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TO: Phil Isenberg, Chair
Delta Stewardship Council

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Introduction

As a member of the Delta Independent Science Board, I was asked to review the *Flood Risk Whitepaper.* This document was prepared for the Delta Stewardship Council by its consultants in October of 2010 to help inform development of the Delta Plan. Recognizing that the Council has a very short timeline for preparation of the Plan, it is not appropriate to conduct a full-scale review. Instead, this memo seeks to amplify and clarify some of the issues raised within the whitepaper and to add additional information the Council may want to consider.

In this memo I make four points that build upon information presented in the whitepaper and are intended to help the Council in their preparation of the Delta Plan:

- Levee fragility, including the different potential causes and consequences of levee failure, is highly variable in the Delta. Therefore, one-size-fits-all levee policies are unlikely to be successful.
- Current levee policy is driven by state and federal levee standards that are uniformly applied, regardless of risk. This leads to inefficiencies at mitigating risk and is unlikely to perform well under changing future conditions.
- Risk-based approaches, which seek to make strategic investments that yield the highest risk reduction, are likely to be most successful, as well as transparent and objective.
- To date, all planning efforts have failed to consider that it is more economically efficient to allow some islands to remain flooded following levee failure. New policies need to be established that address this.

This memo is the observations of a member of the Delta Independent Science Board and should not be construed as representing the views of the entire Board or the Delta Science Program. Under the Board's guidelines, members are allowed to make comment directly to the Stewardship Council.

Flood Threat Assessment

The whitepaper, borrowing principally from the DWR Delta Risk Management Strategy (DRMS) reports, outlines for the Council the current low level of flood protection afforded by levees of the Delta, particularly non-project levees within the Primary Zone. Generally poor construction standards and weak foundations make the levees prone to seepage and settling. In addition, rising sea level, increasing frequency and magnitude of floods, and continued island and levee subsidence are progressively reducing levee reliability. Finally,

despite the protestations of some Delta stakeholder groups and their engineers, there is compelling evidence that earthquakes are a major threat to levee stability in the region.

It is important to remind policymakers that levee stability is not uniform throughout the Delta. Threats to levees in the North and South Delta are primarily associated with high winter and spring flood inflows from the Sacramento, Mokelumne and San Joaquin Rivers. In contrast, most levees in the Western and Central Delta are prone to failure during extreme high tides and winds, and are at higher risk of failure due to earthquakes. In addition, there is high local and regional variability in levee foundations and construction standards, along with regional differences in rates of island subsidence. Finally, land uses, along with land and asset values, are highly variable throughout the Delta.

These regional differences will be amplified by on-going changes in conditions. Rising sea level disproportionately affects the Western and Central Delta, principally through the increase in frequency and magnitude of extreme high tides. Conversely, changes in runoff patterns, along with flood management operations, are having their greatest impact in the Northern and Southern Delta, where tides are less important. These regional variations, both now and in the future, suggest that one-size-fits-all approaches to levee policies are unlikely to be effective at managing risk under changing conditions.

Potential Costs and Benefits of Current Policies

The whitepaper gives limited information on the costs involved in adapting the Delta levee network to existing and future conditions. Yet, after public safety, this is likely to be the single most important factor to be considered in developing levee policy within the Delta Plan. The costs of doing anything, as well as nothing, are very high. The economic activity of the Primary Zone is insufficient to support its current levee network, much less mitigate future conditions. For this reason, along with compelling state interest in protecting water supply, energy and transportation infrastructure, the Delta levee system will rely on significant state and federal subsidies for the indefinite future.

With the exception of the Special Projects program, current levee policy is a one-size-fits-all approach. The Subventions Program, Hazard Mitigation Plan (HMP) standards and PL 84-99 standards are uniformly applied, regardless of the value of assets protected by the levees. As the Council well knows, there is considerable pressure to invest state bond funds in bringing all non-project levees up to the PL 84-99 standard[1]. This upgrade, exceeding $600M (but likely approaching more than $1B) reduces the likelihood of levee failure due to flooding by approximately 10% (Suddeth et al., 2010)[2]. Since these monies would be spread evenly across the Delta, they do little to reduce aggregate risk since investments are made equally in areas with low or high asset values. Additionally, these upgrades provide only marginal benefits in protection against earthquakes.

The HMP and PL 84-99 standards also do a poor job as a policy instrument for adapting to future conditions. Levee crown height standards are based on the estimated elevation of

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[1] The value of meeting the PL 84-99 standard lies principally within the federal commitment to rehabilitate flooded islands if their levees meet this standard.

[2] Suddeth, R., J. Mount, and J. Lund, 2010, Levee Decisions and Sustainability for the Sacramento-San Joaquin Delta: San Francisco Estuary and Watershed Science, http://escholarship.org/uc/item/9wr5j84g

the 1% annual probability flood. This estimation is derived from a statistical projection based on historic flows. The fundamental assumption of this method is that the hydrology of the past is a predictor of the future. As has been documented by numerous reports, the region's hydrology is changing, leading to increasing flood frequency and magnitude. Hydrologic baselines are shifting, creating a constantly moving target for levee standards.

To illustrate the nature of this problem, the current levee height standards are based on hydrologic conditions as measured in 1986. To my knowledge, that standard, as applied to current levees, has not been updated. As outlined in the DRMS reports and in the flood risk whitepaper, the new hydrology, based on 20+ years of additional data, indicates a substantial increase in the elevation of the 1% flood. This means that even if $1B is invested in order to bring all the levees up to the 1986 PL 84-99 standard, the levees would be out of compliance, pending recalculation of the 1% flood. Moreover, as sea level rise and inflows continue to change, the elevations are likely to be frequently revised upward. Thus, changing hydrology, by periodically placing most Delta levees out of compliance with PL 84-99 standards, creates continuous demand for distributing funds broadly rather than strategically, perpetuating inefficiencies in levee investments to reduce system-wide risk.

Risk-Based Prioritization and Cost Efficiency

The challenge for the Council is to develop a mechanism for prioritizing strategic investments in a manner that maximizes risk reduction in a way that is transparent, fair and, from the perspective of the state and federal government, economically efficient. The Delta Vision Strategic Plan recognizes the need for this, and suggests a somewhat elaborate levee classification scheme, involving eight different potential classes of levees depending on the land use protected. The complexity of this classification is likely to present difficulties for policymakers, particularly where levees protect a mix of land uses. In addition, although the Strategic Plan stated repeatedly that levee investments needed to be prioritized, it fell short on identifying the specifics of how to accomplish this goal.

As highlighted in the comprehensive review of California levee policy by Galloway et al. (2007)[3], the argument was made that risk-based (rather than standards-based) approaches are needed to guide levee investments. One approach offered by Suddeth et al. (2010) informs and simplifies the process of prioritizing risk reduction investments. Based on the land and asset values of islands, along with the probability of levee failures, Suddeth et al. (2010) use economic decision analysis to identify those islands that do or do not warrant levee upgrades and/or repair following levee failure. This approach formally incorporates risk—the likelihood of flooding x the economic consequences—into decisions. In effect, those islands for which it makes economic sense to repair or upgrade levees are those islands where levee investments yield the greatest impact at reducing aggregate risk. These islands typically contain key infrastructure and/or high value agricultural land.

The approach presented by Suddeth et al. (2010) provides only a first step. It does not include additional ecosystem services of the Delta that relate to levee stability. For example, several islands in the Delta provide critical habitat for sensitive or listed terrestrial species. In addition, under current export pumping regimes, the five western islands play a

[3] Galloway GE, Boland JJ, Burby RJ, Groves CB, Longville SL, Link LE, Mount JF, Opperman J, Seed RB, Sills GL, Smyth JJ, Stork R, Thomas EA. 2007. A California challenge—flooding in the Central Valley. California Department of Water Resources. Independent Review Panel Report. Available from: http://www.water.ca.gov/news/newsreleases/2008/101 507challenge.pdf.

significant role in maintaining low Delta salinities[4]. The economic value of these services can eventually be incorporated into the economic decision analysis. However, for the purposes of developing the initial Delta Plan, the Suddeth et al. (2010) approach allows for an objective, Delta-wide comparison of the value of potential levee investments.

Potential for Permanently Flooded Islands

The Flood Risk Whitepaper, the Draft Bay Delta Conservation Plan, and documents prepared by the FloodSafe program to date have failed to consider one of the thorniest issues of the Delta: the high likelihood of permanently flooded islands in the future. Current policy dictates that the state will only participate in repair of flooded islands if it is deemed to be in the state's interest. All factors, including sea level rise, subsidence, increasing winter inflows, earthquakes and most importantly the costs of upgrading and repairing levees, suggest that under this policy some islands will be allowed to remain flooded following levee failures. It may well be that the evolution of the Delta as place, as outlined in the 2009 legislative package, will be defined by which islands are or are not restored following levee failures.

One approach to dealing with the issue of permanently flooded islands is to let the stochastic nature of island failures play itself out, with restoration being determined on a case-by-case basis under current state policy. This "fail into a solution" approach may be the simplest and most politically expedient for the purposes of the Delta Plan. An alternative approach would be to link together the plan for future levee investments with a long-range plan for allowing some islands to remain flooded once levees fail or, alternatively, to choose to pre-flood islands under controlled conditions to reduce impacts. This approach would be controversial and fraught with a number of legal hurdles[5]. However, this approach meets two important criteria for managing changing conditions in the Delta. It identifies where targeted levee improvements are likely to be needed to mitigate the increases in levee vulnerability due to flooding of adjacent islands[6]. It also allows for the development of long-term programs to reduce or mitigate third-party impacts.

Summary

As noted above, the Flood Risk Whitepaper provided to the Council outlines many of the critical issues that will need to be considered in developing the Delta Plan. However, the Council will also need to consider how to prioritize investments in levees in the Delta in a way that achieves the greatest economic efficiency. One approach (of many) is to move away from the use of uniform standards tied to the 1% annual probability flood, which effectively transfers risk to the state and federal government, and toward targeted investments that yield the greatest reduction in overall risk. Economic decision analysis is a

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[4] See summaries in Lund, J.R., E. Hanak, W.E. Fleenor, J.R. Mount, R. Howitt, B. Bennett, and P.B. Moyle. 2010. *Comparing Futures for the Sacramento San Joaquin Delta*. Berkeley, CA: UC Press

[5] An analysis of the legal and policy implications of flooded islands is contained in the paper: Suddeth, R., 2011, *Policy implications for permanently flooded islands in the Sacramento-San Joaquin Delta.* San Francisco Estuary and Watershed Science Journal, *in press.*

[6] Flooded islands increase the likelihood of flooding on adjacent islands. This stems from the increase in wave fetch created by flooded islands, leading to greater potential wave erosion of adjacent levees. In addition, in some locations, the high water elevations within flooded islands increase underseepage of levees on adjacent islands.

transparent, objective way to achieve this. From a policy perspective, the most challenging aspect of an approach like this is the likelihood that a modest number of islands will eventually be allowed to remain flooded. The Plan may choose to assess whether islands should remain flooded on a case-by-case basis, or anticipate, if not prescribe which islands remain flooded. The latter case allows for the reduction of landowner and third-party impacts.

Analyses like these tend to operate entirely within the hypothetical, which is often unhelpful for making policy decisions. However, the maps developed in Suddeth et al. (2010) provide a first cut at how the policies described above might play out over the course of a few decades. An example is provided in Figure 1.

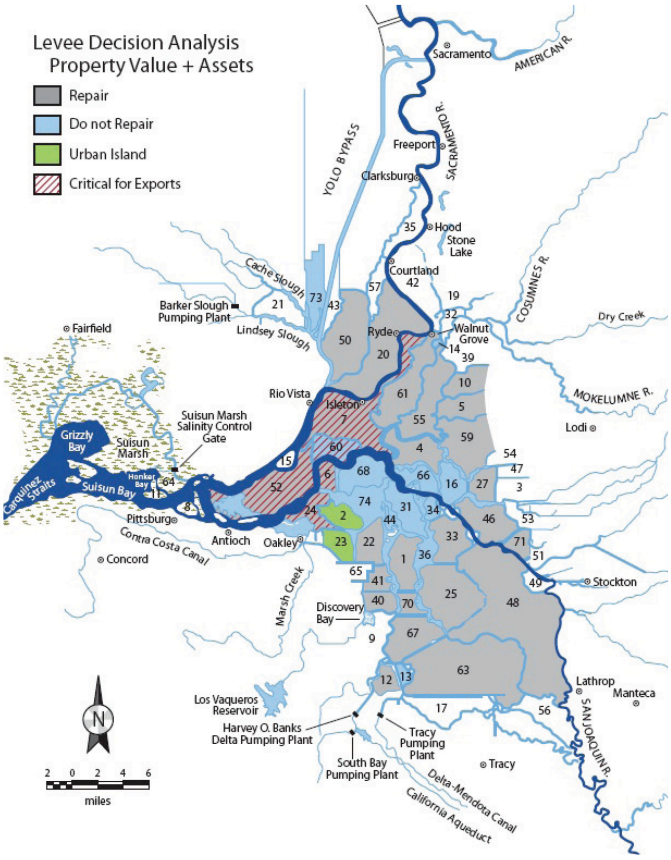

Figure 1. Example of how a risk-based approach to levee investments or repairs, coupled with a decision to not restore some islands following flooding might appear. Analysis excludes islands with extensive urban development. Islands essential for maintaining current water exports are highlighted in red. This is an <u>example</u> of how a policy might translate into a changed Delta and should not be interpreted as a recommended solution.