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Delta Independent Science Board

March 14, 2012

To: Delta Stewardship Council

From: Richard B. Norgaard, Chair, Delta Independent Science Board

Re: Key Issues for Delta Science
A Report of the Delta Independent Science Board

Pursuant to our mandate to review Delta science programs, we held meetings with Delta scientists and users of science to acquire a broad introduction to the science that is ongoing and needed for future decisions. We have also begun the process of looking into specific science programs. We report the following broad findings:

Broad Findings

1. **Nurturing and Sustaining Best Available Science.** To use the best available science, Delta management agencies must have the scientific capability and other resources to do so. Delta science programs, particularly those in state agencies, have difficulty retaining their best scientists, hiring new scientists, and providing support for science. Improved access to the scientific literature, greater participation in scientific conferences, and more opportunities to upgrade skills are needed in state agencies.

2. **Embracing Environmental Complexity.** The CALFED Science Program's report, *The State of Bay–Delta Science, 2008,* suggested several ways to increase the capacity of Delta science to meet the challenge of managing the complex, ever-changing, dynamics of the Delta. These included improved systems models, more effective monitoring, and better access to data. More than three years later, we find that the constructive suggestions of that report remain very appropriate.

3. **Transitioning to Adaptive Management.** The Delta Reform Act of 2009 mandates the use of adaptive management for ongoing ecosystem restoration and water management actions. An effective approach to adaptive management is elaborated in the staff draft Delta Plan. To meet this mandate, participating agencies will require staff trained in adaptive management as well as facilitation throughout the management structure.

4. **Taking the Long View.** During the meetings we heard relatively little from scientists and managers about how they were addressing critical drivers generating foreseeable, long-term problems. Most of the discussion focused on the most immediate issues. Addressing foreseeable long term changes requires that scientists and managers devise management models that take account of such changes.

These broad findings, elaborated on subsequent pages: 1) help establish a 2012 baseline for the state of Delta science, 2) indicate the issues for Delta science programs we find especially important to address, 3) suggest key issues that the proposed Delta Science Plan should seek to improve, and 4) begin to identify how we see our future role.

Background

The Delta Reform Act created The Delta Independent Science Board [Water Code Section 85280 (a)(3)] to "provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs that shall be scheduled to ensure that all Delta scientific research, monitoring and assessment programs are reviewed at least every four years."

To initiate the review process, we undertook an overview of Delta science by soliciting input from and interacting with a broad range of scientists working in the Delta, as well as users of Delta science. These meetings gave us a broad, initial look at how, and how well, Delta science is working. We met on January 12-13, 2012 with a representative of the Bay Delta Conservation Plan (BDCP) to explore how the organization and use of science is being thought about in the design of BDCP. We also met with a representative of the State Water Resources Control Board to review the science behind the determination of flow objectives for the lower San Joaquin River.

We are very pleased and impressed by the willingness and interest of both scientists and users of science to provide input to us on Delta science, how science can be made more effective, and how science can be better communicated to managers, policymakers, and the public. The participants in these meetings were well prepared and came with important messages to impart and discuss. Many provided written comments as well. While we learned much more than we are summarizing in this memo, we find the following points to be especially important to convey to the Delta Stewardship Council and beyond.

1. **Nurturing and Sustaining Best Available Science**

   The Delta Reform Act clearly expresses the expectations of the State Legislature: best available science should play a very significant role in resolving the controversies over the allocation of water between human uses in the near term and sustaining the quality of the unique Delta environment over the long term. We are deeply concerned that the expectations for science spelled out in the Act cannot be met without a considerably stronger legislative and administrative commitment to supporting Delta science.

   The parties brought before us praised existing efforts by the Delta Science Program (DSP) to encourage shared learning and synthesis. The independent reviews, workshops, and seminars of the DSP play a critical role in synthesizing and evaluating science relevant to the Delta and are part of the legislative mandate of the DSP. The DSP's biennial Bay-Delta Science Conferences and the State of the San Francisco Estuary Conferences under the auspices of the San Francisco Estuary Institute serve a vital role in bringing many researchers together to share their latest findings and discuss future research needs. Similarly, the annual workshop of the Interagency Ecological Program (IEP) provides an important forum, especially for younger, or simply newer, scientists working on the Delta.

   Many who spoke before the Board felt that still more such interchanges are needed. We look forward to helping the DSP create additional innovative opportunities to bring scientists together to challenge each other, discuss shared and divergent assumptions in their models, and work toward stronger cohesion of understanding in the Delta scientific community.

Many of those who spoke to us expressed concern that the shrinking State budget and constraints on hiring have seriously impinged on the existing quality and quantity of science. With fewer scientific staff, it becomes increasingly difficult to work with scientists from other agencies and to communicate science effectively beyond those who need it in day-to-day management decisions. Scientists in state agencies do not have the travel funds to present their findings in scientific forums and learn about scientific advances elsewhere. With shrinking budgets, there are fewer opportunities for agency scientists to advance to more challenging positions. Without appropriate support, science becomes weaker and loses its currency.

Some of those who spoke to us expressed a concern that hiring freezes and other constraints were leading to a greater use of science and engineering consultants rather than conducting the science with in-house staff scientists who have accumulated pertinent knowledge based on their experience with the Delta and its stakeholders. The practice of hiring consultants accomplishes an immediate task of providing plans, reviews, and assessments in a timely manner, but, even when well done, does not build and sustain the institutional memory or the capacity of agencies. These in-house scientists must implement the new science and monitoring and engage with it over the long run to improve management. We think the balance of activity needs to shift back to ensure agencies have the in-house capacity to guide and coordinate the science conducted by consultants, other agencies, the academic community, NGOs and the private sector.

All parties who addressed the role of the Delta Science Program were highly supportive of the leadership role it played in facilitating scientific reviews, providing synthesis workshops, helping identify research priorities, and taking a larger and longer term perspective on the Delta. At the same time, many parties noted that an even greater and stronger role for the DSP was needed to ensure improvements in formal models and their appropriate use, coordinate monitoring activities, maintain and assure the quality of data, facilitate access to data, and generally nurture a culture of providing and using best available science.

The staff draft Delta Plan includes the provision that the Delta Science Program prepare a Delta Science Plan one year from adoption of the Delta Plan. This provides an opportunity to explicate what is needed with respect to scientific capacities, administrative organization, and management practices to include best available science in adaptive management of the Delta. We think the Delta Science Plan should:

- Seek ways to assure dependable and adequate science funding,
- Identify ways to nurture the scientific and management culture for developing and using best available science,
- Promote stronger cohesion among the many ways that Delta science is conducted through the myriad of research programs of water and environment agencies, universities, and nongovernmental think tanks, with many efforts assisted by scientific and engineering consulting firms,
- Improve the quality of monitoring and modeling the Delta,
- Increase communication among scientists, and
- Improve the communication of science to legislators, policymakers, stakeholders, and the public at large.

2. Embracing Environmental Complexity

The Delta is a complex and ever-changing ecosystem that is influenced by multiple stressors. Scientific research over the past decade has transformed and improved our understanding of the way this system functions and the impacts of water management on it. But much remains to be learned about how best to manage the Delta and its water to achieve the coequal goals.

The Delta is especially difficult to understand and manage because of the multiple types of human activity that stress the ecosystem and to which it is continually responding. Sometimes the response of the ecosystem to human-induced stress is shorter term, as when a small accidental toxic spill causes local mortality of fish. In most cases, however, the response is long term, as when patterns of inflow significantly and permanently change or when new exotic species become established. The ecosystem may or may not gradually adapt to these new conditions over time. The multiplication of stressors over time can push the ecosystem into an entirely different, yet relatively stable, configuration that may not sustain previously valued species or ecosystem processes. The recent report on the pelagic organism decline (POD 2010) refers to this kind of change as an ecological regime shift. To prevent or adapt to such complex patterns of change management requires a level of coordination and integration of applied science and communication among the providers of science that has not yet been achieved.

The Interagency Ecological Program represents the best example of interagency science coordination and cooperation on science issues in the Delta, and it has paid significant dividends in increased understanding about this complex ecosystem. The Delta Science Program (formerly the CALFED Science Program) represents another approach to integrating Delta science to inform policy. The Science Program employs a number of tools to strengthen and integrate Delta science, including funding policy-relevant science, convening interdisciplinary teams of scientists in a workshop setting to debate and explore problems in the Delta, and overseeing peer review of agency reports and projects. However, the networks of integration and communication developed in the IEP and the Science Program need to be strengthened and enhanced.

Integration of science alone is not sufficient, however. Management also needs to be more nimble, responsive, and better integrated with the science. Policymakers need to be part of rather than independent of this integration so that policy decisions are properly informed by the best available science and so that the science providers are fully cognizant of the needs of policymakers (Palmer 2012). The importance of facilitating and enhancing the communication among scientists and policymakers cannot be overemphasized, because the problems of water and environmental management in the Delta are the kinds of problems that Rittel and Webber (1973) termed “wicked.” As was discussed in *The State of Bay–Delta Science, 2008* report, such problems involve:

- An evolving set of interlocking issues and constraints such that there is no single definitive formulation of “the” problem. Perceptions of the problem and its causes are likely to differ dramatically among interests;
- Because there is no definitive formulation of the problem, there is also no definitive solution;
- Solutions are neither right nor wrong, only better or worse;
- Experience with analogous problems in other contexts may not be relevant;

- Potential solutions are costly and usually irreversible; and
- There is no immediate or ultimate test of a solution. Rather, all solutions have successive waves of consequences and it is impossible to know exactly how all will play out.

Wicked problems are difficult not only for policymakers but also for scientists because every potential solution involves multiple and often conflicting hypotheses. For wicked problems, science can offer useful insight and information but not firm solutions. Agreement on the problem to be tackled by scientists or by policymakers requires negotiation involving stakeholders. Core values play a central role in how different actors perceive the problem, and a collaborative approach to defining both the problem and potential solutions is essential (Weible 2006).

These arguments and accompanying recommendations were elaborated in *The State of Bay–Delta Science, 2008* report, but little progress has occurred in understanding or addressing complexity since 2008, at least in part because of budget constraints and more immediately pressing issues that have had to be addressed. The challenge of bringing science to bear on a complex, dynamic system cannot be ignored.

3. Transitioning to Adaptive Management

Wicked problems are difficult and complex but not intractable. An important tool for addressing these problems is adaptive management. The Delta Reform Act mandates the use of adaptive management (AM) and defines it as "a framework and flexible decision making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specific objectives" [8502]. In our interviews, we found broad support for the general concept of adaptive management but noticed considerable confusion as to how the concept could be applied to particular programs. Furthermore, we have become increasingly aware that AM connotes different things, depending on the background, goals, and perceptions of scientists, policymakers, and stakeholders.

Chapter 2 of the Fifth Staff Draft Delta Plan describes AM as a structured and iterative process to optimize decision making in the face of uncertainty. AM does this by:

- Developing a clear consensus about the problem to be tackled;
- Developing conceptual and simulation models of the problem that allow scientists and managers to explore the ramifications of policy alternatives;
- Implementing promising policies and monitoring the response of the system; and
- Using the results of monitoring to improve and strengthen the conceptual and simulation models and to modify or adapt management policy to reflect the improvements in understanding of the system.

Because AM is both a scientific and a management process, hypotheses testing and experimental frameworks are combined with management strategies to achieve the desired goals. Thus, AM requires the kind of integration among scientists, managers and policymakers described earlier.

At our December meeting, a discussion arose around the experimental nature of AM and the need for an occasional "bold experiment" to better understand how particular aspects of the

Delta system work. This initiated a discussion as to whether Delta politics, California water politics, and indeed California politics as a whole, are sufficiently mature to integrate management with scientific learning. In the conventional formulation, managers use the best science to do the right thing, not to experiment, and to learn about potential future problems as well. The conventional formulation is somewhat disingenuous, however. The outcome of an environmental management action is seldom known for certain; in essence, every management action is to some extent an experiment. AM simply acknowledges this uncertainty and formalizes a way to address it that will improve future understanding. Nevertheless, AM requires public trust, and building sufficient trust requires greater communication with the public.

4. Taking the Long View

Drivers of change in the Delta operate at many different time scales ranging from hours to decades. For example, tidal and seasonal changes in water level and temperatures in the Delta are short-term and short-lived, whereas temperature and sea level changes resulting from climate change will occur over decades and will have significant, foreseeable environmental consequences.

We were disturbed to hear that many scientists and managers within water and environmental agencies are not looking and planning very far into the future. Myopic decisions during times of rapid environmental change can exacerbate problems, reducing the effectiveness of mitigation activities. One participant insightfully argued that Delta scientists will just be monitoring a declining ecosystem if scientists and managers do not develop strategies for addressing climate change and other long-term drivers. Many participants felt we could play an important watchdog role by stressing the long term perspective.

Many of these issues of scale, both geographic and temporal, are discussed in *The State of Bay–Delta Science, 2008* report and readers are referred to this document for a fuller discussion. Although we will continue to remind agencies of these issues, as the Delta Plan is implemented it will be important that management actions be evaluated for their robustness to anticipated future changes in the Delta. In addition to sea level rise, reductions in snow pack associated with global warming and the stresses from increasing urbanization around the margins of the Delta will have foreseeable long-term impacts.

Related to the issue of thinking across different time scales is the issue of thinking across different spatial scales. For example, what structure of the Delta habitat mosaic will maximize ecological services and help preserve the Delta as an evolving place? Habitat is often conceived in a localized context, but how well a particular habitat performs is intimately connected to how it fits into the local mosaic of different habitats as well as the habitat configuration of the larger picture. Moreover, it is important also to consider how the Delta fits into the large-scale mosaic of the Central Valley, the Sierras, and the coastal ocean. Issues of scale pervade virtually all aspects of water and environmental management for the Delta.

Thinking across broader temporal and spatial scales in reaching management decisions is not easy, but is critical to success. Deeper discussion is in order to identify critical questions and begin design research projects that will provide guidance to Delta policy and management about how best to deal with environmental changes at multiple scales.

Implications for the Role of the DISB

Our initial broad look at Delta science gave us a clearer understanding of our future role. We will be a steady voice for funding Delta science at the levels necessary to meet the high expectations for science in managing the Delta. In a world of foreseeable but unpredictable environmental change, policy and management must accept and work with uncertainty. We will be stressing that scientific advances involve moving with the changes, not just aiming to ensure greater certainty. Scientific certainty is much more difficult to achieve in a changing system and there will be times when certainty decreases. There are many practical difficulties in realigning and integrating science and management. We will vigorously promote the development and application of science-based adaptive management to issues in the Delta. Management agencies are under constant pressure to address immediate issues. We will continue to provide reminders about the importance of taking a long view. Finally, we see our role as addressing overarching issues, rather than dealing with the details of particular scientific programs.

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