CALFED Science Program Synthesis
March 2008

Science Issues Related to Delta Conveyance Options for California Water Supply

Results from two workshops regarding Delta conveyance infrastructure

On August 22 and September 11, 2007, the CALFED Science Program convened workshops to identify and discuss key scientific and technical issues pertaining to conveyance of Sacramento River water through or around the California Delta to the state and federal water project export pumps in the south Delta. The first workshop focused on "isolated" conveyance facilities (such as a peripheral canal or pipeline) while the second workshop focused on through-Delta conveyance facilities (such as existing or proposed through-Delta natural or man-made channels, canals, or sloughs) to convey water.

During the series of presentations and discussions by subject-matter experts, several important broad conclusions emerged and are discussed below. The two workshop summaries are attached to this synthesis of key points.

1) All conveyance options involve trade-offs and compromises
No combination of single or multiple project features will satisfy all desired outcomes; every alternative for exporting water from the Delta regardless of location, configuration, or operation, will have benefits, costs, and uncertainties. For example, an isolated facility that diverted higher-quality Sacramento River water around the Delta, thus improving export water quality, would result in a proportionate increase of lower-quality San Joaquin River water in the Delta potentially impacting Delta species and ecosystems. Moving intakes to the Sacramento River will do nothing to solve San Joaquin in-valley water quality issues such as selenium, salt accumulation or pesticide runoff and may increase the impact of pollution in the South Delta.

Not all trade-offs, however, are clear. From an ecological perspective it is difficult to say whether a particular species will benefit from, or is harmed by, the construction and operation of any alternative conveyance infrastructure. Other issues, such as fish entrainment, will be a characteristic of any conveyance system and will have to be addressed regardless of the selected configuration. For example, while an isolated facility can reduce entrainment of smelt in the South Delta, if there is an intake on the lower Sacramento River, there remains the possibility that the Delta smelt can be entrained there, especially in low-flow years. How the system will be operated is critical to estimating its effects.

2) **Science can help select, but not choose, the "best" water conveyance alternative**
Science can help evaluate effects of proposed alternatives for water export and conveyance but cannot provide "the answer" to what conveyance infrastructure choice is the "best" one – this is ultimately a policy decision.

Scientific expertise is best used to:

- comment on science-related aspects of specific system alterations that are within current experience and understanding
- evaluate the veracity of competing claims of association, correlation, and causation of ecosystem and physical function in the Delta
- identify and evaluate underlying assumptions behind conveyance approaches.

3) Clear objectives are critical to a thorough evaluation of conveyance alternatives

A clear articulation of the desired objectives for each Delta conveyance alternative is crucial for meaningful understanding of the questions involved, the methods of project implementation, and the satisfactory resolution of potentially conflicting outcomes. Without clear objectives, there is no way to obtain clear evaluations.

4) A coastal ocean to watershed perspective is needed to effectively evaluate conveyance alternatives

The coastal ocean, Bay, Delta, and its watershed are intimately interconnected and effects in one location affect other locations through a variety of mechanisms, intensities, and time frames. When assessing conveyance alternatives, managers need to look beyond the Delta and consider the large-scale, system-wide connections and effects.

Local analyses, however, must continue and be combined with regional analyses for a complete understanding of the system. For example, Delta Cross Channel operations have local (e.g. fish entrainment at the channel mouth) and regional (e.g. water quality in the Bay and Delta) effects. Hydrodynamic modeling is a powerful tool for understanding system connections on all scales and is critical for a thorough evaluation of alternative water conveyance mechanisms. Existing modeling efforts can greatly benefit from revitalization and improved coordination.

5) Through-Delta conveyance must be made to work effectively for decades into the future

Because any possible alternative to through-Delta conveyance, including an isolated facility, will take decades to construct it will be necessary to make through-Delta conveyance work as effectively as possible for many years. Maintenance and improvements of the current system will require continued investment (financial, monitoring, research, etc.) to meet water demands for decades to come.

6) Adaptive management should be used in implementing any conveyance alternative

Because the future is unpredictable and scientific understanding continues to change, any water conveyance system must be able to adapt to unanticipated change. A sound adaptive-management policy that involves monitoring, analysis, and project review and revision, should be incorporated into the design and implementation of any conveyance alternative, because it can provide an objective way to identify when adaptation is necessary. The Delta ecosystem, for example, is certain to change in unexpected ways. An integrative and continuous program of data collection, analyses, and synthesis is

needed to help conveyance managers understand and respond to changes to achieve their conservation objectives.

Additionally, during the period of transition to a new conveyance system, a flexible or modular approach to constructing any new infrastructure is important for maintaining project reversibility and adaptability to unanticipated changes.

7) Alternative financing must be found to fund the construction of an alternative conveyance system

Historic patterns of financing for major projects like an isolated facility don't include "up front" financing. Additionally, the financing of the current through-Delta conveyance system does not equitably allocate resources or risk to all beneficiaries. When discussing funding mechanisms for alternative conveyance, policymakers should consider ways to distribute resources and risks more fairly, and ways to allow user willingness to pay to define issues of size and operating flexibility in the conveyance system.

CALFED Science Program Workshop Summary

Science Issues Relating to Delta Conveyance Infrastructure: An Isolated Facility

August 22, 2007

This workshop focused on an isolated facility as the conveyance mechanism for moving Sacramento River water to the export pumps. A second workshop scheduled for September 11, 2007 will examine issues associated with various through-Delta conveyance options. Considered together these workshops will help identify the issues and questions that need to be raised in evaluating an effective Delta-region conveyance mechanism for water project exports.

Topics and Speakers:

History of the Isolated Facility - Mr. Dan Odenweller, Regional Water Quality Control Board
Design and Operational Issues - Mr. Dennis Majors, Metropolitan Water District of Southern CA
Environmental Issues - Dr. William Bennett, University of California at Davis
Water Quality Issues - Dr. Samuel Luoma, United States Geological Survey
Economic Issues - Dr. Richard Howitt, University of California at Davis
Synthesis - Dr. Wim Kimmerer, San Francisco State University
Bay-Delta Conservation Planning – Mr. Jerry Johns, Department of Water Resources
Discussion - Dr. Michael Healey, CALFED Science Program

This summary report and the speakers' presentations have been posted on the CALFED Science Program website (http://science.calwater.ca.gov).

Overall Key Messages:

The seven specialists agreed that the current through-Delta system is not working. However, they also found that every conveyance option has benefits, risks, and uncertainties – an Isolated Facility offers no "silver bullet" or "non-impact" way for solving all Delta-based ecological and water supply problems. For example, while an Isolated Facility can reduce entrainment of smelt in the South Delta, if there is an intake on the lower Sacramento River, there remains the possibility that Delta smelt can be entrained there, especially in low-flow years. How the system will be operated is critical to estimating its effects. From an ecological perspective it is difficult to say whether a particular species will benefit from, or be harmed by, the construction and operation of an Isolated Facility.

The panelists also observed that there is a trade-off between obtaining higher quality Sacramento River export water using an Isolated Facility and increased discharge of lower quality San-Joaquin River water into the Delta. Moving intakes to the Sacramento River will do nothing to solve San Joaquin in-valley issues like selenium, salt accumulation, or pesticide runoff, and may increase the impact of pollution in the South Delta.

The panel agreed that we know a lot more now than we did in 1982 about the physical and biological dynamics of the Delta ecosystem and are in a better position to analyze the effects of various management tools like an Isolated Facility. For example, the Bay-Delta (CALFED) science infrastructure is able to evaluate the effects of proposed alternatives for export and conveyance. However, it cannot provide "the answer" with regard to conveyance infrastructure construction options. The panel agreed this was ultimately a policy choice.

Traditional approaches to public funding for an Isolated Facility (e.g. bond financing) is inadequate for underwriting "up-front" construction costs. A system of soliciting up-front user financing could provide an alternative that would employ market mechanisms to establish important aspects of size and operation.

Hydrodynamic modeling is critical for full evaluation of analyzing alternate conveyance systems in the Delta. Existing modeling capacity in the Delta will benefit from improved coordination and revitalization. Bay-Delta water quality discussions need to consider more completely the effects of the Bay and coastal-ocean habitats since the Delta and the Bay are intimately interconnected.

Finally, if an Isolated Facility is to be pursued, a flexible, modular approach for designing and constructing it is important for maintaining an adaptive management capability over the period of transition from the current through-Delta system, and must continue for the lifetime of water conveyance management.

Key Messages Associated With Individual Presentations:

History and Motivations for an Isolated Facility – Dan Odenweller

- The isolated facility concept was first formally considered in 1943 as a way to protect sport and commercial fisheries from pumping impacts and improve export water quality and has been a subject of debate for decades
- The suite of species driving management concerns about pumping has changed over time, and has included shad, bass, salmon, and smelt species
- Original designs for the Isolated Facility (Peripheral Canal) included dedicated supplies applied for dilution of pollutants in the Delta and downstream flushing flows
- There is a continuing need for some sort of conveyance of water from the Sacramento River to the export facilities regardless of measures taken to protect or restore fisheries

Design and Operations Issues – Dennis Majors

- An open, unlined canal will have risks associated with seepage and regional flooding – in various configurations portions of the canal will be elevated and contained in levees or below sea level whether raised or incised, with or without fill embankment
- There will need to be siphons under all stream and slough crossings regardless of design elevation

- There will need to be substantial fish screening facilities, regardless of intake location
- The canal will flow by gravity but there will need to be a lift pump to raise the water to SWP and CVP facility elevation at some point in the system
- The cost of one or more pipelines of a size sufficient to carry the needed volume of water is such that an open canal is preferred

Environmental Issues – William Bennett

- An isolated facility can reduce entrainment of smelt in the south Delta, but if there is an intake on the lower Sacramento River there remains the possibility that you can entrain Delta smelt there, especially in low-flow years – how you operate the conveyance infrastructure is critical to estimating its effects
- The proposed intake location at Hood may increase entrainment of Delta smelt since this location is near spawning locations in and around Liberty Island, Cache Slough, and the Sacramento Deep Water Ship Channel
- Improved hydrodynamic understanding is crucial to assessing impacts of an isolated facility. Current hydrodynamic modeling tools are not universally accepted, and therefore current particle tracking models are uncertain.
- Each management action is an experiment, and management responses and social structures should reflect this fact
- Adaptive Management is necessary for the lifetime of water conveyance management, NOT merely as a precursor to project construction

Water Quality Issues – Sam Luoma

- Bay-Delta water quality discussions need to consider more completely the Bay and coastal ocean (both as independent drivers and recipients). The Delta and the Bay are intimately interconnected
- Every form of conveyance has benefits, impacts, and risks for water quality. The isolated facility will improve export water quality, however most designs will allow more poor quality San Joaquin water to flow into the Delta – there is a need to address in-valley water quality issues via in-valley solutions before implementing conveyance solutions
- Increasing urbanization will lead to more water withdrawal and higher pollutant loadings
- Any configuration of conveyance will need to confront the changes to in-Delta water quality that results from the new configuration and operation

Economic Issues – Richard Howitt

- Historic patterns of financing for major projects like an isolated facility don't include "up front" financing
- Consider pricing the isolated facility by selling water in relation to its reliability of delivery

- Sell water as a product of amount times reliability. Do not sell shares of the canal or an explicit right to a volume of water
- Urban water users are intolerant of variation in supply but tolerant of high price and so will pay a high price for a relatively small but reliable supply. Agriculture, on the other hand, is intolerant of price variation but more tolerant of supply variation and so will purchase high but relatively unreliable volume at low price.
- By auctioning water delivery in relation to its reliability, payment for the isolated facility can be accomplished "up front". By this means the facility can be self-financing, self-sizing, and adaptable to user preference and desire to pay
- Decouple delivery and pricing structures from environmental water (agree up front what absolute supply will be dedicated to the environment)

Synthesis of Issues – Wim Kimmerer

- All science and technical issues related to an isolated facility have high uncertainty. The implications of the isolated facility for ecological processes are particularly uncertain. Proceed with caution
- Eliminating the take of Delta smelt (or other species) at the existing export facilities will not necessarily restore the species and will not restore the Delta ecoregion
- Ecosystem "regime shifts" have become the norm in the Bay-Delta, and should be expected to continue into the future (e.g. invasive species that have affected various parts of the food web). These shifts are not limited to food webs or community identities but include eco-regional productivity modes as well (e.g. pelagic versus benthic)
- Our current project planning procedure is linear and assumes that the Delta of the future will be the same as the Delta of today – it does not effectively incorporate new information or flexible strategies. A more integrative, iterative and experimental approach needs to be implemented to deal effectively with inevitable surprises and future change

Bay-Delta Conservation Planning – Jerry Johns

- Use of an isolated facility can mean that the Delta does not need to be managed as a fresh-water supply source for exports
- An isolated facility potentially removes the conveyance issue from the ecosystem allowing greater flexibility for ecosystem management

Public Discussion

- Statewide water management has tended to use a piecemeal or "atomistic" approach – public policy would be better served with a "big picture" approach integrating high environmental variability with specific water project operational criteria
- There are precedents for legally requiring water delivery systems to operate at less than full capacity (e.g. Mono Lake)

- A flexible, incremental approach to building water supply and management infrastructure is warranted

Final Comments – Michael Healey

- Discussion was less than expected regarding: a) drinking water quality, b) the six "drivers of change," c) alternative locations for intakes, d) competing intake/fish facility designs, and e) whether an isolated facility would be in-ground or above-ground
- The consensus is that the current through-Delta system is not working

CALFED Science Program Workshop Summary

Science Issues Relating to Delta Conveyance Infrastructure: Through Delta Options

Workshop Summary for September 11, 2007

This workshop focused on through-Delta options as the conveyance mechanism for moving Sacramento River water to the export pumps. A preceding workshop held August 22, 2007, examined issues associated with various isolated facility conveyance options. Considered together these workshops will help identify the issues and questions that need to be raised in evaluating an effective Delta-region conveyance mechanism for water project exports.

Topics and Speakers:

Through-Delta Conveyance Options – Dr. Ron Ott, CALFED Science Program
Conceptual Approaches to Water and Environmental Management – Dr. Denise Reed, University of New Orleans
Hydrodynamics Issues – Dr. Pete Smith, United States Geological Survey
Water Quality Issues - Dr. Robin Stewart, United States Geological Survey
Environmental Issues – Mr. Matt Nobriga, CALFED Science Program
Synthesis - Dr. Bruce Herbold, United States Environmental Protection Agency
Discussion - Dr. Michael Healey, CALFED Science Program

This summary report and the speakers' presentations are posted on the CALFED Science Program website (http://science.calwater.ca.gov). An archived webcast of this workshop is available at http://www.visualwebcaster.com/event.asp?regd=y&id=41794.

Key Messages Across Presentations:

- Clear objectives for through-Delta conveyance are crucial to understand the technical questions involved and to resolve any conflicting outcomes
- Objectives need to be specific enough to guide planning. Specific benchmarks or targets need to be set
- Delta Cross Channel operations have local (e.g. entrainment) and regional (e.g. water quality) effects. Therefore both local and regional analyses are needed to assess operational consequences
- Visions of the future are not implementation plans. A step-by-step staging of actions will be needed to craft any future Delta conveyance infrastructure
- Managers need to continually re-examine assumptions underlying engineered solutions to environmental challenges
- In the San Francisco Estuary (as in all estuaries), there is a gradient from predominantly riverine forcing in the upstream (eastern) parts of the Delta to predominantly marine (tidal) forcing in the western Delta.

- An integrative program of data collection, analysis, synthesis, and forecasting for populations and habitats of interest will help managers understand ecosystem and population response to management actions.
- Entrainment will be a characteristic of any conveyance system and will have to be addressed regardless of configuration
- Ecosystems are remarkably resilient – the problem is reconciling human desires for ecosystem services with what the available complex, self-organizing system will offer when adapting to future change
- Any alternative to through-Delta conveyance will take decades to construct. Even if it is decided to proceed with an isolated facility it will be necessary to make through-Delta conveyance work as effectively as possible for many years

Messages Associated With Individual Presentations:

Through-Delta Conveyance Options – Ron Ott

- Improving water quality for export while resolving fishery concerns has been the stated objective for the three modifications of a through-Delta conveyance system considered in CALFED Stage 1: a) Reoperated Delta Cross-Channel, b) Modified Franks Tract, and c) Through-Delta Facility with an intake at Hood*
- In evaluating these options we've learned a lot about how fish, water, and salt move through the Delta: circulation patterns at river bends affect fish behavior; fish move in the water column differently during the day and night; reconfiguration of slough entrances may reduce fish entrainment; and other relationships
- Hydrodynamic modeling tools coupled with sophisticated data collection methods have provided much insight about what will happen to water and fish given various through-Delta configurations
- It is difficult to predict what the specific effects of a particular design or operational change to through-Delta configuration will mean hydrodynamically – "ground-truthing" is a crucial component of incremental designs for through-Delta conveyance
- For various reasons outputs from hydrodynamic models are neither definitive nor complete (e.g. we have not yet overcome difficulties of extending 3-dimensional models to model the entire Estuary, nor have we properly reviewed available particle tracking models)
- Physical (hydrodynamic) understanding and predictability of the Estuary is greater than biological (ecological) understanding or predictability – and will likely remain so
- Piecemeal evaluation of project components will not add up to an understanding of regional impacts at full project build-out –

* In this context "Through-Delta Facility" includes an intake at Hood with a return to the South Fork of the Mokelumne River at New Hope Tract

comprehensive, regional evaluation of conveyance facility operation must be maintained over the lifetime of a through-Delta conveyance system (e.g. flow criteria are now used to close the DCC in winter – this has system-wide effects that may change with future sea level rise)

Conceptual Approaches to Water and Environmental Management – Denise Reed

- Be explicit with objectives. This forces recognition of trade-offs up front and highlights what's "on the table"
- Use benchmarks when possible to enhance clarity of objectives and to help manage public expectations (e.g. performance measures)
- It is difficult to use generalities to set project priorities – even decisions "to protect wildlife" mean different things to different people – it is critical to identify specific project objectives in order to successfully plan and evaluate alternative configurations
- A broad analytic framework is needed to allow scientists and decision-makers to look in a holistic way at the effects of different choices
- The State must recognize the nature of trade-offs between environmental protection and water quality improvement. Decision-analysis support tools have been developed that improve the objectivity of decisions involving social and environmental trade-offs
- Visions for the future do not provide objectives useful for getting us there – there are choices and trade-offs to be made with regard to how, why, and where to go
- Use guiding principles (e.g. those used by the Delta Vision Stakeholders Coordination Group http://deltavision.ca.gov/DeltaVisionStakeholderReports.shtml) to help formulate how to proceed, recognize constraints, consider alternative futures, and be ready for unintended consequences
- In managing coastal ecosystems, guiding can mean staying out of the way – passive engineering may be more appropriate than real-time manipulation
- Integrate planning, investment, and management decision-making into an iterative, learning process rather than a linear, time-dependent one
- Constantly re-examine assumptions underlying engineered solutions to environmental challenges
- Don't forget what we already know – in other words, don't allow concerns about our current knowledge gaps to prevent us from making use of existing knowledge

Hydrodynamics Issues – Pete Smith

- Changes in basin hydrology and in approaches to water management will result in altered Delta water quality because the relationships between Sacramento and San Joaquin River hydrology, timing, volume, etc., will also change

- Hydrodynamic complexity stems, in part, from conveyance system configuration. The specifics of proposed changes to the system will influence what hydrodynamic conditions will exist into the future
- Recent analyses show turbidity is an important component of Delta smelt habitat that may factor into management actions
- Eliminating or altering San Joaquin River connections with Clifton Court Forebay will dramatically alter hydrodynamics in the south Delta
- There will likely be changes to food web linkages as the result of any "re-plumbing" of the Delta; for example, altered hydraulic residence times can change phytoplankton communities and therefore change food availability to other organisms (e.g. fish)
- Hydrodynamic variability is an important factor determining the extent of an "entrainment zone" Delta-wide, and should be included in plans regarding reconfiguration of through-Delta conveyance

Water Quality Issues – Robin Stewart

- Any reconfiguration of through-Delta conveyance will bring with it hydrologically-mediated sediment and contaminant transport complications: transport routes and pathways change, water source and mixtures will change, flushing times will change, local and regional water chemistry will change
- Water quality is the culmination of lots of process chemistry, and specific changes locally can have regional implications. For example, we currently find that there is more methyl mercury in tributaries to the Delta than in the Delta itself – this relationship could change if process chemistry changes
- Food web relationships can mediate water chemistry in the ecosystem (e.g. at Camp Far West Reservoir the pelagic food web seems to more effectively accumulate methyl mercury than does the benthic food web; in Suisun Bay the benthic community accumulates selenium more effectively than the pelagic food web)
- Certain aquatic species have been found to be "super-accumulators" of various environmental pollutants (e.g. overbite clam and selenium) – altering through-Delta hydrology will likely change how, where, and what species are accumulating pollutants and where these accumulated pollutants end up
- Understanding the origin, transport, and fate of selenium, mercury, and other contaminants in the Delta will be critical to an integrated water management plan using through-Delta conveyance
- Integration of existing information using a process-based approach is a critical missing component of current Delta contaminants research and management

Environmental Issues – Matt Nobriga

- The cardinal rule of applied ecology: "if you change the system, the system will change"
- Changes to the Delta's geometry and hydraulics will change ecosystem function. Thus, any change in system conveyance has potentially far reaching ecological consequences
- Each species has a hierarchy of need: habitat↔food↔reproduction↔dispersal. Changes in the aquatic environment of the Delta will have implications at all levels of these hierarchies
- Organisms that are nearest intake facilities have the highest probability of being entrained. Proximity of aquatic organisms to the location of through-Delta intake facilities will largely influence what is entrained and when
- Aquatic habitats are inherently dynamic, and have temporal variability in several parameters simultaneously (salinity, temperature, transparency, for example) – it is difficult to manage for specific aquatic habitat configurations while maintaining large-scale water diversions in a tidal environment because flow regimes and habitat quality are intimately linked
- Species invasions have changed the estuarine food web. They may also have increased the influence of water exports from the Delta on fish food availability in the low-salinity zone
- The Delta ecosystem will continue to change in the future
- The evaluation of conveyance alternatives needs to develop beyond its present focus on fish passage to consider broad implications for ecosystem function

Synthesis – Bruce Herbold

- Recognize that ecosystems are not just fish and birds but include the economy, humans, and cultural resources
- The unexpected happens – design water and environmental management to be robust to change and surprise
- Ecosystems are not fragile: water management systems predicated upon predictable ecosystem behavior may be
- Although our ability to predict physical system behavior is stronger than our ability to predict ecosystem behavior, our understanding of hydrodynamics in relation to fish habitat, entrainment, and population response has nonetheless expanded dramatically in recent years
- For any conveyance design we should recognize that hard structures eventually fail over time
- Exporting water from the Delta involves trying to maximize the beneficial uses of diversions for drinking water, irrigation, and municipal and industrial uses simultaneously with maximizing beneficial ecosystem uses of this same water within an estuary that tends to mix marine and freshwater sources wherever they coexist. It is clear that sustained, long-

term management of these beneficial uses cannot include maximization of any one of them without seriously degrading another
- Confidence when attempting to engineer ecosystems is folly (e.g. supposing that environments won't change or that earthquakes won't happen)
- Societal needs for ecosystem services change with time (e.g. preference for extractive services – exported drinking water – may give way to preference for aesthetic ones – wildlife viewing)
- When considering reconfiguring Delta conveyance we will need to be especially vigilant to the water quality issues presented as the result of changing inputs (both quantities and sources) from the San Joaquin River

Public Discussion – Issues Raised

- What will be the changed needs of a through-Delta conveyance system with regard to trucking, handling, and hauling of salvaged species?
- Can we identify more specific features of habitats needed to achieve conservation of particular species?
- Sea level rise will impact whatever system of conveyance is imposed – but wouldn't some parts of the current system work better if sea level were higher (e.g. more hydraulic head to move water through gravity-flow facilities)?
- Proposed San Joaquin by-pass locations need to take advantage of local knowledge of topography. Locals say the proposed Stewart Tract site is too high, but Paradise Cut has potential. A bypass would flood only very rarely on the San Joaquin but at other times might provide good wildlife habitat
- How do the items discussed in this workshop result in a more informed Delta conveyance policy?
- Can we approach our conveyance infrastructure using an incremental approach and learn as we go?

Final Comments – Michael Healey

- As a scientific and technical community, we don't have the capacity to pre-analyse the multitude of conveyance options. As the discussion begins to focus on a few alternatives we will be better able to focus our limited capacity
- Biological understanding is not as developed as physical understanding at this time. Ecologists simply cannot say with any certainty what flows and hydrology will be most beneficial for the Delta ecosystem
- Whatever conveyance approach is decided upon will be implemented incrementally, so through-Delta conveyance will be with us for many years to come.