Bolinas Lagoon Ecosystem Restoration Feasibility Project

Final Public Reports

VI Peer Review and Public Comments on Previous Draft Reports with Responses

Response to Public Comments

Bolinas Lagoon Ecosystem Restoration Project

Response to Public Comments on the February, 2006 Draft Reports

The following are responses to public comments prepared by the consultants and MCOSD. All letters received during the public comment period were posted on the MCOSD web site on April 18, 2006 and were carefully read and considered. Rather than providing a response to letters individually, the comments and responses were grouped by topic. The consultants will be discussing their responses to these public comments—and providing some additional responses based on further analyses suggested by the commentators— at the next public meeting to be held at 7 pm on May 2, 2006, at the Stinson Beach Community Center.

Contents: Topics and Responses

1. The 50-year projection, the "No-Action Alternative" and the DEIR/S

It is evident from several letters that we have not clearly presented the context of the Report in the overall planning context.

The 1996 Bolinas Lagoon Management Update presented an analysis that suggested that the lagoon had lost significant tidal prism since 1968 and recommended that additional studies be conducted to corroborate this finding and to determine the future magnitude of tidal prism loss. A Reconnaissance Study conducted by the United States Army Corps of Engineers in 1997 concluded that corrective action – dredging and/or other means of removing accumulated sediment or minimizing its entry into the lagoon – was in the national interest. The Corps of Engineers, with financial support from the federal government, the State of California and the Marin County Open Space District (the project's local sponsor), commenced a Feasibility Study in 1998 to develop a plan to restore the lagoon's habitats. The Corps released its Draft Feasibility Report and Draft EIR/EIS for the Bolinas Lagoon Ecosystem Restoration Project in 2002 which proposed to dredge approximately 1.4 million cubic yards of sediment from the lagoon. Public comments on the Draft EIR/EIS focused on the lack of a clear, scientifically sound description of how the lagoon would evolve if no action was taken—without which purpose and need for intervention can not be determined.

The Open Space District contracted with a consulting team to provide a rigorous scientific review of the Draft Feasibility Report and Draft EIR/EIS assumptions and conclusions and to provide a 50-year projection of the lagoon's hydrological and ecological evolution. This projection assumes that no management intervention will take place by definition—in regulatory terms it is the "No-action Alternative" that will be compared to other Action or Intervention Alternatives in the EIR/S. Hence, just because intervention is not discussed in the Report, this does not indicate that intervention is or is not warranted; the purpose and need for intervention will be assessed when the Draft Feasibility Report and Draft EIR/EIS are revised—with significant public input— in the next steps of the planning process.

2. The Report should/should not state that intervention is required.

The Draft Report does not make <u>any</u> recommendations with regard to intervention as specifically directed by our Technical Review Group (TRG). The TRG recommended that the Report focus only on the 50-year projection of the lagoon's evolution that includes past, current and future hydrological and ecological conditions.

Numerous letters suggested that the 50-year projection clearly shows the need for intervention. Other letters stated that the 50-year projection clearly shows that intervention is not warranted. All public comment letters concerning intervention will be considered during the next steps in the planning process where purpose and need for intervention will be determined.

3. The Report should specifically address differences with the DEIR/S

As part of Phase I of the current project, the consultants reviewed all prior data and analyses, including the work done by Tetra Tech and ACOE for the DEIR/S. These reports, reviewed by the TRG, are posted on the Open Space District web-site. The consultants and the TRG identified data gaps and recommended new analyses—the new data and analyses resulted in some fundamental differences in the findings between the DEIR/S and the present study. These differences, and the underlying reasons for these differences, are discussed in these earlier reports.

4. Goals, Objectives, Indicators and Thresholds

The Report refers to the <u>general</u> Goals and Objectives in the 1996 Bolinas Lagoon Management Plan Update. The Report suggests that it would be appropriate to revisit these broad Goals and Objectives in light of our new understanding of how the lagoon functions; on the page following the restatement of the 1996 Goals and Objectives, the Report adds that the management goals and objectives should be based on the concepts of ecological integrity—among these are that 1) coastal lagoons are dynamic, evolving systems, 2) as long as natural physical processes are allowed to occur, the lagoon system can be self-correcting, and 3) human induced changes may interfere with the natural development of the lagoon ecosystem.

The Report then states that these broad goals need to be translated into specific management objectives; the broad Goals and Objectives are not in of themselves appropriate for determining whether or not an ecosystem restoration project is needed. Specific objectives, indicators established to measure these objectives, and thresholds values for the indicators will need to be established. It should also be noted that a range of intervention alternatives— including watershed practices and small projects—may be considered.

Clearly, our current knowledge of how the lagoon functions indicates that the majority of sediments are littoral and that the lagoon <u>tends</u> toward a shallow equilibrium state (albeit a dynamic equilibrium due to constantly changing influences such as sea level rise etc.), punctuated by periodic earthquakes that deepen the lagoon (average duration between earthquakes is 360 years with a range of between 140 and 630 years; data from Byrne's coring report). These results indicate that it is not possible to pick any particular lagoon form to manage for; if major intervention is justified, it should be on the basis that anthropogenic changes have significantly altered the natural trajectory of the lagoon's evolution with corresponding adverse ecological impacts.

5. Monitoring and Adaptive Management Plan

The Report includes sections on monitoring and an outline of an Adaptive Management Plan. The Report recommends monitoring as an essential activity whether or not purpose and need for intervention is demonstrated in the next steps of the planning process. Several letters recommended specific physical and ecological parameters to monitor and these will be included in the revised Report. A detailed monitoring plan that identifies specific indicator species and monitoring methods has not been prepared. However, the report provides examples of species associated with each potentially affected habitat unit in Section 5.9.1 (Expected Shifts in Habitat Distribution and Abundance). For example, monitoring shifts in abundance of diving fish-eating birds, such as common loon, double-crested cormorant, brown pelican, western grebe, osprey, red-breasted merganser, and Forster's tern, would provide useful information to document whether or not a reduction in subtidal habitat is occurring as projected, along with the anticipated associated ecological response. Bolinas Lagoon population trends should be evaluated both locally and within a regional context to determine if population changes are associated with local conditions, or are the result of broader influences. The Draft Report was edited to more clearly address the significance of comparing results of local monitoring to other monitoring programs in the region.

The Adaptive Management Plan is presented only as an outline and includes a discussion about intervention generally, but as noted in the Report, this does not suggest that intervention is (or is not) recommended.

Monitoring can provide useful data to confirm the trajectory of the 50-year projection and will allow us to refine, reanalyze and readjust this projection. If intervention measures—large or small—are implemented, monitoring of the effects of these actions will also allow us to test our understanding of how the lagoon functions and the need and efficacy of additional intervention

The Adaptive Management Plan is presented only as an outline and includes a discussion about intervention generally, but as noted in the Report, this does not suggest that intervention is recommended.

6. Inlet Closure

A number of comments were received involving the inlet closure analysis. These comments can be generally summarized as:

1. How was natural re-opening considered in the analysis?
2. Do creek flows affect inlet stability?
3. Can the probability of closure be quantified?
4. Are there reference sites of periodic inlet closure?

The following paragraphs attempt to clarify these questions, as well as resolve discrepancies in the report.

1. *How was natural re-opening considered in the analysis?*

Natural re-opening of a closed inlet occurs when the water level on one side of the beach barrier rises high enough to overflow its crest and long enough to scour a self-sustaining channel. This can occur on the ocean-side with spring tides and low swell conditions or on the inland-side when runoff fills the lagoon. In the case of Bolinas Lagoon, swell conditions would tend to create barrier beaches higher than spring tide levels. Therefore, the most likely natural re-opening mechanism would be filling the lagoon by creek runoff.

Due to differences in the onset of rainfall and the arrival of energetic ocean waves from the Pacific Ocean, prolonged closure potential is most likely during two parts of the year: late fall and late spring. If closure were induced during by large swells in the late fall prior to the onset of significant rainfall, a high beach barrier could form before impounded freshwater runnoff raised lagoon water levels. If the succeeding winter were relatively dry, it would be possible for the lagoon not to fill because of the small watershed size. This means that closure could extend into the succeeding years until winter rainfall events are large enough to fill the lagoon. Similarly, a closure during the last spring would persist throughout the summer and fall, until the following winter season. In both cases, mechanical intervention may be required to re-open the inlet before large changes in water temperature, salinity and dissolved oxygen affected aquatic species.

2. *Do creek flows affect inlet stability?*

Although creek flows may play an important role in breaching a closed inlet, their scouring power is typically an order of magnitude smaller than that of tidal flow. For the application of the O'Brien analysis at Bolinas Lagoon, we confirmed this by calculating the contribution of tributary inflow to scour power of tidal flows over an entire water year. For example, typically a 1-day in 2-year flow event discharges approximately 0.4 MCY, compared to about 3.5 MCY of tidal water discharged through the inlet.

3. *Can the probability of closure be quantified?*

Assigning a numerical probability of closure is difficult and limited by the period of the data used to carry out simulations in this analysis. The 'once-a-decade' estimate referenced in the report and public meetings was developed from the two events in the 17-year simulation in which the O'Brien index exceeded the critical value established at the two reference sites for which extensive data were available, Crissy Field and Russian River. (Note that the Crissy Field inlet design anticipated frequent closures, using this type of analysis, because of its small tidal prism). Several more closures would need to be simulated over the 17-year period to provide enough data points to establish a probability of closure. Unfortunately, wave buoy data were not available for the 1983 swell conditions. This event is generally regarded as the historic record wave condition along Northern California.

4. *Are there reference sites of periodic inlet closure?*

Although the two reference sites used to establish the critical value of the O'Brien index differ from Bolinas Lagoon with respect to tidal prism and wave climate, these factors have been considered in the analysis. In each application, local wave climate (transformed to nearshore values) and the respective tidal prism and inlet width of the system were used to quantify the O'Brien index. Although not quantified by the O'Brien analysis, there are several examples of coastal lagoons subject to inlet closure to varying degrees of duration and frequency. These include: Drake's Estero (always open); Tijuana Estuary (closes every couple of decades); Pescadero (historically open but now seasonally closed); and Abbot's Lagoon (opens for a short period every several years).

Points of clarification
In addition to the questions above, errors in Table 5-2 generated confusion; the second column incorrectly lists tidal prism values. The corrected table (shown below) is consistent with the narrative in Section 5 and key findings described in Section 2.1. Note that two inlet widths were considered for the 2.0 MCY scenarios since inlet width is expected to diminish with tidal prism. The analysis shows that the lagoon mouth is only expected to close under scenario 4 under the assumptions of the model (please see discussion in the Draft Report).

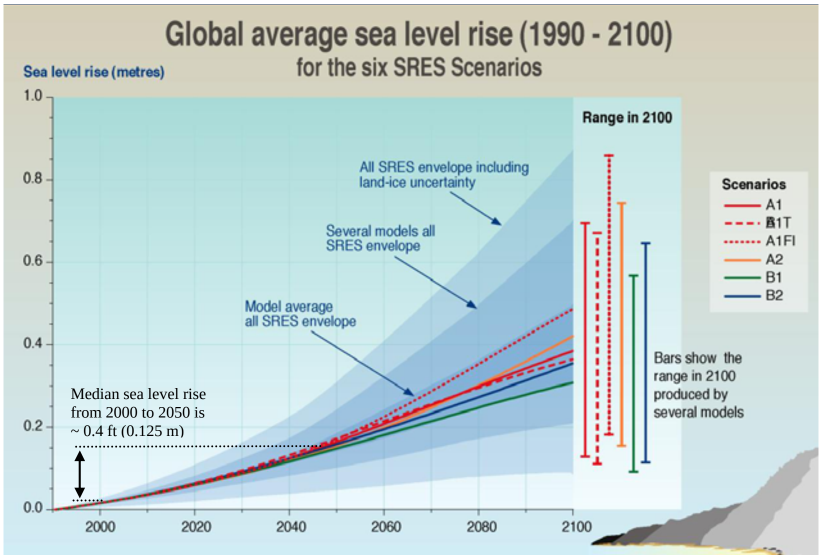
Table 5-2. Results of Inlet Stability Analysis

Scenario	Tidal Prism (MCY)	Inlet Width (ft at MSL)	Number of Closures (S > 12)	Maximum Value of Stability Index
1	3.5	300	0	6.9
2	2.5	300	0	9.2
3	2.0	200	0	9.4
4	2.0	300	2	13.8

We should also note that the other half of the O'Brien index – the wave power – was established by transforming offshore wave energy to nearshore values using coefficients that reflect the sheltering effect of Duxbury Reef. These 'transformation coefficients' are a function of wave direction and period, and were established by analysis of wave data collected in Bolinas Bay in support of the Corps study.

7. Sea Level Rise & Climate Change

Prediction of future sea level rise involves substantial uncertainty. The 0.4-ft increase in mean sea level applied in the 50-year projections of lagoon morphology is approximately the median value of all models used reported by IPCC (2001) (see figure below). Although the effects of thermal expansion are expected to account for the majority of future sea level rise (only 4-6 cm of the 10-90 cm of projected sea level rise over the 21st century is expected from melting artic glaciers (Artic Climate Impacts Assessment 2004)), results from very recent studies suggests that the median value of predicted future sea level rise may be revised upwards. (Note: Estimates of a new 21st century sea level study [Overpeck *et al.* 2004] were mistakenly reported in the March 24th edition of the *San Francisco Chronicle*. The actual projections were up to 3 ft by the end of this century, and this is consistent with prior IPCC projections.)



Source: Intergovernmental Panel on Climate Change (IPCC), 2001.

Sea level rise greater than the value used in our analysis would reduce the future potential of inlet closure and result in smaller habitat changes than projected. In particular, more rapid sea level rise would result in smaller shifts in frequently exposed / submerged mudflats. Projected changes to fluvial delta, salt marsh and subtidal shallow habitats are less sensitive to changes in sea level rise, although the distribution of these units could also be affected if 50-year sea level rise is very different from the 0.4 ft value assumed in our analysis.

Similar to future sea level rise, climatic changes are difficult to predict – especially changes in a particular locale. Although more frequent and intense rainstorms would produce more watershed material by hillslope erosion, a ~ 1% per decade increase in precipitation predicted by some climate changes models would not substantially affect the net sedimentation in the lagoon since the majority of the material is derived from littoral sources.

8. Dynamic Equilibrium

This criticism of the use of the concept of dynamic equilibrium is important as it relates to how we view – and manage – Bolinas Lagoon as a self-sustaining ecosystem. This concept underlies the methodology used in developing predictions of the physical evolution of the lagoon. It is described in Section 3.1 of the report and was the subject of extensive comments by the TRG on the administrative draft report that can be read in their entirety at http://www.marinopenspace.org/pdf/Bolinas-LagoonBLERFP-Peer-Review-Comments.pdf. We believe that this criticism is unjustified, and may be the result of a misunderstanding of how we view the self-organizing physical processes that determine the shape and ecologic integrity of the lagoon as it evolves.

We understand the persistence and sustainability of the physical lagoon over the last seven millennia to be explicable by what is termed in the geomorphic literature [Schumm and Lichty 1965, Schumm 1977, Woodroffe 2004] as 'punctuated dynamic equilibrium' or 'dynamic metastable equilibrium' as illustrated conceptually in Figure 3-3. Within the lagoon individual geomorphic units, like mudflats, channels and marshes evolve towards 'end states' dictated by the balance between erosive and depositional forces. The aggregation and interaction of geomorphic units in their dynamic end states, or as they evolve, dictates the morphology and tidal prism of the whole lagoon.

Erosive and depositional processes vary over different time scales so the end state varies over time. For this reason we use the term 'dynamic' as opposed to static equilibrium. In the case of Bolinas Lagoon evolutionary trajectories can be disrupted and reset by catastrophic earthquakes. For this reason we use the term 'punctuated' to best describe the evolutionary trajectory.

The conceptual model described in the report [Section 3], provides a coherent explanation of the geomorphic and hydrodynamic response to changes in the lagoon over time and is consistent with data from coring of sediments within the lagoon [Byrne and Reidy 1996, Bergquist 1978]. These demonstrate the persistence of a tidally influenced lagoon dominated by intertidal mudflats over approximately the past seven thousand years, the dominance of littoral sediments in the seaward portion of the lagoon, and the absence of an extensive depositional delta at the mouth of Pine Gulch creek.

The implications of this conceptual model are:

1. We can postulate a dynamic 'end state' towards which the lagoon is evolving in response to the current values and variability of forcing mechanisms.
2. This end state will change in response to long term changes in forcing mechanisms like sea level rise.
3. Depending on the frequency of catastrophic events and rate of recovery of individual geomorphic units, for much of the time lagoon morphology will be evolving towards rather than achieving a dynamic equilibrium form.

The TRG commented "*while it is reasonable to state that the lagoon as a physical system exhibits equilibrium seeking behavior [i.e. tends towards a persistent average condition over time] it is not reasonable to imply that equilibrium will actually be achieved'*

Our analysis has developed a prediction of the 'persistent average condition' that could potentially be reached in approximately a hundred years. We recognize that this is a theoretical construct that assumes no catastrophic earthquakes will 'punctuate' and affect the evolution of the lagoon. We also recognize that projections beyond the 50-year planning horizon include considerably larger error bands. Our analysis shows that this end state is substantially different [a smaller lagoon] than the end state that might be inferred from pre-European settlement conditions, 200 years ago, because the forcing mechanisms that dictate how geomorphic units within the lagoon evolve, have changed. In addition our analysis projects 50 years in the future, 150 years after the 1906 earthquake, the lagoon is still evolving towards its end state.

We responded to the TRG's comments on this issue in the draft report as follows:

'The concept of dynamic equilibrium is overly applied.'

> We have edited the report to emphasize geomorphic evolutionary trajectories and the role of major earthquakes in resetting the lagoons evolution. We agree that 'equilibrium seeking behavior' describes the evolution of individual geomorphic units and key attributes of the whole lagoon. However, use of this terminology inevitably poses the question in the publics mind –"what equilibrium?" We have therefore continued to describe 'dynamic equilibrium' as a conceptual end state while acknowledging that because of re-adjustment after major tectonic events the lagoon may have never achieved it.
>
> We believe this discussion of the appropriateness of defining dynamic equilibrium to be very important in interpreting the future of the lagoon. Our conceptual model of the lagoon is that it is a self-organizing sedimentary estuarine form that persists due to the balance between sedimentation, and the creation of 'accommodation space', both from continual sea level rise and from infrequent episodic tectonic subsidence events. In projecting an equilibrium form we have evaluated how the lagoon morphology would adjust over the next few centuries in response only to projected sea level rise. We find that this projected morphology and associated tidal prism–the asymptote of the evolutionary trajectory, does equilibrate as a fully tidal system. In other words, the lagoon does not require another major earthquake within the next few centuries to persist as a tidal system. The role of these earthquakes is to punctuate the dynamic equilibrium state, reinitiating evolutionary trajectories that converge on a particular estuarine morphology, which is in turn changing over time.
>
> We did not intend to imply that the ecosystem is in dynamic equilibrium. Our discussion above, and the use of dynamic equilibrium in the report, is restricted to physical morphology.

9. Wind-Waves and Mudflat Evolution

Many references in coastal geomorphic literature describe the influence of wind-wave and evolution of mudflat profiles (Kirby 1992, Dyer 1998). The concept of equilibrium profiles is discussed by Woodroff (2004), and empirical evidence of how changes to internal wind-wave exposure inside a lagoon may shift mudflat slopes and elevations are presented in Kirby (2000). Observed marsh expansion in sheltered areas (see Figure 3-10) and relatively minor changes in mudflat elevation in exposed areas (Figure 4-5) suggest that these concepts can be applied to projections of future conditions at Bolinas Lagoon.

10. Earthquakes

There was concern from some readers that our analysis did not account for the potential effects of future earthquakes in our 50-year projections. Although a major earthquake along the San Andreas Fault is expected sometime in the future [The USGS estimates earthquake probability along the San Andreas at approximately 20% over the next 30 years. See http://quake.usgs.gov/research/seismology/wg99/index.html], we have neglected such an event in our projections due to several uncertainties that make quantification of its effects extremely difficult. From Byrnes' coring study, average duration between earthquakes at Bolinas Lagoon is 360 years with a range of between 140 and 630 years. It should also be noted that each earthquake may result in very different effects on the lagoon as there maybe differential north-south shifts, east-west differential in down-drop, overall magnitude of down drop, and therefore very different impacts on channel morphology and overall lagoon evolution. Magnitude, trace and other details of the next earthquake will all affect the amount of tidal prism increase and habitat change. Assumptions regarding these effects would include considerable uncertainty.

11. The 1906 Earthquake and Logging Effects

As documented in the Byrne study and summarized in the PWA report, logging and other watershed disturbances accelerated the delivery alluvial sediment to the lagoon. It is difficult to predict the present-day tidal prism had 19th century watershed disturbances not occurred. We speculate that if natural watershed delivery rates persisted throughout the 19th century, the tidal prism of Bolinas Lagoon would have been larger immediate following the 1906 earthquake. However, dispersion of littoral material into the lagoon would have been greater and at least partially offset the hypothetical and incremental increase in tidal prism.

12. Episodic Alluvial Events

We understand that NPS may be collecting flow data along Easkoot Creek and possibly Pine Gulch Creek. Although these data (if collected) could extend the data record through the recent New Year's storms, we do not believe they would substantially change the multi-decade average used in our analysis (which include the even large storms of 1982 and other El Nino years).

13. Littoral Sediment Input / Bolinas Bluffs

Questions from the public concerning the littoral sediment and Bolinas Bluffs focused on the following issues:

- Discrepancies in the report between how much bluff-eroded silt is delivered to the lagoon.
- Changes in beach morphology and littoral drift due to armoring effects along Stinson Spit.

Under contemporary conditions, circulation patterns in Bolinas Bay limit the amount of bluff-eroded material transported through the tidal inlet. However, massive bluff failure *at the time of the 1906 earthquake* would have increased the supply of this material. It is reasonable to expect that the delivery of bluff-eroded material over the past one hundred years has changed. [Note that preliminary data presented at the August 2005 meeting at the Civic Center were revised. Data in the final Byrne and PWA reports are based on a 6.8 mm/yr average sedimentation rate in the North Basin – not the 10 mm/yr reported at the August 2005 meeting.]

Over the long term armoring at Stinson may affect the beach elevation, its planform shape, and possibly the amount of beach sand entering the lagoon. However, late-20th century aerial photographs show a stronger correlation to strong winter storms than armoring at Stinson. Note that the sand transport potential referenced in the report is probably much higher than actual sediment delivery. This is discussed qualitatively in the reports. However, the relevant implication is that the estimate of littoral sediments (beach sands plus bluff-eroded material) available for transport is an order of magnitude greater than observed sedimentation rates within the lagoon, and a more detailed analysis was not needed to confirm that the supply of nearshore sediment is adequate to fill the sediment budget.

14. Sediment Accumulation / Deposition / Tidal Prism Loss

A large amount of information regarding historic and future sediment accumulation and tidal prism change was presented in the Byrne and PWA reports. Public comments involving these issues focused on the following questions:

- What was the basis of projecting tidal prism over the next 50 years, and why is the future rate of loss slower than historic values?
- Are there data to quantify how changes to sedimentation and tidal prism rates will vary within the 50-year planning horizon (e.g., in the next 5 to 25 years)?
- Are there discrepancies between the Byrne data and analysis carried out by PWA?

Future tidal prism loss and habitat change were projected by methodology described in Section 5.1. Generally speaking, this consisted of: (i) estimating changes to each of the geomorphic units to assess habitat distribution; and (ii) aggregating the cumulative effect to across the lagoon to assess tidal prism. While making our projections of each geomorphic unit, we reviewed the major terms of the sediment budget and significant processes affecting sediment dynamics to assess how sediment inputs and outputs are likely to change. Results from this exercise led to our estimate of approximately 1 MCY loss in tidal prism over the next 50 years, or about 20,000 CY/yr on average.

This rate of future tidal prism loss is less than our estimates of historic change (~34,000 CY/yr from 1906-1998) and (~25,000 CY/yr from 1968-1998). This trend of a deceleration of tidal prism loss is consistent with changes in internal sediment dynamics (e.g., diminished strength of tidal dispersion, effects of wind-wave agitation) and accelerated sea level rise, as described in Sections 5.2 and 5.3. Please note that our projection of 50-year evolution does not assume diminished watershed delivery, although the lateral extension of Pine Gulch Creek will slow as it's radius increases and a larger portion is captured on the supratidal 'cone'.

As described in Section 5.4, the projection of 50-year conditions is based on a variety of sources. In the North Basin, we directly applied the results from the Byrne study (6.8 mm/yr) to project changes in shallows, mudflat and marsh since sediment cores collected from this area provided the most reliable dataset. However, the projection of future geomorphic changes outside of the North Basin was based on other data due to the limited coverage of the Byrne dataset (see Figure 5-4). For example, expansion of the Pine Gulch Creek delta was based on the average rate of watershed delivery.

For the purposes of establishing a 20th century sediment budget for the lagoon, we have extrapolated the Byrne average (6.8 mm/yr) over the entire lagoon (~43,000 CY/yr) at the suggestion of the TRG. (The narrative on page 28 incorrectly states that we used 45,000 CY/yr. Results summarized in the Table 3-3 and findings described elsewhere are based on the correct value of 43,000 CY/yr.) Note that our estimate of the ratio of watershed to littoral sedimentation is not based on the stratigraphy results of Byrne; we simply calculated the difference between total sedimentation (43,000 CY/yr) and the average annual watershed delivery (10,000 CY/yr based on Tetra Tech's estimate of watershed yield and our analysis of transport capacity). We expect this ratio to change as watershed delivery continues at its present rate but tidal dispersion diminishes (see Section 5.2.1).

It is important to note that we have based our projection of future lagoon conditions on average annual sediment rates established over several decades. Actual year-to-year sedimentation and morphologic change will differ due to the climatic variability, such as the episodic nature of fluvial delivery and the occurrence of strong ocean storms.

15. Groins and Armoring

Although construction of the Bolinas Groin has been effective at maintaining a wide and high Brighton Beach, it does not appear to restrict littoral delivery under existing conditions since the structure is buried during summer and winter months. At these times, wave action is effective at transporting beach sands along the active littoral zone. During times of energetic winter storms, the zone of active littoral transports further offshore – beyond the extent of the groin.

Aerial photography analyzed as part of this study suggest that sand transport and beach morphology along Stinson Spit over the past are strongly related to the occurrence of El Nino winters. Although the effects of armoring along Stinson Spit are less certain as sea level continues to rise, delivery of beach sand into the lagoon does not appear to be limited by supply or littoral drift along the beach. Rather, the sediment texture (coarse material near the inlet; finer material at the North Basin and South Arm) suggest that the strength of tidal dispersion is the primary factor affecting delivery of beach sands.

16. Easkoot Creek and the South Arm

The 10,000 CY/yr estimate of watershed yield was established by Tetra Tech for the entire 16.7 square mile watershed, including the area tributary to Easkoot Creek. Delivery of alluvial from this creek, in addition to accumulation of littoral sediment in this area, has been included in the 'Macdonald and Byrne' core extracted from this South Arm.

Past changes to the South Arm (as well as other sub-areas) are in Section 3.5.1, with Figure 3-9 mapping the approximate extent in marsh vegetation over a series of four 'snapshots' from 1959 to 1998. Additionally, the placement of artificial fill in the South Arm during construction of Seadrift Lagoon is discussed in Section 3.5.2 and Figure 3-12. Unfortunately, very limited data from dated sediment cores are available to quantify the 20th century sedimentation rate in this area. Several cores taken by Byrne et al. for this study were not useable because of the large amount of disturbance from fill and dredging in the South Arm. However, the results from an older core were similar to the average of the cores recently extracted from the North Basin (both ~6 mm/yr).

17. Bolinas Channel

The gradual and continued reduction in depth, width and cross-sectional area of the Bolinas Channel has been observed over the past several decades. We attribute this to reduction in channel size to accumulation of sediment at the head of the Bolinas Channel associated with progradation of Pine Gulch Creek delta (compare aerial photographs from 1959 and 1998 shown in Figure 3-10). We expect this trend to continue (see narrative at top of Page 74), with the ultimate size of Bolinas Channel dictated by the marsh area which it drains (a portion of the salt marshes on Kent Island and south of Pine Gulch Creek).

18. Wildlife/Habitat Projections

Declines in Birds and Invertebrates:

The Report identifies groups of birds, fish and invertebrates that are expected to decline, remain stable, or increase based on the predicted shifts in habitat (Section 5.9). It is recognized that Bolinas Lagoon is a site of international importance for migratory birds (designated such by RAMSAR) and waterbirds are of particular importance. Studies (1992, G. Chan; & 1993/4, A. Malino) of benthic invertebrates at the lagoon found a diverse species composition and population numbers that are comparable to other northern/central California coastal lagoons and embayments. These surveys were not extensive, area wise of the entire lagoon, but were representative of the typical channels and mud flat areas in the lagoon. Surveys of benthic invertebrates in 2004 (W. Martin) found a slight shift in species composition compared to the earlier studies. This shift was to benthic invertebrates more tolerant of elevated nutrient levels. However, the overall number of species were not significantly different from the number of species found in earlier surveys. Population numbers are much more difficult to quantify given the vagaries of the lagoon environment and as such cannot be directly compared between the two sampling periods without longer term data sets.

Significance of Pine Gulch Creek Delta/Regional Conservation Context

We agree that regional conservation context is important as reflected in the discussion of threatened and endangered wildlife and habitats. We agree that Pine Gulch Creek delta is of significant biological value, in particular for migratory land birds and that many rare species have been observed there. Nevertheless, Pine Gulch Creek delta is an artifact of the creeks channelization and excessive historic watershed sedimentation and contributes to decreased wind-wave effects and increased sediment deposition along the west shore.

Clapper rail habitat

The Report identified several species of birds that are expected to increase in numbers with the expansion of tidal marsh. We did not however, mention that with tidal marsh succession, Bolinas Lagoon may function as a stepping-stone population between Richardson Bay and Point Reyes clapper rail populations. This will be added to the Report.

The invasion of non native cord grass

Establishment of invasive Atlantic cordgrass (*Spartina alterniflora*) in Bolinas Lagoon would be a significant threat to native plant communities and habitats. It grows at higher and lower elevations than the native California cordgrass (*Spartina foliosa*), reducing mudflat and shorebird habitat and replacing pickleweed and other high marsh species. It can also alter tidal circulation by colonizing channel bottoms. In addition, it hybridizes with the native cordgrass and could lead to extirpation of the native species over time.

Invasive Atlantic cordgrass was identified in 2003 Bolinas Lagoon by the San Francisco Estuary Invasive Spartina Project (ISP), a project of the California State Coastal Conservancy and eradicated by Marin County Open Space District and ISP. Reliable morphological characters are not presently known that can be used to positively identify hybrids of *S. alterniflora* and *S. foliosa*. ISP collects samples of suspected invasive cordgrass and conducts genetic testing to determine presence of hybrids with native *S. foliosa*. Ongoing monitoring for Atlantic cordgrass in Bolinas Lagoon is conducted by Marin County Open Space District, Audubon Canyon Ranch and ISP. We agree that a monitoring plan for Bolinas Lagoon should be developed that includes reporting on the ongoing Atlantic cordgrass monitoring and control efforts.

<u>Missed Populations of Plants and Animals/Nomenclature</u>

Several commentators provided information on rare plants and animals that were not found during the surveys and otherwise were not mentioned as potential or known at the Lagoon. Similarly, mistakes in nomenclature were also pointed out. These will be added to the report and corrected, respectively.

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