# 5.0 PLAN EVALUATION

The final array of alternatives are first described, and then evaluated. Each plan is independently evaluated and compared to the No Action plan. In the Plan Evaluation step, factors such as short and long term environmental impacts, short and long term environmental benefits, costs, and "implementability" are taken into consideration. From the Incremental Cost Analysis, which compares the costs to the benefits, the National Ecosystem Restoration (NER) Plan is identified, which serves as the basis for project cost sharing.

## 5.1 Restoration Plans Identified in the Draft Feasibility Report

The plans identified in the Draft Feasibility Report are described below. *It should be noted that the Locally Preferred Plan (LPP) will not officially be selected or approved by the local sponsor until after the public review process. The LPP identified in this Draft Feasibility Report is the "tentatively selected LPP;" the Recommended Plan will not be finalized until the Final Feasibility Report, after continuing coordination with the local sponsor, results of the public review and public involvement process, and continuing refined evaluation of the ecosystem restoration alternatives.*

### 5.1.1 National Ecosystem Restoration Plan

The (NER) Plan is identified by the Federal government as the plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective. It is cost-effective and justified to achieve the desired level of outputs. The NER plan is the restoration alternative that the Federal government will recommend in the Final Feasibility report, unless an exemption from the NER is required, as with a Locally Preferred Plan, for example. The Federal government will cost share up to the price of the NER plan, at 65% Federal and 35% Non-Federal.

### 5.1.2 Locally Preferred Plan

LPP's may be identified in the Draft Feasibility report if the NER, or increments of the NER, are not supported by the public; do not include particular increments desirable to the local sponsor; or are not implementable because of management or funding constraints of the local sponsor. When the LPP is clearly of lesser scope and cost, and meets the Administration's policies for high-priority outputs, the Assistant Secretary for the Army (Civil Works) usually grants an exception for deviation. The increased scope of any plan more expensive than the NER would not warrant Federal cost-sharing participation. Thus, if the Locally Preferred Plan were larger in scope than the NER, the local sponsor would pay 100% of the difference between that plan and the NER.

### 5.1.3 Environmentally Preferred Plan

In the Draft EIS/R, an Environmentally Preferred Plan (EPP) will be identified under the California Environmental Quality Act (CEQA), based on an analysis of the short and long term impacts and benefits of each restoration alternative. It is possible that the Environmentally Preferred Plan will be the same as the NER and the LPP, but it may also be different. Some increments of the EPP may not warrant full Federal cost-sharing participation, be locally supported, or be capable of being financed by the local sponsor. In such a case, it would not be the recommended plan as presented in the Draft Feasibility and Draft EIS/R reports.

### 5.1.4 Recommended Plan

The Draft Feasibility report will present a "tentatively recommended plan" based on the analyses conducted to date. This tentatively recommended plan might be the NER plan, the LPP, the EPP, or a plan that is a combination thereof. As stated previously, the Federal government will share costs up to the cost of the NER plan. If the recommended plan were more expensive than the NER, the remaining cost would be the responsibility of the local sponsor to pay. A final recommendation will not be made until after the public review period, and will be based on public comments. The final recommended plan will appear in the Final Feasibility Report and Final EIS/R.

## 5.2 Plan Evaluation Tools

### 5.2.1 Hydraulic Modeling

To provide some insight into the lagoon's hydraulic conditions, including water levels and velocities, with each alternative constructed, a two dimensional (2D) hydrodynamic numerical model was used. The model used for this study was the Mike21 finite difference model from the Danish Hydraulic Institute (DHI). The model helped to confirm water level change trends, and provided channel velocities for the lagoon, illustrating potential scour (erosion) areas and other problem areas associated with the design of the alternatives. Although models provide important information, they must be used with caution. In addition to the normal shortfalls of any model, the fact that the Mike21 model lacks a movable bed (sediment transport) component must be considered when looking at the results. The background behind the hydraulic modeling and the results of the model runs can be found in the Engineering Appendix.

Because significant sediment movement will occur after construction, the hydrodynamics of the lagoon will probably change after construction. In order to better understand the relationship between the hydrodynamics and sediment movement in the lagoon, sediment transport modeling will be performed in the Pre-Construction Engineering and Design (PED) phase of the project. The results of this modeling will help fine-tune the final design of the restoration alternatives.

### 5.2.2 Habitat Evaluation Tools *Not* Used

#### 5.2.2.1 Habitat Evaluation Procedures (HEP)

The US Fish and Wildlife Service determined that a full HEP analysis was not appropriate for Bolinas Lagoon because of the limitations of HEP in showing habitat functions and benefits in an estuarine system. However, a modified HEP analysis using cover type as a proxy for habitat evaluation was put together for the Draft Coordination Act Report, which appears as an appendix to the Feasibility Report. Although HEP can be used for terrestrial systems and has been adapted for use in wetland areas, as of yet, there have not been any HEP models developed for an estuarine lagoon system. Habitat Units are easy to work with and understand, but unfortunately, a full HEP analysis was not appropriate in this case.

#### 5.2.2.2 Numbers of Species

Numbers of species were also not used as an indicator of project success because of our inability to predict changes in the system after a given stimulus, as well as our inability to decipher (due to a lack of historical ecological data and natural fluctuations in wildlife populations) short term and long term changes in the lagoon. That is, we would not be able to come up with an accurate number of population increase for any particular species because of larger, regional trends in those species or other factors unrelated to Bolinas Lagoon. In addition, because this kind of project has not been conducted before, it would be impractical to predict the exact outcome for any particular species. Using numbers of species as an indicator of project success would yield results with a high degree of uncertainty.

### 5.2.3 Habitat Evaluation Expert Panel (HEEP)

Because of the complexity of Bolinas Lagoon and the link between the hydrology and the biology, the Bolinas Lagoon Executive Committee convened a panel of experts – hydrologists and biologists familiar with the lagoon – to evaluate the alternatives. Modeled after the expert panel used in the Everglades project, and supported by the South Pacific Division, the Habitat Evaluation Expert Panel (HEEP) helped improve the plan formulation process and evaluate the acceptability and effectiveness of the alternatives. The following organizations made up the body of the expert panel: California Department Fish & Game, College of Marin, Gulf of the Farallones National Marine Sanctuary, Point Reyes Bird Observatory, Regional Water Quality Control Board, United States Geological Survey, Audubon Canyon Ranch, United States Fish & Wildlife Service, Golden Gate National Recreation Area, and Point Reyes National Seashore. In addition to the panel, the Corps provided a member of its staff to chair the meetings, a court reporter to make a record of the meetings, and the Bolinas Lagoon Project Team to answer any technical questions. As stated in the HEEP summary report:

> "Considering the complexity of the Bolinas Lagoon environment, as well as the interested and concerned participation of local residents, organizations and agencies, the Bolinas Lagoon Team (including the Corps and the local sponsor)

> [sought] the advice of an expert panel to evaluate each of the proposed project alternatives based on habitat considerations. By seeking the advice and consensus of a panel of experts, we hoped to discern the most effective, efficient and acceptable alternative for accomplishing the objectives of the project. As stated in the Project Study Plan (PSP), the Restoration Goals and Outputs for the Bolinas Lagoon Restoration Project are as follows:
>
> > 'The goal of the environmental restoration work performed at Bolinas Lagoon is to restore intertidal and subtidal habitat and stop further loss of these habitats through restoring tidal prism and improving circulation within the basin, while maintaining key mudflats, marsh vegetation, and other areas of biological importance. Although over the long term, sediment deposition will continue to fill the lagoon, this restoration project is intended to significantly slow the present rate of intertidal and subtidal habitat loss.'
>
> Through many hours of examination and discussion, the Habitat Evaluation Expert Panel has added integrity and durability to the plan formulation process and the analysis of the proposed restoration alternatives."

The HEEP succeeded in modifying the restoration components to make them more effective, expressed their concerns for particular species or groups of species, and identified the hydrological and ecological benefits of the project. Their analysis further promoted the project goals as stated in the PSP.

*Red, Yellow, Green – Ranking the Restoration Components*

As in the Everglades project, the HEEP was originally charged with evaluating the alternatives using a Red-Yellow-Green evaluation system. Red = no, or yes only with significant changes; Yellow = concerns exist, but some modification might appease those concerns; Green = yes. The panel, however, decided that all of the restoration components were different shades of Green; none were Yellow or Red. Because of the significant link between the hydrology and the ecology, the panel decided that any improvement in the hydrology would bring a concomitant improvement in the ecology. This is especially true because of how the alternatives were designed – to mimic historical conditions in the lagoon. One significant result of this analysis was that the panel concluded all of the restoration components were environmentally acceptable.

*The Link Between Hydrology and Ecology*

Since the panel was unable to differentiate the alternatives using the Red-Yellow-Green approach, they were then charged with ranking the alternatives based on their ecological benefit to the lagoon. It was apparent, however, after many hours of discussion, that it was impossible to separate the hydrology from the biology. The panel could establish ecological criteria, but they were unable to rank the alternatives against those criteria because they felt that each criterion had an intrinsic value that could not be ranked above or below another. Furthermore, because each criterion was associated with different hydrological criteria, it was impossible to separate the two, or even justify doing so. As a result, the panel decided to list the ecological and hydrological factors that should be considered when evaluating the components to see if a common link between the two could be found to use for the comparison. Looking at the list of target habitats desired by the panel (ecological factors), and the habitats associated with improving the hydrology of the system (hydrological factors), it became clear that the two were linked.

Target Habitats (Ecological): Shallow subtidal, subtidal, intertidal mudflats, emergent salt marsh, eelgrass, terrestrial, riparian or transition, and tidal nursery habitat

Habitat (Hydraulic): Quantity (or volume) of intertidal and subtidal habitats

The panel also noted what ecological benefits would arise from an increase in intertidal and subtidal habitats. They assumed, for example, that an increase in subtidal habitat would bring about a benefit to fisheries, diving birds, and foraging seals, as well as create the potential for the return of eelgrass once present in the lagoon. A benefit to fisheries in the lagoon would also increase the value of the surrounding streams to the fish, creating an overall benefit for this group. These benefits are brought on by improved foraging habitat (due to an improved habitat for prey), improved rearing and nursery habitat, greater potential for escape from predators, and a greater diversification of habitats in the lagoon. The intertidal habitat zone is a source of food for many species higher in the food chain. The mudflats and wetland areas which serve as habitat for plants and invertebrates serve as feeding areas and nursery habitats for a variety of species. An increase in intertidal habitat is seen as an overall benefit to the lagoon system. Thus, since an increase in intertidal habitat brings about an increase in subtidal habitat, we can assume that the lagoon system would see an overall improvement (an improvement in hydrology and biology) if intertidal volume were increased.

After the panel determined that, not only could they not separate the biology from the hydrology, but that they were unable to rank the alternatives based on the criteria they had developed (after all, any of the restoration components would provide some level of benefit to the lagoon), the Corps suggested intertidal volume would be an appropriate parameter to use to demonstrate an overall benefit to the lagoon system. When this idea was presented to the expert panel, it was approved.

## 5.3 Project Benefits

As mentioned in Section 4.5 of this report (Formulation of Alternative Plans and Initial Screening), intertidal volume was selected as the hydrological parameter by which to measure benefits and compare alternative plans. Intertidal volume is measured in cubic yards, and represents an overall increase in tidal prism, intertidal and subtidal habitats, and a delay of inlet closure potential. This metric was used in the Incremental Cost Analysis, which is presented in Section 5.4.2 under Description of Costs.

### 5.3.1 Historical and Projected Volumes and Habitats

Tables 5.1 – 5.14 show the relationships between the Future Without Project Conditions (that is, what the lagoon would look like in the future with the No Action Plan) to each of the final alternatives. If no action is taken in the lagoon, and current management practices continue, subtidal and intertidal habitats can be expected to decrease at an accelerated rate because of past watershed practices that have already filled a significant portion of the lagoon. The expected losses in habitat between Year 1998 and Year 2008 are estimated to be 523,000 cy to 503,000 cy (a loss of 20,000 cy, or 3.8%) for subtidal habitat, and 3,585,000 cy to 3,242,000 cy (a loss of 343,000 cy, or 9.6%) for intertidal habitat. Between Years 1998 and 2058, the expected loss for subtidal habitat is estimated to be 523,000 cy to 411,000 cy (a loss of 112,000 cy, or 21.4%), and 3,585,000 cy to 1,677,000 cy (a loss of 908,000 cy, or 25.3%) for intertidal habitat. As illustrated in the table however, each restoration alternative plan would increase intertidal and subtidal habitat by varying amounts, "setting the clock back" to a greater or lesser degree. If the trend that was present from 1968 to 1998 were to continue in the future, the projected sediment discharge rate from the watershed is estimated to be 22,000 cy annually.

To facilitate analysis of the data, construction is assumed to take place in the year 2008, and data from 1998 is assumed the current condition. Construction could happen as soon as 2004, and could last as long as nine years (until 2013). Because bathymetries were taken every decade from 1968 – 1998, assuming construction in 2008 is a logical progression, and makes for easier calculations. In addition, because construction would span several years, it's easier to compare the data if it is assumed that construction is "instantaneous." 2008 is also the midway point between 2004 and 2013. For these reasons, 2008 is a convenient year to use for the construction date.

Intertidal and subtidal habitat levels associated with each alternative plan are illustrated in Figures 5.1 (intertidal surface area), 5.2 (intertidal volume), 5.3 (subtidal surface area), and 5.4 (subtidal volume). It is assumed that with construction of these alternative plans, water levels will change in the entire lagoon to reflect the change in equilibrium produced by increased tidal volume. Therefore, the larger the footprint an alternative has, the greater the relative increase in tidal volume that will result.

### 5.3.2 Inlet Closure and Tidal Prism Benefits

In addition to measuring habitat quantities, two key physical or hydraulic parameters were measured for each alternative. The first was tidal prism, determined using bathymetric data. In Chapter 4 (Figure 4.10), tidal prism is shown as intertidal volume since the definitions of each are nearly identical. The second was the "inlet closure index" formulated by O'Brien 1971, the time of potential inlet closure. This parameter is directly related to tidal prism. As tidal volume increases, more water flows through the inlet, which scours the inlet and keeps it open. As tidal volume decreases, less water flows through the inlet, allowing more sediment to deposit, leading to a less stable inlet, which is more prone to closing.

**Table 5.1 Historical Habitats**

| Year | Lagoon Volume (3.15' NGVD) cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 1968 | 6,489,855 | 155.82 | 7,634,688 | 876.12 | 5,580,284 | 213.38 | 641,298 |
| 1978 | 5,635,908 | 197.29 | 7,943,862 | 867.50 | 4,363,639 | 157.06 | 533,966 |
| 1988 | 5,390,737 | 243.43 | 7,894,691 | 844.65 | 3,868,717 | 127.25 | 690,093 |
| 1998 | 5,126,588 | 238.10 | 8,243,436 | 848.53 | 3,584,714 | 146.39 | 523,318 |

**Table 5.2 Without Project Habitats**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 4,883,508 | 252.77 | 8,351,980 | 843.61 | 3,228,889 | 134.45 | 502,281 |
| 2018 | 4,652,007 | 266.74 | 8,455,354 | 838.92 | 2,890,014 | 123.07 | 482,246 |
| 2038 | 4,223,741 | 292.59 | 8,646,590 | 830.25 | 2,263,112 | 102.03 | 445,183 |
| 2058 | 3,841,791 | 315.64 | 8,817,144 | 822.52 | 1,704,008 | 83.26 | 412,128 |

**Table 5.3 Projected Habitats with the North, Central (Estuarine), and South (Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 7,039,849 | 115.05 | 7,619,566 | 862.34 | 6,074,382 | 300.99 | 965,467 |
| 2018 | 6,808,347 | 136.60 | 7,492,470 | 882.57 | 6,046,498 | 229.03 | 668,861 |
| 2038 | 6,380,081 | 162.45 | 7,683,706 | 873.90 | 5,419,596 | 207.99 | 631,798 |
| 2058 | 5,998,132 | 185.50 | 7,854,260 | 866.17 | 4,860,493 | 189.22 | 598,743 |

**Table 5.4 Projected Habitats with the North, Central (Estuarine), and South (No Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,567,513 | 117.47 | 7,568,491 | 832.87 | 5,460,468 | 284.47 | 890,366 |
| 2018 | 6,336,011 | 165.11 | 7,703,385 | 873.01 | 5,355,085 | 205.82 | 627,984 |
| 2038 | 5,907,745 | 190.96 | 7,894,621 | 864.34 | 4,728,183 | 184.78 | 590,921 |
| 2058 | 5,525,796 | 214.01 | 8,065,175 | 856.61 | 4,169,080 | 166.01 | 557,866 |

**Table 5.5 Projected Habitats with the North, Central (Riparian), South (Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 7,031,522 | 119.59 | 7,599,700 | 856.68 | 6,061,159 | 301.96 | 970,362 |
| 2018 | 6,800,020 | 137.10 | 7,496,188 | 882.40 | 6,034,308 | 228.62 | 668,141 |
| 2038 | 6,371,754 | 162.95 | 7,687,424 | 873.73 | 5,407,407 | 207.58 | 631,078 |
| 2058 | 5,989,805 | 186.00 | 7,857,978 | 866.00 | 4,848,303 | 188.81 | 598,023 |

**Table 5.6 Projected Habitats with the North, Central (Riparian), South (No Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,559,185 | 121.97 | 7,547,720 | 827.31 | 5,448,416 | 285.39 | 894,995 |
| 2018 | 6,327,684 | 165.61 | 7,707,103 | 872.84 | 5,342,896 | 205.41 | 627,264 |
| 2038 | 5,899,418 | 191.46 | 7,898,339 | 864.17 | 4,715,994 | 184.37 | 590,201 |
| 2058 | 5,517,469 | 214.51 | 8,068,894 | 856.44 | 4,156,891 | 165.60 | 557,146 |

**Table 5.7 Projected Habitats with the North and Central (Estuarine) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,448,346 | 125.64 | 7,619,159 | 835.12 | 5,304,969 | 272.94 | 855,584 |
| 2018 | 6,216,845 | 172.30 | 7,756,597 | 870.60 | 5,180,648 | 199.97 | 617,671 |
| 2038 | 5,788,579 | 198.15 | 7,947,833 | 861.93 | 4,553,746 | 178.92 | 580,608 |
| 2058 | 5,406,630 | 221.20 | 8,118,387 | 854.20 | 3,994,643 | 160.15 | 547,553 |

**Table 5.8 Projected Habitats with the North and Central (Riparian) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,439,988 | 130.07 | 7,598,088 | 830.54 | 5,297,813 | 272.94 | 855,584 |
| 2018 | 6,208,486 | 172.81 | 7,760,329 | 870.43 | 5,168,412 | 199.56 | 616,948 |
| 2038 | 5,780,221 | 198.65 | 7,951,565 | 861.76 | 4,541,511 | 178.51 | 579,885 |
| 2058 | 5,398,271 | 221.70 | 8,122,120 | 854.03 | 3,982,407 | 159.74 | 546,830 |

**Table 5.9 Projected Habitats with the North and South (Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,422,586 | 179.78 | 7,816,253 | 802.28 | 5,099,668 | 295.64 | 1,019,817 |
| 2018 | 6,191,085 | 173.86 | 7,768,100 | 870.08 | 5,142,940 | 198.70 | 615,442 |
| 2038 | 5,762,819 | 199.70 | 7,959,336 | 861.41 | 4,516,038 | 177.66 | 578,379 |
| 2058 | 5,380,870 | 222.75 | 8,129,890 | 853.68 | 3,956,934 | 158.89 | 545,324 |

**Table 5.10 Projected Habitats with the North and South (No Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 5,950,250 | 197.41 | 7,807,015 | 744.03 | 4,458,622 | 292.70 | 930,011 |
| 2018 | 5,718,749 | 202.36 | 7,979,015 | 860.52 | 4,451,527 | 175.49 | 574,565 |
| 2038 | 5,290,483 | 228.21 | 8,170,251 | 851.85 | 3,824,625 | 154.45 | 537,502 |
| 2058 | 4,908,534 | 251.26 | 8,340,805 | 844.11 | 3,265,522 | 135.68 | 504,447 |

**Table 5.11 Projected Habitats with the Central (Estuarine) and South (Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,349,335 | 125.39 | 7,937,626 | 957.79 | 5,277,954 | 195.21 | 753,233 |
| 2018 | 6,117,834 | 178.28 | 7,800,809 | 868.59 | 5,035,713 | 195.10 | 609,103 |
| 2038 | 5,689,568 | 204.12 | 7,992,045 | 859.92 | 4,408,812 | 174.06 | 572,040 |
| 2058 | 5,307,618 | 227.18 | 8,162,599 | 852.19 | 3,849,708 | 155.29 | 538,985 |

**Table 5.12 Projected Habitats with the Central (Estuarine) and South (No Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 5,876,999 | 134.28 | 7,979,410 | 920.04 | 4,609,638 | 180.50 | 639,675 |
| 2018 | 5,645,497 | 206.78 | 8,011,724 | 859.03 | 4,344,301 | 171.89 | 568,226 |
| 2038 | 5,217,232 | 232.63 | 8,202,960 | 850.36 | 3,717,399 | 150.85 | 531,162 |
| 2058 | 4,835,282 | 255.68 | 8,373,515 | 842.63 | 3,158,295 | 132.08 | 498,108 |

**Table 5.13 Projected Habitats with the Central (Riparian) and South (Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 6,340,935 | 131.15 | 7,972,073 | 949.20 | 5,205,799 | 197.88 | 762,713 |
| 2018 | 6,109,434 | 178.78 | 7,804,560 | 868.42 | 5,023,418 | 194.69 | 608,376 |
| 2038 | 5,681,168 | 204.63 | 7,995,796 | 859.75 | 4,396,516 | 173.64 | 571,313 |
| 2058 | 5,299,218 | 227.68 | 8,166,350 | 852.02 | 3,837,412 | 154.88 | 538,258 |

**Table 5.14 Projected Habitats with the Central (Riparian) and South (No Seadrift) Alternative Plan**

| Year | Lagoon Volume cy | Upland acres | Upland cy | Intertidal acres | Intertidal cy | Subtidal acres | Subtidal cy |
|---|---|---|---|---|---|---|---|
| 2008 | 5,868,599 | 138.62 | 7,974,763 | 914.30 | 4,583,171 | 181.75 | 642,561 |
| 2018 | 5,637,098 | 207.29 | 8,015,475 | 858.86 | 4,332,005 | 171.48 | 567,499 |
| 2038 | 5,208,832 | 233.14 | 8,206,711 | 850.19 | 3,705,103 | 150.43 | 530,435 |
| 2058 | 4,826,882 | 256.19 | 8,377,265 | 842.46 | 3,146,000 | 131.66 | 497,381 |

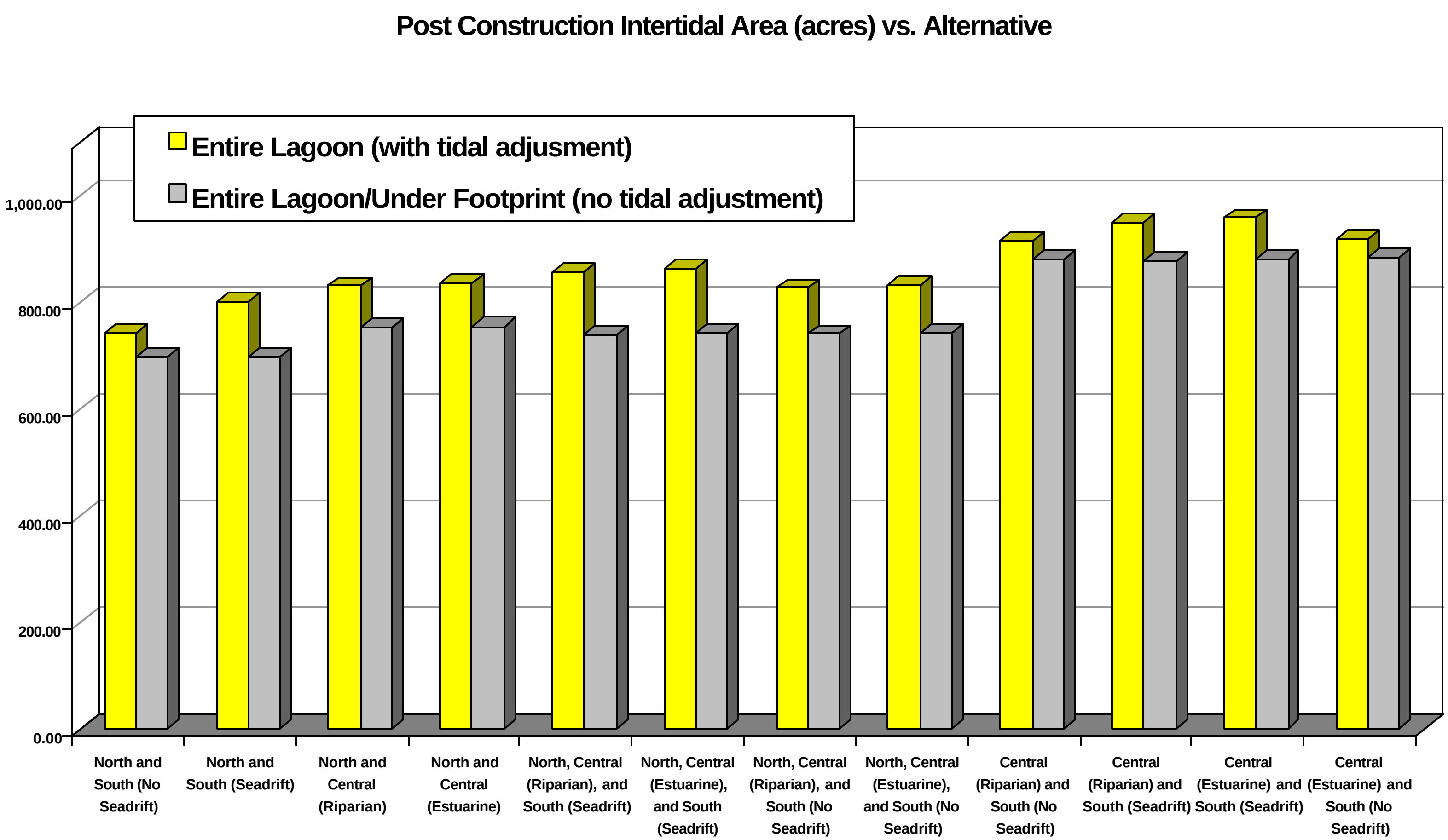


*Figure 5.1 Intertidal Habitat Surface Area Changes with Each Alternative Plan*

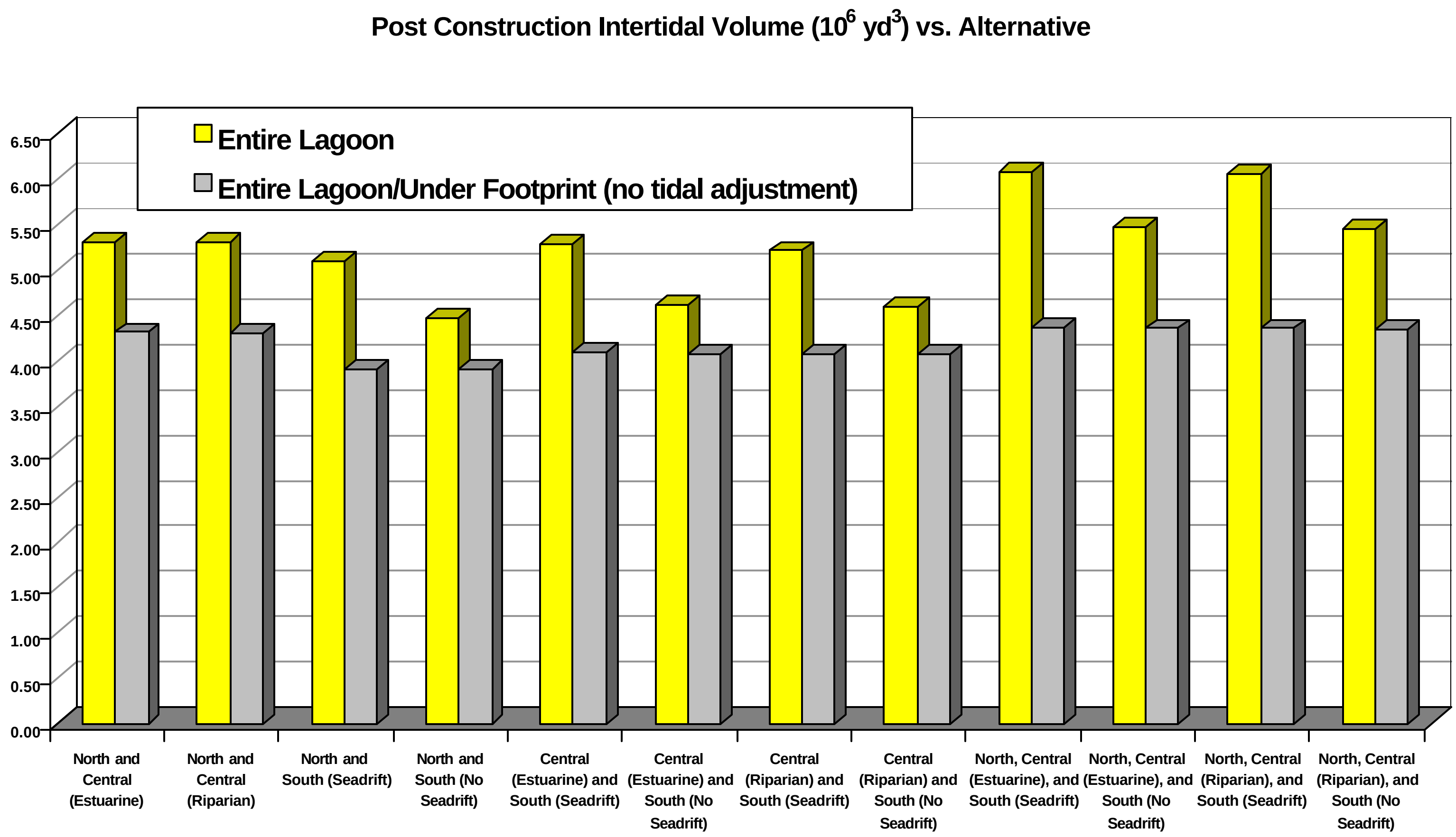


*Figure 5.2 Intertidal Habitat Volume Changes with Each Alternative Plan*

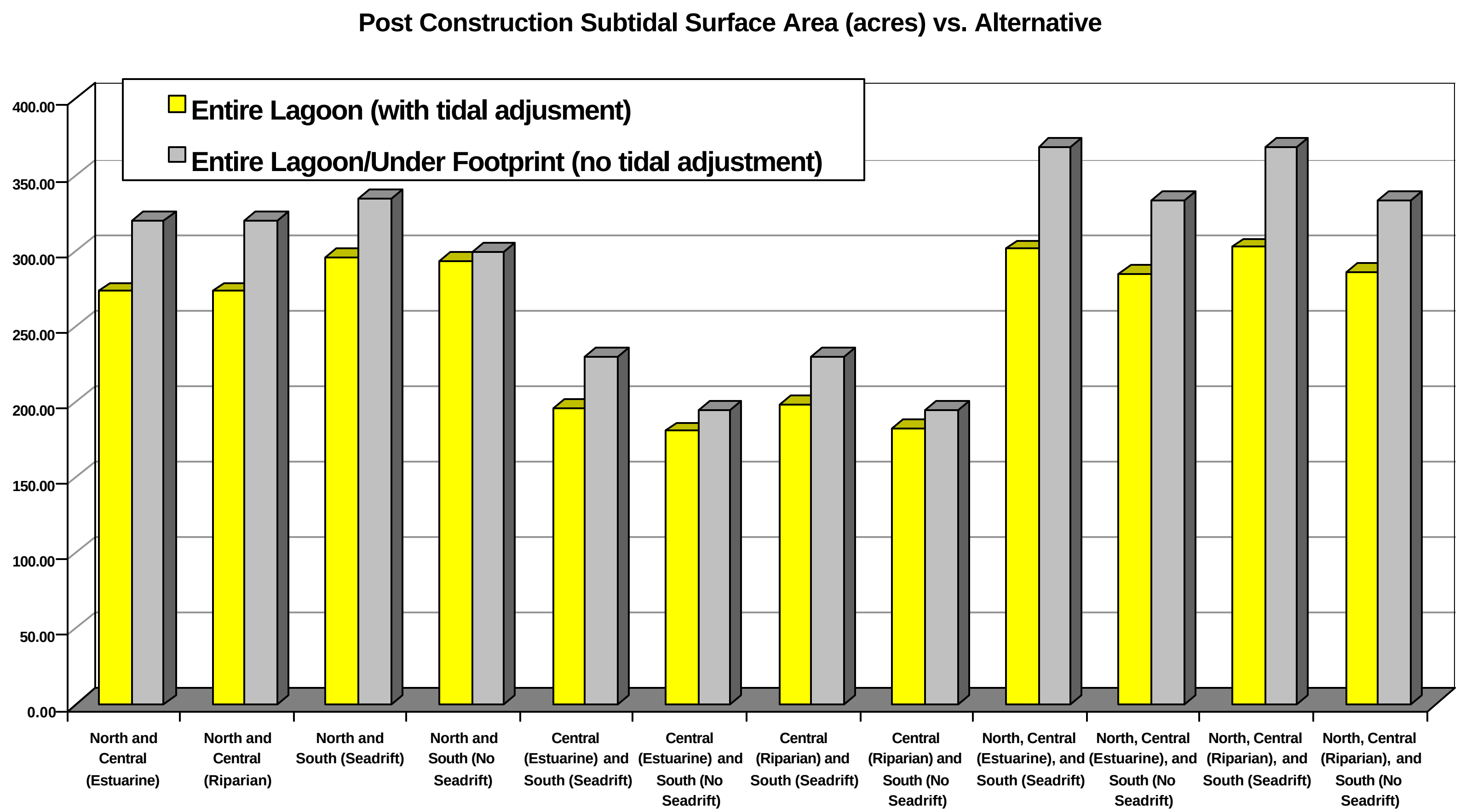


*Figure 5.3 Subtidal Habitat Surface Area Changes with Each Alternative Plan*

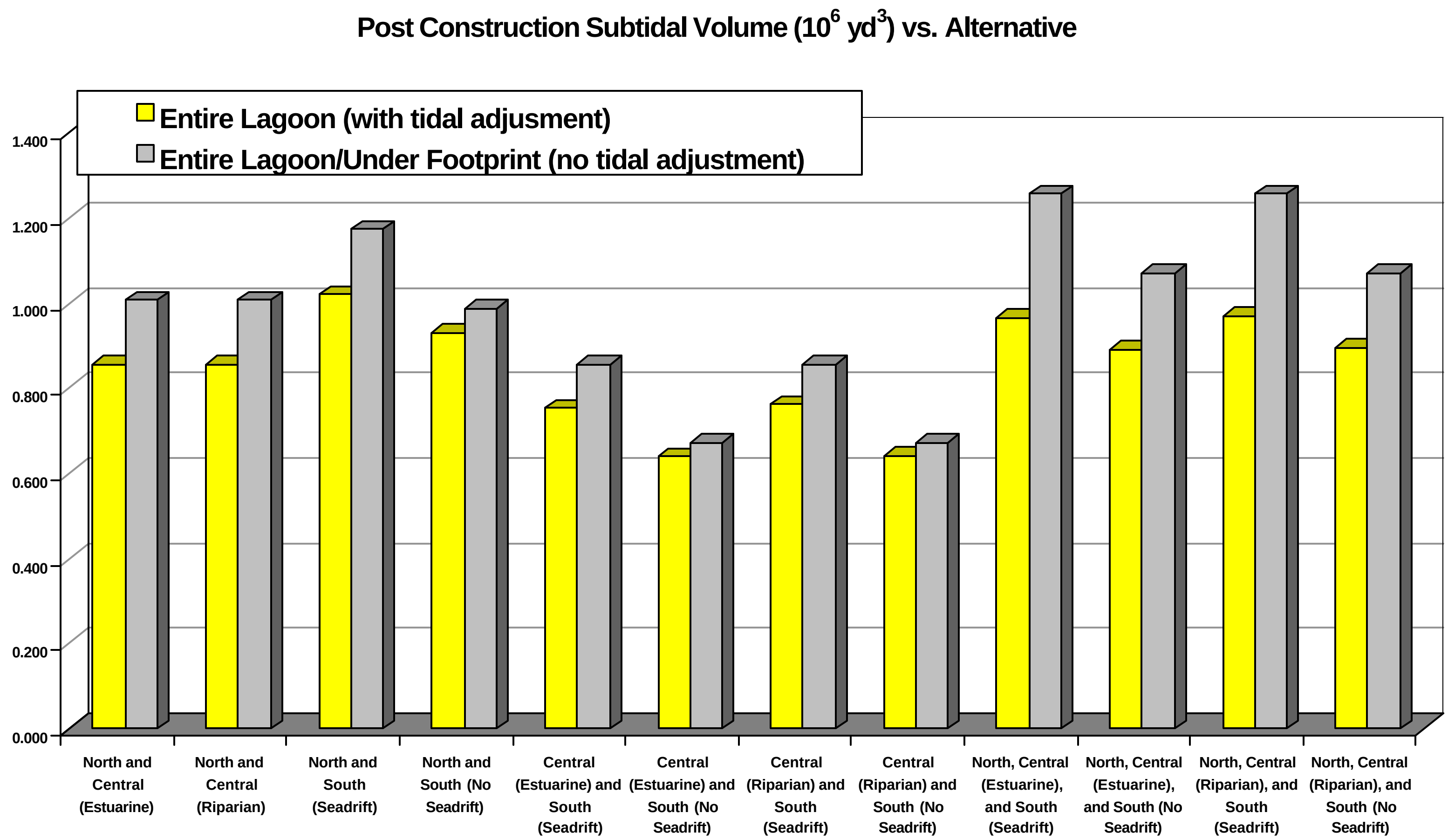


*Figure 5.4 Subtidal Habitat Volume Changes with Each Alternative Plan*

Table 5.15 shows the closure index for 1998 and the resulting closure index for each alternative (including the No Action alternative) out to the year 2058. In the Without Project Condition, under a worst-case scenario, the inlet could close by 2048. Worst case means a large storm (big waves), with little rain over the lagoon's watershed (minimal fresh water input), during a neap tidal cycle (low tidal flow through inlet).

The lower the index number, the less likely the lagoon inlet will experience temporary closure. As Table 5.15 illustrates, the alternative plans that have a larger footprint have lower inlet closure indices, ranging from as low as 8.8, with the full construction alternative plan [North, Central (Estuarine), South (Seadrift)], to 14.0 with the smallest alternative plan [South (No Seadrift)]. The data illustrate how each alternative plan affects future inlet closure potential. With the full construction alternative plan, for example, the inlet would be more stable in 2058 than it is now, 8.8 is lower than 10.5, and it would be far more stable than if no project were constructed, 8.8 is significantly lower than 16.2.

**Table 5.15 Inlet Stability***

| Alternative | Year | | | | |
|---|---|---|---|---|---|
| | 1998 | 2008 | 2018 | 2038 | 2058 |
| Without Project | 10.5 | 11.2 | 12.0 | 13.9 | 16.1 |
| Central (Estuarine) and South (Seadrift) | | 8.4 | 8.5 | 9.4 | 10.4 |
| Central (Estuarine) and South (No Seadrift) | | 9.0 | 9.4 | 10.5 | 11.7 |
| Central (Riparian) and South (Seadrift) | | 8.4 | 8.5 | 9.5 | 10.4 |
| Central (Riparian) and South (No Seadrift) | | 9.0 | 9.4 | 10.5 | 11.8 |
| North and South (Seadrift) | | 8.5 | 8.2 | 9.0 | 9.9 |
| North and South (No Seadrift) | | 9.0 | 9.0 | 10.0 | 11.1 |
| North and Central (Estuarine) | | 8.2 | 8.2 | 9.1 | 10.0 |
| North and Central (Riparian) | | 8.2 | 8.2 | 9.1 | 10.0 |
| North, Central (Estuarine), and South (Seadrift) | | 7.6 | 7.4 | 8.1 | 8.8 |
| North, Central (Estuarine), and South (No Seadrift) | | 8.1 | 8.0 | 8.8 | 9.7 |
| North, Central (Riparian), and South (Seadrift) | | 7.6 | 7.4 | 8.1 | 8.8 |
| North, Central (Riparian), and South (No Seadrift) | | 8.1 | 8.0 | 8.8 | 9.7 |

*closure can occur at condition index of 15

### 5.3.3 Habitat-Based Analysis for Lesser Scaup

This Feasibility Study evaluates an array of alternatives that would increase the tidal prism, enlarge the volume of water in the lagoon, and retard the successional processes that have been converting the lagoon to dry land. While the action alternatives would certainly achieve the physical outputs of improved water quality and sediment flux, these structural components are not, per se, ecological benefits. To further demonstrate the ecological benefits of the project, which are associated with an increase in water volume and surface area, an analysis was conducted to show habitat benefits to one particular species in the diving duck guild, the Lesser Scaup (*Athya affinis*).

Since the restoration alternatives would bring the lagoon bathymetry back to a historical condition (around the 1950's), we would expect to see an increase in the species that are dependent on lower intertidal and subtidal habitat, which have decreased as the lagoon has become shallower. Using available historical data, resource losses and losses in tidal volume have been assessed, tying in the goals of the restoration effort to the restoration benefits that are expected to occur with increases in tidal volume and habitat acreages. This data, along with information on the historic utilization of the lagoon complex by fish and wildlife resources, has been used to evaluate the positive correlation between intertidal volumes and habitat output benefits.

Along with the physical changes of the lagoon, stakeholders have observed a decline in the numbers of migratory waterfowl using the lagoon. Wild populations vary in size over time and space, making it difficult to quantify trends in abundance with census data from any one location. However, coastal lagoons like Bolinas provide very significant feeding and resting habitat for birds that use shallow water habitat, and the conversion of shallow water habitat to mudflat or upland could have a significant adverse impact on waterfowl. As seen in Table 5.2, there has been a 53% reduction in shallow water habitat suitable for diving waterfowl between 1968 and 1998. Project alternatives have the potential to make a substantial increase in this type of habitat.

To illustrate the benefit to the diving waterfowl guild of birds, a brief habitat evaluation was prepared. This habitat metric is derived from: *Habitat Suitability Index Models: Lesser Scaup (Wintering)* U.S. DOI FWS Biological Report 82(10.91) April 1985. This model was selected because the numbers of scaup observed at Bolinas Lagoon have decreased in recent time, and because the variables in the model can be used to assess estuarine habitat. The model contains four variables: percent area with clams, percent area with emergent vegetation, human disturbance of feeding, and mean water depth. For the scaup, the minimal emergent vegetation and low human disturbance are optimal. The lagoon currently has roughly 50 acres of habitat that would be optimal feeding depth (1- 3m) and would be populated with clams.

The results of the Lesser Scaup analysis are detailed in Table 5.16 and Figure 5.5. The full construction alternative plan [North, Central (Estuarine) and South (Seadrift)] would increase optimal feeding habitat to 214 acres, a four fold increase compared to 1998. The minimal construction alternative [South (No Seadrift)] would increase optimal feeding habitat to 71 acres, an increase of approximately 37%.

Although each component of the restoration alternative plans is unique – some increase intertidal and subtidal habitat significantly, some provide a means for water flow to reach new areas of the lagoon (e.g., channels), some create new habitat where once it never existed, or where it was present historically but has been lost over time, and some provide new areas for shoaling – the analyses performed for this Feasibility Study demonstrate that, in general, an increase in tidal volume (i.e., tidal prism), and an improvement in tidal flow and sediment movement in the lagoon will provide an overall benefit to fish and wildlife habitat in the lagoon, and will keep the inlet open for a greater period of time than if no actions were taken. Habitat-based analyses being conducted concurrently with this Feasibility Study by the US Fish and Wildlife Service for the Draft Coordination Act Report, which will show habitat benefits with predicted changes in cover types, are expected to confirm this analysis.

**Table 5.16 Surface Area and Volume of Diving Duck Habitat with Each Alternative Plan (Between Depth of 1m to 3m below MSL; -2.70' and 8.70' NGVD)**

| *Summary* | **Surface Area** Acres | **Volume** cy |
|---|---|---|
| **1968** | 95.64 | 379,986 |
| **1998** | 51.65 | 292,876 |
| **North, Central (Riparian), and South (No Seadrift)** | 185.77 | 530,958 |
| **North, Central (Estuarine), and South (No Seadrift)** | 185.77 | 530,926 |
| **North and South (No Seadrift)** | 173.72 | 493,503 |
| **North and Central (Riparian)** | 195.06 | 550,069 |
| **North, Central (Estuarine), and South (Seadrift)** | 214.36 | 612,675 |
| **North, Central (Riparian), and South (Seadrift)** | 214.36 | 612,707 |
| **North and South (Seadrift)** | 202.31 | 575,252 |
| **North and Central (Estuarine)** | 195.06 | 550,069 |
| **Central (Estuarine) and South (Seadrift)** | 112.20 | 475,044 |
| **Central (Riparian) and South (Seadrift)** | 112.20 | 475,012 |
| **Central (Estuarine) and South (No Seadrift)** | 83.61 | 393,295 |
| **Central (Riparian) and South (No Seadrift)** | 83.61 | 393,263 |

## 5.4 Project Costs

### 5.4.1 Cost Estimates

A summary of the costs associated with each of the restoration alternative plans is listed in Table 5.17, page 18. A more detailed list of these costs, and details about how the design quantities and unit cost estimates were generated, are presented in the Engineering Appendix.

### 5.4.2 Description of Costs

#### 5.4.2.1 Project First Costs

Project first costs are the "financial" costs of the project, including all the costs one would incur if s/he were going to "buy" the project, such as labor, machinery, disposal fees, easement fees, etc. For the Bolinas Lagoon project, first costs include dredging and disposal costs; land construction costs; real estate costs (LERR costs); monitoring and adaptive management costs; and Engineering and Design (E&D), Supervisory and Administration (S&A), and Escalation (to the mid-point of construction).

#### 5.4.2.2 Interest During Construction (IDC) Costs

Interest during construction (IDC) is an economic cost, or an implicit cost. Implicit costs do not involve cash, and are often overlooked in decision analysis. Interest during construction is the opportunity cost of completing the project, or the expense that is incurred, theoretically, while work is not being done (because of dredging windows or

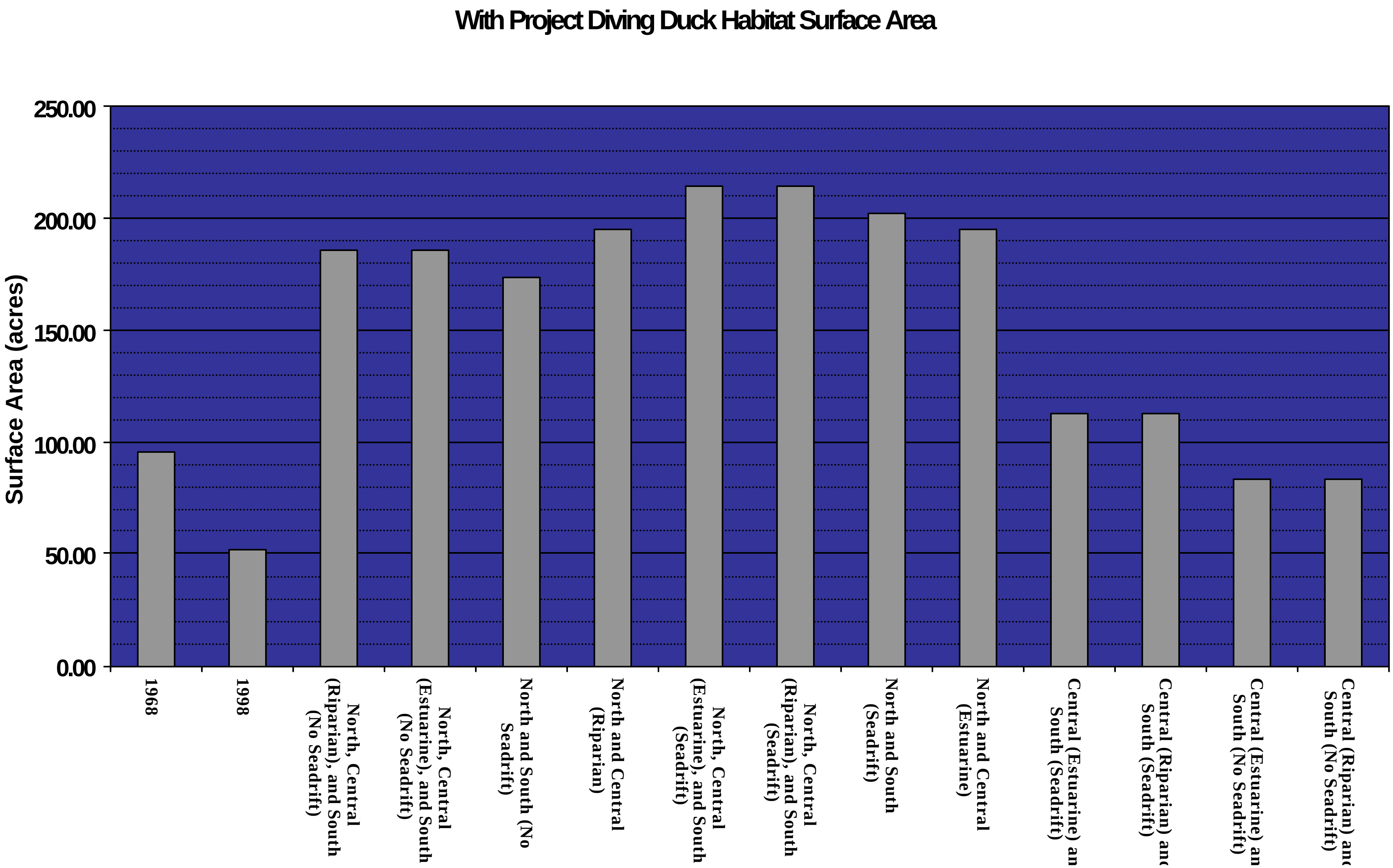


*Figure 5.5 Diving Duck Habitat Surface Areas Associated with Each Alternative Plan*

**Table 5.17 Summary of Costs Associated with Each Alternative Plan**

| Alternative Plans | Dredging & Disposal Costs | Land Construction Costs | Real Estate Costs | Monitoring Costs | Adaptive Management Costs | Construction* Costs | Total Project First Costs |
|---|---|---|---|---|---|---|---|
| **North and Central (Estuarine)** | $62,278,600 | $3,950,800 | $2,031,400 | $682,608 | $2,047,824 | $20,445,475 | **$91,436,707** |
| **North and Central (Riparian)** | $61,655,600 | $4,705,500 | $2,031,400 | $687,917 | $2,063,751 | $20,604,490 | **$92,847,139** |
| **North and South (Seadrift)** | $39,877,600 | $4,105,400 | $2,031,400 | $460,144 | $1,380,432 | $13,782,233 | **$57,147,858** |
| **North and South (No Seadrift)** | $36,673,500 | $2,296,700 | $2,031,400 | $410,016 | $1,230,048 | $12,280,799 | **$54,922,463** |
| **Central and South (Seadrift)** | $41,815,400 | $5,521,200 | $2,031,400 | $493,680 | $1,481,040 | $14,786,703 | **$66,129,423** |
| **Central and South (No Seadrift)** | $38,611,300 | $2,830,333 | $2,031,400 | $434,730 | $1,304,191 | $13,021,043 | **$58,232,997** |
| **Central (Riparian) and South (Seadrift)** | $41,192,400 | $5,558,700 | $2,031,400 | $487,825 | $1,463,475 | $14,611,344 | **$65,345,134** |
| **Central (Riparian) and South (No Seadrift)** | $37,988,300 | $3,750,000 | $2,031,400 | $437,697 | $1,313,091 | $13,109,901 | **$58,630,389** |
| **North, Central (Estuarine) and South (Seadrift)** | $71,985,800 | $6,808,500 | $2,031,400 | $808,257 | $2,424,771 | $24,208,914 | **$108,267,642** |
| **North, Central (Estuarine) and South (No Seadrift)** | $68,781,700 | $4,999,800 | $2,031,400 | $758,129 | $2,274,387 | $22,707,480 | **$101,552,896** |
| **North, Central (Riparian) and South (Seadrift)** | $71,362,800 | $6,806,400 | $2,031,400 | $802,006 | $2,406,018 | $24,021,684 | **$107,430,308** |
| **North, Central (Riparian) and South (No Seadrift)** | $68,158,700 | $4,997,700 | $2,031,400 | $751,878 | $2,255,634 | $22,520,250 | **$100,715,562** |

*Construction costs, in this case, include Engineering & Design (E&D), Supervisory & Administration (S&A), and Escalation to the mid-point of construction.

other restrictions). During those down times, money is committed to the project (or contractor) instead of earning interest. IDC is a cost that is added to the total of all project first costs.

#### 5.4.2.3 Lands, Easements, Rights of Way, and Relocations (LERR) Costs

LERR costs for any alternative plan in the Bolinas Lagoon project would include land costs (fee), permanent channel improvement easements, a temporary pipeline easement, temporary road easements, and temporary work area easements. These costs represent a small percentage of the cost to implement the project, approximately 1 – 2% of the total project costs. LERR costs are also known as Real Estate Costs.

#### 5.4.2.4 Monitoring & Adaptive Management Costs

Monitoring costs are assumed to be 1% of the construction costs of the project, as specified in ER 1105-2-100. Monitoring costs will include pre-implementation baseline measurements, during-construction monitoring, and post-implementation monitoring for a period of up to five years. Any monitoring or surveillance activities after the five year period would be considered Operations and Maintenance (O&M), and would be the responsibility of the local sponsor. As the design of the project is developed during the PED phase, these costs will be further refined to reflect new information.

Adaptive management costs are assumed to be 3% of the construction costs of the project as defined in the Engineering Regulation ER 1105-2-100, where it is stated, "For complex specifically authorized projects that have high levels of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended. The cost of the adaptive management action, if needed, will be limited to 3 percent of the total project cost excluding monitoring costs." Adaptive management activities are expected to continue for at least five years after all of the restoration alternatives have been implemented. Any adaptive management undertaken after the five-year period would be considered O&M, and would be the responsibility of the local sponsor. Once again, as the design of the project is developed during the PED phase, these costs will be further refined to reflect new information. The costs listed for monitoring and adaptive management are a total cost, and are expected to encompass one year of pre-implementation monitoring, 8-9 years of construction, and 5 years of post-implementation monitoring.

#### 5.4.2.5 Operation and Maintenance (O&M) Costs

The Conceptual Monitoring and Adaptive Management Plan, as outlined in Chapter 7 (Section 7.11 Monitoring and Adaptive Management), will form the basis of the O&M plan as all planned O&M activities are expected to be contained within this plan. Because the level of uncertainty is high during the feasibility phase, it is difficult to estimate annual O&M costs. O&M activities include maintenance, surveillance and inspection measures performed to ensure that project benefits are being obtained. Since the lagoon is expected to be self-sustaining, O&M activities for Bolinas Lagoon would most likely be more intensive right after the construction phase ended, and less intensive later on. For feasibility purposes, total O&M costs were assumed to be equal to the total monitoring and adaptive management costs, divided by 15 (years). This is the period of time expected to be the most labor-intensive part of O&M, which is conducted for the life of the project (perpetuity). O&M activities and associated costs will be more fully defined during the PED phase.

### 5.4.3 Cost Assumptions

This section describes the assumptions that were used to develop the cost estimates. These assumptions were developed during the Feasibility Study, and were based on the best available data. As the study progresses, these assumptions can be refined to reflect new information. In addition, as the construction plan and design of the alternatives become more fully developed, the costs can be better defined.

The estimated costs for the alternatives are based on 2001-year price levels. All dredging work was estimated using the Corps of Engineers Dredge Estimating Program (CEDEP) that has built-in databases for the dredging plant and equipment. The labor rates utilized in the CEDEP program have been adjusted using current (02/01) State of California Wage Rate Determination sheets for dredging labor. All land-based work was estimated using the MCACES (Micro-Computer Aided Cost Engineering System) program.

Land-based construction costs have been adjusted by the locality factor of 20% to account for the work being done within the Marin County area of California. Cost for the monitoring of the dredge disposal operation has been adjusted to a factor of 1% of the total first cost of the project. Engineering and Design (E&D) and Support and Administration (S&A), activities during construction, are 8% and 7%, respectively, and are applied to the cost as well. All costs that are part of the total project costs, which are cost-shared, are considered construction or "new work" costs. No Operations and Maintenance (O&M) costs are included with these estimates. O&M responsibilities will be discussed in more detail in Chapter 7 (Section 7.12 OMRR&R Requirements); they are the responsibility of the local sponsor.

Contract Work: The assumption was made that the prime contractor would perform all land-based work 5 days/week, 8 hrs/day, and that all dredging and disposal work would be performed 7 days/week, 24 hrs/day. However, it is expected that on average the dredge vessel would probably use every $7^{th}$ day to perform routine maintenance. Included in the costs are factors for contractor markups: 12% for overhead costs, 10% for profit and 2% for bonds. A contingency of 20% was used for land-based construction only, since there were many unknowns at the time of this estimate.

#### 5.4.3.1 Water-Based Operation (Dredging)

Due to the geographic and physical constraints within the Bolinas Lagoon and the surrounding area, a single 12-inch hydraulic suction pipeline dredge was selected for use in the feasibility-level cost estimates. Other equipment utilized includes up to 16,300 feet of trailing pipeline, two booster pumps, one tugboat, two 3000-cubic yard (cy) scows (receiving the dredged material while anchored in Bolinas Bay), miscellaneous plant and equipment. Production rates range from 75 to 230 cubic yards/hour (depending on pipeline lengths).

The pipeline suction dredge that was used for this estimate is a multi-functional unit that can be transformed into an amphibious dredge, via the use of bolt-on tires. This amphibious conversion allows the dredge to traverse over land and shallow areas, normally not accessible to conventional dredges. In addition, this particular dredge has optional work implements whereby vegetation "harvesting," raking and solid material grappling is possible, when required.

This configuration of equipment is necessary because of the shallow depths of much of the lagoon, the tidal influence of the area, and other environmental concerns, primarily with regards to the safe method of operation during the dredging of the material. The disposal site for all the dredged material would be SFDODS, the designated ocean disposal site, located approximately 55 nautical miles (100 kilometers) offshore of San Francisco.

Due to very limited access to the island by land-based construction equipment, the impracticality of trucking the material through the town of Bolinas, and various environmental constraints, a water-based operation must be used for clearing vegetation off Kent Island. Clearing would entail transporting equipment to the island via a barge with a small crane and a towing vessel (a small tug/boat). The existing vegetation on the island would then be removed by cutting, clearing and mulching by conventional methods, i.e. chainsaw and mulcher. Vegetative material that would be hard to remove by conventional methodology would be cleared and stockpiled by the amphibious dredge for removal.

Transportation of the vegetative material would be via containers on a small barge, transferred to a scow in the area of the dredge platform within the Bolinas Bay, and further transported to the marina at Bodega Bay. At Bodega Bay, the material would be offloaded by a hydraulic excavator bucket or a vacuum system into 12 cubic yard capacity trucks, and then trucked to the Redwood Landfill for disposal, unless otherwise recycled or used for composting.

#### 5.4.3.2 Land-Based Construction (Excavation)

Land-based operations at the Dipsea Road and Highway One Fills sites have material that would be excavated dry, as well as some wet quantities. All material from these sites would be trucked in vehicles capable of carrying loads of up to 12 cy to Redwood Landfill in Novato, California, the upland disposal site. The operation is the same for Pine Gulch Creek Delta. However, in addition to the excavation of soil material, substantial amounts of trees and other vegetation would be removed from the Pine Gulch Creek Delta and Dipsea Road sites. The equipment to be used for this operation includes hydraulic excavators, loaders, cranes, and dump trucks. Cost for mobilization and demobilization of the equipment is included in the estimate.

#### 5.4.3.3 Disposal Sites

*Deep Ocean Site (SFDODS)*

SFDODS is approximately 55 nautical miles (100 kilometers) offshore of San Francisco. Dredged material would be transported to SFDODS by tugs and scows with a 3,000 cubic yard capacity. Once at the disposal site, the dredged material would be disposed of by bottom dumping. The cost estimates reflect a disposal operation for the tug and scow of 24 hours/day, 7 days/week, 2 – 12 hour shifts. (Note: Dredge operation may be limited to six days/week due to equipment maintenance on the $7^{th}$ day).

<u>*Redwood Landfill*</u>

Redwood landfill is located approximately 38 miles from the project site when proceeding east on Highway 1, then north on Highway 101. Excavated material would be transported there by truck. The landfill would charge a disposal fee for the different types of disposal medium; $10 per cy for vegetation to $20 per cy for mixed soil.

#### 5.4.3.4 Dredging and Disposal Cost Analysis: Tradeoffs

The dredged material pumped into the scows is a slurry composed of approximately 25% solids and 75% water. The dredge material disposal costs assume 3,000 cubic yard scows loaded with 25% solids, which is a conservative estimate. If some of the excess water were allowed to port out of the receiving scow during the pumping process, using filter fabric to reduce turbidity in Bolinas Bay, the percent of solids could increase to as much as 80%. This conservative estimate has been used for feasibility purposes to determine the “worst case scenario” (i.e., the most expensive scenario, a conservative estimate). Although overflow would reduce costs by reducing disposal time and total number of barge trips needed, expense must be weighed with concern over the effects of turbidity in Bolinas Bay. This decision would be made by any regulating agencies and, ultimately, by GFNMS. Changes to the current scenario are possible during PED when the design is finalized and the construction implementation plan is fully developed. Since this estimate is conservative, however, modifications would most likely decrease costs.

Another limiting factor is the use of a single dredge. The cost estimate assumes a single dredge primarily because of concern expressed regarding the short term impacts of dredging, and because assuming one dredge creates a more conservative cost estimate. If multiple dredges were used, implementation of the project could be reduced, but again, there is a balance between short term impacts and the number of dredges used. One dredge would have fewer impacts at any particular moment, but the short term impacts would be stretched over a longer period. Two dredges would have more immediate impacts in the lagoon, but the dredging time would be reduced, so overall, there might be fewer short term impacts. The assumption that one dredge would be used is the conservative estimate. As the implementation plan is developed during the PED phase, it is possible that using two dredges may be found to be more efficient and have fewer short term impacts.

### 5.4.4 Incremental Cost Analysis (ICA)

An ecosystem restoration plan should represent the most cost effective means of addressing the restoration problem, and the selected plan should identify the least-cost alternative for producing every attainable level of output. Tools to inform and support environmental investment decision-making include Cost Effectiveness Analysis (CEA) and Incremental Cost Analysis (ICA). CEA is performed to identify the least cost alternative plans and provides for the "best bang for the buck," while the ICA is conducted on the more cost effective plans and identifies changes in costs for increasing levels of environmental output, to assesses whether different levels of restoration are "worth it."

Because this project is not a traditional Corps project, and does not have a monetary measure of project benefits, it is not possible to conduct a traditional benefit-cost analysis for the evaluation of project alternatives; thus, a unique or "optimal" plan cannot be identified. However, an incremental cost analysis (ICA), a valuable planning tool, allowed us to examine the environmental outputs, rule out economically irrational alternatives and compare the relative cost effectiveness of the remaining plans.

Project outputs were expressed as the net amount of tidal water that would be flushed into the ecosystem (cubic yards of tidal prism). Outputs for each alternative were expressed as the average annual amount, assuming a 50-year project life. Project costs used for the ICA include the project first costs, Operation and Maintenance costs and interest during construction. (These costs differ from those for cost-sharing, which are based solely on project first costs). The ICA takes into consideration all costs related to constructing the project, and compares those with the benefits.

Following discussion at the December 14, 2001 Alternatives Formulation Briefing, held by the Corps of Engineers District, Division and Headquarters (HQ) level offices and MCOSD (the local sponsor), the Corps HQ office concluded that restoration in Seadrift Lagoon would not warrant Federal cost sharing participation because of the man-made nature of the lagoon. According to ER 1165-2-501 and the Engineering Pamphlet (EP) 1165-2-502, the goal of Ecosystem Restoration in the Civil Works program is to "partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system. The Corps has decided that Seadrift Lagoon is not a "naturalistic, functioning, and self-regulating system," and therefore is not in the Federal interest to restore. Restoration of such environments would be considered "enhancement" of a man-made feature. The Seadrift Lagoon component was therefore removed from further analysis; the ICA was conducted only for the plans that did not include that component, namely, the alternative plans that contained the South (No Seadrift) alternative. If the Seadrift Lagoon component, or the South (Seadrift) alternative, were to be part of the Locally Preferred Plan, the full cost of restoring Seadrift Lagoon would have to be borne by the local sponsor. For the purpose of comparison, an incremental cost analysis was performed on all of the alternative plans [i.e., those containing both the South (Seadrift) alternative, and the South (No Seadrift) alternative], and the results were similar. Only the ICA results of the alternative plans containing the South (No Seadrift) alternative, however, are detailed in this report.

#### 5.4.4.1 ICA Results

*<u>Step 1 – Eliminating non-cost effective plans</u>*

To start the Incremental Cost Analysis, the alternatives are ordered by increasing levels of output. Alternatives with lower outputs and correspondingly higher costs are considered non-cost effective and are eliminated from the analysis. In this first iteration, the Central (Estuarine) & South (w/o Seadrift) and Central (Riparian) & South (w/o Seadrift) plans are ruled out since the

North and South (w/o Seadrift) plan produces higher outputs at a lower cost. Likewise, the North & Central (Riparian) plan is eliminated because the Central (Estuarine) plan offers higher outputs at lower costs, i.e., it provides a bigger "bang for the buck."

**Table 5.18 First Iteration of the Incremental Cost Analysis**

| 1st Iteration | | | | | |
|---|---|---|---|---|---|
| **Plan** | **Cost: ($)** | **Incremental Cost: ($)** | **Output (Ann Ave. cy)** | **Incremental Output: (Ann Ave. cy)** | **Incremental Cost per Unit (Ann Ave. cy)** |
| No Action Plan | $0 | --- | 0 | --- | --- |
| North and South (w/o Seadrift) | $57,096,550 | $57,096,550 | 1,465,583 | 1,465,583 | $38.96 |
| ~~Central (Estuarine) and South (w/o Seadrift)~~ | ~~$58,687,458~~ | ~~$58,687,458~~ | ~~1,422,917~~ | ~~1,422,917~~ | ~~$41.24~~ |
| ~~Central (Riparian) and South (w/o Seadrift)~~ | ~~$59,087,950~~ | ~~$59,087,950~~ | ~~1,407,078~~ | ~~1,407,078~~ | ~~$41.99~~ |
| North and Central (Estuarine) | $104,518,826 | $104,518,826 | 2,224,010 | 2,224,010 | $47.00 |
| ~~North and Central (Riparian)~~ | ~~$105,331,724~~ | ~~$105,331,724~~ | ~~2,213,044~~ | ~~2,213,044~~ | ~~$47.60~~ |
| North, Central (Riparian) and South (w/o Seadrift) | $118,894,540 | $118,894,540 | 2,381,558 | 2,381,558 | $49.92 |
| North, Central (Estuarine) and South (w/o Seadrift) | $119,883,012 | $119,883,012 | 2,393,713 | 2,393,713 | $50.08 |

*<u>Step 2 – Identifying the "Best Buys" or Least Incremental Cost Alternatives</u>*

Once the "non-cost effective" plans are eliminated, the ICA proceeds by treating the No Action plan as the first increment or baseline. Planners then select the best buy, i.e., the plan with the lowest incremental cost per unit. In this case, the North and South (w/o Seadrift) plan, highlighted in the second iteration table, is the next best alternative a planner can choose above the No Action plan. With an incremental cost of $40.32 per unit of output, this plan offers the most "bang per buck" above the No Action plan. This plan is the best buy; it is the *greatest incrementally* justified plan. This plan forms the baseline for the next iteration.

**Table 5.19 Second Iteration of the Incremental Cost Analysis**

| 2nd Iteration (after removing non-cost effective plans) | | | | | |
|---|---|---|---|---|---|
| **Plan** | **Cost: ($)** | **Incremental Cost: ($)** | **Output (Ann Ave. cy)** | **Incremental Output: (Ann Ave. cy)** | **Incremental Cost per Unit (Ann Ave. cy)** |
| No Action Plan | $ | --- | 0 | --- | --- |
| North and South (w/o Seadrift) | $59,087,950 | $59,087,950 | 1,465,583 | 1,465,583 | $40.32 |
| North and Central (Estuarine) | $104,518,826 | $104,518,826 | 2,224,010 | 2,224,010 | $47.00 |
| North, Central (Riparian) and South (w/o Seadrift) | $118,894,540 | $118,894,540 | 2,381,558 | 2,381,558 | $49.92 |
| North, Central (Estuarine) and South (w/o Seadrift) | $119,883,012 | $119,883,012 | 2,393,713 | 2,393,713 | $50.08 |

*Step 3 - Recalculate Incremental Costs & Outputs and Identify Next Increment*

With the No Action plan comprising the first increment and the North and South (w/o Seadrift) plan making up the second, the planner then recalculates the incremental costs and incremental outputs in relation to the North and South (w/o Seadrift) plan baseline. The North, Central (Estuarine) plan now comprises the third increment since it is the "best buy" and has the lowest incremental costs per unit of output ($59.90) above the second increment, the North and South (w/o Seadrift) plan.

**Table 5.20 Third Iteration of the Incremental Cost Analysis**

**3rd Iteration (after identifying the plan with the lowest incremental cost/unit & removing plans preceding it)**

| Plan | Cost: ($) | Incremental Cost: ($) | Output: (Ann Ave. cy) | Incremental Output: (Ann Ave. cy) | Incremental Cost per Unit (Ann Ave. cy) |
|---|---|---|---|---|---|
| No Action Plan | $ | --- | 0 | --- | --- |
| North and South (w/o Seadrift) | $59,087,950 | $59,087,950 | 1,465,583 | 1,465,583 | $40.32 |
| | | | | | |
| North and Central (Estuarine) | $104,518,826 | $45,430,876 | 2,224,010 | 758,428 | $59.90 |
| North, Central (Riparian) and South (w/o Seadrift) | $118,894,540 | $59,806,590 | 2,381,558 | 915,975 | $65.29 |
| North, Central (Estuarine) and South (w/o Seadrift) | $119,883,012 | $60,795,061 | 2,393,713 | 928,130 | $65.50 |

*Step 4 – Repeat Process*

Using the North, Central (Estuarine) & South (w/o Seadrift) increment as the baseline, the North, Central (Estuarine), and South (w/o Seadrift) plan is the final increment; its incremental cost per unit is $90.54.

**Table 5.21 Fourth Iteration of the Incremental Cost Analysis**

**4th Iteration (after identifying the plan with the lowest incremental cost/unit & removing plans preceding it)**

| Plan | Cost: ($) | Incremental Cost: ($) | Output: (Ann Ave. cy) | Incremental Output: (Ann Ave. cy) | Incremental Cost per Unit (Ann Ave. cy) |
|---|---|---|---|---|---|
| No Action Plan | $0 | --- | 0 | --- | --- |
| North and South (w/o Seadrift) | $59,087,950 | $59,087,950 | 1,465,583 | 1,465,583 | $40.32 |
| North and Central (Estuarine) | $104,518,826 | $45,430,876 | 2,224,010 | 758,428 | $59.90 |
| | | | | | |
| North, Central (Riparian) and South (w/o Seadrift) | $118,894,540 | $14,375,714 | 2,381,558 | 157,548 | $91.25 |
| North, Central (Estuarine) and South (w/o Seadrift) | $119,883,012 | $15,364,186 | 2,393,713 | 169,703 | $90.54 |

*Step 5 – Final Array of Increments ("Winners")*

With no more plans left to analyze, the three remaining plans are the top plans, or the best buys, that are incrementally justified. Any of these top plans could be the NER Plan.

**Table 5.22 Fifth Iteration of the Incremental Cost Analysis**

| 5th Iteration (Final Array of Increments/"Winners") | | | | | |
|---|---|---|---|---|---|
| **Plan** | **Cost: ($)** | **Incremental Cost: ($)** | **Output: (Ann Ave. cy)** | **Incremental Output: (Ann Ave. cy)** | **Incrementa Cost per Unit (Ann Ave. cy)** |
| No Action Plan | $0 | --- | 0 | --- | --- |
| North and South (w/o Seadrift) | $59,087,950 | $59,087,950 | 1,465,583 | 1,465,583 | $40.32 |
| North and Central (Estuarine) | $104,518,826 | $45,430,876 | 2,224,010 | 758,428 | $59.90 |
| North, Central (Estuarine) and South (w/o Seadrift) | $119,883,012 | $15,364,186 | 2,393,713 | 169,703 | $90.54 |

ICA is not a conclusion, but rather a guideline for decisions based on outputs desired and available costs. Abrupt changes in the incremental cost curve identify potential decision points for focusing the "Is it worth it?" questioning process. Significant changes in the curve are referred to as the breakpoint, the spike, or the "knee of the curve." They occur where an incremental cost increases relatively sharply in contrast to the preceding or following incremental costs. These points provide decision makers with reasons to question the causes of the changes, and whether the additional incremental costs are "worth it." Depending on the circumstances (and the amount of money available), a large increase in incremental costs may be justified, or it may not be. The incremental cost analysis shows at what point the incremental costs per unit – the additional cost for an extra unit of output – that is too high to be justified.

In this case, there is no apparent "spike" in the curve, each increment is approximately 50% greater than the previous increment. Since all three plans are economically justifiable (they are the best three plans that are economically justified), the effectiveness of each of the top three plans at achieving the goals of the project must be compared in order to identify the best possible plan as the NER Plan. The first plan, North and South (w/o Seadrift), only addresses the north and south ends of the lagoon. Because many of the local groups that have been involved with the progress of the project have suggested that the most significant problem area, and therefore the area most in need of restoration, is the central part of the lagoon, the first alternative plan would not be the most desirable. The second plan, North and Central (Estuarine), addresses the central part of the lagoon, but it does not address the lagoon as a whole (that is, the North, Central and South regions), and therefore does not address the project goals as fully as other plans available. The last plan, North, Central (Estuarine) & South (w/o Seadrift) is the most complete, most effective plan at achieving the restoration goals of the project. While the costs are the highest out of the top three plans, the benefits are also the greatest. The study team believes that this plan would be the best plan to address the problem areas of the lagoon, and would provide for a fully encompassing restoration project.

### 5.4.4.2 Sensitivity Analysis

This ICA was undertaken using outputs expressed in average annual terms, using total project costs (which are project first costs plus interest during construction). Additional ICA's have been performed using first costs as well as annualized project costs; the final array of cost effective plans were identical to those using the total project costs.

### 5.4.4.3 The National Ecosystem Restoration (NER) Plan

For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, is identified as the National Ecosystem Restoration (NER) Plan. The results of the Bolinas Lagoon incremental cost analysis (Figures 5.6 and 5.7) show the plan which provides the most outputs at an incrementally justified cost is the North, Central (Estuarine) and South (No Seadrift) Alternative Plan. As illustrated in the fourth iteration of the ICA, the North, Central (Riparian) & South (No Seadrift) alternative plan has an incremental cost almost identical to the North, Central (Estuarine) & South (No Seadrift) plan. That is, if the costs were rounded, they would be the same ($91.00). Thus, the NER could essentially be either of these two plans, but because the Riparian plan fell out of the cost analysis in the 4$^{th}$ iteration, the Estuarine plan has been identified as the NER Plan. The advantage of the Estuarine plan is that it provides more benefits, consistent with the restoration goals of the project. The NER Plan provides the basis of the project cost sharing; the LPP would most likely be the same or cheaper than the NER, and would therefore be fully Federally cost-shared.

The NER Plan is the North, Central (Estuarine), and South (No Seadrift) alternative plan. The incremental cost analysis determined that this Alternative Plan is cost effective and would warrant Federal interest if recommended for implementation. Because the outputs were measured as cubic yards of intertidal habitat, we can draw certain conclusions about the benefits that would be provided by the LPP. For example, with an increase in cubic yards of intertidal habitat, we can assume that the LPP Plan would provide an increase in intertidal habitat (and, it is assumed, subtidal habitat), intertidal volume and a decrease in the potential of inlet closure. Concomitant ecological benefits include an increase in habitat quantity and quality for intertidal species (algae and marsh plants, invertebrates and shore birds), subtidal species (eelgrass, fish, diving birds and marine mammals), and an overall benefit to the lagoon ecosystem, the region, and the Pacific Flyway.

The total project first cost of the NER Plan is $101,553,000. Cost sharing for ecosystem restoration projects is 65% Federal and 35% non-Federal (local sponsor), for a total of $66,009,450 Federal and $35,543,550 non-Federal. The costs associated with the Lands, Easements, Rights-of-Way, and Relocations (LERR), which would be paid for in full by the local sponsor as part of their 35% share, are expected to be minimal. The entire non-Federal cost share would be financed in cash.

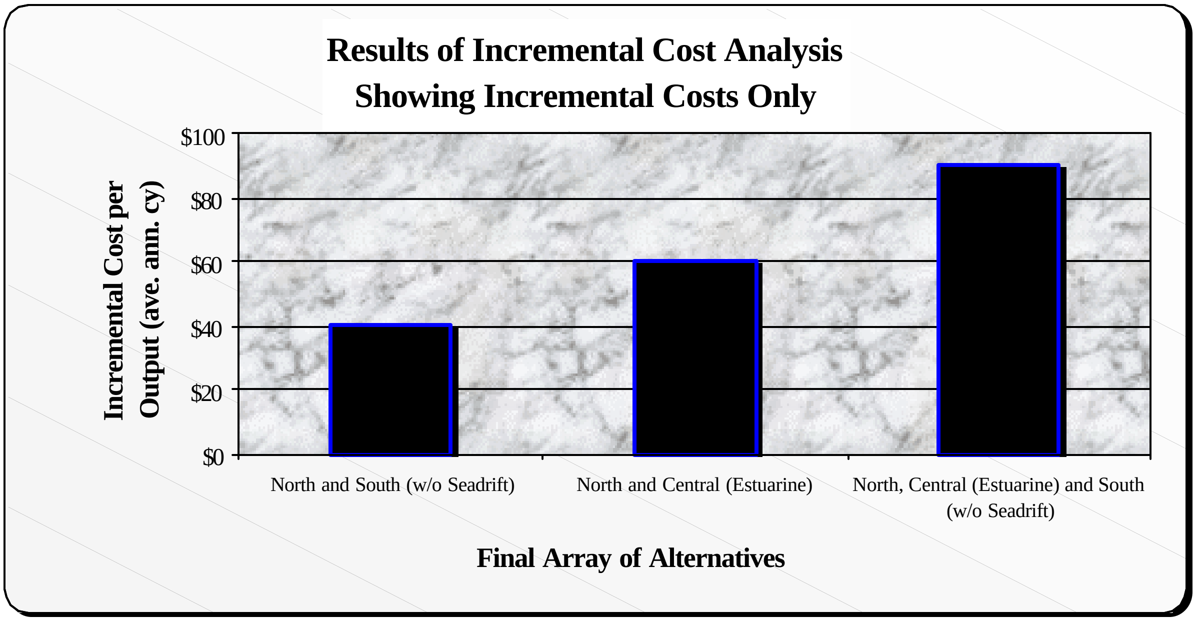


*Figure 5.6 "Winners" of the Incremental Cost Analysis,*
*Illustrating Incremental Costs Only*

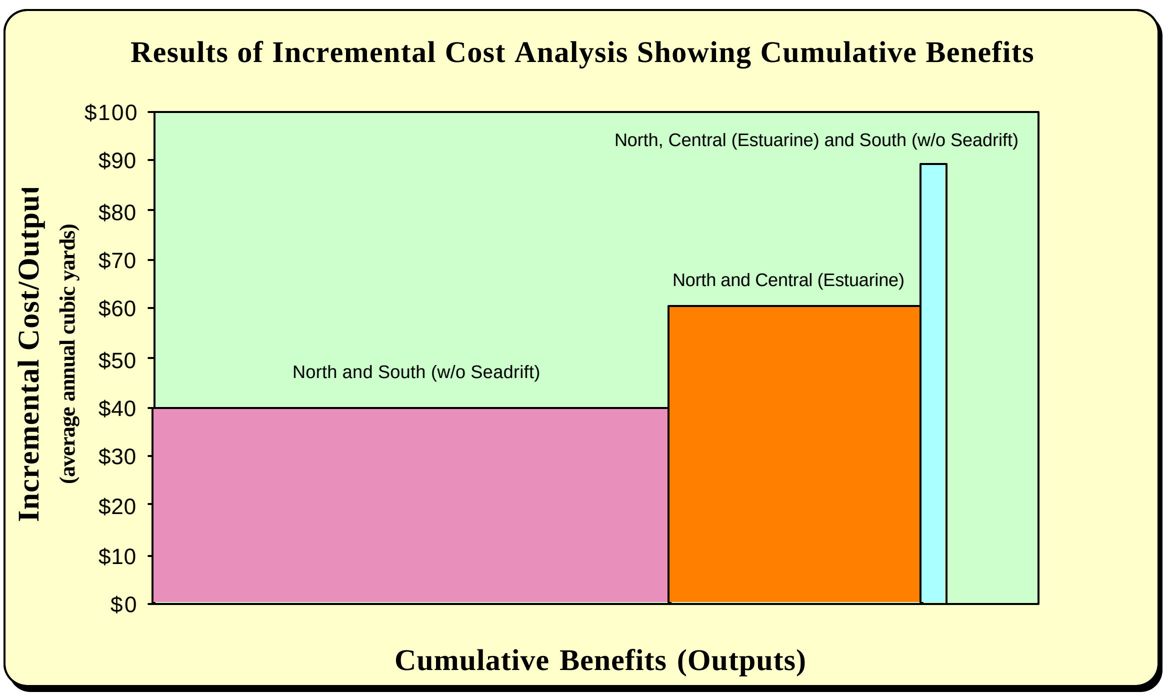


*Figure 5.7 "Winners" of the Incremental Cost Analysis,*
*Illustrating Cumulative Benefits & Incremental Costs*

### 5.4.4.4 The Tentatively Selected Locally Preferred Plan (LPP)

The local sponsor wanted to ensure that the concerns of the local communities were taken into consideration for the draft reports. During the HEEP meetings, it became clear that there was a real debate over the Pine Gulch Creek Delta restoration component with respect as to whether or not some of the riparian habitat area should be removed. Two plans were developed to address these concerns (the Estuarine component and the Riparian component), and have been fully analyzed in this Feasibility Report. Because the NER Plan contains the Central (Estuarine) alternative, the local sponsor felt that it was necessary to include the Central (Riparian) plan in the Locally Preferred Plan to give the public the opportunity to debate the merits of each. After public review, one plan (either the NER or the LPP) will be selected for recommendation in the final reports.

The North, Central (Riparian) and South (No Seadrift) Alternative Plan, identified as the LPP, is cost effective and achieves the desired level of output. Because the outputs were measured as cubic yards of intertidal habitat, we can draw certain conclusions about the benefits that will be provided by the LPP. For example, with an increase in cubic yards of intertidal habitat, we can assume that the LPP Plan would provide an increase in intertidal habitat (and, it is assumed, subtidal habitat), intertidal volume and a decrease in the potential of inlet closure. Concomitant ecological benefits include an increase in habitat quantity and quality for intertidal species (algae and marsh plants, invertebrates and shore birds), subtidal species (eelgrass, fish, diving birds and marine mammals), and an overall benefit to the lagoon ecosystem, the region, and the Pacific Flyway. In addition, benefits not accounted for in the ICA are those associated with saving the existing introduced riparian habitat on Pine Gulch Creek. Although these benefits are not necessarily related to estuarine habitats, some groups perceive the benefits as inherently valuable.

The LPP Plan has a total project first cost of $100,716,000. Cost sharing for ecosystem restoration projects is 65% Federal and 35% non-Federal (local sponsor), for a total of $65,465,400 Federal and $35,250,600 non-Federal. The costs associated with the Lands, Easements, Rights-of-Way, and Relocations (LERR), which would be paid for in full by the local sponsor as part of their 35% share, are expected to be minimal. The entire non-Federal cost share would be financed in cash.