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MEMORANDUM

DATE: February 26, 2014

TO: James Raives, Senior Open Space Planner, Marin County Parks
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SUBJECT: Draft Synthesis/Summary of Bolinas Lagoon Restoration Project Design Review Group Meeting (SFBJV)

BOLINAS LAGOON RESTORATION PROJECT
DESIGN REVIEW GROUP (DRG) MEETING
SAN FRANCISCO BAY JOINT VENTURE (SFBJV)
MEETING SUMMARY AND SYNTHESIS DRAFT

Preparer: Peter Baye, Coastal Ecologist and meeting participant, from real-time notes (P. Baye & K. Bimrose, Farallones Marine Sanctuary Association (FMSA)), and audio recording notes
Draft date: January 31, 2014
Original meeting date and location: July 31, 2013, Audubon Canyon Ranch, Stinson Beach, CA, 10 a.m. - 4 p.m.
Moderators: Sandra Scoggin, SFBJV; Kate Bimrose, FMSA

SFBJV DRG SCIENCE PEER REVIEW/ADVISORS

Peter Baye, Coastal Ecologist, independent consultant
Bill Carmen, Ecologist, Carmen and Associates
Josh Collins, Ecologist, San Francisco Estuary Institute, Chief Scientist
Laurel Collins, Geomorphologist, independent consultant
Rachel Kamman, Hydrologist, Kamman Hydrology and Engineering
Gary Page, Ecologist, Wildlife Biologist, Point Blue Conservation Science
John Takekawa, Ecologist, Wildlife Biologist, US Geologic Survey (USGS)

PARTICIPANTS, ATTENDANTS:

Maria Brown, Gulf of the Farallones National Marine Sanctuary (GFNMS)
Kate Bimrose, Farallones Marine Sanctuary Association

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Rudy Ferris, Bolinas Lagoon Advisory Council
Gwen Heistand, Audubon Canyon Ranch and Bolinas Lagoon Advisory Council
Linda Dahl, Marin County Parks
Ron Miska, Marin County Parks
Mischon Martin, Marin County Parks
James Raives, Marin County Parks

PRESENTERS

John Takekawa, US Geologic Survey (USGS)
Kelley Higgason, Gulf of the Farallones National Marine Sanctuary

INTRODUCTION

The primary goal of the meeting was to review the assumptions, perspectives, rationale, recommendations, and conclusions of the *Bolinas Lagoon Restoration Project : Recommendations for Restoration and Management*, also known as the "Locally Preferred Plan" (LPP), taking into account a) the latest and best available scientific research on climate change (including revised sea level rise rate estimates), and b) findings from the 2008 UC Berkeley sediment core analysis of Bolinas Lagoon (Roger Byrne and others).

An overarching aim of the discussion was to identify important new scientific evidence to inform Bolinas Lagoon ecosystem restoration approaches and designs, and resolve any differences in scientific perspectives. A specific objective for the meeting was to reappraise the LPP's original project concepts and premises, and identify any appropriate new scientific insights and recommendations for revisions in the LPP restoration proposals or priorities.

Meeting Summary Approach: The following synthesis is not an abbreviated transcript of the meeting, but a distillation of key points and perspectives, including "paradigm shifts" (*e.g.,* fundamental changes in emphasis, project priority rationale, importance, predictive physical processes/dynamics, or far-reaching long-term conclusions) with direct applicability to ecosystem restoration project selection and design. The emphasis of this synthesis is on abbreviated and reconstructed discussion threads that are most relevant to public, federal, and county review of environmental management policy for Bolinas Lagoon. Many scientific details of the discussion, and attribution of statements by individual participants, are not included unless they are essential for explanation. Where scientific terms are essential to the summary, explanations are provided in parentheses.

Meeting Structure: The SFBJV meeting began with participant introductions, followed by two presentations about new data collection and models that address changes in Bolinas Lagoon bathymetry (water depth/sediment elevations), sediment accretion, and

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erosion (John Takekawa, USGS), and models developed for Our Coast Our Future (GFNMS, Point Blue Conservation Science, and USGS) to explore local submergence and storm flooding effects associated with accelerated sea level rise and climate change. Following these presentations, the group had a wide-ranging discussion that covered area-specific restoration issues (sub-regions in the lagoon, and actions both within and beyond the scope of the original LPP), as well as large-scale physical and ecological processes that drive environmental changes and ecological services in the lagoon.

PRESENTATIONS SUMMARY

John Takekawa (USGS) provided background on current sea level rise and climate change models, and data collection on bathymetry in Bolinas Lagoon using multiple methods. He also described some of the important updates in climate change and sea level rise models since the 2005 International Panel on Climate Change (IPCC) assumptions and predictions, which were prevalent at the time of the Bolinas LPP, including:

- Sea level rise "middle ground" estimates for the year 2100 are in the range of 1.2-1.4 meters/century for the coast around and within San Francisco Bay -- substantially higher than the conservative estimates used by IPCC in 2005, on which previous Bolinas Lagoon restoration plans relied.
- The frequency and magnitude of extreme coastal storm events are now viewed as an imminent issue for coastal change than sea level rise itself. The frequency of extreme storms previously expected once a century are likely to increase to decade-scale frequency, even by 2030 or 2040. Storm impacts significantly intensify sea level rise impacts in the short-term.
- The combined impact of sea level rise and extreme storm events, previously not considered in the LPP, should be considered in discussions of project priority, location, and timeliness.
- Much intertidal habitat is likely to become submerged, becoming subtidal habitat, with 40-70% or more loss of existing intertidal habitat in the San Francisco Bay region.

The revised background assumptions about climate change/sea level rise have profound and systemic implications for Bolinas Lagoon restoration approaches and design review.

John Takekawa and the scientific review group discussed some important methodological and issues about measuring the accuracy and precision of bottom (sediment) elevations in Bolinas Lagoon, and their relation to stable, reliable elevation benchmarks that are used to determine changes of lagoon depths over time. This issue remains fundamental to determining rates of lagoon submergence or sediment accretion that drive the purpose an need for LPP restoration projects. Older bathymetric surveys (1968-1998) had basic problems with accuracy that were revealed by subsequent scientific peer review. This review concluded that the older elevation data were inaccurate, and not comparable with post-1998 data for purposes of long-term trend analysis. DRG experts, without dissent, recommended that development of accurate, reliable elevation benchmarks for Bolinas Lagoon is a necessary and feasible step for

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both monitoring the lagoon, and developing meaningful long-term future restoration projects.

Kelley Higgason, GFNMS, demonstrated the “Our Coast Our Future” (OCOF) online decision tool (graphic topographic model of flooding due to sea level rise and storm surge from Half Moon Bay to Bodega Bay). The online tool identifies uncertainty of predictions and accuracy. The DRG discussed the elevation precision constraints for intertidal wetlands (identified in the first presentation) in terms of the OCOF model accuracy. The OCOF model does not currently address factors of coastal change involving fluvial (stream) flooding or beach morphology changes such as shoreline retreat, wave washover, dune erosion, or tidal inlet shoal processes that affect Kent Island, Stinson Beach, and lower Bolinas Lagoon.

DRG DISCUSSION SUMMARY

Overview of Project History

Bill Carmen (ecologist for the Bolinas Lagoon Restoration Project) began the meeting with an overview of the project history, and the main findings of the PWA (Philip Williams & Associates; now ESA-PWA, hydrology consultant team) report (2008), prepared after 2008 investigations of the lagoon’s sedimentation history.

The overall restoration effort at Bolinas Lagoon was originally motivated by lagoon tidal sedimentation trends (infilling, rising tidal flat elevations, shallower lagoon channels), and concern about loss of tidal prism (tidal volume) previously estimated to be about 25% of the lagoon volume over about 25-30 years. Southern California lagoons influenced the perspective about long-term trends of lagoon evolution as an analog of Bolinas Lagoon. Some southern California lagoons suffered from artificial filling and loss of tidal prism. This resulted in progressive sedimentation and increased frequency of tidal inlet closure, due to choking with beach sand when wave power exceeded the weak erosive power of diminished tidal flows. This condition caused water quality and ecological problems in southern California lagoons, and generated perceived risks about tidal inlet closure at Bolinas, in addition to reduction in water depths and growth of tidal flats.

The design approach to correct the perceived problem of excessive tidal sedimentation was to formulate a major dredging project, aimed at removing what was assumed to be mostly residual watershed sediment from early historical agriculture and logging. After reconsideration of the “no project” alternative, University of California Berkeley (UC) scientists, led by Dr. Roger Byrne, initiated new investigations of the deep sediment history of Bolinas Lagoon.

The UC research did not support the original hypothesis of progressive lagoon sedimentation triggered by man-made excessive sediment from early historical logging and agriculture. The new UC research revealed that most of the sedimentation in the lagoon was from natural marine sources and tidal processes. The main physical driver of sedimentation in the lagoon in the 20th century was recovery from rapid (instantaneous) major subsidence of the lagoon during the earthquake of 1906. UC research on

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sediment cores revealed that the lagoon bed subsidence depth in 1906 was significantly greater than previously estimated: the lagoon deepened by as much as four feet during the 1906 earthquake.

The subsidence of the lagoon has occurred repeatedly, on an irregular cycle of about 300 years. This natural subsidence forms and maintains the lagoon. After each earthquake "re-set" of the deepened lagoon bottom, equilibrium is re-established by increased marine sedimentation in the lagoon. This post-seismic recovery phase dominated the 20th century, and kept ahead of the rate of sea level rise (about 20 cm/century). Watershed sedimentation (stream delta deposition) actually declined about 50% by 50-70 years ago, and is not the major contributing cause of lagoon sedimentation today. Past predictions about the lagoon over-filling with sediment and risking lagoon closure in the 21st century relied on obsolete estimated future rates of sea level rise that were similar to those observed during the 20th century rates. These rates are far below even the conservative estimates of the 21st century sea level rise rates, which make the risk of lagoon over-filling with sediment in the long term very unlikely (see DRG discussion below).

Accordingly, the major dredging approach was set aside, and LPP projects were reoriented towards correcting human impacts to the lagoon ecosystem, under the assumptions about climate change and sea level rise prevalent before 2008. The DRG considered those assumptions, and suggested that the lead agencies may want to re-consider project designs and priorities.

General DRG Perspectives Emerged

Some important new perspectives emerged in DRG discussions, based on updated climate and sea level rise models, and the findings of recent research. Some of the outstanding unifying themes are summarized below.

- **Accelerated sea level rise replaces the risk of excessive lagoon sedimentation (tidal prism loss) as an overriding ecosystem concern.** In contrast with previous concerns about long-term sedimentation in the lagoon, long-term lagoon submergence due to accelerated sea level rise is a major challenge to Bolinas Lagoon ecosystem health and resilience. The 19th century historical sediment legacy is relatively unimportant; it was overcompensated by the 1906 earthquake subsidence event. This inverts the previous perspective on tidal sedimentation of the lagoon and, in some cases, stream sedimentation rates, as the major threats to its ecosystem. Short-term tidal sedimentation may be conspicuous, but in the long-term (e.g., by mid-21st century or sooner), high lagoon sedimentation rates will be needed to keep pace with accelerated rates of sea level rise.

- **Sediment values can be neutral, beneficial, or adverse – depending on location, timing, magnitude, and context.** In context of sea level rise adaptation and lagoon ecosystem resilience, sediment can be an important and even essential asset to the lagoon. Sedimentation can be an asset to evolution of the lagoon, not just an impact. The presumption that sediment is excessive and in need of reduction

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or removal in Bolinas Lagoon to "restore" ecological services is no longer applicable in most circumstances.

- **Accommodation space (room for the lagoon to migrate into lowlands of stream and fault valleys as sea level rises) is a primary concern for long-term health and stability of Bolinas Lagoon.** A major shift in strategy for lagoon conservation is to re-focus on adjacent lowlands for the lagoon's shallowest margins to occupy as sea level rises, so it can adapt to rising sea level and maintain its essential upper intertidal marshes and transition zones with terrestrial and riparian habitats. This realignment of the lagoon's margins is inevitable, and will require reconfiguration of roads, other infrastructure and existing land uses, forced by increased flooding frequency and rising groundwater linked to sea level. Two related, recurrent, and informal themes include "look upslope" for priorities in managing and restoring Bolinas Lagoon, and "get out of the way" to avoid costly and futile artificial efforts to stabilize infrastructure and land uses.

- **Bolinas Lagoon's barrier spit (Stinson Beach and Seadrift) and tidal inlet ("mouth") are essential components of its evolution in response to sea level rise and climate change.** Future changes in the lagoon's barrier beach and tidal inlet will occur in response to accelerated sea level rise and coastal storms. These inevitable processes have to be considered in scientific models of the evolution of the lagoon interior, and cannot be excluded without distorting the accuracy of models. This is a fundamental new perspective made without prejudice to current ownership or land use, and with emphasis on Bolinas Lagoon's resilience and response to sea level rise. Conceptual and predictive models of the evolution of the spit and tidal inlet, under multiple scenarios of sea level rise, storm event magnitude and frequency, and engineering responses, should be evaluated to inform potential consequences for both the lagoon and for existing or alternative future land uses.

Regional DRG Recommendations and Findings

- **Conceptual models of Bolinas Lagoon's geomorphic, hydrologic, and ecological evolution should be developed as a framework to guide ecosystem planning, prioritization, and public education, and especially LPP project re-evaluation.** Conceptual models should be based on the best available interdisciplinary science, without reference to jurisdiction or ownership over Bolinas Lagoon or adjacent lowlands and uplands (in the path of rising sea level and storm surge or related fluvial flooding).

- **The DRG recommends that planning for the ecological health of Bolinas Lagoon be based on a range of possible, contingent, but foreseeable circumstances, like responses to major storm or flood events, rather than fixed project planning.** Extreme flood events, extreme coastal storm events, and other discrete or threshold changes (such as rapid channel migration, major stream avulsion or depositional events) should be considered as the premise or trigger for conditional responses and opportunities, including future land acquisition following major storm or flood events, to provide room for natural processes to occur without conflicting infrastructure.

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- **Armoring (hardened, stabilized shorelines) is a liability for lagoon resilience and adaptation to rising sea level.** Artificial shoreline or channel (fluvial or tidal) stabilization is likely to impair dynamic processes essential to the inevitable reconfiguration of lagoon habitats, and it is likely to fail in the long-term. Armoring is often a default reactive defense to severe shoreline or channel erosion events, so plans for addressing erosion should anticipate shoreline change, and apply adaptive designs that are compatible with Bolinas Lagoon's adjustment to higher sea level and more frequent, intense storms.

Project-Specific and Area-Specific Findings and Recommendations

Discussions about LPP projects and new project concepts focused on several sub-regions of Bolinas Lagoon and its adjacent lowlands, with increased emphasis on adjacent lowland floodplains, valleys, and stream deltas because of the importance of accommodation space (room for the estuary to migrate landward), interactions of fluvial and tidal physical processes that control ecosystem services, and the new emphasis on floodplains as platforms for the 21st century margins of rising Bolinas Lagoon.

Pine Gulch Creek Delta and Floodplain Processes

There was consensus that long-term maintenance of channelization of Pine Gulch Creek was detrimental to the long-term evolution of the lagoon, and contributes to conflicts between flood management and land uses. Traditional channelization of Pine Gulch Creek excavated simple channels designed to concentrate and convey flood flows most efficiently like flood control channels or ditches. One effect of this channel simplification was the concentration of stream delta sediment into the intertidal lagoon, rather than the floodplain above most tides. The DRG recommends a complex and dynamic, irregular system of channels that distributes and spreads flood flows and sediments within reestablished historical flood plains. Integration of flood sediment deposition patterns that may be compatible with farming was proposed for feasibility study.

The delta and floodplain are essential platforms for the future rising lagoon edges; without gently sloping migrating transition zones, the lagoon's complex tidal-terrestrial gradients will suffer "coastal squeeze" against armoring or berms. Alternative future approaches should include designs to spread flood flows and sedimentation, develop complex distributary channel patterns, and reduce the concentration of channelized high-turbulence flood flows into the intertidal lagoon where they carry and drop coarse sediment loads to the lagoon, instead of dispersing them in the terrestrial floodplain).

There was no consensus, however, about whether the relatively artificial growth of Pine Gulch Creek delta into the intertidal lagoon is actually a liability to Bolinas Lagoon's resilience to sea level rise today. One DRG perspective is that it may be a self-correcting platform for a submerging estuary, and a low priority for active removal. Another DRG perspective is that the artificially extended delta may be sheltering some mudflats from wave action that would otherwise tend to erode and disperse mudflat and salt marsh. The differences in DRG perspectives on relative benefits and liabilities of the modern delta and its effects on the lagoon are related to time frame (near-term versus long-term)

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and scenarios of sea level rise rates. Higher rates of sea level rise make the value of sediment deposition greater in the long term.

Existing roads and culverts across the Pine Gulch Creek floodplain will eventually need to be replaced with raised or relocated roads, as flood frequency and magnitude increases. Freshwater influences of the delta, both surface flows and high groundwater, are important aspects of the tidal transition zone to conserve.

Lewis and Wilkins Gulches, also known as "The Y

The head of the lagoon, aligned along the shear zone of the San Andreas Fault lowlands, is another highly important zone for lagoon accommodation space during accelerated sea level rise. The area currently is subject to flooding. The DRG recommended that when flood flooding frequency and magnitude increase to the point at which, road reconfiguration or redesign is necessary, road realignment and redesign should provide accommodation space for the lagoon (be compatible with unobstructed fluvial and tidal flows, and with habitat connectivity between lagoon and terrestrial lowlands. The DRG also recommended reducing road constraints of channels locations and dynamics, and accommodating complex distributary channel systems in Lewis and Wilkins Gulches.

East shore drainages

The relatively steep, coarse-sediment drainages of the eastern shore of Bolinas Lagoon have sediment-choked culverts and aggraded sediment and wetlands above Highway 1. Their stream valleys are also potentially important accommodation space for the lagoon (though smaller and narrower than the Lewis and Wilkins Gulches and Pine Gulch delta), and support distinctive coarse sediment with strong groundwater seeps maintaining brackish marsh zones. As road flooding increases and forces redesign, culverts should be replaced by bridges or raised roads to reconnect the stream valley with the rising lagoon, and reduce choking of flood sediments above the road.

Easkoot Creek

Marin County is currently evaluating potential alternatives to address flooding along Easkoot Creek. In addition, the GGNRA plans to study the potential impacts of sea level rise, storm events, and flooding on parklands at Stinson Beach and develop climate adaptation strategies to address likely future changes. The lowlands behind Stinson Beach are an historical freshwater nontidal portion of Bolinas Lagoon wetlands. The backdune flats are a zone of high groundwater seepage through the backdune flats foredunes. This area is naturally conducive to freshwater swamp and marsh (which exists in patches there now). As sea level rises, and foredunes retreat over backdune wetland flats with higher groundwater that rises relative to sea level, there may be a need to relocate infrastructure, which would enable freshwater wetlands to re-establish here.

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