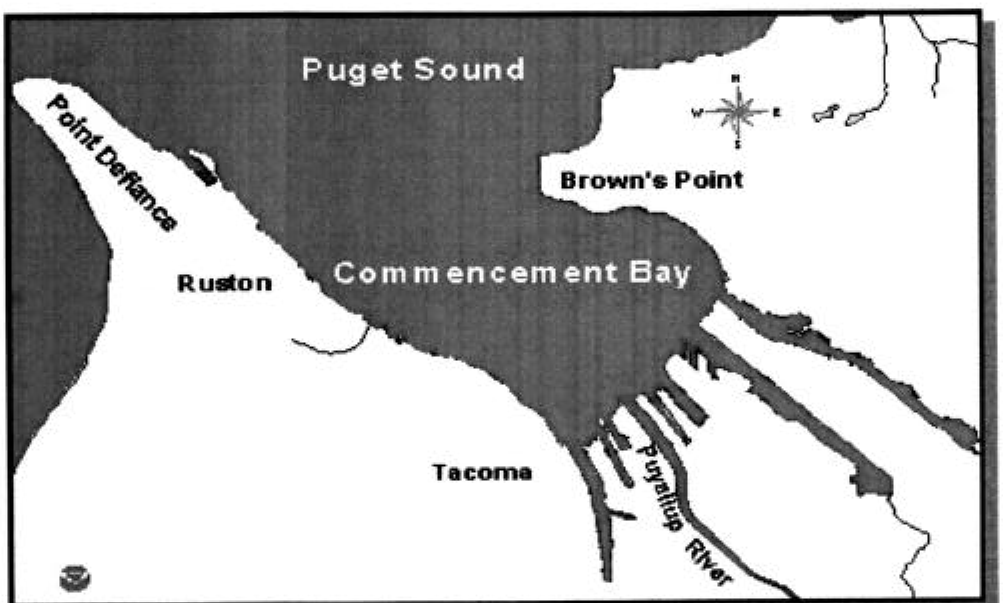
# COMMENCEMENT BAY
# NATURAL RESOURCE DAMAGE ASSESSMENT
# (CB/NRDA)

## RESTORATION MONITORING PROGRAM




**MARCH 2001**

## FACT SHEET

## COMMENCEMENT BAY NATURAL RESOURCE DAMAGE ASSESSMENT (CB/NRDA) RESTORATION MONITORING PLAN

**CB/NRDA TRUSTEES:** National Oceanic and Atmospheric Administration (NOAA) U.S. Department of the Interior (DOI): U.S. Fish and Wildlife Service (USFWS), Bureau of Indian Affairs (BIA) Puyallup Tribe of Indians, Muckleshoot Indian Tribe, State of Washington: Departments of Ecology (lead state trustee), Fish and Wildlife, and Natural Resources

**ABSTRACT:** The CB/NRDA Trustees are engaged in conducting a natural resource damage assessment for Commencement Bay. A Restoration Plan (*Plan*) was prepared to set out the restoration goals and objectives and the Trustees' framework for conducting restoration in the Bay. As part of the implementation of the Plan, the Trustees are initiating a Monitoring Program (Program) to evaluate all of the NRDA restoration projects in Commencement Bay (*see* Figure 1).

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## ACRONYMS

| | |
|---|---|
| BSC | Biological success criteria |
| CSL | Cleanup Screening Level |
| cm | centimeter |
| Corps | U.S. Army Corps of Engineers |
| CSC | Chemical success criteria |
| DOI | U.S. Department of the Interior |
| EPA | U.S. Environmental Protection Agency |
| GPS | global position system |
| HPA | Hydraulic Project Approval |
| LIDAR | Laser Infrared Detection and Ranging |
| m | meter |
| mm | millimeter |
| MLLW | mean lower low water |
| NGVD | national geodetic vertical datum |
| NOAA | National Oceanic and Atmospheric Administration |
| NRDA | natural resource damage assessment |
| PAHs | polynuclear aromatic hydrocarbons |
| PCBs | polychlorobiphenyls |
| Plan | NRDA Restoration Plan (Commencement Bay) |
| ppb | parts per billion |
| ppt | parts per thousand |
| Program | NRDA Restoration Monitoring Program (Commencement Bay) |
| PSC | Physical Success Criteria |
| PSEP | Puget Sound Estuarine Protocols |
| RP/EIS | Restoration Plan/Programmatic Environmental Impact Statement (Commencement Bay) |
| SQO | Sediment Quality Objectives (State of Washington) |
| SQS | Sediment Quality Standards (State of Washington) |
| TBT | *tributyltin* |
| USFWS | U.S. Fish and Wildlife Service |

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## 1.0 INTRODUCTION

The Commencement Bay Natural Resource Trustees (Trustees) (the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce, the U.S. Department of the Interior, including the U.S. Fish and Wildlife Service and the Bureau of Indian Affairs, the Puyallup Tribe of Indians, the Muckleshoot Indian Tribe, the Washington Department of Ecology (lead state trustee), the Washington Department of Fish and Wildlife, and the Washington Department of Natural Resources) are engaged in conducting a natural resource damage assessment (NRDA) for Commencement Bay. To guide decision-making regarding the implementation of natural resource restoration activities, the Trustees prepared a NRDA Restoration Plan/Programmatic Environmental Impact Statement (RP/EIS), built in part upon the Commencement Bay Cumulative Impact Study (May/June 1993), a multi-agency cooperative project to study the natural habitat in the Commencement Bay environment. The Restoration Plan (Plan) sets out the restoration goals and objectives and the Trustees' framework for conducting restoration in the Bay.

As part of the implementation of the Plan, the Trustees are initiating a Monitoring Program (Program) to evaluate all of the NRDA restoration projects in Commencement Bay (*see* Figure 1). The Trustees believe that regional monitoring programs should be developed that use similar assumptions and protocols to ensure consistency and a correspondence in measurements of the physical, biological and chemical attributes among restoration projects in the Puget Sound region. For this reason, the Commencement Bay Trustees have incorporated many of the criteria and discussions from the Elliott Bay/Duwamish Restoration Program, the monitoring plan from the Trustees' pilot project at the Middle Waterway, and other monitoring protocols. Appendix F provides a brief review of a few of those documents.

### 1.1 PURPOSE AND NEED FOR THE PROGRAM

The Program is designed to generate practical information for evaluating the trajectory of project development, identifying successful and unsuccessful techniques or restoration strategies, and implementing mid-course corrections when necessary. It is intended to fulfill several important purposes:

1. To measure success. This plan describes the reference sites and criteria against which performance and success can be measured. This purpose responds to two basic monitoring questions: 1) Is a project performing as planned? 2) How is the project contributing to the overall intent of the program and each round of questions regarding success?

2. To identify adaptive management activities ("contingency planning") that will define a range of mid-course correction actions that could be implemented if the projects fail to perform.

3. To address the monitoring requirements under various permitting authorities. A detailed site-specific monitoring plan is a standard requirement for compliance with state and federal permits, *e.g.*, section 404 of the Clean Water Act and the State of Washington's Hydraulic Project Approval (HPA) process.

4. To ensure inter-project monitoring consistency within the CB/NRDA Restoration Program. This consistency allows for the comparison of NRDA and non-NDRA projects as well as assessing the overall function of the program to meet its objectives.

5. To serve as an outreach tool to provide information to interested parties regarding the progress of the projects and the program.

## 1.2 GOALS AND OBJECTIVES OF THE PROGRAM

This Program has been developed for use in evaluating and managing all NRDA restoration projects. The goals and objectives of restoration monitoring are to quantitatively measure these parameters:

| Program Goals | Program Objectives |
|---|---|
| Assess the performance (success) of restoration projects. | *Compare similar sites with eachother, to site criteria and area reference sites.* |
| Determine reasons for projects not attaining goals. | *Compare the development and characteristics of the project to the Program's physical, biological, and chemical success criteria.* |
| Establish recommendations to improve the project (adaptive management). | *Select appropriate contingency measure(s).* |
| Compliance with permit conditions. | *Compare with regulatory requirements.* |
| Create databases for future restoration planning efforts and to prepare project reports. | *Document the development of the physical, chemical, and biological characteristics. Provide information for use in the design of future restoration projects.* |
| Provide information to interested parties. | *Provide education and outreach tools.* |

The Program serves as the foundation upon which project-specific monitoring plans are based. This plan sets forth a wide suite of sampling protocols from which each site-specific project plan is developed. The purpose of developing these protocols is to enable each plan to target specific parameters and develop for each site a specific combination of measurements, sampling types, and tools tailored to the specific objectives of that project. Should a project fail to meet its objectives, additional protocols may be selected from the Program to aid in establishing the reason(s) for the failure and to suggest alternative adaptive management activities. The project-specific monitoring protocols are set out in Appendix G.

## 2.0 MANAGEMENT METHODS AND MONITORING CRITERIA

The intent of the Program is to implement the NRDA Restoration Plan by creating an overall structure to coordinate and streamline the field sampling, data processing, interpretation and report preparation thereby minimizing costs and oversight for project-specific monitoring plans. For example, most of the monitoring protocols are consistent among projects so a field team can conduct the monitoring for several projects within one sampling period.

## 2.1 MONITORING OF PHYSICAL ATTRIBUTES

To successfully restore a habitat, it is necessary to construct the physical site conditions (*e.g.*, hydrology, slope, substrate, vegetation) that will facilitate habitat development and use. The following success criteria provide guidance for monitoring whether or not post-construction site characteristics meet these criteria. Evaluating project performance against each criterion is intended to be an ongoing process that will take place for a number of years. At a minimum, five years of sampling will meet permit requirements although some monitoring efforts should extend to 10 years or beyond. Monitoring may continue for longer periods depending on project objectives and funding availability. The individual Physical Success Criteria (PSC) sampling sheets are located at Appendix A.

## 2.2 MONITORING BIOLOGICAL ATTRIBUTES

Biological success criteria (BSC) identified in this Program fall into two broad categories. There are those criteria that provide evidence that "attributes" of functioning intertidal habitat are developing within the project. For example, are the prey resources, an essential foraging function for juvenile chinook salmon, present in sufficient numbers and sizes to indicate the habitat is functioning properly? In addition, are there criteria that directly evaluate fish and wildlife presence within the project? While it may seem that this second set of criteria are sufficient to determine the success of the project, this is not always the case. Presence or absence of a target species fails to quantify the value of the habitat for the species. Failure to observe the target species within the project does not always mean that it has not, or will not, use the area.

This Program relies on the evaluation of habitat attributes such as vegetation and prey resources to evaluate project success. This data may be supplemented with some direct measurement of target species, including juvenile salmonids and other estuarine fish, as well as bird use of the restoration project sites. The individual BSC sampling sheets are located at Appendix B; Table 2 lists native species of intertidal plants observed in the Bay.

## 2.3 MONITORING OF CHEMICAL ATTRIBUTES

Monitoring of chemical attributes is especially important when evaluating a project that has not met the physical and biological success criteria. In general, chemical monitoring will only be implemented when there is a specific (*e.g.*, permit) and/or scientifically-based need. Chemical success criteria (CSC) sampling sheets are located at Appendix C.

## 2.4 SUMMARY

The Trustees recognize that most assessment and monitoring programs are constrained by funding and by the availability of personnel who are qualified to sample for such things as nitrogen fixation. Since the main purpose of monitoring is to characterize the structure and functioning of the habitat, the sampling program must be able to withstand the review of field ecologists. A monitoring program must identify the habitats being characterized, it should have replicate sampling stations within each habitat, and it should provide data that document ecologically meaningful changes when they occur. General analyses of the data should indicate that the sampling program is encountering the bulk of the species present, and that variances among replicate sampling stations are not excessively high.

This monitoring plan can be expanded or reduced in different ways, *e.g.*, by varying the number of attributes examined, the frequency of the examination, and the number of sampling stations. Additional modifications could include the level of detail of examination in the field within sampling stations (*e.g.*, depths at which soil salinity is measured) and at the laboratory (*e.g.*, determination of invertebrates to family or to species, chemical analysis is pooled or individual soil samples from each sampling station).

Priority attributes. The attributes can be prioritized based upon what we need to know and how much information is provided by the data (priority 1 = most needed; 2 = desirable; 3 = worthwhile). It should be noted that these priority designations are tentative. As the Trustees understand more about wetland ecosystem functioning, they will be better able to select the appropriate and more specific indicators of function.

Sampling frequency. Daily fluctuations occur in migratory bird attendance and colonization of sites. In contrast, plant invasions or local extinctions usually become obvious only after a year or two. Some attributes may be measured as often as weekly, others seasonally or annually, and some only after major events are noted.

Not all habitat types have the same temporal variability so it is difficult to suggest a simple program that can fit all systems. Monitoring programs must be tailored to fit the needs of the system being monitored, beginning with frequent measurements and reducing sampling if experience suggests that reducing the frequency will not significantly reduce information about the system. Monitors should be prepared to increase sampling frequency in response to events such as floods, wastewater spills, algal blooms, inlet closure, or project failure.

Numbers of sampling stations. Field monitoring programs should provide an adequate sample of the area. Adequacy in this case relates to the ability of the sampling effort to evaluate whether the management objective has been achieved. Experienced field ecologists usually can visit a site and easily define habitat areas that are "relatively homogeneous." Aerial photographs can provide additional identification tools. Within each habitat area, replicate samples are taken at a minimum of three stations. Initial sampling will provide estimates of heterogeneity (variance of each attribute measures). If initial replicate stations give high variance (*e.g.*, if the standard error exceeds 10% of the mean), additional replicate samples are needed to adequately characterize the attribute. Because the system's variability dictates the number of replicate samples needed, the exact number samples at each site cannot yet be predicted. It is, however, prudent to plan for a large number of replicate stations and cut back if variances are low. Results can be summarized to test for differences between different locations (*e.g.*, restored and natural wetlands) or differences with time (*e.g.*, year-to-year changes). Further information on the number of replicate samples needed to provide ecologically meaningful data can be found in Krebs (1989).

An alternative approach to replicate sampling within a study area is appropriate where gradients of environmental conditions are present. For estuarine channels that range from a high to low salinity, it is more useful to position sampling stations along the gradient and to plot water quality characteristics against distance. Instead of clumping stations within a homogeneous area, one would distribute the station intervals proceeding upstream from the saltwater inlet. Conversely, stations should be closer together where environmental changes are likely to be present. Results can be summarized as graphs of each attribute against distance from the inlet, looking for spatial trends and evidence of shifts through time.

In addition, a prefered alternative to determine the number of sampling stations needed is to conduct a small pilot study in order to determine the sample size needed to achieve the sampling objective. From pilot sampling, we can estimate the population mean and standard variation and use those numbers to calculate a coefficient of variation. We then use coefficient of variation to compare different sampling schemes - the smaller the coefficient of variation, the more efficient (e.g., fewer samples equals greater statistical power) is the sample design.

Here is one example of how to determine the number of samples needed:

1. Prior to pilot sampling, determine what the target goals are for restoration (e.g., restore population of species X to at least 30 plants per quadrat by year Y). These goals should be determined in part from sampling at appropriate reference sites.

The initial sample size should depend on the relative amount of variation in the data, start with few samples (e.g., 10) if there is little variation among quadrats and more samples (e.g., >15) if the number of plants of a given species varies from quadrat to quadrat.

3. Calculate the mean and standard deviation of species X from the quadrat measures. Determine acceptable levels of type I (á) and type II (â, also know as the precision level or power level) error. The reason for determining these error rates is to ensure that your monitoring program detects the biologically important changes that it has been designed to track.

4. Calculate an initial, uncorrected sample size using the following equation (Elzinga et al. 1998):

$$n = [(Z_\alpha)^2(s)^2]/(\beta)^2$$

where n = uncorrected sample size estimate

$Z_\alpha$ = standard normal coefficient (see Table 1 below). This value corresponds to your acceptable level of type I error, which is usually expressed as a confidence interval (e.g., 90% confidence interval equals 10% type 1 error rate or á = 0.10).

s = standard deviation

β = desired precision level. This value needs to be expressed in absolute terms instead of as a percentage. For example, if you wanted the sample mean estimate to be within 10 percent of the true population mean and the sample mean is 10 plants per quadrat, then

β = (0.10 * 10) = 1.

Table 1. Standard Normal Deviates ($Z_\alpha$) for Various Confidence Levels.

| Confidence Level | Type I (or Alpha) Error Rate | $Z_\alpha$ |
|---|---|---|
| 80 % | 0.20 | 1.28 |
| 90% | 0.10 | 1.64 |
| 95% | 0.05 | 1.96 |
| 99% | 0.01 | 2.58 |

5. To obtain an adjusted sample size estimate (n*), correct n using Table 2. This table provides correction values for single parameter estimates. It was created by Elzinga et al. (1998) using an algorithm reported by Kupper and Hafner (1989).

*Example (Elzinga et al. 1998):*

Management objective: Restore the population of species X in population Y to a density of at least 40 plants per quadrat by the year 2005.

Sampling objective: Obtain estimates of the mean density and population size with 90% confidence that they are within 20% of the true population mean. [Type I error rate (á) = 0.10 and type II error rate (â) = 0.20.]

Results of pilot study: Mean density = 14 plants/quadrat   Standard deviation = 5.12 plants

Sample size equation:
β = (0.20*14) = 2.8   N = $(1.64)^2(5.12)^2/(2.8)^2$ = 8.9, which is rounded up to 9 samples for the unadjusted sample size.

Go to Table 2 to adjust this preliminary estimate and find n = 9 and the corresponding n* value in the 90% confidence level column of the table. For n = 9, the corrected sample size is 16.

*Thus, the corrected estimated sample size needed to be 90% confidence that the estimate of the population mean is within 20% of the true mean is 16 quadrats.*

*Determining Quadrat Size.* Quadrat size and shape should be determined during the pilot study. In general, the quadrat size should be determined by the project area and the spatial distribution of the plants you are sampling (e.g., clumped, uniform). You should avoid a quadrat size that is small enough to render many zero measurements, meaning that no plants are encountered in the quadrat, and that is so large that hundreds of plants have to be measured in each quadrat. To determine an appropriate quadrat size and shape, first wander around the project site to get a feel for the spatial distribution of plants at the site, and then ask and answer the following questions (Elzinga et al. 1998): At what scale can you detect clumping? How large are the clumps and what are the distances between the clumps? How long will quadrats need to be to avoid having many quadrats with zero plants in them? How narrow will quadrats need to be to avoid counting hundreds of plants whenever the quadrat intersects a dense clump? How wide an area can be efficiently searched from one edge of a quadrat? Efficient sampling using quadrats of appropriate size and shape can greatly reduce the number of samples needed to be measured and, thus, reduce the overall time and resources needed for monitoring.

Reference: Elzinga, C.L., D.W. Salzer, J.W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. BLM Technical Reference 1730-1. Bureau of Land Management, Denver, Colorado.

**Table 2. Sample size correction table for single parameters.**

| 80% Confidence Level | | | | | | 90% Confidence Level | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| n | n* | n | n* | n | n* | n | n* | n | n* | n | n* |
| 1 | 5 | 51 | 65 | 101 | 120 | 1 | 5 | 51 | 65 | 101 | 120 |
| 2 | 6 | 52 | 66 | 102 | 121 | 2 | 6 | 52 | 66 | 102 | 122 |
| 3 | 7 | 53 | 67 | 103 | 122 | 3 | 8 | 53 | 67 | 103 | 123 |
| 4 | 9 | 54 | 68 | 104 | 123 | 4 | 9 | 54 | 69 | 104 | 124 |
| 5 | 10 | 55 | 69 | 105 | 124 | 5 | 11 | 55 | 70 | 105 | 125 |
| 6 | 11 | 56 | 70 | 106 | 125 | 6 | 12 | 56 | 71 | 106 | 126 |
| 7 | 13 | 57 | 71 | 107 | 126 | 7 | 13 | 57 | 72 | 107 | 127 |
| 8 | 14 | 58 | 73 | 108 | 128 | 8 | 15 | 58 | 73 | 108 | 128 |
| 9 | 15 | 59 | 74 | 109 | 129 | 9 | 16 | 59 | 74 | 109 | 129 |
| 10 | 17 | 60 | 75 | 110 | 130 | 10 | 17 | 60 | 75 | 110 | 130 |
| 11 | 18 | 61 | 76 | 111 | 131 | 11 | 18 | 61 | 76 | 111 | 131 |
| 12 | 19 | 62 | 77 | 112 | 132 | 12 | 20 | 62 | 78 | 112 | 132 |
| 13 | 20 | 63 | 78 | 113 | 133 | 13 | 21 | 63 | 79 | 113 | 134 |
| 14 | 22 | 64 | 79 | 114 | 134 | 14 | 22 | 64 | 80 | 114 | 135 |
| 15 | 23 | 65 | 80 | 115 | 135 | 15 | 23 | 65 | 81 | 115 | 136 |
| 16 | 24 | 66 | 82 | 116 | 136 | 16 | 25 | 66 | 82 | 116 | 137 |
| 17 | 25 | 67 | 83 | 117 | 137 | 17 | 26 | 67 | 83 | 117 | 138 |
| 18 | 27 | 68 | 84 | 118 | 138 | 18 | 27 | 68 | 84 | 118 | 139 |
| 19 | 28 | 69 | 85 | 119 | 140 | 19 | 28 | 69 | 85 | 119 | 140 |
| 20 | 29 | 70 | 86 | 120 | 141 | 20 | 29 | 70 | 86 | 120 | 141 |
| 21 | 30 | 71 | 87 | 121 | 142 | 21 | 31 | 71 | 88 | 121 | 142 |
| 22 | 31 | 72 | 88 | 122 | 143 | 22 | 32 | 72 | 89 | 122 | 143 |
| 23 | 33 | 73 | 89 | 123 | 144 | 23 | 33 | 73 | 90 | 123 | 144 |
| 24 | 34 | 74 | 90 | 124 | 145 | 24 | 34 | 74 | 91 | 124 | 145 |
| 25 | 35 | 75 | 91 | 125 | 146 | 25 | 35 | 75 | 92 | 125 | 147 |
| 26 | 36 | 76 | 93 | 126 | 147 | 26 | 37 | 76 | 93 | 126 | 148 |
| 27 | 37 | 77 | 94 | 127 | 148 | 27 | 38 | 77 | 94 | 127 | 149 |
| 28 | 38 | 78 | 95 | 128 | 149 | 28 | 39 | 78 | 95 | 128 | 150 |
| 29 | 40 | 79 | 96 | 129 | 150 | 29 | 40 | 79 | 96 | 129 | 151 |
| 30 | 41 | 80 | 97 | 130 | 151 | 30 | 41 | 80 | 97 | 130 | 152 |
| 31 | 42 | 81 | 98 | 131 | 152 | 31 | 42 | 81 | 99 | 131 | 153 |
| 32 | 43 | 82 | 99 | 132 | 154 | 32 | 44 | 82 | 100 | 132 | 154 |
| 33 | 44 | 83 | 100 | 133 | 155 | 33 | 45 | 83 | 101 | 133 | 155 |
| 34 | 45 | 84 | 101 | 134 | 156 | 34 | 46 | 84 | 102 | 134 | 156 |
| 35 | 47 | 85 | 102 | 135 | 157 | 35 | 47 | 85 | 103 | 135 | 157 |
| 36 | 48 | 86 | 104 | 136 | 158 | 36 | 48 | 86 | 104 | 136 | 158 |
| 37 | 49 | 87 | 105 | 137 | 159 | 37 | 49 | 87 | 105 | 137 | 159 |
| 38 | 50 | 88 | 106 | 138 | 160 | 38 | 50 | 88 | 106 | 138 | 161 |
| 39 | 51 | 89 | 107 | 139 | 161 | 39 | 52 | 89 | 107 | 139 | 162 |
| 40 | 52 | 90 | 108 | 140 | 162 | 40 | 53 | 90 | 108 | 140 | 163 |
| 41 | 53 | 91 | 109 | 141 | 163 | 41 | 54 | 91 | 110 | 141 | 164 |
| 42 | 55 | 92 | 110 | 142 | 164 | 42 | 55 | 92 | 111 | 142 | 165 |
| 43 | 56 | 93 | 111 | 143 | 165 | 43 | 56 | 93 | 112 | 143 | 166 |
| 44 | 57 | 94 | 112 | 144 | 166 | 44 | 57 | 94 | 113 | 144 | 167 |
| 45 | 58 | 95 | 113 | 145 | 168 | 45 | 58 | 95 | 114 | 145 | 168 |
| 46 | 59 | 96 | 115 | 146 | 169 | 46 | 60 | 96 | 115 | 146 | 169 |
| 47 | 60 | 97 | 116 | 147 | 170 | 47 | 61 | 97 | 116 | 147 | 170 |
| 48 | 61 | 98 | 117 | 148 | 171 | 48 | 62 | 98 | 117 | 148 | 171 |
| 49 | 62 | 99 | 118 | 149 | 172 | 49 | 63 | 99 | 118 | 149 | 172 |
| 50 | 64 | 100 | 119 | 150 | 173 | 50 | 64 | 100 | 119 | 150 | 173 |

**Table 2. (cont.)**

| 95% Confidence Level | | | | | | 99% Confidence Level | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| n | n* | n | n* | n | n* | n | n* | n | n* | n | n* |
| 1 | 5 | 51 | 66 | 101 | 121 | 1 | 6 | 51 | 67 | 101 | 122 |
| 2 | 7 | 52 | 67 | 102 | 122 | 2 | 8 | 52 | 68 | 102 | 123 |
| 3 | 8 | 53 | 68 | 103 | 123 | 3 | 9 | 53 | 69 | 103 | 124 |
| 4 | 10 | 54 | 69 | 104 | 124 | 4 | 11 | 54 | 70 | 104 | 126 |
| 5 | 11 | 55 | 70 | 105 | 125 | 5 | 12 | 55 | 72 | 105 | 127 |
| 6 | 12 | 56 | 71 | 106 | 126 | 6 | 14 | 56 | 73 | 106 | 128 |
| 7 | 14 | 57 | 72 | 107 | 128 | 7 | 15 | 57 | 74 | 107 | 129 |
| 8 | 15 | 58 | 74 | 108 | 129 | 8 | 16 | 58 | 75 | 108 | 130 |
| 9 | 16 | 59 | 75 | 109 | 130 | 9 | 18 | 59 | 76 | 109 | 131 |
| 10 | 18 | 60 | 76 | 110 | 131 | 10 | 19 | 60 | 77 | 110 | 132 |
| 11 | 19 | 61 | 77 | 111 | 132 | 11 | 20 | 61 | 78 | 111 | 133 |
| 12 | 20 | 62 | 78 | 112 | 133 | 12 | 21 | 62 | 79 | 112 | 134 |
| 13 | 21 | 63 | 79 | 113 | 134 | 13 | 23 | 63 | 80 | 113 | 135 |
| 14 | 23 | 64 | 80 | 114 | 135 | 14 | 24 | 64 | 82 | 114 | 136 |
| 15 | 24 | 65 | 81 | 115 | 136 | 15 | 25 | 65 | 83 | 115 | 138 |
| 16 | 25 | 66 | 83 | 116 | 137 | 16 | 26 | 66 | 84 | 116 | 139 |
| 17 | 26 | 67 | 84 | 117 | 138 | 17 | 28 | 67 | 85 | 117 | 140 |
| 18 | 28 | 68 | 85 | 118 | 139 | 18 | 29 | 68 | 86 | 118 | 141 |
| 19 | 29 | 69 | 86 | 119 | 141 | 19 | 30 | 69 | 87 | 119 | 142 |
| 20 | 30 | 70 | 87 | 120 | 142 | 20 | 31 | 70 | 88 | 120 | 143 |
| 21 | 31 | 71 | 88 | 121 | 143 | 21 | 32 | 71 | 89 | 121 | 144 |
| 22 | 32 | 72 | 89 | 122 | 144 | 22 | 34 | 72 | 90 | 122 | 145 |
| 23 | 34 | 73 | 90 | 123 | 145 | 23 | 35 | 73 | 92 | 123 | 146 |
| 24 | 35 | 74 | 91 | 124 | 146 | 24 | 36 | 74 | 93 | 124 | 147 |
| 25 | 36 | 75 | 92 | 125 | 147 | 25 | 37 | 75 | 94 | 125 | 148 |
| 26 | 37 | 76 | 94 | 126 | 148 | 26 | 38 | 76 | 95 | 126 | 149 |
| 27 | 38 | 77 | 95 | 127 | 149 | 27 | 39 | 77 | 96 | 127 | 150 |
| 28 | 39 | 78 | 96 | 128 | 150 | 28 | 41 | 78 | 97 | 128 | 152 |
| 29 | 41 | 79 | 97 | 129 | 151 | 29 | 42 | 79 | 98 | 129 | 153 |
| 30 | 42 | 80 | 98 | 130 | 152 | 30 | 43 | 80 | 99 | 130 | 154 |
| 31 | 43 | 81 | 99 | 131 | 154 | 31 | 44 | 81 | 100 | 131 | 155 |
| 32 | 44 | 82 | 100 | 132 | 155 | 32 | 45 | 82 | 101 | 132 | 156 |
| 33 | 45 | 83 | 101 | 133 | 156 | 33 | 46 | 83 | 103 | 133 | 157 |
| 34 | 46 | 84 | 102 | 134 | 157 | 34 | 48 | 84 | 104 | 134 | 158 |
| 35 | 48 | 85 | 103 | 135 | 158 | 35 | 49 | 85 | 105 | 135 | 159 |
| 36 | 49 | 86 | 105 | 136 | 159 | 36 | 50 | 86 | 106 | 136 | 160 |
| 37 | 50 | 87 | 106 | 137 | 160 | 37 | 51 | 87 | 107 | 137 | 161 |
| 38 | 51 | 88 | 107 | 138 | 161 | 38 | 52 | 88 | 108 | 138 | 162 |
| 39 | 52 | 89 | 108 | 139 | 162 | 39 | 53 | 89 | 109 | 139 | 163 |
| 40 | 53 | 90 | 109 | 140 | 163 | 40 | 55 | 90 | 110 | 140 | 165 |
| 41 | 54 | 91 | 110 | 141 | 164 | 41 | 56 | 91 | 111 | 141 | 166 |
| 42 | 56 | 92 | 111 | 142 | 165 | 42 | 57 | 92 | 112 | 142 | 167 |
| 43 | 57 | 93 | 112 | 143 | 166 | 43 | 58 | 93 | 114 | 143 | 168 |
| 44 | 58 | 94 | 113 | 144 | 168 | 44 | 59 | 94 | 115 | 144 | 169 |
| 45 | 59 | 95 | 114 | 145 | 169 | 45 | 60 | 95 | 116 | 145 | 170 |
| 46 | 60 | 96 | 116 | 146 | 170 | 46 | 61 | 96 | 117 | 146 | 171 |
| 47 | 61 | 97 | 117 | 147 | 171 | 47 | 62 | 97 | 118 | 147 | 172 |
| 48 | 62 | 98 | 118 | 148 | 172 | 48 | 64 | 98 | 119 | 148 | 173 |
| 49 | 63 | 99 | 119 | 149 | 173 | 49 | 65 | 99 | 120 | 149 | 174 |
| 50 | 65 | 100 | 120 | 150 | 174 | 50 | 66 | 100 | 121 | 150 | 175 |

How long to monitor. From the standpoint of the biota, a 20-year monitoring period is not unreasonable. It may take longer for the restored marsh to fully develop its potential as *habitat for rare species such as endangered birds or for the soil organic matter to increase to* natural levels. It may take even longer for herbivory problems to become controlled by native predators. Long-term monitoring allows one to distinguish between short-term shifts (*e.g.*, annual variability in shorebird use) and long-term directional changes (*e.g.*, expansion of marsh, declines of endangered bird populations).

This Program is intended to be implemented over a 10-year period, however, it is designed to be implemented for five years at which time a decision point to continue for the remaining five years will be addressed. A summary of the physical, biological and chemical monitoring, along with schedules and contingencies, can be found in Table 1 (Appendix E).

## 3.0 REFERENCE SITES

The criteria for reference sites are based upon a restoration project's similarity or intended similarity to another restored or natural site. Simply stated, if a constructed marsh is intended to develop into a habitat like the Nisqually River delta, then it will be compared to the Nisqually system. If a cobble shoreline is being preserved and intended to perform the same functions as the Dumas Bay shoreline, it will be compared to the Dumas Bay shoreline using the criterion described previously in Section 2. For example, physical features, such as substrate type and slope (*e.g., the fine sediments and gentle slopes of the Nisqually delta), will be* contrasted with comparable physical features at the restored project sites in Commencement Bay. The specific monitoring to be undertaken at the reference sites will be determined by the project specific monitoring plans.

The data gathered at the reference sites will be used to formulate hypotheses regarding habitats:

- Function;
- Climate and hydrology;
- Influences of human access and economic activities;
- Size, morphology, water depth, wetland zones, and their proportion;
- General vegetation types and requirements;
- Soils and non-soil substrates; and
- Access and use by fish and wildlife.

## 4.0 ADAPTIVE MANAGEMENT (CONTINGENCY PLANNING)

The criteria established in the Program are defined by the Trustees' restoration goals and objectives and serve as a means of determining the triggers for mid-course corrections. The contingency measures are based upon scientific principles, best professional judgment, local knowledge, and an evolving understanding of natural processes in the Commencement Bay environment. A mid-course correction would involve going from a less intrusive to a more intensive solution depending upon the nature and type of problem. For example, if the Trustees believe, based upon monitoring results, that there is a slope stability issue at a particular site then their first steps would include adjustments using non-engineered controls such as planting different species and the placement of erosion control mats. If the problem is not mitigated through such actions, more engineered methods such as wave action controls (*e.g.*, booms) might be installed. In severe cases, fish-rock might be placed in problem areas.

## 5.0 VOLUNTEER / STEWARDSHIP PARTICIPATION

The Trustees strongly believe that a successful restoration project depends on the interest and investment of the community in which it resides and grows. For this reason, the Trustees will be identifying particular activities that could be successfully conducted in cooperation with area volunteer groups. This may include, but is not limited to, such actions as planting native vegetation, destroying or weeding of invasive species, vegetation sampling, and bird monitoring. Each project's specific monitoring plan will outline potential activities and education opportunities for volunteers and site stewards.

## 6.0 BUDGET

The budget for the Program is dependent upon the complexity of the individual restoration projects, the number and type of criteria which will be used to evaluate the project, and the number of sites being monitored. There is an economy of scale and each additional site may not have an equal increase in the cost. Detailed budgets will be prepared for individual plans once the Trustees determine the final level of sampling effort. These individual plans will be attached to this document at Appendix G.

## 7.0 REPORTING/DATABASES

Databases and reports will be developed in order for the Trustees to analyze and interpret the physical, biological, and if triggered, the chemical trends, occurring at the restored areas in contrast with the selected reference sites. Monitoring reports will be produced in Years 1, 2, 3, 5, and Years 7 and 10 if funding is available. Each report will take into consideration all previous monitoring years and findings. At a minimum, the reports will summarize:

- Monitoring tasks completed (methods, sampling locations, dates),
- Data and monitoring results,
- Status of projects sites,
- Trends in data for both individual sites and the overall program in relation to goals and objectives,
- "Triggers" indicating the need for contingencies and adaptive management,
- External conditions which may be influencing results,
- Recommendations and alternatives for action,

- Recommendations for future planning,
- An overall comparison of how each site is developing, and
- *Lessons learned for the individual projects and the Program.*

A draft report will be submitted to the Commencement Bay Natural Resource Trustee Council for review and comment within three months of completion of an annual sampling period. The Trustee Council may request an oral presentation of the results. Adaptive management/contingency planning will be initiated and approved by the Trustee Council. The Final Monitoring Report will incorporate Trustee comments and any planned adaptive management activities.

## *8.0 CONCLUSION*

The Trustees are initiating this CB/NRDA Monitoring Program to evaluate all of their restoration projects in Commencement Bay. The Trustees believe that this plan could serve, in part, as the basis for an intertidal monitoring regime under a regional monitoring program. The Trustees believe that monitoring programs should be developed that use similar assumptions and protocols to ensure consistency and a correspondence in measurements of the physical, biological and chemical attributes among restoration projects in the Puget Sound region.

This Program will be updated to reflect improvements in technology and our continually evolving knowledge and understanding about natural and modified environments. The intent in the Program is to evaluate the success of the goals and objectives of the NRDA restoration projects. The Program will be periodically reviewed to ensure that it is producing the type of data necessary to achieve its overall goals and maintain its usefulness.

The following sections define the criteria, methodologies, success criteria, contingency measures and sampling schedules for the selected reference sites and the NRDA restoration project sites covered under this Program. A summary table (Table 1 in Appendix E) contains the components of the program in tabular format.

## 9.0 REFERENCES

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