activity has been successful), and the monitoring hypotheses and questions (i.e., the restoration will establish a target plant community).

Thus, expected outcome of the restoration project, as described in the site conceptual model, will indicate the specific habitat parameters that will be affected by the project. These parameters form the basis for the identification of data needed for a management decision and therefore measuring these parameters forms the basis for monitoring. Previous studies that collected data on habitat parameters at the project location or at a reference site of similar habitat type can also provide information on monitoring data characteristics.

4.2 DETERMINATION OF MONITORING BOUNDARIES

The monitoring boundaries represent the “what, where, and when” aspects of monitoring. In defining these boundaries, the monitoring team answers the following questions:

- What data are needed?
- How should samples be collected (discrete or composite)?
- Where should monitoring samples be collected?
- When should monitoring samples be collected?
- How often should sampling continue? and
- How long should sampling continue?

The type of data to be sampled will be based largely on the data needs identified earlier in Step 4 (see Section 4.1). For example, information regarding the formation of hydric soils may be needed for a wetland restoration project. The Monitoring Plan study design must identify where soil samples should be collected (in terms of both soil depth and spatially across the site) to provide the necessary data regarding formation of hydric soils. The spatial area from which the data should be collected will be a function of the location and size of the restoration site.

Once the necessary data have been identified and the spatial boundaries selected, the temporal boundaries for the Monitoring Plan should be established. Identification of the temporal boundaries should include information on (1) when samples should be collected (e.g., spring, summer, dawn, dusk, etc.), (2) how often they should be collected (e.g., hourly, daily, weekly, etc.), and (3) how long sampling should continue (e.g., 6 months, 2 years, or until a specified condition is reached). The temporal sampling boundaries will be directly related to the type of mitigation project being implemented and the environmental parameter of interest.

Monitoring Boundaries

Monitoring boundaries specify the spatial and temporal locations and limits for data collection.

- Define the geographic areas for data collection.
- Determine when to collect samples.
- Identify the time frame in which management decisions will be made.

For example, monitoring the success of a wetland restoration project may require vegetation sampling twice during the growing season (in spring [May/June] and late summer [August /September]) to assure adequate identification of plant species present on the site that are only identifiable at different times during the year. Sampling groundwater or surface water parameters for hydrologic monitoring may involve a weekly, monthly, or quarterly sampling frequency, depending on the purpose of the data. In contrast, sampling of tidal cycles may require measurements at least daily. A 5-year monitoring period is frequently used for habitat mitigation projects. Tables 4.4, 4.5, and 4.6 identify relative time frames for observable changes in different categories of chemical, biological, and physical monitoring data.

4.3 SELECTION OF DATA COLLECTION AND ANALYSIS METHODS

The specific data collection methods will be a direct function of the data needs, and for a specific data need there may be a variety of approaches to collecting the necessary data. In addition, it will be very unlikely that any single data set will be sufficient to provide data of appropriate quality and quantity to address the decision rules and support a management decision. Rather, data for a variety of parameters will likely be needed to support a decision regarding the success or failure of the habitat restoration project.

It is not necessary to identify specific sampling designs at this stage of the Monitoring Plan design. Specific sampling designs are developed during optimization of the data collection design (see Section 4.5.1). Instead, at this point, data collection methods are identified that may be appropriate to collect the required data, and a preliminary determination is made of the feasibility of using those approaches to collect the data with the required characteristics and within the required time and cost restraints.

TABLE 4.4 Relative Response Times for Observing Changes in General Categories of Potential Chemical Monitoring Data[a]

	Monitoring Variable				
Habitat Type	Water Quality	pH	REDOX	DO	Salinity
Freshwater wetlands	S–M	S–M	M	S–M	NA
Estuarine wetlands	S–M	S–M	M	S–M	S
Coastal wetlands	S–M	S–M	M	S–M	S
SAV	NA	NA	NA	NA	NA
Artificial reef	NA	NA	NA	NA	NA
Stream	NA	S–M	NA	S–M	NA
Bottomland forest	S–M	S–M	M	S–M	NA
Upland forest	S–M	NA	NA	NA	NA
Grassland	NA	NA	NA	NA	NA

[a] Abbreviations: DO = dissolved oxygen; M = moderate response time; NA = not applicable; REDOX = reduction/oxidation; S = short response time; and SAV = submerged aquatic vegetation.

TABLE 4.5 Relative Response Times for Observing Changes in General Categories of Potential Biological Monitoring Data[a]

	Monitoring Variable					
Habitat Type	Species Composition	Species Density	Vegetation Cover	Fish and Wildlife Use	Biomass	Abundance of Native and Exotic Vegetation
Freshwater wetlands	S–L	S–L	S–M	S–L	S	S–L
Estuarine wetlands	S–L	S–L	S–M	S–L	S	S–L
Coastal wetlands	S–L	S–L	S–M	S–L	S	S–L
SAV	S–L	S–L	S–M	S–L	S	NA
Artificial reef	S–L	S–L	NA	S–L	NA	NA
Stream	S–L	S–L	NA	S–L	NA	NA
Bottomland forest	S–L	S–L	S–M	S–L	S	S–L
Upland forest	S–L	S–L	S–M	S–L	S	S–L
Grassland	S–L	S–L	S–M	S–L	S	S–L

[a] Abbreviations: L = long response time; M = moderate response time; NA = not applicable; S = short response time; and SAV = submerged aquatic vegetation.

TABLE 4.6 Relative Response Times for Observing Changes in General Categories of Potential Physical Monitoring Data[a]

	Monitoring Variable							
Habitat Type	Surface Water	Groundwater	Hydrodynamics	Turbidity	Temperature	Soil or Substrate	Geomorphology	Area
Freshwater wetlands	S	S–M	S	S	S–M	S–L	NA	S–M
Estuarine wetlands	S	NA	S	NA	NA	S–L	S–M	S–M
Coastal wetlands	S	NA	S	NA	NA	S–L	S–M	S–M
SAV	NA	NA	NA	S	NA	S–M	NA	S–M
Artificial reef	NA	NA	NA	NA	NA	M–L	NA	NA
Stream	S	NA	S	S	S–M	S–M	S–L	NA
Bottomland forest	S	S–M	S	NA	NA	S–L	NA	S–M
Upland forest	NA	NA	NA	NA	NA	S–M	NA	S
Grassland	NA	NA	NA	NA	NA	S–M	NA	S

[a] Abbreviations: L = long response time; M = moderate response time; NA = not applicable; S = short response time; and SAV = submerged aquatic vegetation.

4.3.1 Data Collection Methods

The methods for collecting monitoring data will depend directly on the data needs, characteristics, and boundaries. Once these specifics are determined, then the monitoring team should identify and evaluate methods for collecting the needed data. On the basis of the data needs and the data characteristics identified, a variety of methods may be available that could provide the necessary data. The monitoring team should identify the methods that may be suitable for addressing the specified monitoring data needs.

For a particular type of data, there may be a number of data collection methods with widely varying costs, advantages, and limitations. For example, the evaluation of submerged aquatic vegetation (SAV) restoration projects has included the collection of data associated with habitat function, such as animal abundance, taxonomic composition, complexity of the seagrass canopy, and macroalgal abundance (Fonesca et al. 1998). The collection of these types of data can be effort intensive and costly and involve lengthy periods of data analysis. In contrast, area coverage of the SAV and the persistence of that coverage have been shown to reflect habitat function and could be readily and inexpensively measured (Fonesca et al. 1998). While coverage and persistence may not provide detailed data on specific features of the habitat, data on these parameters may be sufficient for the decision criteria developed for the project.

A wide variety of methods are available for sampling terrestrial plant communities. Quadrat sampling (Hays et al. 1981; Bonham 1989) is an efficient method of collecting representative vegetation data over both large and small mitigation sites, and is one of the most widely used methods of vegetation sampling on habitat mitigation sites.

Alternately, vegetation may be sampled using the point-intercept transect method in which the species occurring at specific data points along the transect are recorded (Bonham 1989). Variations of this method include the use of a single pin or rod to record species present at each sampling point (only plants contacting the pin are counted) or a point frame, which may contain 10 pins, which is placed at the sampling point (Hays et al. 1981; Bonham 1989). When using this method, however, only species presence is recorded; the percent cover data for each species is not collected.

The line-intercept method is also used to sample vegetation along a transect; however, data are recorded continuously along the transect line rather than at distinct points or quadrats (Hays et al. 1981; Bonham 1989). This method may be efficient and very accurate, particularly in short vegetation, but may be difficult to use where the visual determination of transect interception of plant canopy becomes difficult, as with tall or diffuse vegetation.

On very large restoration sites, such as tidal marsh restorations covering hundreds of hectares, aerial photography may be used to measure vegetation development. Areas dominated by highly visible species of interest, such as common reed, may be readily identified and delineated on aerial photographs. Patches may be measured using a geographic information system (GIS). Photographs taken periodically may be used to record changes in size or changes in number of such populations. Similarly, unvegetated areas within the mitigation site may be delineated and measured.

Aerial photography may also be used to measure the development of tidal channels in tidal marsh restoration projects. The size, number, and complexity of channel development can be delineated and measured on aerial photographs with a GIS. Areas of open water can also be measured periodically to record changes during the growing season and from year to year.

4.3.2 Data Analysis Methods

Monitoring is the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective. It is critical that the monitoring design and data analysis methods can distinguish between natural variability in the data and actual response in the parameter under evaluation. Analysis of the monitoring data will likely involve some form of statistical analysis. In cases where habitat restoration is being conducted to provide a specified aerial coverage of habitat, a target species diversity or other specified condition, statistical analysis may not be necessary. However, for many restoration projects, analysis of the monitoring data will employ some combination of descriptive and inferential statistics as well as time-series analysis.

A variety of statistical tests may be employed to evaluate the monitoring data. The specific type of tests that are deemed valid will depend on the nature of the monitoring hypotheses and questions, the type of data and the collection methods (sample size, replication, etc.), the desired level of decision error, and on the nature of the preliminary decision rules. Some common data analysis methods are described in detail in *Guidance for Data Quality Assessment* (QA/G-9) (U.S. EPA 2000d).

4.3.2.1 Descriptive and Inferential Statistics

Descriptive and inferential statistics can be used to compare the data collected from the restoration site to similar data from a reference site or to predisturbance data. Descriptive statistical analysis of the monitoring data will typically involve a determination of the central tendency of the data, such as the mode, median, or mean, and also identification of the dispersion (e.g., range, standard deviation) and frequency distribution (e.g., normal, bimodal) of the data. Inferential statistics examine a set of data in order to accept or reject a specific hypothesis. Information on descriptive and inferential statistics can be found in a variety of sources (e.g., Sokal and Rohlf 1981; Zar 1984; U.S. EPA 2000b).

For habitat restoration projects, there will be two general types of hypotheses that the statistical analysis may support: (1) the null hypothesis that the expected outcome of the habitat mitigation has been attained, or (2) the alternative hypothesis that the expected mitigation outcome has not been attained. For example, a preliminary decision rule may be: "If the species diversity of the restored prairie habitat is the same as the diversity at a prairie reference site, then the habitat mitigation project is a success." In this case, mean plant diversity at a prairie restoration site can be statistically compared with similar data from a reference area to determine if there are differences in the species diversity between the two sites.

4.3.2.2 Trend Analysis

Trend analysis evaluates data collected at specified intervals over a specified period in order to determine if conditions are changing over time, and if so, how they are changing (i.e., the magnitude and direction of the change). Trend analyses can be applied to biological, chemical, or physical monitoring data. In addition, trend analysis may provide better interpretation of natural variability effects (such as occasional herbivory or unusual weather conditions) on habitat parameters and thus provide a better picture of the habitat development than can be determined by year-to-year comparisons.

The amount of data needed to conduct a trend analysis will depend on the nature of the data being collected and the expected outcome of the activity. While several years of data may be needed for the analysis of trends in some parameters (such as plant community structure), sufficient data may be collected in a relatively short period to allow for trend analysis of other parameters. For example, suppose the success of a habitat restoration project is being evaluated on the basis of the restored habitat providing suitable nesting habitat to support a given density of nesting birds. Since nesting may only occur yearly (i.e., during the breeding season), several years of data would be needed before any analysis of a trend in habitat restoration could be conducted.

Trend analysis may also be employed to predict how parameters of interest might respond in the future, or how well an activity is progressing toward its stated objectives. Such an analysis can help in determining the direction in which the habitat may be changing and the rate and magnitude of the change. The results of such trend analyses may be used to refine or revise site activities (e.g., herbicide applications, planting, and frequency of controlled burns) and thus

assist future site management planning. The results may indicate whether the habitat is developing toward meeting the criteria rapidly enough for the project to be successful within the time frame anticipated, such as in a 5-year monitoring period.

Trend analysis can also play an important role in the adaptive management of the habitat restoration project. For example, trend analysis may show that the abundance and diversity of benthic invertebrates in a restored SAV habitat is increasing at a rate exceeding original expectations, which would suggest earlier-than-expected attainment of benthic abundance and diversity. On the basis of the trend analysis results, a decision may be made to reduce the frequency of sampling of the benthic community, with the expectation that restoration success will be reached sooner than expected and that restoration activities and monitoring may be terminated sooner than expected.

4.3.3 Uncertainty Analysis

Evaluation of the monitoring data must also consider the uncertainty associated with the data. The nature and magnitude of any uncertainty may strongly affect the interpretation of how well the data are meeting the DQO specifications, and whether the data support the decision rule. There may be several sources of uncertainty associated with the monitoring data, such as incomplete monitoring conceptual models, natural variation in the parameter being measured by the monitoring program, and analytical uncertainty or variability. The monitoring team should be aware of the uncertainties associated with the data and its analysis and interpretation, and especially of how any such uncertainties may affect management decisions regarding mitigation success or failure.

4.4 FINALIZATION OF THE MONITORING PLAN DESIGN

At this point in designing the habitat mitigation monitoring plan, the monitoring team will have:

- Developed the monitoring objectives;
- Developed the monitoring hypotheses, questions, and conceptual models;
- Formulated the preliminary monitoring decision rules;
- Identified data needs, data characteristics, and data collection and analysis methods; and
- Determined the spatial and temporal boundaries for data collection.

This information represents the preliminary design parameters for the preliminary monitoring plan, as developed through the first six steps of the DQO process. These DQOs identify the why, what, when, and how aspects of data collection and analysis for the Monitoring

Plan. The Monitoring Plan is finalized using the DQO process to optimize the study design, refine the monitoring action levels, and finalize the decision rules.

4.4.1 Optimizing the Monitoring Study Design

During optimization of the study design (Step 7 of the DQO process), the sampling and analysis methods previously identified are reviewed with regard to satisfying the monitoring DQOs. In addition, alternative methods should be reviewed with regard to:

- Cost of data collection activities,
- Ease of data collection, and
- Method limitations.

Table 4.7 presents some general advantages and limitations of some data collection methods commonly used in monitoring habitat restoration projects. Sources of information on data collection methods for habitat monitoring include BLM (1986), U.S. EPA (1989), and USACE (2001).

From the alternatives determined to best satisfy the DQOs, those that are the most resource-effective (cost, effort) should be selected for use in monitoring. For example, larger plots or belt transects may be used for sampling vegetation with relatively widely spaced plantings, such as tree seedlings or saplings (Hays et al. 1981; Bonham 1989). This type of sampling, however, would not be an efficient method for collecting data for densely planted herbaceous vegetation because of the difficulty in estimating the cover for each species over a large area. For herbaceous vegetation, smaller subplots may be established within the plot, and data collected as in a quadrat.

During the optimization, a decision is made on which of these approaches or combination of approaches would best meet the monitoring DQOs. Once an optimized monitoring design has been completed, the data collection methods should be further evaluated to ensure that they can be successfully implemented under site conditions and within cost and budget constraints.

4.4.2 Finalizing the Decision Rules

During the initial development of the monitoring study design, specific investigations were identified to provide the data needed by the decision rules and success criteria to support a management decision on the habitat restoration project. As the monitoring study design is optimized, the preliminary monitoring decision rules should be revisited and refined so that they directly relate to the specific parameters being measured and the data being collected. This refinement of the decision rule should include the following for each parameter of interest:

TABLE 4.7 Advantages and Limitations of Some Commonly Used Monitoring Data Collection Methods

Method	Advantages	Limitations
Quadrat	Useful in conducting species inventories, collecting presence and absence data, determination of occurrence frequency, and estimation of percent plant cover.	Estimation of cover values can be time- and labor-intensive
Point-intercept	Many data points can be quickly surveyed; useful for estimation of species abundance.	Uniform spacing of data collection points may result in unrepresentative data.
Line-intercept	Provides accurate measurements of vegetative cover by species.	Visual determinations of cover may be difficult in some vegetation types.
Plot/belt transect	Rapid collection of data on tree or shrub plantings; useful for estimation of species density.	Not suitable for estimation of herbaceous species cover.
Aerial photography	Identification and measurement of vegetation and hydrologic features over large land areas.	Greatly reduced species identification.
Screened groundwater wells	Permanent, easily sampled hydrologic data points; useful for collection of time-series groundwater data.	May not provide accurate determination of final wetland boundary; cannot determine groundwater levels below well depth.
Soil pit	Provides easy examination of soil profile for determination of hydric characteristics; allows easy examination of groundwater levels.	Must be redone at a different, undisturbed point each time; can be difficult in saturated loose soils or inundated soils.
Soil core/boring	Rapid acquisition of samples; may be effective in saturated loose soils or inundated soils.	May compress soil profile; observation of redoximorphic features and groundwater levels may be difficult.

- Identification of the specific monitoring study endpoint metric (e.g., species diversity or habitat area),
- Identification of specific action levels (e.g., a specific numerical diversity value or habitat acreage), or
- Identification of a time frame within which the action level is expected to be reached.

For example, a preliminary decision rule for a terrestrial habitat restoration project may identify a native understory plant community with a desired diversity as the focus of the action level to be used to determine restoration success. In this form, the preliminary decision rule action level is vague and open to interpretation. A variety of parameters (and associated data

collection methods) may be appropriate for evaluating the native understory vegetation. The specific parameters selected will depend on the objectives of the restoration project as well as on the availability of methods that can discriminate actual responses from natural variability. For this example, parameters of interest may include:

- Native plant species richness (i.e., a minimum number of the desired native species), or

- Vegetative cover of the site (i.e., the vegetative cover of the project site should be dominated by the desired native species).

Once these parameters are identified and specific data collection methods are selected, the preliminary action levels should be revised to identify specific values (or conditions) for these parameters that will represent the success criteria for the restoration project. For the above example, the final decision rule may be stated as:

> "*If* native plant species account for at least 90% of all understory plant species, and native vegetation accounts for at least 80% of the understory vegetative cover, *then* the restoration has reached its objectives and no further restoration will be necessary."

In this final decision rule, the overall parameter of interest remains the understory plant community; however, it has now been divided into two subparameters for which measurable data will be collected. These parameters are plant species richness and native vegetative cover. In contrast to the vague action levels identified in the preliminary decision rule (i.e., a desired understory plant community), the action levels in the final decision rule specify measurable numeric values that represent the success criteria, namely an understory plant community with native species comprising 90% of the community and 80% of the plant cover.

4.4.3 Adaptive Management Considerations

Ongoing evaluation of monitoring data allows for adaptive management of the restoration project. Adaptive management greatly increases the potential for success of a habitat restoration project by providing for the early detection of problems in the habitat's development and the immediate remedies. The final decision rules should incorporate ongoing evaluation of the monitoring program as data are collected and analyzed, and support changes to the monitoring design as deemed appropriate.

4.5 PREPARATION OF A MONITORING QUALITY ASSURANCE PROJECT PLAN

The final habitat restoration monitoring plan should be documented in a Monitoring Quality Assurance Project Plan (QAPP). The Monitoring QAPP should include:

- An overview and general background of the habitat restoration project for which the Monitoring Plan was developed;
- A description of the restoration and monitoring objectives;
- The monitoring hypotheses, questions, and monitoring conceptual model;
- The data needs and characteristics;
- The data collection methods, including sampling location, timing, and frequency;
- The sampling equipment and procedures;
- The data handling requirements;
- The data analysis methods; and
- The QA and QC procedures necessary to evaluate the data and ensure that the data are of sufficient quality to support the DQOs and a management decision.

Documentation of the final monitoring plan in a Monitoring QAPP serves a variety of important purposes. First, it documents the rationale behind the development of the monitoring design, including identification of the monitoring objectives, data needs, data collection and analysis methods, and decision criteria for determining project success. Second, the Monitoring QAPP presents the detailed data collection, analysis, and interpretation procedures to be implemented during the monitoring program. Third, it specifies when and how adaptive management will be used to maximize the potential for mitigation success and potentially reduce project costs. Finally, if the habitat mitigation project is being conducted as part of a larger, CERCLA remediation project, the Monitoring QAPP would satisfy U.S. EPA requirements for a QAPP when environmental data are being collected (U.S. EPA 2000b).

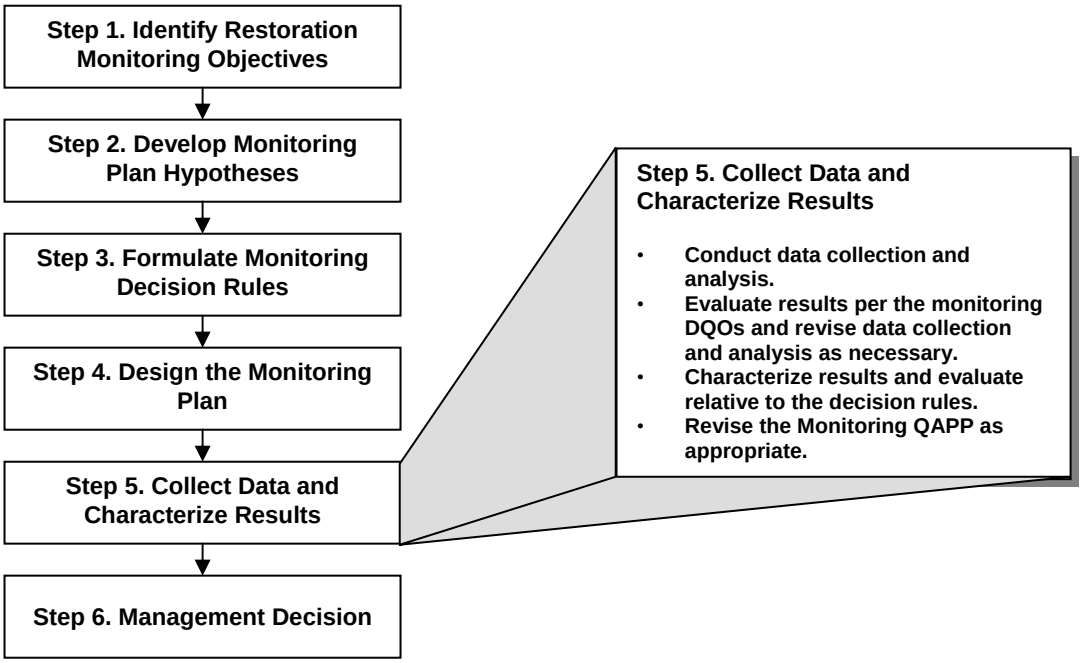
The Monitoring QAPP may take the form of a stand-alone document or as an addendum to the remediation project QAPP.

4.6 SCIENTIFIC MANAGEMENT DECISION POINT

The SMDP for Step 4 is the finalized Monitoring QAPP.

(This page intentionally blank.)

STEP 5 COLLECT DATA AND CHARACTERIZE RESULTS



At the completion of Step 4, a Monitoring QAPP has been developed. Implementation of the plan, including data collection and analysis, occurs in Step 5, and the results of the Step 5 analyses will be used to support a management decision in Step 6 regarding success of the habitat restoration project. As the monitoring data are collected and analyzed, the data are evaluated against the Monitoring Plan DQOs, and a causative factor assessment is conducted to determine the cause of any deviations from the DQOs. As a result of this analysis, a revision to the Monitoring Plan and/or the restoration project may be indicated. The data are further evaluated with regard to the monitoring decision rules to determine whether a management decision regarding habitat restoration success may be supported.

5.1 DATA COLLECTION AND ANALYSIS

During Step 5, the data collection activities should strictly adhere to the study design identified in the Monitoring QAPP and be conducted at the times, locations, and frequencies specified by the DQOs. Thus, a major component of Step 5, in addition to data collection and analysis, is the evaluation of the data (as they are collected) with regard to the DQOs. This evaluation assists the monitoring team in determining whether changes in the implementation of the Monitoring Plan and/or the habitat restoration project may be warranted. In addition, this continuous data evaluation may indicate early success of the habitat restoration project and support a management decision to terminate both the mitigation project and the associated monitoring plan.

During the conduct of Step 5, the monitoring team should be continually evaluating and interpreting the data with regard to three basic questions:

1. Do the monitoring data meet the DQOs specified in the Monitoring QAPP?

2. If yes, can the monitoring data (collected to date) support a decision rule? or

3. If the data do not meet the DQOs, why not and what changes should be made so that the data meet the specified DQOs?

These evaluations may be conducted as part of a data quality assessment (DQA), which assesses the type, quantity, and quality of data in order to verify that the planning objectives, QAPP components, and sample collection procedures specified in the Monitoring QAPP were satisfied and that the data are suitable for its intended purpose. Guidance for conducting a DQA can be found in U.S. EPA (2000c). Depending on how well the monitoring results meet the DQO requirements, the monitoring program may either proceed as identified in the Monitoring QAPP, be revised, or proceed to a management decision (Figure 5.1).

5.2 CONTINUED OPTIMIZATION OF THE MONITORING PLAN

Optimization occurs during finalization of the Monitoring Plan (see Section 4.4.1) and should continue throughout the monitoring period. As monitoring data are generated and evaluated, the QAPP should be revisited to see if improvements or modifications could be implemented that continue to meet the monitoring DQOs without compromising the quality of previously collected data. Optimization of the Monitoring QAPP during monitoring would be largely associated with the availability of new or previously unavailable sampling technologies or approaches that may be easier to implement, less costly, more effective, and/or more rapid than the monitoring methods being used.

5.3 EVALUATION OF ANALYTICAL RESULTS

Throughout the monitoring period, assurance must be made that the data generated meet the DQOs specified in the Monitoring QAPP. Analysis of the monitoring data should occur as the data are generated and successfully undergo the DQO review. Data analyses will employ the analytical methods identified in the Monitoring QAPP, and the results of these analyses should be evaluated (as they are generated) with regard to the monitoring hypotheses, the DQOs, and the monitoring decision rules.

Consequences of DQO Deviations

- The restoration project and monitoring program continue as planned.
- The restoration project and/or monitoring plan are modified.
- The restoration project and associated monitoring are terminated.
- A longer-than-planned duration for the restoration project and associated monitoring is required.

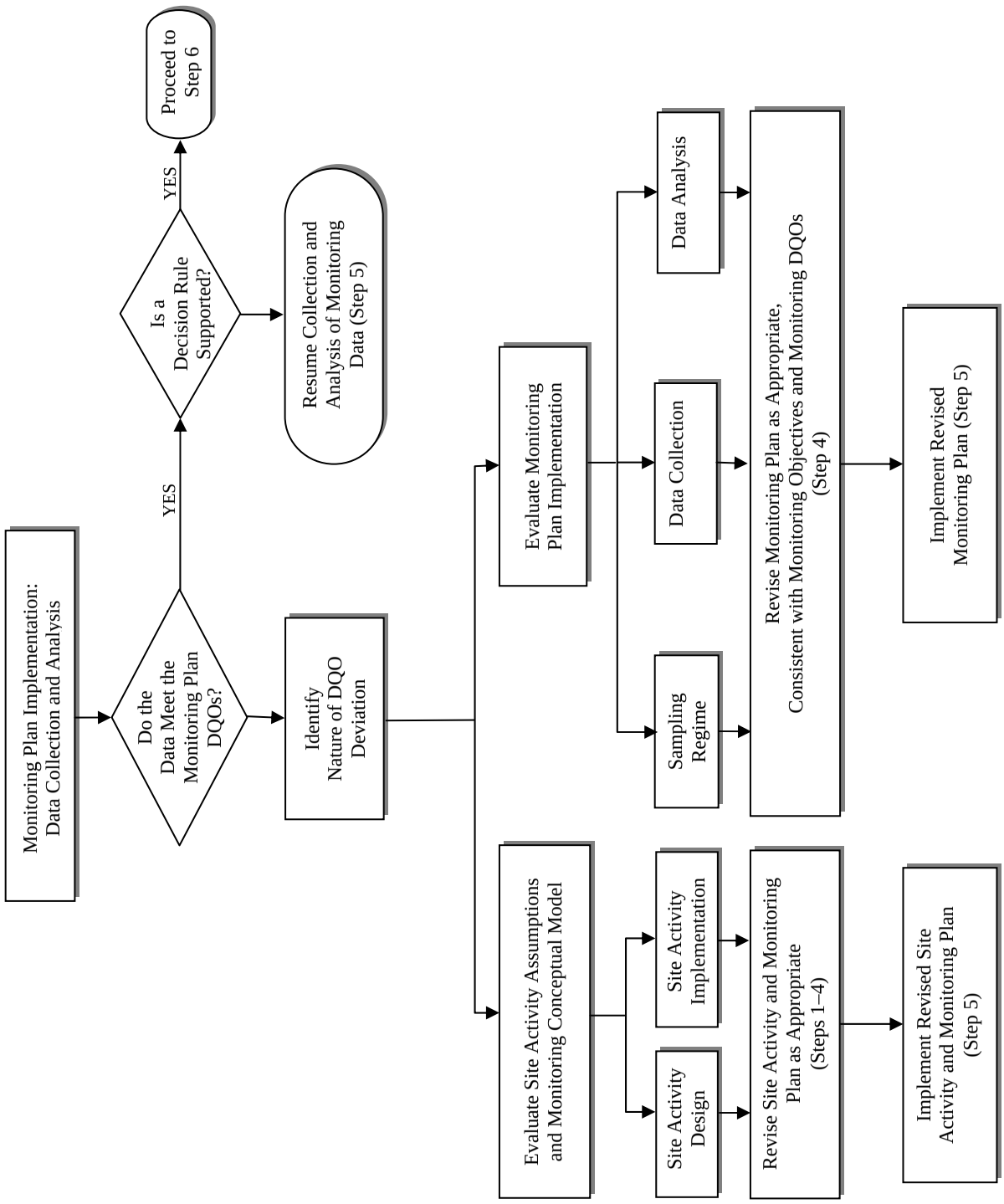


FIGURE 5.1 Decision Path during Monitoring Implementation and Data Collection and Analysis

If the DQOs are met, a determination should be made regarding the ability of the data collected thus far to support a decision rule. If the data can support a decision rule, then the habitat restoration monitoring program should proceed to Step 6, the management decision (Figure 5.1). If the DQOs are not met, a determination must be made as to why the DQOs have not been met, and a subsequent decision made to (1) continue the restoration project and monitoring program as planned, (2) revise the Monitoring QAPP and/or the habitat restoration project, or (3) terminate the project.

An evaluation of the monitoring results may show that the habitat restoration project is proceeding as expected toward its goal, and that the collection of monitoring data would continue as prescribed in the Monitoring QAPP. If the data indicate that the success of the restoration project is proceeding more rapidly than expected and may reach its goal sooner than planned, a revision to the monitoring data collection schedule may be warranted. In this case, the frequency of some restoration activities (e.g., seeding or herbicide treatments) may be reduced.

In contrast, the monitoring results may indicate a much smaller change in the measured habitat parameters or overall habitat condition than expected, or even that habitat quality is decreasing (e.g., due to increases in invasive species). In such cases, the restoration project and the Monitoring Plan should be reevaluated, and revisions to either the restoration project, the Monitoring Plan (including design and implementation), or both, may be necessary and appropriate.

Alternately, the monitoring results may support a decision rule, and if the data meet the criteria for success of the habitat restoration, consideration should be given to proceeding to a management decision to terminate restoration activities and monitoring. However, habitats in early stages of restoration often do not have the stability typically associated with mature habitats. Therefore, continuation of some level of the habitat restoration project and its associated monitoring may be appropriate for the scheduled mitigation project period.

5.3.1 Relationship of the Results to the Habitat Restoration Monitoring Hypotheses

Recall that the basic monitoring hypothesis is “Has (is) the habitat mitigation project reached (reaching) its stated objectives?” This hypothesis is based, in part, on specific assumptions of how the restoration project is expected to reach its objectives. As the monitoring program generates data, the monitoring team should continually analyze those data with regard to how well the data support the monitoring hypotheses and the underlying restoration assumptions (as developed in the monitoring conceptual model). Evaluation of the data may show that the habitat restoration project is proceeding as expected, better than expected, or worse than expected. The specific evaluation outcome will determine whether any modifications or adjustments to the restoration project or to implementation of the Monitoring QAPP may be appropriate.

For example, suppose a habitat restoration project is initiated to restore a wetland (and its functions) that was impacted during a cleanup action (see Example 2.1). The monitoring hypothesis may be that surface grading will create conditions suitable for the formation of hydric

soils, which in turn will support wetland vegetation, and that annual planting of native wetland vegetation will reestablish the desired wetland plant community and restore previous wetland functions. If the monitoring data indicate that the development of hydric soils and the desired wetland plant community are proceeding as expected, data collection would continue as described in the Monitoring QAPP.

If the data indicate a better than expected response (i.e., hydric soils are rapidly developing and native wetland vegetation is becoming rapidly established), then the monitoring team may consider revising the Monitoring QAPP. In this case, it may be appropriate to revise not only the expected duration of the restoration project and the associated monitoring program (5 years), but also aspects of the planting regime and associated vegetation sampling (to document establishment of the plant community). It may be possible to reduce the frequency of planting and vegetation sampling, and/or proceed to a monitoring decision and overall site management decision sooner than was originally planned (i.e., 5 years), thereby reducing overall project costs.

In contrast, the monitoring data may indicate little or no change in soil conditions of the plant community, or an increase in nonnative vegetation. In this case, it may be appropriate to evaluate both the restoration project and the Monitoring Plan with regard to implementation and underlying assumptions, and identify possible revisions to the Monitoring QAPP, the restoration project, or both (Figure 5.1).

5.3.2 Data Adherence to the Data Quality Objectives

Throughout data collection and analysis, the monitoring team should pay special attention to ensuring that the specifications established by the DQOs for the monitoring design are being adequately met. These specifications include where and when the monitoring data are being collected (the spatial and temporal boundaries), how the data are being collected (the collection methods, including the sampling equipment and procedures), and how the data are being evaluated (data analysis). The monitoring team should ensure that (1) all data collection and analysis activities conform to the QA/QC policies and procedures identified in the Monitoring QAPP (see Section 4.5), and (2) all data validations procedures identified in the QAPP are carried out on all data generated by the monitoring program.

5.3.3 Data Support of the Decision Rules

As the monitoring data are collected, they should be compared with the decision rules identified in the Monitoring QAPP. Recall that the decision rules specify the criteria for continuing, stopping, or modifying the monitoring program and/or the habitat restoration project. For example, a monitoring decision rule associated with a wetland restoration project might be "If the areas of the wetland restoration project site undergoing seeding with native wetland vegetation exhibit 80% areal coverage by the native vegetation, then restoration of the seeded areas has been successful." If at any point during the collection and analysis of monitoring data the results support the decision rule, then the restoration project could proceed to Step 6.

Alternately, if the results do not support the decision rule, then both seeding and vegetation monitoring would continue as identified in the Monitoring QAPP (Figure 5.1).

5.4 ADDRESSING DATA DEVIATIONS FROM THE MONITORING DQOs

Deviations from the DQO specifications presented in the Monitoring QAPP can arise for a variety of reasons, such as natural variability, unexpected data collection problems, analytical errors in the laboratory, or computational errors during data analysis (Figure 5.1). Uncertainties associated with the monitoring conceptual model or assumptions regarding the expected performance and outcome of the habitat mitigation project may also be the basis for any observed DQO deviations.

Causes of Monitoring DQO Deviations

- Natural variability.
- Underlying habitat restoration assumptions incorrect.
- Inadequate sampling regime.
- Inadequate data collection methods.
- Inappropriate analytical methods.

If evaluation of the monitoring data indicates DQO deviations, the monitoring team should determine the underlying basis for the observed deviations and consider the consequences of those deviations on the success of the continued conduct of the monitoring program and on the success of the restoration project. If unacceptable consequences are indicated, then actions necessary to address the DQO deviations should be identified. In general, deviations from the monitoring DQOs may be due to (1) design and/or implementation problems with the habitat restoration project, or (2) implementation problems with the Monitoring QAPP. Actions to address these deviations may include (1) changes to the design and/or implementation of the restoration project, and/or (2) changes in the implementation of the Monitoring QAPP (Figure 5.1).

5.4.1 Natural Variability

Natural variability in the chemical, physical, and biological parameters being measured by the monitoring program may result in data that greatly deviate from the Monitoring Plan DQO specifications. In such cases, there are no aspects of the restoration project or the Monitoring QAPP that could be revised to obtain more suitable data. Natural variability is outside of the control of the monitoring team and will likely result in extending the duration of both the restoration project and the Monitoring Plan. A reference site will be needed to confidently attribute DQO deviations to natural variability for many monitoring parameters. However, the occurrence of atypical climatic conditions (e.g., a summer drought, above-average rainy season) preceding or during implementation of the mitigation project may be expected to affect many monitoring variables.

5.4.2 Evaluating the Habitat Restoration Project

The monitoring team should examine the implementation, expected and ongoing performance, and success of the habitat restoration project as monitoring data are collected. Because deviations from the monitoring DQOs could be the result of problems associated with implementation of the restoration project or with underlying project assumptions, examination of the monitoring conceptual model may greatly aid in this evaluation. Recall that during early development of the monitoring program, a monitoring conceptual model was developed to identify known and expected relationships between the restoration project and the monitoring goals and objectives (see Step 2). Once developed, this conceptual model was used to identify the monitoring data needs and develop the Monitoring Plan. If the monitoring data indicate that one or more of the restoration project assumptions are incorrect or that implementation of the project is incorrect, then changes in the assumptions, design, and/or implementation of the habitat restoration project and/or the Monitoring QAPP will be necessary.

Problems with implementation of the restoration project may arise for a variety of reasons. For example, wetland or upland vegetation may be planted in locations with inappropriate soil characteristics, moisture regimes, or light availability to support adequate seed germination or survival of seedlings or live plantings, thus preventing or delaying the establishment of a desired plant community.

The assumptions underlying the habitat restoration design and expected success may be incorrect because of unforeseen or unexpected conditions. For example, agricultural drain tiles present at a wetland restoration site may have been assumed to be fully functioning and effectively draining the site. However, monitoring data collected following tile removal indicate a lower degree of groundwater rebound than expected. In this example, the tiles may not have been fully functioning as assumed, and thus the removal of the tiles resulted in a less than expected and inadequate hydrologic regime for the planned wetland. In this example, the restoration project was modified to include a weir to reduce surface outflow from the site and thereby provide the desired hydrologic regime.

In another example, herbivory of woody plantings by deer or beaver may have been assumed to be the primary threat to the survival of plantings for a wetland restoration project, and measures to control deer and beaver access to the site were provided. However, the site conditions created by the restoration project attracted large numbers of Canada geese that subsequently destroyed much of the emergent wetland plants installed near open water areas. To address this problem, the restoration project was modified to include the installation of netting to discourage use of the site by geese.

In these examples, the assumptions for the habitat restoration were incorrect, and the projects themselves were modified to address the DQO deviations. Following any changes to the restoration project proper, the monitoring team should revisit the Monitoring QAPP and determine whether any revisions to the Monitoring Plan may be necessary.

5.4.3 Evaluating Implementation of the Monitoring Plan

Evaluation of the monitoring data may indicate that the observed monitoring DQO deviations are due to problems associated with implementation of the Monitoring QAPP and not with the habitat restoration project itself (Figure 5.1). Implementation problems may be associated with one or more of the following aspects of data collection: (1) the sampling regime, (2) the data collection methods, or (3) the data analysis methods (Figure 5.1).

Sampling Regime: Problems with the sampling regime may be related to the spatial and temporal boundaries of the sampling design (i.e., sampling location and frequency). The monitoring team should examine the monitoring data, the current sampling regime, and the nature of the DQO deviations, and determine whether changes in the sampling design may be warranted to rectify the DQO deviations. Such changes may include an increase or decrease in the number of samples collected during each sampling event from current sampling locations, an increase or decrease in sampling locations, a change in the sampling location, or a change in the frequency or timing of sampling events.

For example, the Monitoring QAPP may identify a biannual (May and September) vegetation sampling regime at a grassland restoration site and have a decision rule that identifies a specific species richness of grass species as indicative of restoration success. Determination of species richness (the number of species in a community) requires taxonomic identification of vegetation. Under the sampling regime in the QAPP, it may not be possible to identify many of the grass species at the site because they flower and seed (plant parts necessary for taxonomic identification) at times that fall between the sampling periods. Data collected in May and September would miss many of the grass species and thus not be able to support the decision rule. The addition of a sampling event in summer may be necessary to ensure adequate identification of grasses on the restoration site.

Any changes in the sampling regime should be consistent with the underlying monitoring hypotheses, DQOs, and decision rules identified in the Monitoring QAPP and should not require changes in data collection and analysis methods. If the sampling regime is modified, the Monitoring QAPP should be updated to include the changes.

Data Collection Methods: In some cases, evaluation of the monitoring data may show that sampling methods are the basis for the DQO deviations. Such a problem could result from a variety of factors related primarily to unexpected environmental conditions (e.g., a greater than expected aquatic vegetation density that reduces benthic grab sampler efficiency). If such problems are encountered, the monitoring team should determine if the data collection method could be revised or whether an alternative method should be implemented.

In some cases, the changes may be relatively straightforward and easy, such as simply changing from one type of sediment sampler to another (e.g., Eckman dredge versus core sampler). In other cases, a completely different sampling method may be needed (e.g., electrofishing versus gill netting). With any change in data collection methods, the monitoring team should ensure that the subsequent data would provide data of sufficient quality to meet the DQO specifications and the needs of the decision rules. If not, additional aspects of

the Monitoring QAPP, such as the monitoring goals, hypotheses, and/or DQOs, may also have to be revised. Data collection methods may also be changed as new technologies become available, or as alternative methods with increased efficiency and/or reduced costs are identified.

Data Analysis Methods: In some cases, inability of the monitoring data to meet the DQO specifications may be related not to sampling regime or data collection methods, but rather to the analytical methods being employed. For example, matrix interference is a commonly encountered problem in the chemical analysis of environmental media, and, if not carefully considered, may lead to the generation of erroneous data.

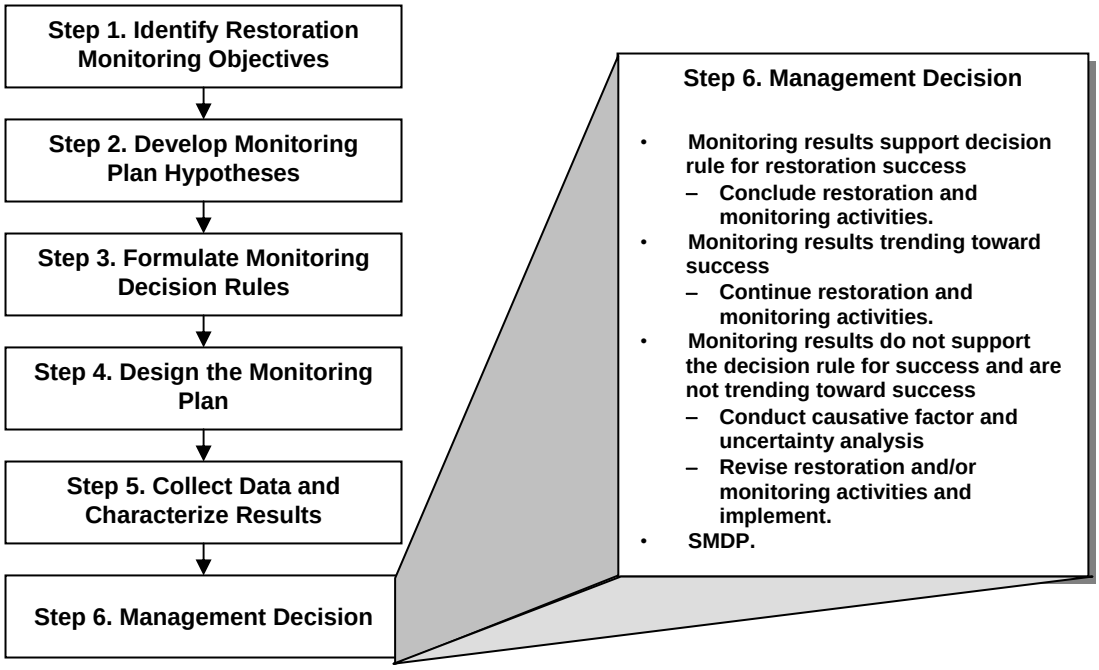
Inappropriate statistical analyses may also play a role in any observed DQO deviations. For example, during development of a monitoring plan it may have been assumed that the monitoring data would be normally or lognormally distributed and that parametric methods for statistical analyses would be appropriate. However, if the monitoring data are not normally distributed, then the use of parametric analyses would produce incorrect statistical results. In this case, the monitoring team would replace the parametric methods with a nonparametric (distribution-free) data analysis approach.

5.5 REVISING THE MONITORING PLAN

Any changes in the sampling regime, data collection and analysis methods, monitoring objectives and hypotheses, or decision rules should be documented as an addendum to, or a revision of, the Monitoring QAPP.

(This page intentionally blank.)

STEP 6 MANAGEMENT DECISION



In Step 6, the monitoring results are evaluated with respect to the monitoring decision rules, and a determination is made as to how well the habitat restoration project has met its stated objectives. If the monitoring results support the decision rules, the interpretation will be that the restoration project has successfully reached its specified outcome. In this case, the management decision will be to discontinue both the activity and its monitoring program. Alternately, if the monitoring results do not support the decision rules, the interpretation may be that the mitigation project has not been successful. In this case, the management decision will be to determine why the project was unsuccessful and to identify what, if any, actions may be necessary to achieve the restoration goals. In both cases, the management decision has consequences that affect the restoration project and future costs.

6.1 GENERAL MANAGEMENT DECISIONS

At the end of the data collection, analysis, and characterization, as specified in the Monitoring QAPP, the monitoring results will point toward one of three conclusions (Figure 6.1) relevant to the monitoring objectives and decision rules:

- The monitoring decision rules have been met (results indicate that the habitat restoration project is successful),

- The data are trending toward meeting the decision rules (results indicate that the restoration project is trending towards success), or

- The monitoring decision rules have not been met (results indicate that the restoration project has not achieved its stated objective).

6.1.1 Monitoring Results Indicate Habitat Restoration Is Successful

The most desired outcome of the monitoring program would be that the results meet the monitoring decision rules, thus indicating that the habitat restoration project has reached its stated objectives. For this outcome, the management decision may be to conclude the restoration project and the associated monitoring program (Figure 6.1).

It is critical that the monitoring results be carefully examined with regard to the monitoring decision rules, and especially with regard to how well the results met the specifications of the monitoring DQOs. Uncertainties associated with the monitoring data should be qualitatively or quantitatively identified and carefully examined in relation to the consequences the uncertainties may have on the management decision (i.e., concluding the restoration project and monitoring program before restoration success has actually been reached). If the project is being conducted to meet a permit requirement or as part of a CERCLA cleanup action, all appropriate parties should agree that the monitoring results (and the associated uncertainty) have met the decision rules.

6.1.2 Monitoring Results Indicate Habitat Restoration Is Trending toward Success

In some cases, the monitoring data may not meet the decision rules indicating habitat restoration success (Figure 6.1). However, the data may show a strong trend indicating that restoration success will likely be met sometime in the foreseeable future. In this case, the restoration project is simply taking longer to meet its objectives than was anticipated during development of the monitoring program. If a data trend toward a timely restoration success is indicated, the management decision may be to continue both the restoration project and its associated monitoring program for the completion time indicted by the trend analysis (Figure 6.1), if funding permits.

If the data are indicating a trend toward restoration success and the decision is made to continue monitoring, it may be appropriate at this time to evaluate the estimated time to completion and the monitoring frequency and determine whether sampling frequency could be changed. Depending on the observed trend in the monitoring data (especially with regard to an estimated time to completion), a reduction in sampling frequency (and concurrent decrease in monitoring costs) could be warranted. For example, trend analysis on 3 years of monitoring data that were collected on a quarterly schedule may indicate that the restoration is steadily proceeding toward success; however, only minimal changes are observable between any two or three samples. In this case, reducing the monitoring frequency to an annual basis would provide a similar level of tracking restoration success, but with a greatly reduced cost. A similar reduction in the monitoring frequency may be appropriate if the monitoring data indicate a very strong trend toward success.

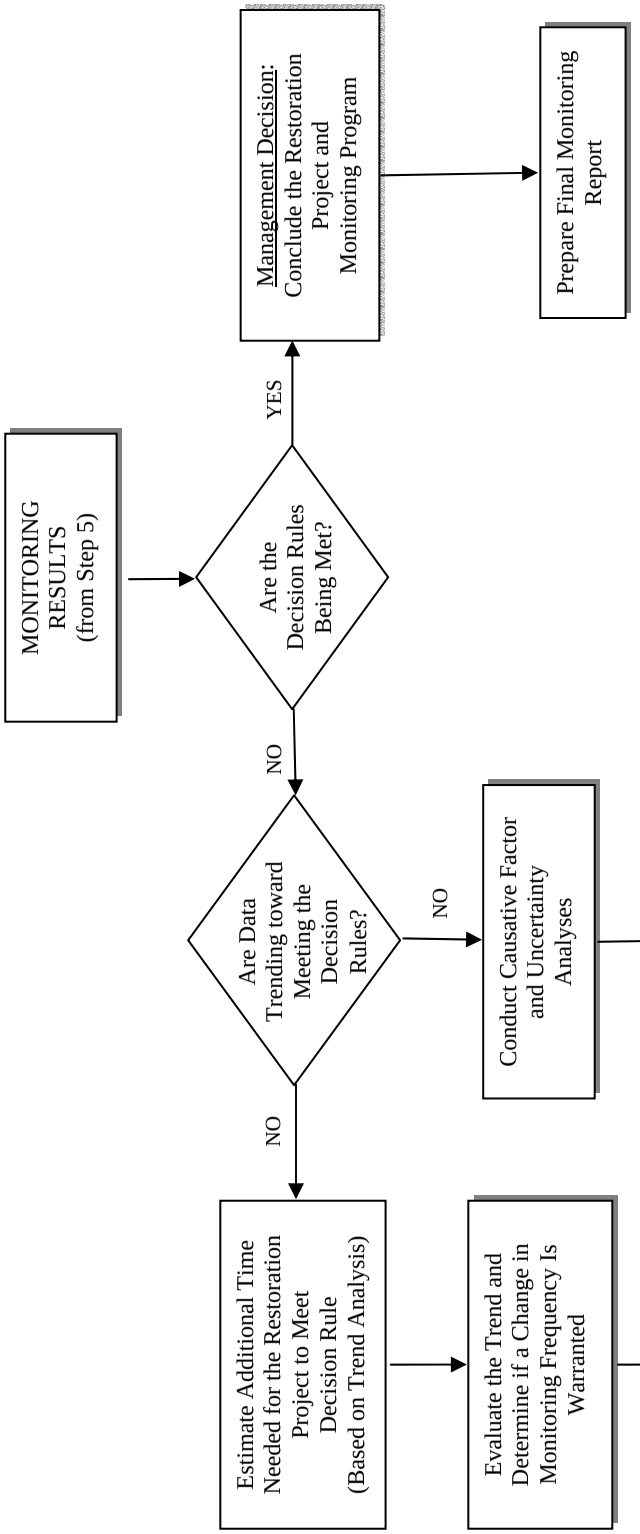


FIGURE 6.1 Monitoring Outcome Management Decision Path

6.1.3 Monitoring Results Indicate Habitat Restoration Is Unsuccessful

If the monitoring results do not indicate habitat restoration success, the monitoring team should examine all aspects of the restoration project in order to identify the causative factors responsible for the project's inability to meet its stated restoration objectives. Causative factors may be associated with problems implementing the restoration project, or an inappropriate restoration activity. Causative factors may also be associated with a number of non-project-related issues, such as unexpected natural variability in environmental (i.e., an extended period of drought affecting groundwater conditions or aquatic biological communities) or biological conditions (i.e., unexpected disease outbreak). The monitoring team should also consider conducting an uncertainty analysis to determine to what extent the uncertainties associated with the restoration project and the monitoring program may have affected the interpretation of restoration success (i.e., how well the monitoring results meet the decision rules).

Once the causative factors and potentially important uncertainties have been identified, the monitoring team should identify the actions that may be needed to address those factors and uncertainties. The resulting management decision could be to (1) revise the restoration project and/or monitoring program and continue restoration and monitoring, or (2) conclude the restoration and monitoring (Figure 6.1). Additional cost and effort requirements for continuing the restoration and/or monitoring should be considered in the management decision.

Revisions to the restoration project or monitoring program may or may not require the development of an entirely new Monitoring QAPP. If the new restoration and/or monitoring activity has the same or similar objectives, then a complete revision of the Monitoring QAPP (e.g., going through Steps 1 through 4) would not be warranted. Rather, the existing plan (including the monitoring hypotheses, DQOs, and decision rules) may be revised to incorporate the new restoration and monitoring activities. A new Monitoring QAPP, including new decision rules, would be needed only if the revised restoration project has objectives that are completely different from the original restoration objectives.

It is possible that the causative factors evaluation may also identify errors in the collection and analysis of the monitoring data. Such errors should have been identified and corrected in Step 5 as part of the DQO evaluations. However, if such errors are now found (i.e., in Step 6), the monitoring team should correct the errors, and, in the case of analytical errors, reexamine the monitoring data with regard to DQO compliance (Step 5) and meeting the monitoring decision rules (Step 6). A subsequent management decision would then be based on this new evaluation.

6.2 DOCUMENTATION AND SCIENTIFIC MANAGEMENT DECISION POINT

The management decision made in Step 6 on the basis of the monitoring results should be documented. The specific nature of the monitoring decision document will depend on the decision made (Table 6.1). This document serves as the SMDP for Step 6.

6.2.1 Interim Annual Monitoring Reports

An annual monitoring report should be prepared for each year of the restoration project and may be required to meet permit requirements of other regulatory obligations. The annual report should:

- Describe the restoration project and its objectives;
- Summarize the Monitoring QAPP (i.e., the monitoring hypotheses, monitoring study design, decision rules, and DQOs);
- Present the monitoring results for the year covered by the report;
- Discuss overall status of the restoration project and its progress toward achieving its mitigation objectives; and
- Identify any revisions to the project or the monitoring program that may have been implemented, including the basis for any such revisions.

6.2.2 Final Monitoring Report — Conclude Habitat Restoration

If at the conclusion of monitoring the restoration project is determined to have successfully reached its objectives, the final management decision will be to conclude the

TABLE 6.1 Monitoring and Management Decision Documentation

Management Decision	Monitoring Document Component	Monitoring Document	New or Revised Monitoring QAPP Needed?
Conclude restoration and monitoring	• Management decision • Monitoring decision rules • Monitoring results • Uncertainty description	Annual and final	No
Continue restoration and monitoring	• Management decision • Monitoring decision rules • Monitoring results, including trend analyses • Uncertainty description	Annual and final	No
Revise restoration	• Management decision • Monitoring decision rules • Monitoring results • Causative factor analysis • Uncertainty description • Suggested activity revisions	Annual and final	Yes

restoration project and associated monitoring. The final report should present the following information:

- A description of the restoration project and its objectives,
- A summary of the Monitoring QAPP (i.e., the monitoring hypotheses, monitoring study design, decision rules, and DQOs),
- A summary of the monitoring results,
- A description of the final condition of the restoration site, and
- A statement of the management decision that the restoration has reached its objectives and that no further mitigation or monitoring is warranted.

Alternately, the monitoring results may indicate that the habitat restoration project has failed to reach its restoration objectives, and the management decision may be to conclude the restoration project and associated monitoring. The final report should present the same information as above. However, rather than a statement regarding restoration success and the conclusion of restoration and monitoring, the final report should present the management decision for no further restoration or monitoring and the basis for that decision (i.e., low expectations for future success).

6.2.3 Final Monitoring Report — Continue Habitat Restoration and Monitoring

A final monitoring report should be prepared at the specified project and monitoring end date. If at the conclusion of monitoring the restoration project is determined to not yet have reached its objectives but is proceeding toward attainment of the restoration goals, the final management decision will be to continue restoration and monitoring (as specified in the Monitoring QAPP) and possibly with a reduced monitoring frequency. The final report should present:

- A description of the restoration project and its objectives;
- A summary of the Monitoring QAPP (i.e., the monitoring hypotheses, monitoring study design, decision rules, and DQOs);
- A summary of the monitoring results;
- A description of the final condition of the restoration site;
- A description of the revised monitoring frequency (and supporting rationale), if appropriate; and

- A statement of the final management decision (and supporting rationale) for continuing restoration or monitoring.

Because the decision is to continue the restoration project and monitoring (as described in the QAPP), no revisions will be needed to the Monitoring QAPP. Additional annual monitoring reports should be prepared for each additional year of restoration and monitoring, and a revised final report prepared upon attainment of the restoration objectives.

6.2.4 Final Monitoring Report — Revise the Habitat Restoration Project

If the monitoring results effect a decision to revise the restoration project, the final monitoring report should present:

- A description of the restoration project and its objectives;
- A summary of the Monitoring QAPP (i.e., the monitoring hypotheses, monitoring study design, decision rules, and DQOs);
- A summary of the monitoring results;
- A description of the final condition of the restoration site;
- A statement of the final management decision (and supporting rationale) to revise the restoration project and the underlying monitoring results and decision rules on which the decision is based;
- A description of the causative factor and uncertainty analyses and a summary of the results, showing as clearly as possible why the decision rules for restoration success were not met; and
- A description of the actions needed to address the causative factors and uncertainties associated with the lack of restoration success.

If the need for a completely new restoration approach is identified, then the development of a new or revised Monitoring QAPP will be necessary; development of the QAPP would follow Steps 1 through 4 of the Monitoring Plan development process described in this guidance. Following implementation of the revised restoration project and its monitoring program, annual and final monitoring reports should be prepared as previously described.

(This page intentionally blank.)

7 REFERENCES

Bonham, C.D., 1989, *Measurements for Terrestrial Vegetation*, John Wiley & Sons, Inc., New York, N.Y.

BLM (Bureau of Land Management), 1986, *Inventory and Monitoring of Wildlife Habitat*, Cooperider, A.Y., R.J. Boyd, and H.R. Stuart (editors), U.S. Department of Interior, Bureau of Land Management, Service Center, Denver, Colo., Sept.

Clewell, A, J. Rieger, and J. Munro, 2000, *Guidelines for Developing and Managing Ecological Restoration Projects*, published by The Society for Ecological Restoration, Tucson, Ariz., June 24.

Elizinga, C., D. Salzer, and J. Willoughby, 1998, *Measuring & Monitoring Plant Populations*, BLM Technical Reference 1730-1, BLM/RS/ST-98/005+1730, Bureau of Land Management, Natural Science and Technology Center, Lakewood, Colo.

Fonseca, M.S., W.J. Kenworthy, and G.W. Thayer, 1998, *Guidelines for the Conservation and Restoration of Seagrass in the United States and Adjacent Waters*, Decision Analysis Series No. 12, National Oceanic and Atmospheric Administration, Coastal Ocean Program, Silver Spring, Md.

Hays, R.L., C. Summers, and W. Seitz, 1981, *Estimating Wildlife Habitat Variables*, FWS/OBS-81/47, Biological Report, U.S. Fish and Wildlife Service, Washington, D.C.

NOAA (National Oceanic and Atmospheric Administration), undated, "Monitoring Requirements under the Estuary Restoration Act," *NOAA & the ERA Estuary Restoration Act, EPA Information: Monitoring Protocols*. Available at http://restoration.nos.noaa.gov/htmls/era/era_monitoring.html.

SER (Society for Ecological Restoration), 2002, *The SER Primer on Ecological Restoration*, published by the Science and Policy Working Group, Tucson, Ariz., April.

Society of Wetland Scientists, 2001, "Position Paper on Performance Standards for Wetland Restoration and Creation," *Society of Wetland Scientists Bulletin* 18(4):21–23.

Sokal, R.R., and F.J. Rohlf, 1981, *Biometry*, 2nd ed., W.H. Freeman and Co., San Francisco, Calif.

USACE (U.S. Army Corps of Engineers), 2001, *Guidance for the Establishment and Maintenance of Compensatory Mitigation Projects under the Corps Regulatory Program Pursuant to Section 404(a) of the Clean Water Act and Section 10 of the River and Harbors Act of 1899*, Regulatory Guidance Letter, Oct. 31.

U.S. EPA (U.S. Environmental Protection Agency), 1989, *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish*, EPA/444/4-89-001, Office of Water, Washington, D.C., May.

U.S. EPA, 2000a, *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW Final, EPA/600/R-00/007, Office of Environmental Information, Washington, D.C., Jan.

U.S. EPA, 2000b, *U.S. EPA Order 5360.1 A2, Policy and Program Requirements for the Mandatory Agency-Wide Quality System*, Office of Environmental Information, Washington, D.C., May. Available at www.epa.gov/quality/qs-docs/5360-1.pdf.

U.S. EPA, 2000c, *U.S. EPA Quality Manual for Environmental Programs, 5360 A1*, Office of Environmental Information, Washington, D.C., May.

U.S. EPA, 2000d, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, EPA QA/G-9, QA00 Update, EPA/600/R-96/084, Office of Environmental Information, Washington, D.C., July.

U.S. EPA, 2002, *Principles for the Ecological Restoration of Aquatic Resources*, Office of Water, River Corridor and Wetland Restoration. Available at http://www.epa.gov/owow/wetlands/restore/principles.html.

U.S. EPA, 2003, *An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement*, EPA 843B03001, Interagency Working Group on Wetland Restoration, Washington, D.C., Sept. Available at http://www.nmfs.noaa.gov/habitat/habitatprotection/pdf/Wet%20 Res%20Guidance_FINAL.pdf.

U.S. EPA, 2004, *Guidance for Monitoring at Hazardous Waste Sites: Framework for Monitoring Plan Development and Implementation*, OSWER Directive No. 9355.4-28, Office of Solid Waste and Emergency Response, Washington, D.C., Jan.

Zar, J.H., 1984, *Biostatistical Analysis*, 2nd ed., Prentice-Hall, Inc., Englewood Cliffs, N.J.

APPENDIX A:

CASE STUDY

LONG TERM WETLAND MONITORING PLAN
AREA A DOWNSTREAM/OBDA
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT[1]

[1] The Long Term Monitoring Plan (LTMP) was designed prior to the development of this guidance. While the LTMP was not developed following the process advocated in this guidance, it includes and illustrates many of the aspects (e.g., monitoring decision rules) advocated in the guidance.

(This page intentionally blank.)

U.S. NAVY ENGINEERING FIELD ACTIVITY NORTHEAST
REMEDIAL ACTION CONTRACT (RAC)
CONTRACT NO. N62472-99-D-0032
CONTRACT TASK ORDER NO. 0063

FINAL
LONG TERM WETLAND MONITORING PLAN
AREA A DOWNSTREAM/OBDA
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

September 2001

Prepared by

Foster Wheeler Environmental Corporation
133 Federal Street
Boston, Massachusetts 02110

ND01-081
9/14/01

U.S. NAVY ENGINEERING FIELD ACTIVITY NORTHEAST
REMEDIAL ACTION CONTRACT (RAC)
CONTRACT NO. N62472-99-D-0032
CONTRACT TASK ORDER NO. 0063

FINAL
LONG TERM WETLAND MONITORING PLAN
AREA A DOWNSTREAM/OBDA
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

September 2001

Prepared by

Foster Wheeler Environmental Corporation
133 Federal Street
Boston, Massachusetts 02110

Revision	Date	Prepared by	Approved by	Pages Affected
1	9/14/01	J. Fischl	L. Kahrs, P.E.	1-12

ND01-081
9/14/01

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 PRE-REMEDIAL CONDITIONS 2
- 2.1 Upper Pond Wetland 2
- 2.2 Lower Pond Wetland 3
- 2.3 OBDA Wetland 3
- 2.4 Stream 1 Wetland 4
- 2.5 Stream 2 Wetland 4
- 2.6 Stream 3 Wetland 5
- 2.7 Stream 4 Wetland 5
- 2.8 Stream 5 5

3.0 PERFORMANCE STANDARDS 6

4.0 MONITORING COMPONENTS 7
- 4.1 Vegetation 7
- 4.2 Soils 8
- 4.3 Hydrology 8
- 4.4 Functions and Values Assessment 9
  - 4.5 Benthic Community Analysis 9
  - 4.6 Post-restoration Wetland Delineation 11

5.0 REPORT 11

6.0 REFERENCES 12

LIST OF APPENDICES

Appendix A As Built 1-foot Contour Drawing
Appendix B Seed Mixes
Appendix C Woody Planting Material
Appendix D Wetlands Functions and Values
Appendix E Overview of Monitoring Program
Appendix F U.S. Army Corps of Engineers, New England District Highway Methodology, Standard Wetland Function and Evaluation Form
Appendix G WEThings Potential Indicator Species
Appendix H WEThings Standardized Data Form
Appendix I New England District Performance Standards and Supplemental Definitions for Use with the 1987 Corps Manual

1.0 INTRODUCTION

Between July 1999 and August 2000, contaminated soils and sediments were remediated at the Area A Downstream Watercourses and Over Bank Disposal Area (Area A Downstream/OBDA) at Naval Submarine Base - New London in Groton, Connecticut. Remedial activities involved removal, treatment, and discharge of surface waters; excavation of contaminated soil and sediment; onsite dewatering of excavated soil and sediment to remove free water; treatment and discharge of removed water; and offsite disposal of dewatered media at approved landfills. As a result of soil and sediment excavation and removal, 2.90 acres of palustrine emergent, scrub-shrub and forested wetlands and open water were disturbed. Pursuant to the wetland restoration plan, as outlined in the 100% Design (FWENC, 2000a), compensatory mitigation for this impact required the restoration of 2.43 acres of palustrine emergent, scrub-shrub and forested wetlands and 0.47 acres of open water.

Planned restoration of impacted wetlands was completed in two stages:

- Stage 1 – Grading and Herbaceous Cover Establishment; and
- Stage 2 – Woody Cover Establishment.

The wetland restoration was planned in two stages to allow for groundwater monitoring prior to the planting of woody material since pre-remediation water table data were not available. Stage 1 seeding of disturbed areas was planned to provide soil erosion/sediment control, establish desirable wetland or upland species and prevent establishment of weedy invasive species.

Stage 1 Restoration was completed on August 24, 2000 (FWENC, 2000b). All disturbed areas were restored to final grade with a topsoil mix supplemented with organic material upon completion of excavation, backfilling and rough grading. Final grading was completed sequentially between April 13, 2000 and July 24, 2000. Final grades are presented in Figure 1, Appendix A. Once final grading was complete, areas were re-seeded with native wetland and upland herbaceous species. Seed mixes used for restored areas are provided in Appendix B, Tables B-1 through B-5.

All reseeded areas were allowed to equilibrate or "settle" through the first winter and early spring post-remediation. Reseeded areas were monitored during this period for the following parameters: germination and aerial coverage of seeded material, encroachment of invasive species, and ground water levels. Monitoring results were evaluated and hydrological zones were established (FWENC, 2001). Figure 1 (Appendix A) shows hydrology zones where soils were saturated or ponded for 10 consecutive days during the growing season (emergent zone), or within 10 inches of the surface (scrub/shrub–forested zone).

Stage 2 involves establishment of woody cover. This Stage of the restoration was completed on April 26, 2001. Species and general locations are provided in Appendix C, Tables C-1, and C-2. Placement of woody plants was based on hydrological requirements and tolerance of each species. Appropriate species were planted in established hydrological zones as indicated on Figure 1, Appendix A. Restored wetlands will be monitored after completion of planting and their successful establishment will be determined by meeting performance standards presented in this plan.

The long-term goal of the Wetlands Restoration Plan is re-establishment of wetlands disturbed during site remediation. The specific objectives of the Wetland Restoration Plan are fourfold:

1. Restore 2.90 acres of palustrine wetlands and open water (1.26 acres emergent, 1.17 acres scrub-shrub/forested, and 0.47 acres open water) disturbed during removal of contaminated soils and sediments;
2. Establish a self sustaining, functional palustrine wetland system composed of emergent, scrub-shrub, forested and open water cover classes;
3. Establish a plant community that has a competitive advantage over invasive species; and
4. Restore and enhance pre-remediation wetland functions.

2.0 PRE-REMEDIAL CONDITIONS

A general description of the Area A Downstream/OBDA is included in the Preliminary Design Report. Pre-remedial conditions for the Area A Downstream/OBDA wetlands, including detailed descriptions of fauna, flora, soils, and hydrology, are included in two previous reports; a wetlands delineation report (Atlantic 1995); and the functions and values assessment (Niering and Brawley 1997). The existing wetland conditions have also been previously summarized in the ROD (Brown and Root, 1997). A summary of the existing conditions of each wetland area affected by the selected remedial action is presented below. Table D-1, Appendix D provides a summary of the functions and values performed by each of these wetlands.

One wetland previously identified within Area A Downstream/OBDA was not directly affected by soil and sediment removal. A small (0.027 acre) isolated palustrine scrub/shrub and forested wetland just north of the Lower Pond Wetland was not identified as having contaminated soil or sediment, and was not excavated. Additionally, wetland areas immediately northeast and south of the OBDA Pond also did not exhibit contamination and were partitioned and protected from any removal activities. These wetlands are not discussed further in this Wetland Restoration Plan.

2.1 Upper Pond Wetland

The Upper Pond Wetland is located approximately 300 feet downstream from the Area A wetland. Prior to remedial activities Upper Pond Wetland was a palustrine, shallow, open-water wetland surrounded by palustrine emergent, non-persistent, narrow-leaved wetlands with an artificial water regime (Atlantic 1995). Water depth had been reported to range from approximately 1.5 to 4 feet. The Upper Pond has historically dried out seasonally. Soils in Upper Pond Wetland included poorly to very poorly drained fine-textured marine sediments that were naturally transported into the pond from the upgradient Area A wetland. The sediments were very fine and were generally unconsolidated. The dominant plant species within this wetland was common reed (*Phragmites australis*). Red maple (*Acer rubrum*) was the dominant tree species along the perimeter of the pond, while gray birch (*Betula populifolia*), black birch (*Betula lenta*), sassafras (*Sassafras albidum*), and flowering dogwood (*Cornus florida*) were also present in the canopy. Sweetpepper bush (*Clethra alnifolia*) and winged sumac (*Rhus copallina*) were present within the sparse shrub layer. A layer of decomposing leaves and two aquatic plants, duckweed (*Lemna minor*) and water starwort (*Callitriche heterophylla*), covered most of the pond's sediment. Frogs and turtles had occasionally been observed in Upper Pond Wetland, but it did not contain fish. No threatened or endangered species had been observed in the wetland.

After remediation, the open water portion Upper Pond encompasses an area of 0.24 acres. Water depth ranges from 3 to 8 feet. The shallower periphery of Upper Pond remains a palustrine wetland dominated by emergent, non-persistent, narrow-leaved vegetation. The lower banks were seeded with Northeast Wetland Grass/Forb Mix (Appendix B, Table B-3) and the upper banks with Northeast Upland Wildlife Mix (Appendix B, Table B-5). Woody material planted within the vicinity of Upper Pond includes red maple (*Acer rubrum*), gray birch (*Betula populifolia*), black birch (*Betula lenta*), sweet pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*) and maple-leaved viburnum (*Viburnum acerifolium*).

2.2 Lower Pond Wetland

The 0.48-acre Lower Pond Wetland is located approximately 50 feet downgradient from Upper Pond Wetland, but is not hydrologically connected to Upper Pond by any surface flow. Lower Pond Wetland is classified as a palustrine, shallow, open-water wetland, and prior to remedial activities was surrounded by palustrine scrub/shrub and forested broad-leaved deciduous wetlands (Atlantic 1995). Lower Pond Wetland had a seasonal water regime, with standing water generally present only during the winter and spring. The tree layer was dominated by red maple (*Acer rubrum*) and also contained black gum (*Nyssa sylvatica*). The shrub layer was dominated by sweet pepperbush (*Clethra alnifolia*), and also contained highbush blueberry (*Vaccinium corymbosum*), winterberry (*Ilex verticillata*), and black chokeberry (*Aronia melanocarpa*). The herbaceous layer of this wetland formerly contained cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), marsh fern (*Thelypteris palustris*), loose-flowered sedge (*Carex laxiflora*), and barnyard grass (*Echinochloa crusgalli*). Following remedial activities, woody planted material surrounding Upper Pond includes red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), sweetpepper bush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*) and maple-leaved viburnum (*Viburnum acerifolium*). Disturbed wetland areas within and surrounding Lower Pond were seeded with the Northeast Wetland Grass/Forb mix (Appendix B, Table B-3).

Mapped soils in the vicinity of the Lower Pond Wetland were classified as native Ridgebury fine sandy loam which are poorly drained, moderately course textured, glacial till developed over compact till. A thick layer of decomposing and partially decomposed leaves covered the sediments in the open water portion. Neither fish nor amphibians were previously observed in Lower Pond Wetland. The Lower Pond Wetland was considered to be the least disturbed wetland within Area A Downstream/OBDA, and provided the greatest number of positive wetland functions and values (Niering and Brawley 1997). No threatened or endangered species had been previously observed in the wetland.

2.3 OBDA Wetland

The 0.74-acre OBDA Wetland is located immediately below the northwest slope of the dike that forms the Area A wetland. This wetland prior to remedial activities formed a complex of a palustrine emergent, non-persistent, narrow-leaved wetlands (OBDA Pond) surrounded by scrub/shrub and forested broad-leaved deciduous wetlands (OBDA Ponds Wetland) with a non-tidal seasonal water regime (Atlantic 1995). The emergent vegetation was dominated by a monotypic stand of common reed (*Phragmites australis*), with small clumps of soft rush (*Juncus effusus*). Tulip tree (*Liriodendron tulipifera*) and gray birch (*Betula populifolia*) dominated the forest canopy along the perimeter of the pond. Witch hazel (*Hamamelis virginiana*) was formerly abundant in the shrub stratum, with mountain laurel (*Kalmia latifolia*) and sweet pepperbush (*Clethra alnifolia*) also common. Mapped soils in the vicinity of the OBDA Wetland are classified as native Ridgebury fine sandy loam, which is poorly drained, moderately coarse textured, glacial till developed over compact till. Past Navy activities may have resulted in the placement of fill in this area. The pond's primary source of water was and still is a seep that flows year round and enters the pond from the base of the dike. Groundwater also likely

contributes to the pond during high water table conditions. Prior water depth was 1 to 1.5 feet. Frogs had occasionally been observed within the wetland, but the wetland did not contain fish. No threatened or endangered species had been previously observed in the wetland.

After remediation, the regraded OBDA pond was seeded with the Northeast Wetland Diversity Mix (Appendix B, Table B-2). Red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), sweet pepperbush (*Clethra alnifolia*), spicebush (*Lindera benzoin*), and highbush blueberry (*Vaccinium corymbosum*) were planted along the OBDA pond. Tuliptree (*Liriodendron tulipifera)* was planted in the transition area between the OBDA Pond and surrounding uplands.

2.4 Stream 1 Wetland

The Stream 1 Wetland is approximately 380 feet long and runs between the outlet of OBDA Pond Wetland and Stream 6, a culverted stream that exits Area A Downstream/OBDA and runs along the south side of North Lake. Approximately 0.55-acre of palustrine scrub/shrub and forested broad-leaved deciduous wetland was associated with Stream 1 prior to remedial activities. This wetland was dominated by red maple (*Acer rubrum*), mixed with tuliptree (*Liriodendron tulipifera*), red oak (*Quercus rubra*), and white oak (*Q. alba*). The shrub layer in this wetland previously consisted of witch hazel (*Hamamelis virginiana*) and sweet pepperbush (*Clethra alnifolia*), with a herbaceous layer of a variety of species including cinnamon fern (*Osmunda cinnamomea*), Virginia water horehound (*Lycopus virginicus*), cardinal flower (*Lobelia cardinalis*), false nettle (*Boehmeria cylindrica*), royal fern (*Osmunda regalis*), sensitive fern (*Onoclea sensibilis*), soft rush (*Juncus effusus*), wool grass (*Scirpus cyperinus*), and bur-reed (*Sparganium americanum*). Following remediation the wetland was planted with red maple (*Acer rubrum*), tuliptree (*Liriodendron tulipifera)* black gum (*Nyssa sylvatica*), buttonbush (*Cephalanthus occidentalis*), sweet pepperbush (Clethra alnifolia), witch hazel (*Hamamelis virginia*), spicebush (*Lindera benzoin*), maple-leaved viburnum (*Viburnum acerifolium*), and seeded with the Northeast Wetland Grass Seed Mix (Appendix B, Table B-4). Stream 1 was a low energy, first order stream prior to remediation and remains as such following remedial activities. During the spring of 1995, the stream ranged from 1.5 to approximately 3 feet wide and 4 to 8 inches deep. A thick mat of decomposing leaf litter and detritus formerly covered the stream's bottom. The western portion of the streambed was a mix of gravel, cobble, and sediments in a ripple and pool complex. No threatened or endangered species had previously been observed in the wetland.

2.5 Stream 2 Wetland

The Stream 2 Wetland is approximately 170 feet long and runs between the outlet of Lower Pond and a storm drain. Prior to remediation it included approximately 0.11 acres of palustrine scrub/shrub and forested broad-leaved deciduous wetland. A hardwood forest of red maple (*Acer rubrum*), white ash (*Fraxinus americana*), and black gum (*Nyssa sylvatica*) previously surrounded this stream. The shrub layer within this drainage way was dominated by sweet pepperbush (*Clethra alnifolia*) and highbush blueberry (*Vaccinium corymbosum*). The herbaceous layer contained sensitive fern (*Onoclea sensibilis*) and loose-flowered sedge (*Carex laxiflora)*. After remediation the wetland was planted with red maple (*Acer rubrum*), white ash (*Fraxinus americana*) black gum (*Nyssa sylvatica*), sweet pepperbush (*Clethra alnifolia*), spicebush (*Lindera benzoin*), highbush blueberry (*Vaccinium corymbosum*), and seeded with the Northeast Wetland Grass Seed Mix (Appendix B, Table B-4). Stream 2 was previously and remains a small, low energy first order stream. The substrates were highly organic and composed of partially decomposed leaves and detritus. No gravel or cobble was formerly observed in the streambed. Prior to remediation Stream 2 was approximately 2 feet wide and 4 to 8 inches deep. Post remediation dimensions approximate pre-remediation dimensions. The Stream 2 Wetland, along with the Lower

Pond Wetland, is the least disturbed wetland on site. No threatened or endangered species have been observed in the wetland.

2.6 Stream 3 Wetland

The Stream 3 Wetland is approximately 400 feet long and runs between Upper Pond and a culvert under Triton Avenue. The Stream 3 Wetland formerly was a narrow, palustrine emergent wetland approximately 0.13 acre in size. Oaks (*Quercus sp.*), black birch (*Betula lenta*), red maple (*Acer rubrum*), and flowering dogwood (*Cornus florida*) dominated uplands surrounding this stream. The wetland vegetation found along this streambank previously included northern willow herb (*Epilobium glandulosum*), water purslane (*Ludwigia palustris*), Virginia water horehound (*Lycopus virginicus*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), soft rush (*Juncus effusus*), and rice cutgrass (*Leersia oryzoides*). Post remediation the wetland was planted with red maple (*Acer rubrum*), black birch (*Betula lenta*), black gum (*Nyssa sylvatica*), sweet pepperbush (*Clethra alnifolia*), spicebush (*Lindera benzoin*), highbush blueberry (*Vaccinium corymbosum*), and seeded with the Northeast Wetland Grass Seed Mix (Appendix B, Table B-4).

Prior to remedial activities Stream 3 had a straight (man-made channel) with relatively hard-packed substrates and relatively deep, steep-sided banks that cut through marine sediments apparently washed downgradient from the Area A Wetland. It was reconstructed with a more sinuous channel. The stream bottom formerly consisted of a combination of fine clay and sand. Stream 3 is approximately 3 feet wide an 8 to 12 inches deep. Post remediation dimensions approximate prior dimensions. Parts of the stream bank were previously dominated by common reed (*Phragmites australis*), particularly those portions adjacent to the Upper Pond. No threatened or endangered species have been observed in the wetland.

2.7 Stream 4 Wetland

The Stream 4 Wetland is approximately 300 feet long, and runs from just downslope of the outlet from Area A Wetland to Upper Pond. The Stream 4 Wetland formerly was a narrow, palustrine emergent and forested wetland approximately 0.07 acre in size. Red maple (*Acer rubrum*) and black birch (*Betula lenta*) dominated the canopy of this wetland. The shrub layer contained mountain laurel (*Kalmia latifolia*) and highbush blueberry (*Vaccinium corymbosum*). Herbaceous vegetation included white wood aster (*Aster divaricatus*), striped wintergreen (*Chimaphila maculata*), blue stemmed goldenrod (*Solidago caesia*), rough stemmed goldenrod (*S. rugosa*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), low sedge (*Carex lurida*), and upland bentgrass (*Agrostis perennans*). Post remediation the wetland was planted with red maple (*Acer rubrum*), black birch (*Betula lenta*), mountain laurel (*Kalmia latifolia*), highbush blueberry (*Vaccinium corymbosum*), and seeded with the Northeast Wetland Grass Seed Mix (Appendix B, Table B-4). Stream 4 drains into Upper Pond, and was a man made channel with relatively hard-packed substrates. Stream 4 is approximately 3 to 4 feet wide and 6 to 8 inches deep. Post remediation conditions approximate pre-remedial conditions. No threatened or endangered species had been previously observed in the wetland.

2.8 Stream 5

Stream 5 is approximately 560 feet long. It receives water through an underground culvert from Stream 3 and eventually discharges to the Thames River. Stream 5 was a man made channel with primarily sand and gravel substrates in the streambed and higher organic content in the adjacent floodplain. Stream 5 is approximately 3 to 4 feet wide and 4 to 6 inches deep during low flow periods and 20 to 30 feet wide and 12 to 18 inches deep during flood stages. Based on a delineation conducted prior to commencement of remedial activities at Stream 5 (FWENC, 2000c), it was determined that wetlands were not associated

with Stream 5. There was evidence of accumulated sandy sediments indicating that active deposition occurs within the floodplain. The lack of hydrophytic vegetation and hydrology led to the conclusion that the floodplain associated with Stream 5 is not wetlands. Following remediation the streambank was planted with the Northeast Upland Wildlife Seed Mix (Appendix B, Table B-5). No threatened or endangered species had been previously observed in the stream.

3.0 PERFORMANCE STANDARDS

The following standards will be used to determine the successful reestablishment of all restored wetlands at the Area A Downstream/OBDA site at the end of the monitoring:

Vegetation

1. A minimum of 80% areal cover, excluding planned open water areas, by noninvasive hydrophytic species for all seeded areas;
2. Greater than 50% of dominant plant species that have a wetland indicator status of facultative (FAC), facultative wetland (FACW), or obligate wetland (OBL) with no more than 50% of FAC species;
3. For planted woody species, a minimum of 80% survival based on stem count; and
4. A 20% increase in tree height and diameter at breast height.

Soils

1. Trend towards hydric condition within upper 18 inches of soil profile.

Hydrology

1. Emergent zone hydrology that consists of soil saturated to the surface, water on the surface or a combination of surface water and saturated soils for at least 10 consecutive days during the growing season; and
2. Scrub/shrub and forested zone hydrology that consists of soil that is saturated to the surface, or the groundwater table that is within 10 inches of the surface, for at least 10 consecutive days of the growing season.

Functions and Values

1. All streams and ponds show a trend toward greater biological diversity in the benthic invertebrate community;
2. Post-remedial functions and values equal to or greater than pre-remedial functions and values;
3. Predicted potential habitat for 27% (16) of all wetland-dependent amphibians, reptiles, and mammals evaluated by the WEThings Method; and
4. Restoration of 1.26 acres of emergent wetland, 1.17 acres of scrub/shrub/forested wetland and 0.47 acres open water.

For the purpose of the vegetation performance standard No. 1, invasive species will be defined as one of the following:

- Cattails (*Typha latifolia, T. angustifolia, T. glauca*);
- Common Reed (*Phragmites australis*);
- Purple Loosestrife (*Lythrum salicaria*); and
- Reed Canary Grass (*Phalaris arundinacea*).

4.0 MONITORING COMPONENTS

Long-term monitoring will consist of four components: vegetation, soils, hydrology, and functions and values. Long-term monitoring will commence upon the completion of the Stage 2 plantings. Monitoring will be initially conducted for three years based on the contingency that all the performance standards are met and successful restoration of disturbed wetlands is clearly demonstrated. If at the end of the third year of monitoring, the above performance standards are not achieved, two additional years of monitoring will be conducted and appropriate adjustments recommended (*i.e.*, additional plantings). In addition, the information and review of annual monitoring reports will initiate technical meetings between concerned parties to discuss the status of the long-term monitoring and to determine whether mid-course corrections are necessary. This plan will not address control of common reed (*Phragmites austalis*), as the Navy has included its potential control as part of their base-wide maintenance program. A general overview of the long-term monitoring program is presented in Appendix E, Table E-1.

4.1 Vegetation

Vegetation will be monitored biannually, once in the spring and once in the fall of each monitoring year. Planted woody material and seeded herbaceous material will be monitored separately. The survival and vigor of planted trees and shrubs will be assessed directly for each plant. For survival status, the number of live or dead trees and shrubs will be recorded by species. To determine vigor of planted trees, the height and diameter at breast height of all trees will be recorded. For shrub species, the height of ten randomly selected shrubs per species will be recorded per monitoring event. Each planted woody plant will be tagged with an identification number. An as-built drawing will be prepared indicating the location of each planted tree and shrub. Data will be entered into a GIS database allowing assessment of survival and growth by species, hydrological zone, and location.

Seeded herbaceous material will be assessed by sampling plants either along 200-foot transects or within one meter square plots. A total of three 200-foot transects will be located throughout Lower Pond, OBDA Pond and Stream 1, one at each location. Twelve one-meter square plots will be located throughout the wetlands associated with Upper Pond, and Streams 2, 3 and 4, three within each wetland. Locations of the sample transects and plots are indicated on the Figure 1, Appendix A. Data recorded at each sample transect and plot will include plant count by species, indicator status, total percent cover, and percent species cover. For linear transects, intercept length of the ground surface condition (bare ground, open water, species coverage) will be recorded by linear distance. For plant species the perpendicular projection of foliage to the line will be measured to estimate coverage. For one-meter plots, number of individual plants within the plot will be enumerated by species. Cover estimates will be based on visual assessment of areal cover for the total plot and for each species encountered.

As part of the herbaceous sampling effort, special attention will be paid to the occurrence of invasive species. For this purpose invasive species will be defined as cattails (*Typha latifolia, T. angustifolia,*

T. glauca), common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinacea*). The location and extent of invasive species occurrence will be mapped. This map will be updated annually to indicate new invasions or areas of successful removal. Additionally, photographs will be taken at standardized locations for each wetland or water body (Upper Pond, Lower Pond, OBDA Pond, OBDA Pond Wetland, and Streams 1 through 4) concurrent with vegetation monitoring during each monitoring event. Photo locations will also be indicated on the site map.

Preliminary assessments of the woody plantings at the Area A Downstream site indicate steadily progressing extensive, severe deer browse damage, especially to certain woody sapling species. The first biannual vegetation monitoring, scheduled for the fall of 2001, will include a thorough assessment of deer browse damage to all woody plantings at the site. The subsequent monitoring report will quantify deer browse damage on a species specific level and make recommendations for deer browse damage control and replanting in the spring of 2002. Based on the amount and severity of the browse damage, recommendations may be made to either replant heavily damaged species and protect those plantings with deer repellants, caging or site perimeter fencing, replant heavily damaged species with larger specimens to discourage deer browse, or shift the species composition mix from heavily damaged species to lightly damaged species through the replanting of those species observed to have incurred little or no deer damage.

4.2 Soils

Soils will be examined for the development of hydric soil characteristics during the fall of each monitoring year. Soil borings will be extracted from restored wetlands at Upper Pond, Lower Pond, ODBA Pond, OBDA Pond Wetland, and Streams 1, 2, 3, and 4 Wetlands. Soils profiles will be examined in the fall of each year to determine development of hydric characteristics. Profiles will be recorded in standard log format by horizon. Information to be recorded will include color, structure, texture and hydric soil indicators, e.g., oxidized root channels, mottling, present of sulfuric odors, iron and manganese concretions. In addition, pH and redox potential field measurements will be recorded with an Orion oxidation-reduction potential meter, model SA250A, at each soil boring location.

4.3 Hydrology

Hydrology will be monitored every two weeks during the growing season. The growing season will be defined as that portion of the year when soil temperatures are higher than biological zero and is approximated by the number of frost-free days. Estimated start and stop dates for the growing season will be based on the 28°F air temperature thresholds at a frequency of five years in ten. According to the Soil Survey of New London County, Connecticut, this represents a 199 day period (Crouch, 1983). Depth to ground water will be measured at 24 piezometers located throughout the restored wetland areas. Piezometer locations are shown on Figure 1, Appendix A. Depth of ponding will be measured at three staff gauges located at Upper Pond, Lower Pond and OBDA Pond.

Additionally, flow rates (channel center and sides) and water depths (channel center and sides) will be recorded at Streams 1, 2, 3, and 4 during the spring and fall of each monitoring year. Flow rates will be estimated using channel morphology and a timed float trial. A minimum of three trials will be run per event and a daily average calculated. Rainfall data generated from the National Weather Service certified Meteorological Station located at Groton / New London Airport (KGON 41-19-39N 072-02-58W) will be accessed and used to evaluate seasonal patterns. This weather station is located approximately 4 miles from the site and represents site conditions. Rainfall data from each growing

season will be compared to the 10-year average to evaluate the seasonal trends affecting the wetland system.

4.4 Functions and Values Assessment

Wetland functions and values will be assessed using two methods: 1) the U.S. Army Corps of Engineers New England District Highway Methodology (1995) and the Wetland Habitat Indicators for Nongame Species (WEThings) (Whitlock, et. al. 1994a,b). Each of the seven restored wetlands will be evaluated individually. These assessments will be conducted at the end of the third year after wetlands have been delineated as described below.

The Highway Methodology involves a descriptive approach to evaluate the aspect and importance of 13 wetland functions and values (groundwater recharge/discharge, fish and shellfish habitat, floodflow alteration, sediment retention, nutrient removal, production export, shoreline stabilization, wildlife habitat, recreation, education/scientific value, uniqueness, aesthetics, and endangered species habitat). Data will be recorded on a standard wetland function and evaluation form (Appendix F). In addition, all observations of fish and wildlife will be recorded and photographs will be taken at each site. Post remedial functions and values will be compared to those determined by Niering and Brawley (1997) for pre-remedial conditions.

The Wetland Habitat Indicators for Nongame Species (WEThings) rapid assessment method will be used to further evaluate wildlife functions in the restored wetlands. WEThings provides a standardized, fully documented method of determining habitats of amphibians, reptiles, and nongame mammals endemic to New England. This method evaluates wetland systems, as defined by the U.S. Fish and Wildlife Service Classification System (Cowardin et. al., 1979) and assumes that an approved state or federal method has been used to delineate wetland boundaries.

The WEThings assessment involves four steps. Step 1 employs a matrix evaluation to generate a list of species that potentially use wetlands in the site's specific geographic location. A list of species that would potentially use restored wetlands is presented in Appendix G, Table G-1. Step 2 involves refining the species list through a field evaluation of specific wetland components: vegetation, substrate, hydrology, and specific upland features. Discrete assessment areas are identified for this evaluation. In this case the assessment areas will be equal to each of the seven restored wetlands. Data will be entered on a standardized data form (Appendix H). Step 3 entails analysis of the field data using the WEThings computer program to generate a potential species list. Step 4 requires review and interpretation of the generated lists. This step involves reviewing the individuals species models and modifying the generated lists, if required, using best professional judgement.

4.5 Benthic Community Analysis

The objective of the benthic survey is to monitor the recolonization of the benthic community in restored waterbodies. In October 2000 a benthic macroinvertebrate survey was conducted as part of the short term monitoring effort. This survey represents the post-remedial baseline for comparison of subsequent monitoring results. The benthic community will be sampled in the fall of each monitoring year. Seven locations will be monitored: Streams 1 through 4, Upper Pond, Lower Pond, and OBDA Pond.

During each sample event, three replicate samples will be collected from each of the water bodies, Streams 1 through 4, Upper Pond, Lower pond, and the OBDA Pond. A total of 21 samples will be collected. Each year, the samples will be collected at a new location within the water body, to avoid depletion of the substrate at a single point, and to avoid monitoring the post-sampling recovery of a

location as opposed to monitoring the post-restoration recovery of each water body. However, each of the samples collected from within each water body will be located in areas within the water body with similar flow regimes (pools, riffles) and substrates. Water quality data and a description of the benthic substrate will be recorded at each sample station. Sampling will be conducted in accordance with Hicks (1997) and Barbour et al. (1999).

The benthic macroinvertebrate community at Upper Pond will be sampled using a petite ponar ($0.023m^2$). Streams 1, 2, 3, and 4, Lower Pond, and OBDA Pond will be sampled using a kick net. Kick net sampling will be conducted using a 30" x 30" kick net with 500 µm mesh. A 1 foot by 3 feet area (3 square feet) will be sampled. The kick net will be held vertical, perpendicular to the flow in the water column. Disturbance/washing of the substrates will be held constant to a period of five minutes for each of the replicates collected. Following sample collection, the collected sediment and detritus collected in the net will be examined for invertebrates.

Replicates will be collected moving in an upstream direction at each station so as to minimize disturbance to the unsampled upstream replicates during sampling. Coarse material (i.e., woody debris, stones, whole leaves) will be examined before being removed from the sample and the leavings washed into a No. 35 (500 µm mesh) standard testing sieve from which the remaining sample will be condensed. Each replicate collected will be preserved in a separate 500 milliliter (ml) polyethylene sample container, with the sample identified by an internal and external label. Samples will be preserved in 70% ethanol or an equivalent preservative and shipped to a subcontractor laboratory for formal identification to lowest practical taxon and enumeration.

The identification and enumeration data provided by the laboratory will be presented in tabular format for each sample location. In addition, the data will be summarized in tabular format for the entire site. The data will be used to derive metrics which describe community composition, as presented in the New England Freshwater Wetlands Invertebrate Biomonitoring Protocol (Hicks, 1997). In addition, the Shannon-Wiener Diversity Measure (Wilson & Bossert, 1971) will be calculated. The metrics to be calculated are as follows:

- Total organisms – Total number of organisms collected at each location.
- Percent Composition of Dominant Family/Group – Describes relative representation of dominant taxa at a particular location.
- Taxa Richness – Total number of identified taxa (families or genera) present at each site.
- EOT Richness – Total of the Ephemeroptera (Mayflies), Odonata (Dragonflies and Damselflies), and Trichoptera (Caddisflies) families present at each site.
- EOT/Chironomidae Ratio – Total Avg. density (individuals) EOT /Total Avg. density (individuals) Chironomidae.
- Shannon-Wiener Diversity Measure – $H' = -\quad (p_i)(\ln p_i)$,
  where:
  H' = the Shannon-Wiener diversity value (unitless)
  p_i = proportion of individuals in taxa i to the total number of individuals sampled
  $\ln p_i$ = the natural logarithm of p_i

The calculated metrics for each sample event will then be compared to calculated metrics for the baseline benthic survey event, conducted in October 2000. The comparison will be used to monitor the recolonization of the water bodies by benthic macroinvertebrates. Improvement will be considered as the following:

- An increase in total organisms, taxa richness, EOT richness, EOT/Chronomidae ratio, and the Shannon-Wiener diversity measure.
- A decrease in percent composition of dominant family group.
- Stabilization of metrics over time.

Variation in metrics will be considered relative to physical and hydrological variations among sampling events.

4.6 Post-restoration Wetland Delineation

A post-restoration wetlands delineation will be conducted near the end of the third growing season and the wetlands boundary compared to the boundary proposed in the final wetlands restoration design. The status of this comparison will be included in the three-year monitoring report. Site wetlands will be field delineated using the routine on-site determination method identified in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987). In addition, the delineation will follow guidance provided by the U.S. Army Corps of Engineers, New England District in *New England District Performance Standards and Supplemental Definitions for Use with the 1987 Corps Manual* (2000).

The 1987 Federal Manual incorporates a three-parameter approach using vegetation, soils, and hydrology to identify the presence of freshwater wetlands. Wetland boundaries are initially identified through visual assessment of vegetation and hydrology. After the initial assessment, paired sample stations are located along the identified wetland boundary. Generally only two stations, a wetland and an upland station, are sampled for each wetland. These sample stations typically confirm the initial wetland boundary. The wetland boundary line will be marked with flagging at 50 to 75 foot intervals (depending on line of sight) and numbered sequentially. Soil logs, indicating the center of each sample station, will be flagged and numbered. Photographs will be taken at selected locations, which will be indicated on the site drawing showing wetland boundaries. The direction in which each photograph is taken will also be noted.

Vegetation, soil, and hydrology indicators will be examined at each station where dominant plant species and estimated cover were recorded by stratum. Data will be recorded for tree, vine, sapling (0.4 to 5 inches diameter at breast height 20 feet tall or greater), shrubs (at least 3 feet tall but less than 20 feet tall), and seedling/herb strata according to guidance provided in the *New England District Performance Standards and Supplemental Definitions for Use with the 1987 Corps Manual* (U.S. Army Corps of Engineers, 2000). The data sheet to be used for the Wetland Delineation is provided in Appendix I. Visual estimates of areal cover will be made separately for all strata. Soil pits generally will be dug to a depth of 18 to 20 inches or greater and observations will be recorded in standard soil log format. Hydrological indicators, consisting of obvious signs of flooding and saturation will be noted at each sample station.

5.0 REPORT

An annual report will be prepared and submitted to the US EPA and Connecticut DEP following the completion of each monitoring season. The annual report will discuss the status of restoration, including monitoring results, progress toward achieving performance standards, corrective actions taken, and any recommendations for future corrective actions, if required. The annual report will include the

photographs taken during spring and fall monitoring events. All reports will be provided to the agencies by the first of December of each year.

Following completion of three years of monitoring, a three-year monitoring report will be submitted documenting the status of revegetation success. The report will include a recommendation of whether or not additional monitoring, and/or supplemental planting and seeding is required based on the success of revegetation. The results of the comparison of the post-restoration wetland delineation and the wetland boundary proposed in the final wetland restoration design will be included in the three-year monitoring report.

A wetland delineation report will be prepared documenting the results of the on-site wetland delineation effort conducted at the end of the third growing season. The report will characterize the wetlands identified, on-site methodologies employed in delineating wetlands, provide a description of the site, and a description of vegetation, soils and hydrology. The report will also include a summary, list of references, and resumes of personnel involved in the completion of the project. A compilation of species recorded and their indicator status, photographs with captions, soil logs, and data forms will be included as appendices. The wetland delineation report will be included as an appendix to the three-year monitoring report.

6.0 REFERENCES

Atlantic Environmental Services, Inc., 1995. "Wetland Delineation, Area A. Naval Submarine Base - New London, Groton, CT", Atlantic Environmental Services, Inc., Colchester, CT.

Barbour, M.T., J. Gerritsen, B D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Brown & Root Environmental, 1997. "Record of Decision for Soil and Sediment, Area A Downstream Water Courses/Overbank Disposal Area, Naval Submarine Base - New London, Groton, CT", Brown & Root Environmental, Wayne, PA.

Crouch, Marc, H. 1983. Soil Survey of New London County, Connecticut. U.S. Department of Agriculture, Soil Conservation Service In Cooperation with the Connecticut Agricultural Experiment Station and the Storrs Agricultural Experiment Station.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979. "Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79/31.

Environmental Laboratory, 1987. "Corps of Engineers Wetlands Delineation Manual," Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Foster Wheeler Environmental Corporation, 2000a. "100% Design Area A/OBDA, Naval Submarine Base - New London, Groton, CT," Foster Wheeler Environmental Corporation, Boston, MA.

Foster Wheeler Environmental Corporation, 2000b. "Removal Action Report for Area A/OBDA, Naval Submarine Base - New London, Groton, CT," Foster Wheeler Environmental Corporation, Boston, MA.

Foster Wheeler Environmental Corporation, 2000c. "Wetland Assessment Area A Downstream - Stream 5 Naval Submarine Base New London Groton, Connecticut," Foster Wheeler Environmental Corporation, Boston, MA.

Foster Wheeler Environmental Corporation, 2001. "Draft Post Construction Monitoring Report, Area A/OBDA, Naval Submarine Base - New London, Groton, CT", Foster Wheeler Environmental Corporation, Boston, MA.

Hicks, A.L., 1997. New England Freshwater Wetlands Invertebrate Biomonitoring Protocol. United States Department of Agriculture.

Niering, William A. and A. Hunter Brawley, 1997. "Functions and Values Assessment of Area A Downstream Wetlands and Waterways, Naval Submarine Base - New London (NSB-NLON), Groton, CT.

U.S. Army Corps of Engineers, New England Division, 1995. The Highway Methodology Workbook Supplement, Wetland Functions and Values, A Descriptive Approach.

U.S. Army Corps of Engineers, 2000. "New England District Performance Standards and Supplemental Definitions for Use with the 1987 Corps Manual," Revised July 1, 2000.

Wetzel, R.G., 1983. "Limnology, Second Edition." Saunders College Publishing, New York, New York.

Wilson, E.O. and W.H. Bossert, 1971. "A Primer of Population Biology." Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts.

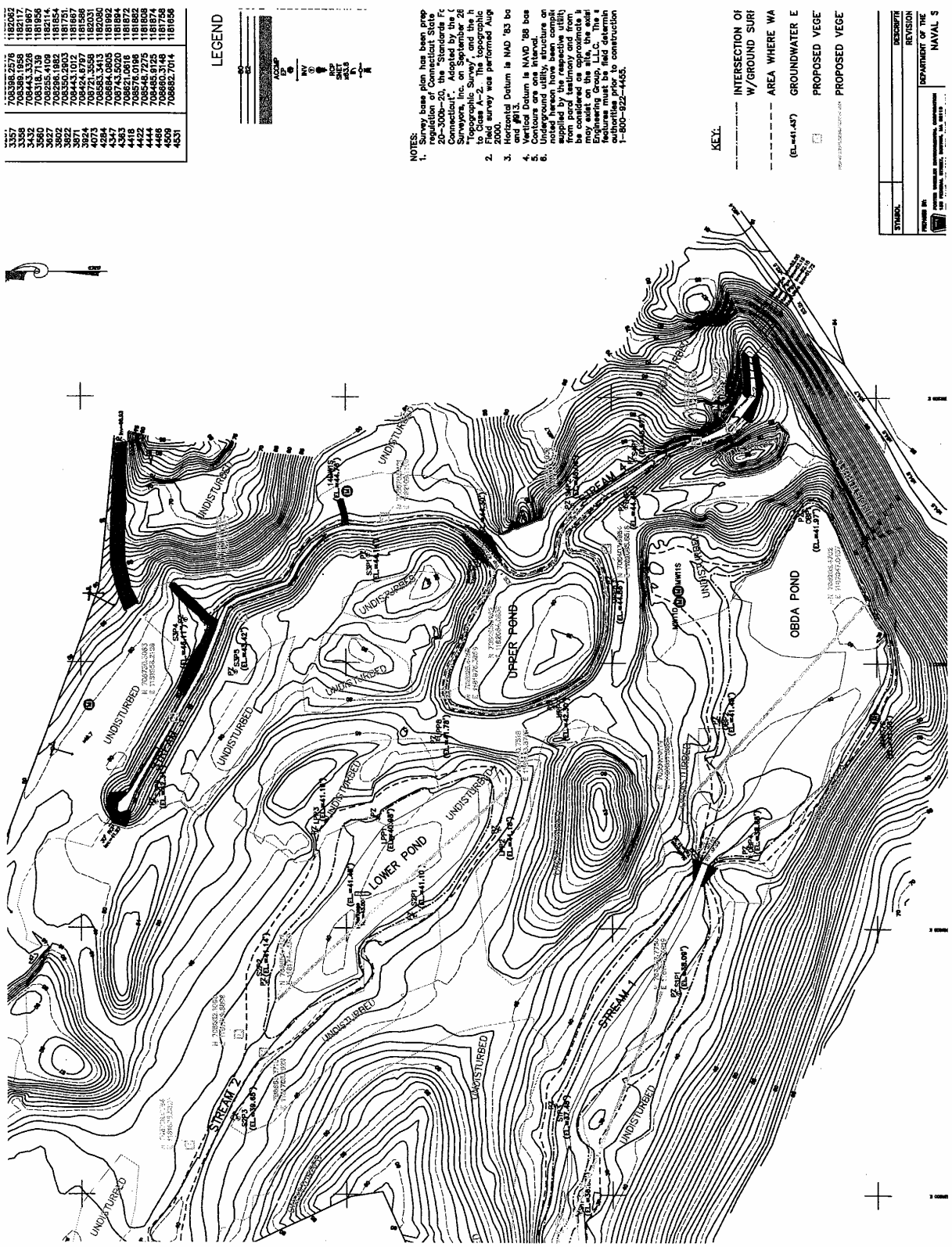
Whitlock, A.L., N.M. Jarman, J.A. Medina, and J.S. Larson, 1994a. "WEThings: Wetlands Habitat Indicators for Nongame Species. Volume I." TEI Publication 94-1. The Environmental Institute, University of Massachusetts, Amherst, MA.

Whitlock, A.L., N.M. Jarman, and J.S. Larson, 1994b. "WEThings: Wetlands Habitat Indicators for Nongame Species. Volume II." TEI Publication 94-1. The Environmental Institute, University of Massachusetts, Amherst, MA.

APPENDIX A

AS BUILT 1-FOOT CONTOUR DRAWING

ND01-81
9/14/01


LEGEND
NOTES:
KEY:
DEPARTMENT OF THE NAVAL S
UPPER POND
LOWER POND
OBDA POND
STREAM 1
STREAM 2
STREAM 4
UNDISTURBED

APPENDIX B

SEED MIXES

ND01-081
9/14/01

Table B-1
Seeding Mixes

Seed Mix	Upper Pond	Lower Pond	OBDA Wetland	OBDA Pond	Stream 1 Wetland	Stream 2 Wetland	Stream 3 Wetland	Stream 4 Wetland	Stream 5	Uplands
Northeast Wetland Grass					X	X	X	X		
Northeast Wetland Diversity				X						
Northeast Wetland Grass/Forb	X	X	X							
Northeast Upland Wildlife Seed									X	X

ND01-081
9/14/01

Table B-2
Northeast Wetland Diversity Seed Mix

Scientific Name	Common Name	Percent By Number of Seeds[1] (not by weight)
Scirpus atrovirens	Green Bulrush	28.82%
Juncus effusus	Soft Rush	13.05%
Mimulus ringens	Monkey Flower	12.01%
Carex vulpinoidea	Fox Sedge	8.35%
Penthorum sedoides	Ditch Stone Crop	7.83%
Glyceria grandis	Reed Meadowgrass	6.68%
Scirpus cyperinus	Wool Grass	5.22%
Verbena hastata	Blue Vervain	4.18%
Eupatorium perfoliatum	Boneset	2.09%
Leersia oryzoides	Rice Cut Grass	1.57%
Helenium autumnale	Common Sneezeweed	1.48%
Glyceria canadensis	Canada Mannagrass	1.36%
Eupatorium maculatum	Joe Pye Weed	0.89%
Aster Novae-angliae	New England Aster	0.73%
Alisma plantago-aquatica	Water Plantain	0.52%
Euthamia graminifolia	Grassleaf Goldenrod	0.47%
Solidago rugosa	Wrinkled Goldenrod	0.47%
Cyperus strigosus	Straw Colored Flatsedge	0.47%
Aster puniceus	Purple Stemmed Aster	0.42%
Cephalanthus occidentalis	Buttonbush	0.38%
Scirpus tabernaemontanii	Soft Stem Bulrush	0.36%
Aster umbellatus	Flat-Top White Aster	0.35%
Carex comosa	Bearded Sedge	0.31%
Carex crinita	Fringed Sedge	0.26%
Solidago gigantea	Giant Goldenrod	0.24%
Panicum clandestinum	Deertongue	0.24%
Bidens cernua	Nodding Beggar-Ticks	0.22%
Sium suave	Water Parsnip	0.21%
Scirpus microcarpus	Small Fruited Bulrush	0.18%
Cicuta maculata	Water Hemlock	0.16%
Elymus canadensis	Wild Rye	0.10%
Bidens frondosa	Devil's Beggar-Ticks	0.08%
Angelica atropurpurea	Purple-Stem Angelica	0.06%
Rumex verticillatus	Water Dock	0.05%
Carex lurida	Shallow Sedge	0.05%
Polygonum pensylvanicum	Pennsylvania Smartweed	0.04%
Asclepias incarnata	Swamp Milkweed	0.04%
Elymus riparius	Riverbank Wild Rye	0.03%
Carex lupulina	Hop Sedge	0.02%
Iris versicolor	Blue Flag	0.01%

[1] The percentages shown are approximate and may vary slightly based on seed harvest of prior season.

ND01-081
9/14/01

Table B-3
Northeast Wetland Grass/Forb Mix

Scientific Name	Common Name	Percent By Number of Seeds[1] (not by weight)
Glyceria canadensis	Canada Mannagrass	37.3%
Glyceria grandis	Reed Meadowgrass	29.3%
Calamagrostis canadensis	Blue Joint	7.5%
Panicum dichotomiflorum	Smooth Panic-Grass	7.3%
Leersia oryzoides	Rice Cut Grass	4.9%
Echinochloa crusgalli	Japanese Millet	3.9%
Verbena hastata	Blue Vervain	3.0%
Elymus canadensis	Canada Wild Rye	1.7%
Alisma plantago-aquatica	Water Plantain	1.5%
Polygonum pensylvanicum	Pennsylvania Smartweed	0.9%
Bidens cernua	Nodding Bur-Marigold	0.8%
Cicuta maculata	Spotted Water Hemlock	0.7%
Cinna arundinacea	Stout Wood-Reedgrass	0.7%
Bidens frondosa	Beggar-Ticks	0.3%
Rumex verticillatus	Swamp Dock	0.2%

Table B-4
Northeast Wetland Grass Mix

Scientific Name	Common Name	Percent By Number of Seeds[1] (Not by weight)
Agrostis stolonifera	Creeping Bentgrass	63.0%
Poa trivialis	Rough Bluegrass	17.0%
Alopecurus arundinaceus	Meadow Toxtail	11.0%
Panicum clandestinum	Deertongue	4.5%
Lolium multiflorum	Annual Ryegrass	4.5%

Table B-5
Northeast Upland Wildlife Seed Mix

Scientific Name	Common Name	Percent By Number of Seeds[1] (not by weight)
Perennials		
Phleum pratense	Timothy	42.5%
Trifolium hybridum	Alsike Clover	24.9%
Dactylis glomerata	Orchard Grass	15.6%
Lespedeza bicolor	Bicolor Lespedeza	3.9%
Panicum virgatum	Switchgrass	3.5%
Andropogon virginicus	Broom-Sedge	0.9%
Annuals		
Setaria italica	Fox-Tail Bristle Grass	5.3%
Helianthus annuus	Common Sunflower	1.9%
Polygonum pensylvanicum	Pennsylvania Smartweed	0.8%
Avena sativa	Oats	0.7%

[1] The percentages shown are approximate and may vary slightly based on seed harvest of prior season.

ND01-081
9/14/01

APPENDIX C

WOODY PLANTING MATERIAL

ND01-081
9/14/01

Table C-1
Plantings by Location

Species	Common Name	Indicator Status	Upper Pond	Lower Pond	OBDA Wetland	OBDA Pond	Stream 1 Wetland	Stream 2 Wetland	Stream 3 Wetland	Stream 4 Wetland	Stream 5	Uplands
Trees												
Acer rubrum	Red Maple	FAC	X	X	X		X	X	X	X		
Betula lenta	Black Birch	FACU	X[2]						X[2]	X[2]		X
Betula populifolia	Gray Birch	FAC	X									
*Fraxinus **americana***	White Ash	FACU						X[2]				
Liriodendron tulipifera	Tuliptree	FACU			X[2]		X[2]					X
Nyssa sylvatica	Black Gum	FAC		X	X		X	X	X			
Quercus rubra	Northern Red Oak	FACU-										X
Quercus alba	White Oak	FACU-										X
Shrubs												
Cephalanthus occidentalis	Buttonbush	OBL					X					
Clethra alnifolia	Sweet Pepperbush	FAC+	X	X	X		X	X	X			X
Hamamelis virginia[1]	Witch Hazel	FAC-			X		X					X
Kalmia latifolia	Mountain Laurel	FACU								X		
Lindera benzoin	Spicebush	FACW-			X		X	X	X			
Myrica pennsylvanica	Northern Bayberry	FAC										X
Vaccinium corymbosum	Highbush Blueberry	FACW-	X	X	X			X	X	X		X
Viburnum acerifolium[1]	Maple-leaved Viburnum	UPL			X		X					X

1 One of these three plants will be planted at the discretion of the Wetlands Biologist.
2 Trees will be randomly placed in transition area/uplands within 15 feet of delineated wetland boundary.

ND01-081
9/14/01

Table C-2
Wetland Plant Material Specifications

Species	Common Name	Type	Height	Caliper	Total Number
Acer rubrum	Red Maple	tree	6-8 feet	¾ inch	45
Acer rubrum	Red Maple	tree	5-6 feet	½ inch	8
Acer rubrum	Red Maple	tree	10-12 feet	1½ inch	5
Betula lenta	Black Birch	tree	6-7 feet	¾ inch	74
Betula populifolia	Gray Birch	tree	6-8 feet	¾ inch	10
Fraxinus americana	White Ash	tree	6-8 feet	¾ inch	10
Liriodendron tulipifera	Tuliptree	tree	6-8 feet	¾ inch	14
Nyssa sylvatica	Blackgum	tree	6-8 feet	¾ inch	21
Quercus rubra	Northern Red Oak	tree	6-8 feet	¾ inch	22
Quercus rubra	Northern Red Oak	tree	10-12 feet	1½ inch	5
Quercus alba	White Oak	tree	6-8 feet	¾ inch	19
Cephalanthus occidentalis	Buttonbush	shrub	3-4 feet	3-4 canes	27
Clethra alnifolia	Sweet Pepperbush	shrub	2-3 feet	3-4 canes	191
Hamamelis virginiana[2]	Witch Hazel	shrub	2-3 feet	3-4 canes	52
Kalmia latifolia	Mountain Laurel	shrub	2-3 feet	3-4 canes	3
Lindera benzoin	Spicebush	shrub	3-4 feet	3-4 canes	15
Myrica pennsylvanica	Bayberry	shrub	2-3 feet	3-4 canes	39
Vaccinium corymbosum	Highbush blueberry	shrub	2-3 feet	3-4 canes	55
Viburnum acerifolium	Maple-leaf viburnum	shrub	15-18 inches	1-2 canes	39
				Total	654

ND01-081
9/14/01

APPENDIX D

WETLAND FUNCTIONS AND VALUES

ND01-081
9/14/01

Table D-1
Summary of Existing and Proposed
Wetlands Functions and Values[1]

	Upper Pond Wetland		Lower Pond Wetland		OBDA Wetland		Stream 1 Wetland[2]		Stream 2 Wetland[3]		Stream 3 Wetland[3]		Stream 4 Wetland[5]	
	Exist.[6]	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
Groundwater Recharge/Discharge	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Floodflow Alteration	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fish and Shellfish Habitat	N	P	P	PN	N	N	N	N	P	N	N	N	N	N
Sediment/Toxicant Retention	Y*	Y	Y*	Y	Y*	Y	Y	Y	Y*	Y	Y*	Y	Y*	Y
Nutrient Removal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Production Export	P	P	Y	Y	P	P	P	P	Y	Y	P	P	P	P
Sediment/Shoreline Stabilization	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Wildlife Habitat	P	P	Y*	Y	P	P	P	P	Y*	Y	P	P	P	P
Recreation	N	P	N	P	N	P	N	P	N	P	N	P	N	P
Educational Scientific Value	N	P	P	P	N	P	N	P	P	P	N	P	N	P
Uniqueness/Heritage	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Visual Quality/Aesthetics	N	N	Y*	P	N	Y	N	N	Y*	Y	N	N	N	N
Endangered Species Habitat	N	N	N	N	N	N	N	N	N	N	N	N	N	N

1 Existing Functions and Values from Niering and Brawley, (1997) .
2 Stream 1 Wetland included with OBDA Pond Wetland in Niering and Brawley (1997).
3 Stream 2 Wetland included with Lower Pond Wetland in Niering and Brawley (1997).
4 Assessment of existing functions and values of Stream 3 Wetland not included in Niering and Brawley (1997).
5 Stream 4 Wetland included with Upper Pond Wetland in Niering and Brawley (1997).
6 N = No, Y = Yes, P = Potential, *indicates principal function/value.

ND01-081
9/14/01

APPENDIX E

OVERVIEW OF MONITORING PROGRAM

ND01-081
9/14/01

Table E-1
Overview of Monitoring Program

Component	Frequency	Sample Method	Sample Location
Vegetation	Biannual, Spring and Fall	Herbaceous Layer – total percent cover, species composition (200 foot transects, one per location).	Lower Pond, OBDA Pond, Stream 1 Wetland
		Herbaceous Layer – total percent cover, species composition (square meter plots, 3 per location).	Upper Pond, Streams 2, 3, and 4 Wetlands
		Trees and shrubs – enumeration of live/dead trees/shrubs by species, height and diameter breast height of all trees, height of ten shrubs per species.	Upper Pond, Lower Pond, OBDA Pond, OBDA Pond Wetlands, Stream 1, 2, 3, and 4 Wetlands
		Aquatic bed – total percent cover, species composition.	Upper Pond, Lower Pond, OBDA Pond, Streams 1, 2, 3, and 4
Soils	Biannual, Spring and Fall	Soil profile of upper 18 inches at one designated location along each restored wetland. pH and redox potential field measurements for each sample location.	Upper Pond, Lower Pond, OBDA Pond, OBDA Pond Wetlands, Streams 1, 2, 3, and 4 Wetlands
Hydrology	Biweekly, during the growing season	Piezometer field measurements	Upper Pond (3), Lower Pond (3), OBDA Pond (4), Stream 1 Wetland (3), Stream 2 Wetland (3), Stream 3 Wetland (5), and Stream 4 Wetland (3)
		Staff gauge field measurements	Upper Pond, Lower Pond, and OBDA Pond
		Flow rates - (channel center and sides) Water depths -	Streams 1, 2, 3, and 4
Functions and Values – Benthic Communities	Annual, Fall	Petite ponar ($0.023m^2$) grab sample from 0-10 cm depth interval.	Upper Pond (3), OBDA Pond (3) and Stream 2 (3)
		Kick Net Samples	Lower Pond (3), Stream 1 (3), Stream 3 (3), and Stream 4 (3)
Functions and Values – Assessment	End of Third Growing Season	U.S. Army Corps of Engineers Highway Methodology Assessment (1995).	Upper Pond, Lower Pond, OBDA Pond Wetlands, Streams 1, 2, 3, and 4 Wetlands
Functions and Values – Assessment	End of Third Growing Season	Wetland Habitat Indicators for Nongame Species (WEThings) (Whitlock, et. al. 1994a,b).	Upper Pond, Lower Pond, OBDA Pond Wetlands, Streams 1, 2, 3, and 4 Wetlands
Functions and Values – Wetland Delineation	End of Third Growing Season	*Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987), and the New England District in *New England District Performance Standards and Supplemental Definitions for Use with the 1987 Corps Manual* (1995).	Upper Pond, Lower Pond, OBDA Pond Wetlands, Streams 1, 2, 3, and 4 Wetlands

ND01-081
9/14/01

APPENDIX F

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT HIGHWAY METHODOLOGY
STANDARD WETLAND FUNCTION AND EVALUATION FORM

ND01-081
9/14/01

Wetland evaluation supporting documentation; Reproducible forms.

Below is an example list of considerations that was used for a New Hampshire highway project. Considerations are flexible, based on best professional judgment and interdisciplinary team consensus. This example provides a comprehensive base, however, and may only need slight modifications for use in other projects.

GROUNDWATER RECHARGE/DISCHARGE— This function considers the potential for a wetland to serve as a groundwater recharge and/or discharge area. It refers to the fundamental interaction between wetlands and aquifers, regardless of the size or importance of either.

CONSIDERATIONS/QUALIFIERS

1. Public or private wells occur downstream of the wetland.
2. Potential exists for public or private wells downstream of the wetland.
3. Wetland is underlain by stratified drift.
4. Gravel or sandy soils present in or adjacent to the wetland.
5. Fragipan does not occur in the wetland.
6. Fragipan, impervious soils, or bedrock does occur in the wetland.
7. Wetland is associated with a perennial or intermittent watercourse.
8. Signs of groundwater recharge are present or piezometer data demonstrates recharge.
9. Wetland is associated with a watercourse but lacks a defined outlet or contains a constricted outlet.
10. Wetland contains only an outlet, no inlet.
11. Groundwater quality of stratified drift aquifer within or downstream of wetland meets drinking water standards.
12. Quality of water associated with the wetland is high.
13. Signs of groundwater discharge are present (e.g., springs).
14. Water temperature suggests it is a discharge site.
15. Wetland shows signs of variable water levels.
16. Piezometer data demonstrates discharge.
17. Other

FLOODFLOW ALTERATION (Storage & Desynchronization) — This function considers the effectiveness of the wetland in reducing flood damage by water retention for prolonged periods following precipitation events and the gradual release of floodwaters. It adds to the stability of the wetland ecological system or its buffering characteristics and provides social or economic value relative to erosion and/or flood prone areas.

CONSIDERATIONS/QUALIFIERS

1. Area of this wetland is large relative to its watershed.
2. Wetland occurs in the upper portions of its watershed.
3. Effective flood storage is small or non-existent upslope of or above the wetland.
4. Wetland watershed contains a high percent of impervious surfaces.
5. Wetland contains hydric soils which are able to absorb and detain water.
6. Wetland exists in a relatively flat area that has flood storage potential.
7. Wetland has an intermittent outlet, ponded water, or signs are present of variable water level.
8. During flood events, this wetland can retain higher volumes of water than under normal or average rainfall conditions.
9. Wetland receives and retains overland or sheet flow runoff from surrounding uplands.
10. In the event of a large storm, this wetland may receive and detain excessive flood water from a nearby watercourse.
11. Valuable properties, structures, or resources are located in or near the floodplain downstream from the wetland.
12. The watershed has a history of economic loss due to flooding.
13. This wetland is associated with one or more watercourses.
14. This wetland watercourse is sinuous or diffuse.
15. This wetland outlet is constricted.
16. Channel flow velocity is affected by this wetland.
17. Land uses downstream are protected by this wetland.
18. This wetland contains a high density of vegetation.
19. Other

FISH AND SHELLFISH HABITAT (FRESHWATER) — This function considers the effectiveness of seasonal or permanent watercourses associated with the wetland in question for fish and shellfish habitat.

CONSIDERATIONS/QUALIFIERS

1. Forest land dominant in the watershed above this wetland.
2. Abundance of cover objects present.

STOP HERE IF THIS WETLAND IS NOT ASSOCIATED WITH A WATERCOURSE

3. Size of this wetland is able to support large fish/shellfish populations.
4. Wetland is part of a larger, contiguous watercourse.
5. Wetland has sufficient size and depth in open water areas so as not to freeze solid and retain some open water during winter.
6. Stream width (bank to bank) is more than 50 feet.
7. Quality of the watercourse associated with this wetland is able to support healthy fish/shellfish populations.
8. Streamside vegetation provides shade for the watercourse.
9. Spawning areas are present (submerged vegetation or gravel beds).
10. Food is available to fish/shellfish populations within this wetland.
11. Barrier(s) to anadromous fish (such as dams, including beaver dams, waterfalls, road crossing) are absent from the stream reach associated with this wetland.
12. Evidence of fish is present.
13. Wetland is stocked with fish.
14. The watercourse is persistent.
15. Man-made streams are absent.
16. Water velocities are not too excessive for fish usage.
17. Defined stream channel is present.
18. Other

Although the above example refers to freshwater wetlands, it can also be adapted for marine ecosystems. The following is an example provided by the National Marine Fisheries Service (NMFS) of an adaptation for the fish and shellfish function.

FISH AND SHELLFISH HABITAT (MARINE) — This function considers the effectiveness of wetlands, embayments, tidal flats, vegetated shallows, and other environments in supporting marine resources such as fish, shellfish, marine mammals, and sea turtles.

CONSIDERATIONS/QUALIFIERS

1. Special aquatic sites (tidal marsh, mud flats, eelgrass beds) are present.
2. Suitable spawning habitat is present at the site or in the area.
3. Commercially or recreationally important species are present or suitable habitat exists.
4. The wetland/waterway supports prey for higher trophic level marine organisms.
5. The waterway provides migratory habitat for anadromous fish.
6. Essential fish habitat, as defined by the 1996 amendments to the Magnuson-Stevens Fishery & Conservation Act, is present (consultation with NMFS may be necessary).
7. Other

SEDIMENT/TOXICANT/PATHOGEN RETENTION — This function reduces or prevents degradation of water quality. It relates to the effectiveness of the wetland as a trap for sediments, toxicants, or pathogens in runoff water from surrounding uplands or upstream eroding wetland areas.

CONSIDERATIONS/QUALIFIERS

1. Potential sources of excess sediment are in the watershed above the wetland.
2. Potential or known sources of toxicants are in the watershed above the wetland.
3. Opportunity for sediment trapping by slow moving water or deepwater habitat are present in this wetland.
4. Fine grained mineral or organic soils are present.
5. Long duration water retention time is present in this wetland.
6. Public or private water sources occur downstream.
7. The wetland edge is broad and intermittently aerobic.
8. The wetland is known to have existed for more than 50 years.
9. Drainage ditches have not been constructed in the wetland.

STOP HERE IF WETLAND IS NOT ASSOCIATED WITH A WATERCOURSE.

10. Wetland is associated with an intermittent or perennial stream or a lake.
11. Channelized flows have visible velocity decreases in the wetland.
12. Effective floodwater storage in wetland is occurring. Areas of impounded open water are present.
13. No indicators of erosive forces are present. No high water velocities are present.
14. Diffuse water flows are present in the wetland.
15. Wetland has a high degree of water and vegetation interspersion.
16. Dense vegetation provides opportunity for sediment trapping and/or signs of sediment accumulation by dense vegetation is present.
17. Other

NUTRIENT REMOVAL/RETENTION/TRANSFORMATION — This function considers the effectiveness of the wetland as a trap for nutrients in runoff water from surrounding uplands or contiguous wetlands and the ability of the wetland to process these nutrients into other forms or trophic levels. One aspect of this function is to prevent ill effects of nutrients entering aquifers or surface waters such as ponds, lakes, streams, rivers, or estuaries.

CONSIDERATIONS/QUALIFIERS

1. Wetland is large relative to the size of its watershed.
2. Deep water or open water habitat exists.
3. Overall potential for sediment trapping exists in the wetland.

4. Potential sources of excess nutrients are present in the watershed above the wetland.
5. Wetland saturated for most of the season. Ponded water is present in the wetland.
6. Deep organic/sediment deposits are present.
7. Slowly drained fine grained mineral or organic soils are present.
8. Dense vegetation is present.
9. Emergent vegetation and/or dense woody stems are dominant.
10. Opportunity for nutrient attenuation exists.
11. Vegetation diversity/abundance sufficient to utilize nutrients.

STOP HERE IF WETLAND IS NOT ASSOCIATED WITH A WATERCOURSE.

12. Waterflow through this wetland is diffuse.
13. Water retention/detention time in this wetland is increased by constricted outlet or thick vegetation.
14. Water moves slowly through this wetland.
15. Other

PRODUCTION EXPORT (Nutrient) — This function evaluates the effectiveness of the wetland to produce food or usable products for humans or other living organisms.

CONSIDERATIONS/QUALIFIERS

1. Wildlife food sources grow within this wetland.
2. Detritus development is present within this wetland
3. Economically or commercially used products found in this wetland.
4. Evidence of wildlife use found within this wetland.
5. Higher trophic level consumers are utilizing this wetland.
6. Fish or shellfish develop or occur in this wetland.
7. High vegetation density is present.
8. Wetland exhibits high degree of plant community structure/species diversity.
9. High aquatic vegetative diversity/abundance is present.
10. Nutrients exported in wetland watercourses (permanent outlet present).
11. "Flushing" of relatively large amounts of organic plant material occurs from this wetland.
12. Wetland contains flowering plants that are used by nectar-gathering insects.
13. Indications of export are present.
14. High production levels occurring, however, no visible signs of export (assumes export is attenuated).
15. Other

SEDIMENT/SHORELINE STABILIZATION — This function considers the effectiveness of a wetland to stabilize streambanks and shorelines against erosion.

CONSIDERATIONS/QUALIFIERS

1. Indications of erosion or siltation are present.
2. Topographical gradient is present in wetland.
3. Potential sediment sources are present up-slope.
4. Potential sediment sources are present upstream.
5. No distinct shoreline or bank is evident between the waterbody and the wetland or upland.
6. A distinct step between the open waterbody or stream and the adjacent land exists (i.e., sharp bank) with dense roots throughout.
7. Wide wetland (>10') borders watercourse, lake, or pond.
8. High flow velocities in the wetland.
9. The watershed is of sufficient size to produce channelized flow.
10. Open water fetch is present.
11. Boating activity is present.
12. Dense vegetation is bordering watercourse, lake, or pond.
13. High percentage of energy-absorbing emergents and/or shrubs border a watercourse, lake, or pond.
14. Vegetation is comprised of large trees and shrubs that withstand major flood events or erosive incidents and stabilize the shoreline on a large scale (feet).
15. Vegetation is comprised of a dense resilient herbaceous layer that stabilizes sediments and the shoreline on a small scale (inches) during minor flood events or potentially erosive events.
16. Other

WILDLIFE HABITAT — This function considers the effectiveness of the wetland to provide habitat for various types and populations of animals typically associated with wetlands and the wetland edge. Both resident and/or migrating species must be considered. Species lists of observed and potential animals should be included in the wetland assessment report.[1]

CONSIDERATIONS/QUALIFIERS

1. Wetland is not degraded by human activity.
2. Water quality of the watercourse, pond, or lake associated with this wetland meets or exceeds Class A or B standards.
3. Wetland is not fragmented by development.
4. Upland surrounding this wetland is undeveloped.
5. More than 40% of this wetland edge is bordered by upland wildlife habitat (e.g., brushland, woodland, active farmland, or idle land) at least 500 feet in width.
6. Wetland is contiguous with other wetland systems connected by a watercourse or lake.
7. Wildlife overland access to other wetlands is present.
8. Wildlife food sources are within this wetland or are nearby.
9. Wetland exhibits a high degree of interspersion of vegetation classes and/or open water.
10. Two or more islands or inclusions of upland within the wetland are present.
11. Dominant wetland class includes deep or shallow marsh or wooded swamp.
12. More than three acres of shallow permanent open water (less than 6.6 feet deep), including streams in or adjacent to wetland, are present.
13. Density of the wetland vegetation is high.
14. Wetland exhibits a high degree of plant species diversity.
15. Wetland exhibits a high degree of diversity in plant community structure (e.g., tree/shrub/vine/grasses/mosses)
16. Plant/animal indicator species are present. (List species for project)
17. Animal signs observed (tracks, scats, nesting areas, etc.)
18. Seasonal uses vary for wildlife and wetland appears to support varied population diversity/abundance during different seasons.
19. Wetland contains or has potential to contain a high population of insects.
20. Wetland contains or has potential to contain large amphibian populations.
21. Wetland has a high avian utilization or its potential.
22. Indications of less disturbance-tolerant species are present.
23. Signs of wildlife habitat enhancement are present (birdhouses, nesting boxes, food sources, etc.).
24. Other

---

[1]In March 1995, a rapid wildlife habitat assessment method was completed by a University of Massachusetts research team with funding and oversight provided by the New England Transportation Consortium. The method is called WEThings (wetland habitat indicators for non-game species). It produces a list of potential wetland-dependent mammal, reptile, and amphibian species that may be present in the wetland. The output is based on observable habitat characteristics documented on the field data form. This method may be used to generate the wildlife species list recommended as backup information to the wetland evaluation form and to augment the considerations. Use of this method should first be coordinated with the Corps project manager. A computer program is also available to expedite this process.

RECREATION (Consumptive and Non-Consumptive) — This value considers the suitability of the wetland and associated watercourses to provide recreational opportunities such as hiking, canoeing, boating, fishing, hunting, and other active or passive recreational activities. Consumptive opportunities consume or diminish the plants, animals, or other resources that are intrinsic to the wetland. Non-consumptive opportunities do not consume or diminish these resources of the wetland.

CONSIDERATIONS/QUALIFIERS

1. Wetland is part-of a recreation area, park, forest, or refuge.
2. Fishing is available within or from the wetland.
3. Hunting is permitted in the wetland.
4. Hiking occurs or has potential to occur within the wetland.
5. Wetland is a valuable wildlife habitat.
6. The watercourse, pond, or lake associated with the wetland is unpolluted.
7. High visual/aesthetic quality of this potential recreation site.
8. Access to water is available at this potential recreation site for boating, canoeing, or fishing.
9. The watercourse associated with this wetland is wide and deep enough to accommodate canoeing and/or non-powered boating.
10. Off-road public parking available at the potential recreation site.
11. Accessibility and travel ease is present at this site.
12. The wetland is within a short drive or safe walk from highly populated public and private areas.
13. Other

EDUCATIONAL/SCIENTIFIC VALUE — This value considers the suitability of the wetland as a site for an "outdoor classroom" or as a location for scientific study or research.

CONSIDERATIONS/QUALIFIERS

1. Wetland contains or is known to contain threatened, rare, or endangered species.
2. Little or no disturbance is occurring in this wetland.
3. Potential educational site contains a diversity of wetland classes which are accessible or potentially accessible.
4. Potential educational site is undisturbed and natural.
5. Wetland is considered to be a valuable wildlife habitat.
6. Wetland is located within a nature preserve or wildlife management area.
7. Signs of wildlife habitat enhancement present (bird houses, nesting boxes, food sources, etc.).
8. Off-road parking at potential educational site suitable for school bus access in or near wetland.
9. Potential educational site is within safe walking distance or a short drive to schools.
10. Potential educational site is within safe walking distance to other plant communities.
11. Direct access to perennial stream at potential educational site is available.
12. Direct access to pond or lake at potential educational site is available.
13. No known safety hazards exist within the potential educational site.
14. Public access to the potential educational site is controlled.
15. Handicap accessibility is available.
16. Site is currently used for educational or scientific purposes.
17. Other

UNIQUENESS/HERITAGE — This value considers the effectiveness of the wetland or its associated waterbodies to provide certain special values. These may include archaeological sites, critical habitat for endangered species, its overall health and appearance, its role in the ecological system of the area, its relative importance as a typical wetland class for this geographic location. These functions are clearly valuable wetland attributes relative to aspects of public health, recreation, and habitat diversity.

CONSIDERATIONS/QUALIFIERS

1. Upland surrounding wetland is primarily urban.
2. Upland surrounding wetland is developing rapidly.
3. More than 3 acres of shallow permanent open water (less than 6.6 feet deep), including streams, occur in wetlands.
4. Three or more wetland classes are present.
5. Deep and/or shallow marsh or wooded swamp dominate.
6. High degree of interspersion of vegetation and/or open water occur in this wetland.
7. Well-vegetated stream corridor (15 feet on each side of the stream) occurs in this wetland.
8. Potential educational site is within a short drive or a safe walk from schools.
9. Off-road parking at potential educational site is suitable for school buses.
10. No known safety hazards exist within this potential educational site.
11. Direct access to perennial stream or lake exists at potential educational site.
12. Two or more wetland classes are visible from primary viewing locations.
13. Low-growing wetlands (marshes, scrub-shrub, bogs, open water) are visible from primary viewing locations.
14. Half an acre of open water or 200 feet of stream is visible from the primary viewing locations.
15. Large area of wetland is dominated by flowering plants or plants that turn vibrant colors in different seasons.
16. General appearance of the wetland visible from primary viewing locations is unpolluted and/or undisturbed.
17. Overall view of the wetland is available from the surrounding upland.
18. Quality of the water associated with the wetland is high.
19. Opportunities for wildlife observations are available.
20. Historical buildings are found within the wetland.
21. Presence of pond or pond site and remains of a dam occur within the wetland.
22. Wetland is within 50 yards of the nearest perennial watercourse.
23. Visible stone or earthen foundations, berms, dams, standing structures, or associated features occur within the wetland.
24. Wetland contains critical habitat for a state- or federally-listed threatened or endangered species.
25. Wetland is known to be a study site for scientific research.
26. Wetland is a natural landmark or recognized by the state natural heritage inventory authority as an exemplary natural community.
27. Wetland has local significance because it serves several functional values.
28. Wetland has local significance because it has biological, geological, or other features that are locally rare or unique.
29. Wetland is known to contain an important archaeological site.
30. Wetland is hydrologically connected to a state or federally designated scenic river.
31. Wetland is located in an area experiencing a high wetland loss rate.
32. Other

VISUAL QUALITY/AESTHETICS — This value considers the visual and aesthetic quality or usefulness of the wetland.

CONSIDERATIONS/QUALIFIERS

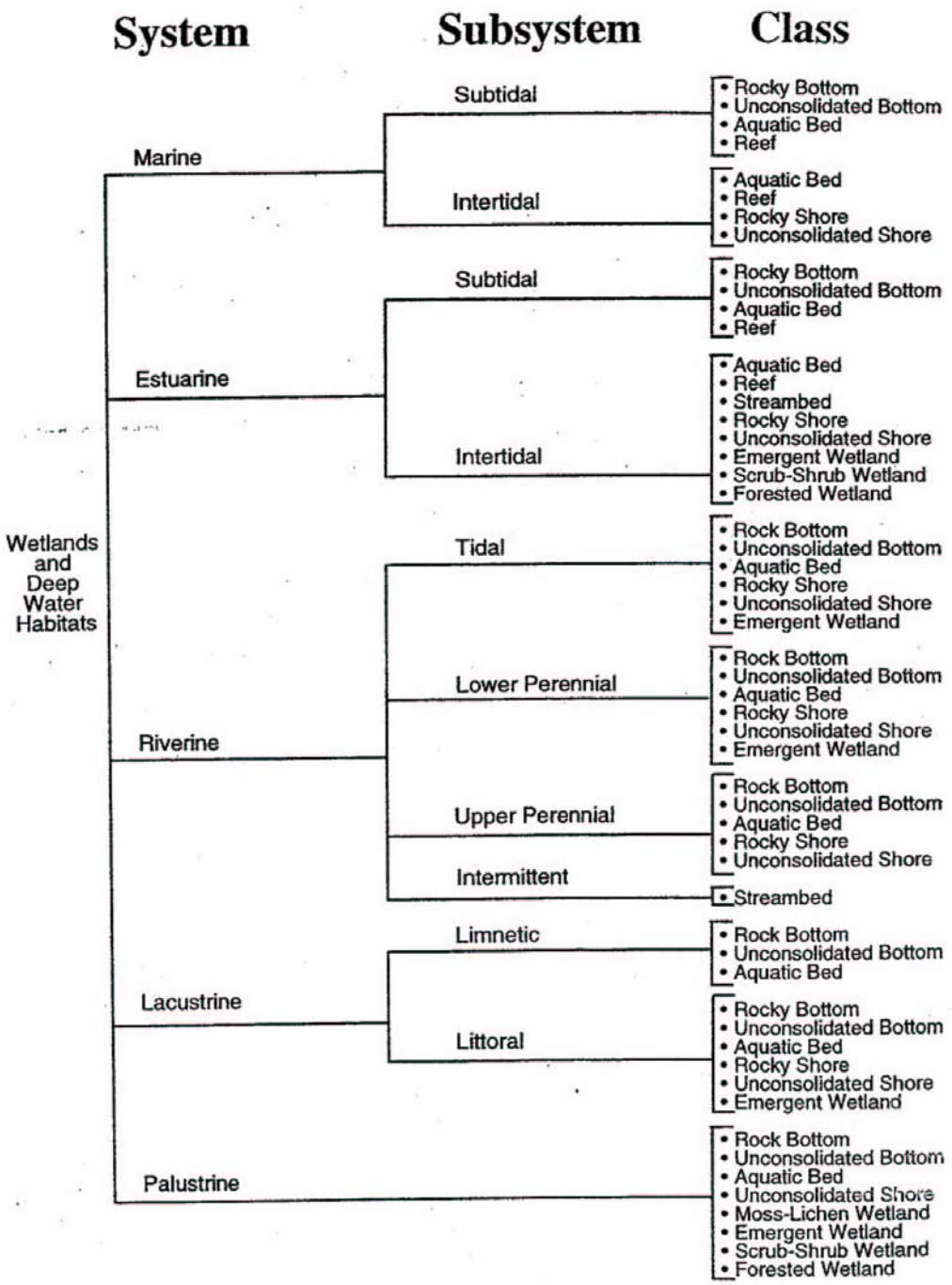
1. Multiple wetland classes are visible from primary viewing locations.
2. Emergent marsh and/or open water are visible from primary viewing locations.
3. A diversity of vegetative species is visible from primary viewing locations.
4. Wetland is dominated by flowering plants or plants that turn vibrant colors in different seasons.
5. Land use surrounding the wetland is undeveloped as seen from primary viewing locations.
6. Visible surrounding land use form contrasts with wetland.
7. Wetland views absent of trash, debris, and signs of disturbance.
8. Wetland is considered to be a valuable wildlife habitat.
9. Wetland is easily accessed.
10. Low noise level at primary viewing locations.
11. Unpleasant odors absent at primary viewing locations.
12. Relatively unobstructed sight line exists through wetland.
13. Other

ENDANGERED SPECIES HABITAT — This value considers the suitability of the wetland to support threatened or endangered species.

ES

CONSIDERATIONS/QUALIFIERS

1. Wetland contains or is known to contain threatened or endangered species.
2. Wetland contains critical habitat for a state or federally listed threatened or endangered species.


System
Subsystem
Class
Wetlands and Deep Water Habitats
Marine
Subtidal
• Rocky Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Reef
Intertidal
• Aquatic Bed
• Reef
• Rocky Shore
• Unconsolidated Shore
Estuarine
Subtidal
• Rocky Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Reef
Intertidal
• Aquatic Bed
• Reef
• Streambed
• Rocky Shore
• Unconsolidated Shore
• Emergent Wetland
• Scrub-Shrub Wetland
• Forested Wetland
Riverine
Tidal
• Rock Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Rocky Shore
• Unconsolidated Shore
• Emergent Wetland
Lower Perennial
• Rock Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Rocky Shore
• Unconsolidated Shore
• Emergent Wetland
Upper Perennial
• Rock Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Rocky Shore
• Unconsolidated Shore
Intermittent
• Streambed
Lacustrine
Limnetic
• Rock Bottom
• Unconsolidated Bottom
• Aquatic Bed
Littoral
• Rocky Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Rocky Shore
• Unconsolidated Shore
• Emergent Wetland
Palustrine
• Rock Bottom
• Unconsolidated Bottom
• Aquatic Bed
• Unconsolidated Shore
• Moss-Lichen Wetland
• Emergent Wetland
• Scrub-Shrub Wetland
• Forested Wetland

Wetland Function-Value Evaluation Form

Total area of wetland_____ Human made?_____ Is wetland part of a wildlife corridor?_____ or a "habitat island"?_____

Adjacent land use_____ Distance to nearest roadway or other development_____

Dominant wetland systems present_____ Contiguous undeveloped buffer zone present_____

Is the wetland a separate hydraulic system?_____ If not, where does the wetland lie in the drainage basin?_____

How many tributaries contribute to the wetland?_____ Wildlife & vegetation diversity/abundance (see attached list)

Wetland I.D._____

Latitude_____ Longitude_____

Prepared by:_____ Date_____

Wetland Impact:
Type_____Area_____

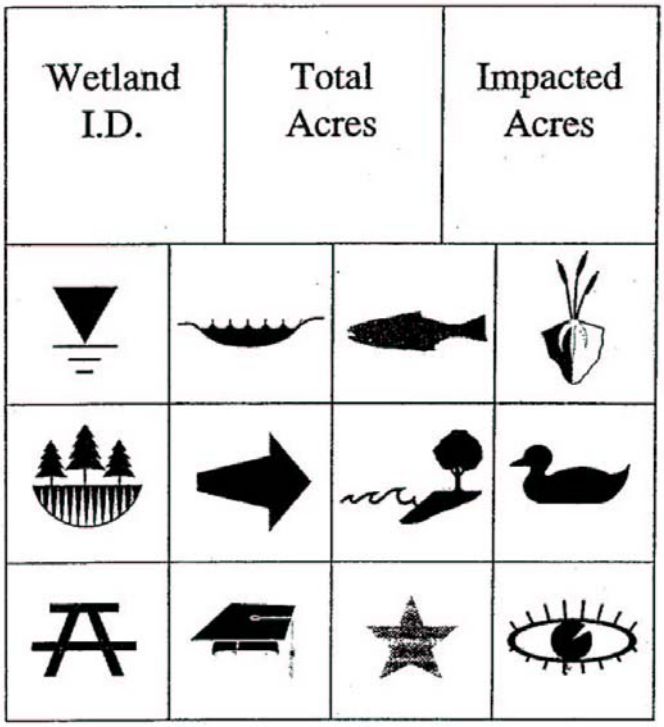
Evaluation based on:
Office_____ Field_____

Corps manual wetland delineation completed? Y____ N____

Function/Value	Suitability Y	Suitability N	Rationale (Reference #)*	Principal Function(s)/Value(s)	Comments
Groundwater Recharge/Discharge					
Floodflow Alteration					
Fish and Shellfish Habitat					
Sediment/Toxicant Retention					
Nutrient Removal					
Production Export					
Sediment/Shoreline Stabilization					
Wildlife Habitat					
Recreation					
Educational/Scientific Value					
Uniqueness/Heritage					
Visual Quality/Aesthetics					
ES Endangered Species Habitat					
Other					

Notes:

*Refer to backup list of numbered considerations.



Symbols Key

Groundwater Recharge/ Discharge

Floodflow Alteration (Storage & Desynchronization)

Fish and Shellfish Habitat

Sediment/Toxicant Retention

Nutrient Removal/ Retention/Transformation

Production Export (Nutrient)

Sediment/Shoreline Stabilization

Wildlife Habitat

Recreation(Consumptive & Non-Consumptive)

Educational/Scientific Value

Uniqueness/Heritage

Visual Quality/Aesthetics

ES Endangered Species

29

APPENDIX G

WETHINGS
POTENTIAL INDICATOR SPECIES

ND01-081
9/14/01

TABLE G-1

WETHINGS
POTENTIAL INDICATOR SPECIES

Common Name	Species
Amphibians	
Northern Spring Peeper	*Hyla crucifer*
Bullfrog	*Rana catesbeiana*
Pickerel Frog	*Rana palustris*
Green Frog	*Rana clamitans*
Birds	
Mallard	*Anas platyrhynchos*
Yellow Warbler	*Dendroica petechia*
Gray Catbird	*Dumetella carlinensis*
Common Yellowthroat	*Geothlypis trichas*
Song Sparrow	*Melospiza melodia*
Red-winged Blackbird	*Agelaius phoeniceus*
American Goldfinch	*Carduelis tristis*

ND01-081
9/14/01

APPENDIX H

WETHINGS
STANDARDIZED DATA FORM

ND01-081
9/14/01

Appendices

FIELD DATA FORM FOR THE WEThings METHOD
SECTION A
CHARACTERIZATION OF WETLAND SYSTEM

Site Technician Date

A1. Where is the wetland located? Town _____ County _____ State _____

Geographic area:

- ☐ Northern Vermont
- ☐ Central Vermont
- ☐ Southern Vermont
- ☐ Northern New Hampshire
- ☐ Central New Hampshire
- ☐ Southern New Hampshire
- ☐ Inland Maine
- ☐ Transitional Maine
- ☐ Coastal Maine
- ☐ Massachusetts (except southeast, Cape Cod and islands)
- ☐ Southeastern Massachusetts, Cape Cod and islands
- ☐ Connecticut
- ☐ Rhode Island

A2. In which of the following landforms is the wetland located?

- ☐ Calcareous valley
- ☐ Atlantic Coastal Plain
- ☐ Glacial sand deposit
- ☐ Major river valley
- ☐ Major forested wetland system
- ☐ Other (please describe) _____

A3. How many wetland cover types are present? _____

A4. How many upland cover types are present? _____

A5. Cowardin classification of all wetland cover types present:

Cover type #	System	Subsystem	Class	Subclass	Descriptors

A6. List all upland cover types present:

Cover type #	Description

FIELD DATA FORM FOR THE WEThings METHOD
SECTION A
CHARACTERIZATION OF WETLAND SYSTEM

Site Technician Date

A7. Draw a diagram showing the relationship between wetland and upland cover types and areas of open water. Number each cover type to correspond with data sheets. Include some measure of scale. Label the diagram as fully as possible.

Appendices

FIELD DATA FORM FOR THE WEThings METHOD
SECTION A
CHARACTERIZATION OF WETLAND SYSTEM

Site Technician Date

Answer questions A8 and A9 for forested and scrub-shrub cover types only.

A8. List the cover type number(s) from A7 that are at least 100 m in width: _____

A9. List the cover type number(s) from A7 that border a river or stream channel for at least 15 m in length: _____

A10. Landscape features with approximate distances from the wetland:

	100 m	200 m	300 m	400 m	500 m	1 km
Upland forest(s)	☐	☐	☐			
Deciduous or mixed upland forest(s)	☐	☐	☐	☐	☐	☐
Open canopy, upland sandy soil	☐	☐	☐			
Permanently flooded wetland(s)	☐	☐	☐	☐	☐	
Non-permanently flooded wetland(s)	☐	☐	☐	☐	☐	☐
Palustrine forested wetland(s)	☐	☐	☐			
Lacustrine wetland(s)	☐	☐	☐	☐		
Permanently/seasonally flooded wetland(s)	☐	☐	☐			

FIELD DATA FORM FOR THE WEThings METHOD
SECTION B
CHARACTERIZATION OF INDIVIDUAL WETLAND COVER TYPES

Site _____ Wetland cover type # _____ Technician _____ Date _____

B1. Cowardin classification of wetland cover type: _____

VEGETATION

B2. Wetland vegetation:

Type	Present	% cover	Dominant species
Submergents	☐	_____	_____
Surface plants	☐	_____	_____
Persistent emergents	☐	_____	_____
Non-persistent emergents	☐	_____	_____
Ground cover (moss lichen)	☐	_____	_____
Shrubs	☐	_____	_____
Trees	☐	_____	_____
No vegetation	☐	_____	_____

B3. Maximum depth of mosses: _____ cm

B4. Tree canopy closure over cover type: ☐ Open ☐ Partial ☐ Closed

HYDROLOGY

B5. Hydrologic classification of cover type (check one):

☐ Permanently flooded
☐ Intermittently exposed
☐ Semi-permanently flooded
☐ Seasonally flooded
☐ Saturated
☐ Temorarily flooded
☐ Intermittently flooded
☐ Artificially flooded

B6. Water depth:

Palustrine or Lacustrine System
Average _____ m
Maximum _____ m
Max. at low water _____ m

Riverine System
Runs _____ m
Riffles _____ m
Pools _____ m
Max. at low water _____ m

B7. If surface waters are not present, what is the depth to groundwater? _____ cm

B8. Is the cover type adjacent to or hydrologically connected with deep water systems? ☐ Yes ☐ No

Appendices

FIELD DATA FORM FOR THE WEThings METHOD
SECTION B
CHARACTERIZATION OF INDIVIDUAL WETLAND COVER TYPES

Site | Wetland cover type # | Technician | Date

B9. Characterization of water flow (check one):

☐ All fast water ☐ Laminar flow ☐ Intermittent flow
☐ Complex of rapids and pools ☐ Trickle of seeps or springs ☐ No flow

B10. In Riverine system, what is the discharge rate?

☐ Less than 0.1 cm ☐ Between 0.1 and 30 cm ☐ More than 30 cm

B11. Are there areas of quiet shallow water present in the cover type? ☐ Yes ☐ No

B12. If the wetland cover type is not permanently flooded, at what time of year does it flood?

☐ Spring ☐ Summer ☐ Fall ☐ Winter ☐ Not seasonal ☐ Do not know

B13. Are there areas that do not freeze to the bottom in winter? ☐ Yes ☐ No ☐ Do not know

B14. In Palustrine system, are vernal ponds present? ☐ Yes ☐ No

SUBSTRATE AND STRUCTURAL COMPONENTS

B15. Substrate in wetland cover type (check all that apply):

☐ Peat ☐ Silt ☐ Gravel ☐ Bedrock
☐ Muck/mud ☐ Sand ☐ Cobbles/rocks
☐ Clay ☐ Loam ☐ Boulders

B16. Is moist mull humus present at the water's edge? ☐ Yes ☐ No

B17. Structural components are located (check all that apply):

☐ Under water's surface ☐ Within 2 m of water's edge
☐ At the water's surface ☐ More than 2 m from water
☐ Above water's surface ☐ No structural components present

Answer questions B18-22 according to boxes checked in question B17.

B18. Structural components present under water's surface:

☐ Organic debris ☐ Crevices ☐ Sloping sand
☐ Rocks ☐ Overhanging dirt banks ☐ Mud banks
☐ Flat rocks

FIELD DATA FORM FOR THE WEThings METHOD
SECTION B
CHARACTERIZATION OF INDIVIDUAL WETLAND COVER TYPES

Site | Wetland cover type # | Technician | Date

B19. Structural components present at water's surface:

- ☐ Organic debris
- ☐ Rocks
- ☐ Flat rocks
- ☐ Crevices
- ☐ Overhanging dirt banks
- ☐ Sloping sand
- ☐ Mud banks
- ☐ Tussocks
- ☐ Sphagnum hummocks
- ☐ Shrubs
- ☐ Beaver lodges/dams

B20. Structural components present above water's surface:

- ☐ Organic debris
- ☐ Rocks
- ☐ Flat rocks
- ☐ Crevices
- ☐ Overhanging dirt banks
- ☐ Tussocks
- ☐ Sphagnum hummocks
- ☐ Shrubs

B21. Structural components present within 2 m of water's edge:

- ☐ Organic debris
- ☐ Rocks
- ☐ Flat rocks
- ☐ Crevices
- ☐ Tussocks
- ☐ Sphagnum hummocks
- ☐ Shrubs
- ☐ Beaver lodges/dams

B22. Structural components present more than 2 m from water's edge:

- ☐ Organic debris
- ☐ Rocks
- ☐ Flat rocks
- ☐ Crevices
- ☐ Tussocks
- ☐ Sphagnum hummocks
- ☐ Low dense vegetation
- ☐ Shrubs

Answer questions B23-B27 if "organic debris" was checked in any of the corresponding questions, B18-B22, above.

B23. Type(s) of organic debris under water's surface:

- ☐ Leaf litter
- ☐ Logs
- ☐ Boards
- ☐ Stumps
- ☐ Branches
- ☐ Overhanging branches

B24. Type(s) of organic debris at the water's surface:

- ☐ Leaf litter
- ☐ Logs
- ☐ Water soaked/ rotten logs
- ☐ Boards
- ☐ Stumps
- ☐ Branches
- ☐ Overhanging branches

Appendices

FIELD DATA FORM FOR THE WEThings METHOD
SECTION B
CHARACTERIZATION OF INDIVIDUAL WETLAND COVER TYPES

Site _____ Wetland cover type # _____ Technician _____ Date _____

B25. Type(s) of organic debris above water's surface:

- ☐ Leaf litter
- ☐ Logs
- ☐ Water-soaked/ rotten logs
- ☐ Boards
- ☐ Stumps
- ☐ Water soaked/ rotten stumps
- ☐ Branches
- ☐ Overhanging branches

B26. Type(s) of organic debris within 2 m of water's edge:

- ☐ Leaf litter
- ☐ Logs
- ☐ Stumps
- ☐ Overhanging branches
- ☐ Mats of algae or other vegetation (may condense to Algae mats)

B27. Type(s) of organic debris more than 2 m from water's edge:

- ☐ Leaf litter
- ☐ Logs
- ☐ Stumps
- ☐ Water soaked/ rotten stumps
- ☐ Branches

B28. Sloping sand is: ☐ Absent ☐ Limited ☐ Abundant

B29. What is the degree of interspersion of structural features and standing water?

☐ Low ☐ Moderate ☐ High

WATER QUALITY

B30. Water salinity: ☐ Freshwater ☐ Brackish with freshwater influx ☐ Predominantly saline

B31. What is the water pH? ☐ Less than 6 ☐ Between 6–7.4 ☐ Greater than 7.4

B32. Is the water oligotrophic? ☐ Yes ☐ No

B33. Water color: ☐ Clear ☐ Tea-colored ☐ Murky ☐ Muddy

B34. Are any of the following types of disturbances present? (check all that apply)

- ☐ Algal blooms
- ☐ Chemical pollutants
- ☐ High level of recreational activity
- ☐ Urbanization
- ☐ None of the above
- ☐ Other (please describe) _____

FIELD DATA FORM FOR THE WEThings METHOD
SECTION B
CHARACTERIZATION OF INDIVIDUAL WETLAND COVER TYPES

Site _____ Wetland cover type # _____ Technician _____ Date _____

WETLAND SIZE / PHYSICAL CHARACTERIZATION

Answer questions B35–B37 for Lacustrine systems only

B35. Are wave-formed shorelines present? ☐ Yes ☐ No

B36. What is the wetland size? ☐ Less than 8 ha ☐ Greater than 8 ha

B37. For wetland greater than 8 ha, are irregular shorelines present? ☐ Yes ☐ No

Answer questions B38–B42 for Riverine systems only.

B38. Is there more than 0.8 km of stream reach present? ☐ Yes ☐ No

B39. What is the stream gradient? ☐ Less than 5% ☐ 5–14 % ☐ At least 15%

B40. What is the bank height? ☐ Less than 0.2 m ☐ At least 0.2 m

B41. What is the width of the stream/river? ☐ Less than 1 m ☐ At least 1 m

B42. What is the bank slope? ☐ Less than 10 degrees ☐ At least 10 degrees

WILDLIFE OBSERVATIONS

B43. Are fish present? ☐ Yes ☐ No

B44. List wildlife species or their sign observed in this cover type. If invertebrate indicators were used to determine wetland hydrology, list those also.

B45. Additional notes and comments:

Appendices

FIELD DATA FORM FOR THE WEThings METHOD
SECTION C
CHARACTERIZATION OF INDIVIDUAL UPLAND COVER TYPES

Site _____ Upland cover type # _____ Technician _____ Date _____

C1. Upland cover type: ☐ Forest ☐ Scrub-shrub ☐ Fields/meadow ☐ Other

Answer questions C2 and C3 for forested upland cover types only.

C2. Which term best describes the forest type?
☐ Deciduous ☐ Mixed deciduous ☐ Evergreen

C3. Forest understory: ☐ Open ☐ Not open

Answer the remaining questions for all upland cover types:

C4. Tree canopy closure over upland cover type: ☐ Open ☐ Partial ☐ Closed

C5. Upland substrate (check all that apply):
☐ Silt ☐ Gravel ☐ Bedrock
☐ Sand ☐ Cobbles/rocks
☐ Loam ☐ Boulders

C6. Are the soils in this cover type well drained? ☐ Yes ☐ No

C7. Structural components present in upland cover type (check all that apply):
☐ Organic debris ☐ Sand piles/banks/dunes ☐ Low dense vegetation
☐ Rocks ☐ Tunnels ☐ Man-made structures

☐ Other (please describe): _____

C8. Type(s) of organic debris present in upland cover type (check all that apply):
☐ Leaf litter ☐ Hollow logs ☐ Boards
☐ Logs ☐ Stumps ☐ Branches

C9. Are large crevices present in rocks or log piles? ☐ Yes ☐ No

C10. Additional notes or comments:

APPENDIX I

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
PERFORMANCE STANDARDS AND SUPPLEMENTAL DEFINITIONS
FOR USE WITH THE 1987 CORPS MANUAL

ND01-081
9/14/01

PROJECT TITLE: TRANSECT: PLOT:

DELINEATOR(S): DATE

VEGETATION Stratum and Species	Dominance Ratio	Percent Dominance	D O M	NWI Status

OBL FACW FAC Other Hydrophytes FAC- FACU UPL

Hydrophyte Subtotal (A): _____ Non-hydrophyte Subtotal (B): _____

PERCENT HYDROPHYTES (100A/A+B): _____

HYDROLOGY

☐ RECORDED DATA:
Stream, lake or tidal gage Identification: _____
Aerial Photograph Identification: _____
Other Identification: _____

☐ NO RECORDED DATA

☒ OBSERVATIONS:
Depth to free water: _____
Depth to saturation (including capillary fringe): _____
Describe altered hydrology: _____

☐ Inundated ☐ Saturated In upper 12 inches ☐ Water Marks ☐ Drift Lines ☐ Sediment Deposits ☐ Drainage Patterns within Wetlands

☐ Other
(explain) : Irregularly inundated by stream drainage.

ND01-081
9/14/01

SOIL

Depth	Horizon	Matrix Color	Redoximorphic Features (color, abundance, size & contrast)	USDA Texture: and nodules, concretions, masses, pore linings, restrictive layers, root distribution, soil water, etc.

Hydric Soil indicator(s):

References:

Optional Soil Data:

References:

Taxonomic Subgroup:

Map Unit Name:

Soil Drainage Class:

Depth to Active Water Table:

NTCHs Hydric Soil Criterion:

CONCLUSIONS

	Yes	no
Greater than 50% Hydrophytes?	☐	☐
Hydric Soils Criterion Met?	☐	☐
Wetland Hydrology Met?	☐	☐

Is This Datapoint Within A Wetland? yes ☐ no ☐

Remarks:

PROJECT TITLE: TRANSECT: PLOT:

ND01-081
9/14/01