

Appendix to Phase 1 Report: Core Indicators and Plan PRELIMINARY DRAFT—September 5, 2006

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Introduction:

Each of the subgroups for the development of indicators and performance measures for the CALFED program objectives were given a list of questions to guide their discussions through the process. This appendix provides the documentation of those discussions, which has been summarized for Chapter 4. The list of questions covered the following basic topics:

Section A: Overall questions

- What strategic objectives were selected to work on for this phase and why?
- What other efforts do you need to coordinate with, including linkages to the other subgroup topics?
- Identify which indicators have linkages for environmental justice, working landscapes, watershed management.

Section B: Questions specific to each strategic objectives and outcome indicator:

- What are the strategic goals and objectives, and the narrative or quantitative performance goals and targets in the program documents related to this indicator?
- Document any conceptual models and quantitative models that identify drivers related to the outcome indicator, and also if there are additional conceptual (& quantitative) models for the drivers.
- Document what monitoring data exist for the outcome indicator and the driver indicators, and any information available about the data quality.
- Identify the significant data and information gaps and provide a short-term ballpark estimate of resources needed to complete monitoring, evaluation and reporting of this performance measure.

In most of the subgroup sections of the appendix you will find two tables:

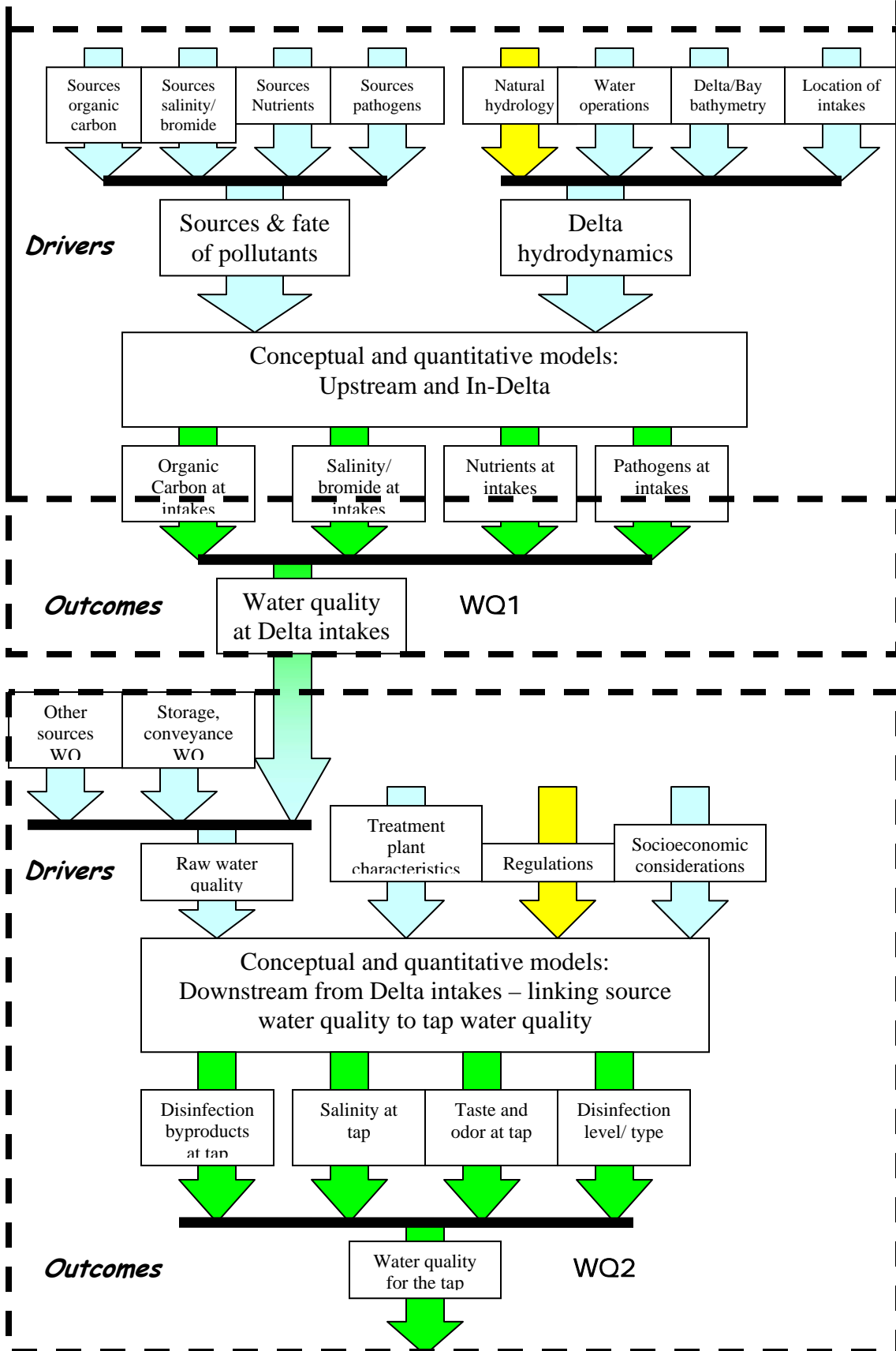
1. Describes the goals and objective, performance targets and related outcome indicator
2. Information inventory on conceptual models

This was a fairly extensive and comprehensive set of questions that required a great deal of work from the members participating in the subgroups. Due to the short-time frame and lack of dedicated resources for this effort, not all of the subgroups were able to answer all of the questions. This appendix provides the progress to date by the subgroups in selecting and documenting a “core” set of indicators for further development.

I. Drinking Water

A. Overall questions for subgroup

1. List the criteria for selection of core indicators and associated strategic objectives (SOW #4)
The constituents for drinking water were selected based on the analyses and recommendations in the following documents:
 - CALFED ROD and Water Quality Program Plan
 - Water Quality Program Initial Assessment
 - Central Valley Drinking Water Policy work products (prioritized constituents, conceptual model recommendations)
 - CALFED WQP Strategic Planning Draft materials
2. List of strategic objectives for first round (those that will be assembled for the Phase 2 analysis and report) (SOW#4)
Four general topics were chosen for indicator development:
 - **Water quality at the Delta intakes**
 - **Water quality for the tap (post-treatment/pre-distribution)**
 - Cost
 - Reliability/FlexibilityThe first two will be developed in Phase 2. The others will be developed in later phases.
3. List of other efforts relevant to these core indicators and coordination strategy (SOW #3)
 - Regional ELPH Pilot Plans and Regional Planning Framework
 - Franks Tract/Delta Cross Channel/Through Delta Facility projects
 - CALFED Storage Investigations
 - San Joaquin Water Quality Management Group
 - Stockton Dissolved Oxygen Project – nutrient studies
 - Regional WQCB/State WRCB Salinity Strategy
 - Local drinking water utilities master planning for water quality improvements
 - Municipal Water Quality Investigations program
 - National research on drinking water treatment, CALFED-funded treatment demonstration studies
4. Develop more detailed questionnaire and table of information for each strategic objective / core indicator. (See section B below)
 - B.1 Water quality at the Delta intakes
 - B.2 Water quality for the tap
5. Identify which indicators are linked to other CALFED program elements and other non-CALFED efforts. (SOW #8)
(Work with list in #3)
6. Identify which indicators have linkages for environmental justice, working landscapes or citizen involvement and education.
7. Compile information and prioritize information gaps and resource needs to complete monitoring, data acquisition, data analysis, information organization and presentation. (SOW# 10) Detailed analysis from Section B to be summarized.



B. 1 Outcome indicator questionnaire and breakout table
Water Quality at the Delta intakes

1. **Short description** or key phrase:
Water Quality at the Delta intakes. This will include data for 4 groups of constituents (organic carbon, nutrients, salinity/bromide, pathogens) and from the 5 Delta intakes (State Water Project-Banks Pumping Plant (DWR), Central Valley Project-Tracy Pumping Plant (USBR), Old River and Rock Slough (CCWD), North Bay aqueduct (DWR)).
2. What **goal(s) and objective(s)** are the outcome indicator related to? What is the rationale or supporting information for how this indicator relates to the goal and objective. (Please provide a reference in the CALFED documents for specific objectives).
The program goal is to provide good water quality for all beneficial uses (CALFED Record of Decision).

The strategic objective for drinking water quality is:

CALFED Agencies have adopted a general target of continuously improving Delta water quality for all uses, including in-Delta environmental and agricultural uses. Program actions designed to improve water quality to protect environmental uses are generally included in the Ecosystem Restoration Program (ERP) discussed above. For the drinking water quality program, CALFED

Agencies have developed a specific goal based upon extensive stakeholder and agency involvement. CALFED Agencies' target for providing safe, reliable, and affordable drinking water in a cost-effective way, is to achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control and treatment technologies. (Page 65 CALFED Record of Decision)

3. Documents any **long-term performance objectives** in the CALFED documents that related to this goal and indicator. Document any **short-term performance goals or targets** in the CALFED documents related to this goal and indicator. (provide references)
How does this indicator relate to performance goals and targets in the documents?
CALFED ROD only discusses long-term performance objectives, although it does require an end of Stage I evaluation on progress towards the objectives (CALFED ROD). The quantitative long term performance measures listed in the ROD are 50 ug/L Bromide and 3 mg/L Total Organic Carbon at the Delta intakes or an equivalent level of public health protection at the tap. The Water Quality Program Plan (Appendix of the ROD) also includes a table of goals for the drinking water constituents.
4. If there is a lack of performance measures or targets in CALFED documents for this indicator – **draft a qualitative (non-numeric) long-term performance objective related** to the goal and indicators. The long-term performance objective should describe what success would “look like” for this goal and indicator. Provide any supporting reasoning or rationale. If quantitative targets or performance goals are needed – note in the table.
The Central Valley Drinking Water Policy development will evaluate and provide recommendations for regulatory objectives for the constituents of concern, including re-evaluation of the organic carbon and bromide targets.
5. **Document any conceptual or quantitative models that are related to this outcome indicator** and describe what factors are or may be influencing the outcome. How complete are they for documenting linkages between the outcome and the controlling factors? Does the conceptual model have references from peer-reviewed literature?

Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix.

Yes, there are two conceptual models. Water quality at the intakes is an outcome and a driver in the "Equivalent Level of Public Health" (ELPH) conceptual model. Water quality at the pumps is an outcome in the conceptual model and sub-models being developed for the Central Valley Drinking Water Policy.

The ELPH conceptual model was developed by the CALFED Drinking Water Subcommittee. In this conceptual model, water quality at the Delta intakes is an outcome of upstream processes and a driver that affects the water quality at the tap delivered by water utilities using Delta water (see water quality at the tap indicator for information on other drivers and the conceptual model). Because there are specific goals about water quality at the Delta intakes, and it is a major driver affecting delivered water quality, it is important enough to be addressed as an intermediate outcome indicator, even though it is a driver for another outcome indicator (water quality for the tap).

The other conceptual model is a collection of quantitative and conceptual models that describe how water quality at the pumps is controlled by tributary inputs (flows and concentrations of pollutants) and the complex hydrodynamics of the Delta that influences which of the tributary and Delta inputs shows up at the intakes. This is complicated by the fact that it will be somewhat different for each of the 5 Delta intakes, and for each of the 4 groups of constituents of concern. The sources, fate and transport of the constituents must each be considered by a separate conceptual model. Hydrodynamic models are used to understand the transport through the Delta and the mix of tributary inputs (or a "fingerprint") that constitutes the water quality at each intake throughout the year.

6. **Provide a list of the major drivers** in the conceptual model that are likely to influence the outcome. Note which ones are uncontrollable factors (by this program) and which are management actions (or potential management actions). For each one, list whether it also has a related conceptual and/or quantitative model related to it. Add to the list any drivers that are identified in the driver conceptual models.

The major drivers for water quality at the intakes include:

Delta hydrodynamics, which are influenced by:

- Natural hydrology (uncontrollable factor)
- Water operations (management actions include reservoir releases, conveyance manipulations and pumping rates, all of which have constraints)
- Location of the intake (possible management action)
- Delta and bay bathymetry and geometry (possible management action to modify bathymetry to influence hydrodynamics)

Sources, fate and transport of constituents of concern (all have drivers with both uncontrollable factors and potential management actions)

- Organic carbon
- Nutrients
- Salinity and bromide
- Pathogens

7. **Document any conceptual or quantitative models associated with the drivers.** Similar to question 5. How complete are the conceptual or quantitative models for documenting linkages between the driver (intermediate outcome) and the controlling factors? Does the conceptual model have references from peer-reviewed literature?

Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix. Provide a reference list of key documents or scientific papers that would be useful to managers and decision makers who would like more detailed information about the topic.

Hydrodynamic models:

There are several quantitative models currently being used to model Delta hydrodynamics, each with some benefits and limitations.

The DSM2 model is a one-dimensional model developed by DWR that can model water movement over long time scales, but it does not work well in modeling areas that are more open water such as Frank’s tract, or where river reaches are wide. DSM2 has some capabilities for modeling some of the water quality constituents, but _____. The DSM2 model has been validated and verified for specific purposes.

The RMA model is a proprietary 1 and 2-dimensional model that is being used to understand hydrodynamics at smaller time scales and finer detail. It can be used for modeling areas such as Frank’s tract or other open water areas. The RMA model is not good for analyzing long time scales, as the scale and calculations make it too slow for long time frames. The RMA model has been validated and verified for specific purposes.

Multi-dimensional models are needed in some cases to accurately evaluate salinity movement, particularly in areas of the estuary where gravitational circulation of salinity is an important process for salt transport during the tidal cycle. Changes in bathymetry in key areas for salinity gravitational circulation could have dramatic effects on seawater intrusion into the Delta due to tidal dynamics.

Water operations models:

The CALSIM II model is a general-purpose reservoir-river basin simulation model for the planning and management of the State Water Project and the federal Central Valley Project. It is used by the Department of Water Resources and US Bureau of Reclamation to determine the effects of water operation management actions such as reservoir releases, diversions and conveyance manipulations such as the Delta Cross Channel operations. CALSIM II does not have a lot of capability for modeling water quality constituents.

Conceptual and quantitative models for sources, fate and transport of constituents:

The Central Valley Drinking Water Quality Policy is developing conceptual models for the constituents of concern: organic carbon, nutrients, salinity and pathogens. The status of these conceptual models is described in the table below. The conceptual models include literature review and identification of key processes in fate and transport, data identification, and load analyses based on export rates and flow regressions. Future refinements of the models would attempt to quantify key processes and controllable sources.

Constituent	Model Type	Source	PR Refs?	Reviewed /Validated?	Model status/quality
Organic Carbon	Conceptual	CVDWP	Yes	No	Good first step, second step underway, moderate amount of information available
Salinity/ Bromide	Conceptual	CVDWP	Yes	No	Just started, lot of information available

Nutrients	Conceptual	CVDWP	Yes	No	Final in June, good first step, moderate amount of info available, but more complicated than OC
Pathogens	Conceptual	CVDWP	Yes	No	Draft due in June (?) Don't expect high level of detail due to monitoring complexity and shortage of data.
Organic Carbon	Quantitative	DWR (DSM2)	Yes	Yes	Based on limited data and substantial assumptions, working to improve
Salinity	Quantitative	DWR (DSM2, RMA)	Yes	Yes	RMA expected to improve handling of north delta by end of 2006. Basically good models of Delta, San Joaquin River
Nutrients	Quantitative				Related to DO effort...

Drivers identified in conceptual models:

Drivers will be identified in the constituent conceptual models. The first organic carbon conceptual model report has recently been completed and identifies the following list of drivers. Note that the organic carbon conceptual model is focused on drinking water quality, but it is hoped to draw out a discussion on the ecosystem interactions with organic carbon.

The following are the sources/drivers identified for organic carbon sources, although analysis is still needed to determine their relative contributions:

- Runoff from Natural sources (controllable but not economically)
- Runoff from Anthropogenic sources (controllable to some degree)
- Stormwater discharges (can be treated at point of entry)
- Wastewater discharges (can be treated at industrial sources and POE)
- Primary productivity (limited ability to influence through nutrient source control and water operations)
- Hydrology (effects runoff, not controllable)

8. Do any data exist for the outcome indicator?

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the outcome indicator? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to this outcome indicator. Discuss data availability.
- b. To the extent possible, evaluate the quality of the data to use as an outcome indicator. What field methods are used for sampling, what methods for lab analysis (if applicable). In general, what is known about the Quality Assurance program and the quality of the data to be used?

Data from multiple sources have been compiled into one database for analysis. The sources of data include CDEC, Department of Water Resources Municipal Water Quality Investigations, Contra Costa Water District, and U.S. Bureau of Reclamation.

The organic carbon conceptual model report provides details about these issues for the water quality at Delta intakes. It also identifies fingerprint modeling as a tool to determine the timing of riverine and estuary influences, and identify potential in-Delta influences. There is a fairly good set of data at the Delta intakes and CALFED has funded purchase and installation high-frequency monitoring of organic carbon at Banks and Tracy Pumping Plants.

9. **Do any data exist for the driver indicators?** (See list generated in number 6).
 - a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the major driver indicators? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to the driver indicators. Discuss data availability.
 - b. To the extent possible, evaluate the quality of the data for the major driver indicators. What field methods are used for sampling, what methods for lab analysis (if applicable)? In general, what is known about the Quality Assurance program and quality of the data to be used.

As part of the Central Valley Drinking Water Policy Development, water quality data from multiple sources have been compiled into one database for analysis. This database includes water quality monitoring data on the constituents of concern throughout the Central Valley watershed. The data sources include: Central Valley Regional Water Quality Control Board, Sacramento River Watershed Program, US Geological Survey, DWR Municipal Water Quality Investigations, Sacramento stormwater data, Sacramento Regional Treatment Plant monitoring, University of California Davis, and agricultural drainage monitoring. Details about the water quality data are described in the Meta Data report and conceptual model reports being developed by the Central Valley Drinking Water Policy Group. The second step of conceptual modeling is attempting to determine where data are robust and where additional data are needed.

It is recognized that there are also extensive data collected to support the Delta modeling efforts, but it is beyond the scope of this effort to adequately survey the data available and data gaps for hydrodynamic and water operations modeling. In general, types of data needed for detailed modeling of hydrodynamic modeling of water quality constituents includes: detailed flow data, bathymetry and elevation data (channels, water elevations and land surfaces), water quality monitoring data, and information about water quality processes and rates. Flow data is available from CDEC and USGS.

10. **Review the list** of drivers and outcome indicators. **Are there linkages** for environmental justice concerns, working landscapes, or watershed management (affected by local decisions)? Linkages are defined as affecting the indicator or being affected by the indicator. Discuss the linkages for each of those topics.
11. **What are the significant data and information gaps?** The purpose of this is to help prioritize the monitoring and research needs for gathering and synthesizing the information. Provide a list of significant gaps related to the conceptual or quantitative models or the data and data analysis needed related to the outcome and driver indicators. Rank each item on this list as one of the following:
 - A: information needed for reporting on outcomes (monitoring data)
 - B: information needed for better understanding of the linkages between drivers and outcomes and improvements in the conceptual model. (research)
 - C: information needed for reporting on drivers (monitoring data)
12. Provide a **ballpark estimate** of how much it would cost (provide a cost basis – per year, or one time) **to fill the significant information gaps**. Try to provide a separate estimate for each line item and then add them together for each category (A,B,C).
13. With a target date of spring 2007, **estimate how much staff time** would be needed to develop a web-based information organization of conceptual models and data related to outcome and driver indicators (including data acquisition and analysis). What staff time is currently available to work on this (break it out by agency)? What are the resource needs to complete this?

A great deal of data processing and statistical analysis is still needed to understand these questions. I would estimate approximately .5 PY to complete this task by spring 2007. Currently CVDWP consultant and CBDA staff are undertaking this task, but are not able to devote sufficient time to this task.

Table Key:

ID: Used to organize and link to table in main report

Key phrase: Short phrase or word to describe outcome indicator (e.g. Water quality at the tap)

Type of indicator: Use key below to select outcome, intermediate outcome or driver type

Key for type of indicator:

OI- Outcome indicator

D/IOI – Driver / Intermediate outcome indicator

D/UF = Driver / Uncontrollable factor

D/MA = Driver / Potential management action

For the next 5: provide a ranking of how much information is currently available related to the indicator:

Key for information ranking

--: Not applicable

0 = no information available

1 = minimal information available

2 = some information available but major gaps

3 = lot of information available but minor gaps

4 = information is fairly complete

- **Conceptual model:** Characterize how much information is available in the conceptual model that documents the understanding of how the outcomes and drivers are related.
- **Quantitative model:** If a quantitative model is available, estimate how much information is available to explain the relationship of the outcomes and drivers, including some assessment of the applicability and quality of the model.
- **Drivers identified:** How much information is available about the drivers that are affecting this outcome? If there are no drivers, use –not applicable.
- **Past monitoring data:** How much historic data are available to evaluate the status and trend of this outcome indicator?
- **Current / future monitoring data:** Are there current or planned monitoring programs or studies that will collect data on the outcome indicator in the short-term future?

Linkages: (check if yes)

EJ: Does this indicator have linkages to environmental justice concerns?

WL: Does this indicator have linkages to working landscapes issues?

WM: Does this indicator have linkages to watershed management such as local land use decisions and land management?

Comments: Provide any brief additional comments to clarify. The main text of the appendix should be used for explanations of any length.

Break-out table for indicator: _____

Key for type of indicator:

- OI- Outcome indicator
- D/IOI – Driver / Intermediate outcome indicator
- D/UF = Driver / Uncontrollable factor
- D/MA = Driver / Potential management action

Key for information ranking

- : Not applicable
- 0 = no information available
- 1 = minimal information available
- 2 = some information available but major gaps
- 3 = lot of information available but minor gaps
- 4 = information is fairly complete

Indicator description			Conceptual basis			Monitoring data		Linkages			Comments
ID	Key phrase for indicator	Type of indicator or	Conceptual Model	Quant. model	Drivers identified	Past indicator data	Current indicator data	EJ	WL	WM	
WQ1	Water Quality at intakes	OI	2.5	2	2	2	3	Y	Y	Y	Summarization of the 4 constituent areas
WQ1A	Salinity/bromide at intakes	OI	4	4	4	4	4	Y	Y	Y	EJ linkages with agriculture and water mgmt
WQ1B	Organic carbon at intakes	OI	3	3	2.5	3	4	—	Y	Y	Work in progress on conceptual model
WQ1C	Nutrients at intakes	OI	2	2	2	2	2	—	Y	Y	
WQ1D	Pathogens at intakes	OI	2	0	2	1	1	—	Y	Y	Difficult & expensive to monitor at intakes and of limited value
WQ1.a	Delta hydrodynamics	D/MA	3.5	3	4	3	3	Y	Y	Y	Summarization of the sub-drivers for hydrodynamics
WQ1.a.1	Natural hydrology	D/UF	3	3	3	4	4	—	—	Y	Need future projections for hydrology with climate change
WQ1.a.2	Water operations	D/MA	4	4	4	4	4	Y	Y	Y	
WQ1.a.3	Location of intakes	D/MA	4	4	4	4	4	Y	Y	Y	
ID	Key phrase for indicator	Type of indicator or	Conceptual Model	Quant. model	Drivers identified	Past indicator data	Current indicator data	EJ	WL	WM	Comments
WQ1.a.4	Delta / Bay bathymetry	D/MA	3	2	4	2	2	—	—	—	

WQ1.b	Sources /fate of pollutants	D/MA	2	1	2	2	2	—	Y	Y	Summarization of the 4 constituent areas
WQ1.b.1	Salinity/bromide sources and fate	D/MA	3	3	3	3	3	—	Y	Y	
WQ1.b.2	Organic carbon sources and fate	D/MA	2	1	2	2	2	—	Y	Y	
WQ1.b.3	Nutrients sources and fate	D/MA	2	1	2	1	1	—	Y	Y	
WQ1.b.4	Pathogens sources and fate	D/MA	1	0	2	1	1	—	Y	Y	

B.2 Outcome indicator questionnaire and breakout table
Water quality for the tap

14. **Short description** or key phrase:
Water Quality for the drinking water tap (post-treatment, pre-distribution?). This will include data for 4 groups of regulated constituents (bromate/THMs/HAA5, salinity/bromide, disinfection level, taste and odor) and for treatment plants utilizing water from the 5 Delta intakes (State Water Project (DWR), Central Valley Project (USBR), Old River and Rock Slough (CCWD), North Bay aqueduct (DWR). The CALFED ROD does not include implementation of treatment plant upgrades, which is the responsibility of local utilities.
15. What **goal(s) and objective(s)** is the outcome indicator related to? What is the rationale or supporting information for how this indicator relates to the goal and objective? (Please provide a reference in the CALFED documents for specific objectives).
The program goal is to provide good water quality for all beneficial uses (CALFED Record of Decision).

The strategic objective for drinking water quality is:

CALFED Agencies have adopted a general target of continuously improving Delta water quality for all uses, including in-Delta environmental and agricultural uses. Program actions designed to improve water quality to protect environmental uses are generally included in the Ecosystem Restoration Program (ERP) discussed above. For the drinking water quality program, CALFED Agencies have developed a specific goal based upon extensive stakeholder and agency involvement. CALFED Agencies' target for providing safe, reliable, and affordable drinking water in a cost-effective way, is to achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control and treatment technologies. (Page 65 CALFED Record of Decision) These numeric targets are the result of a California Urban Water Agencies-commissioned expert panel to assess the source water quality requirements to meet certain hypothetical/potential future regulatory standards, such as a 5 µg/L bromate standard and stricter disinfection requirements.

16. Documents any **long-term performance objectives** in the CALFED documents that related to this goal and indicator. Document any **short-term performance goals or targets** in the CALFED documents related to this goal and indicator. (provide references)
How does this indicator relate to performance goals and targets in the documents?
CALFED ROD only discusses long-term performance objectives, although it does require an end of Stage I evaluation on progress towards the objectives (CALFED ROD). The quantitative long term performance measures listed in the ROD are 50 µg/L Bromide and 3 mg/L Total Organic Carbon at the Delta intakes or an equivalent level of public health protection at the tap. The ROD calls for an evaluation of alternative treatment technologies as part of a final program assessment by the Delta Drinking Water Council or its successor. The Water Quality Program Plan (Appendix of the ROD) also includes a table of goals for the drinking water constituents.
17. If there is a lack of performance measures or targets in CALFED documents for this indicator – **draft a qualitative (non-numeric) long-term performance objective related** to the goal and indicators. The long-term performance objective should describe what success would “look like” for this goal and indicator. Provide any supporting reasoning or rationale. If quantitative targets or performance goals are needed – note in the table.

Long-term targets are those presented in the expert panel report, which should be periodically reevaluated as technologies advance. A level of reevaluation will be included in the final assessment, by the end of 2007.

18. **Document any conceptual or quantitative models that are related to this outcome indicator** and describe what factors are or may be influencing the outcome. How complete are they for documenting linkages between the outcome and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix.

The ELPH conceptual model was developed by the CALFED Drinking Water Subcommittee. In this conceptual model, water quality at the Delta intakes is an outcome of upstream processes and a driver that affects the water quality at the tap delivered by water utilities using Delta water (see water quality at the tap indicator for information on other drivers and the conceptual model). Because there are specific goals about water quality at the Delta intakes, and it is a major driver affecting delivered water quality, it is important enough to be addressed as an intermediate outcome indicator, even though it is a driver for another outcome indicator (water quality for the tap).

There is a need to develop conceptual models that link water quality at the Delta intakes to treated water quality. Both the Central Valley Drinking Water Policy and the final assessment will be working on these.

19. **Provide a list of the major drivers** in the conceptual model that are likely to influence the outcome. Note which ones are uncontrollable factors (by this program) and which are management actions (or potential management actions). For each one, list whether it also has a related conceptual and/or quantitative model related to it. Add to the list any drivers that are identified in the driver conceptual models.

The major drivers for water quality for the tap include:

- Raw water quality (including at intake and through conveyance and storage, both above ground and underground) blending, timing
- Treatment plant facilities/Operational efficiencies
- Economic considerations (for choices involved in construction and/or operations; may include choices made for purposes of economics (e.g., greater efficiencies to save costs), or limitations of choices because of economic constraints (e.g., can't afford to make changes that would otherwise be desirable))
- Institutional capacity (amount of water, personnel capacity)
- Federal and State Regulations (biggest driver—though these aren't controllable, they are generally predictable, since there is usually considerable lead time for implementation)
- Disruptions / emergency situations

20. **Document any conceptual or quantitative models associated with the drivers.** Similar to question 5. How complete are the conceptual or quantitative models for documenting linkages between the driver (intermediate outcome) and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix. Provide a reference list of key

documents or scientific papers that would be useful to managers and decision makers who would like more detailed information about the topic.

There are a number of numerical models describing treatment processes, which are probably too detailed for this purpose. The CUWA expert panel developed relationships between source water quality and treated water quality. The MWQI group at DWR is working on extending the DSM2 hydrodynamic model down the California Aqueduct (modeling daily water quality). Many local utilities have modeled their conveyance and storage systems.

It is too early to describe the additional drivers (beyond those influencing source water quality) for these conceptual models, they may also be dependent on infrastructure and/or water sources.

21. Do any data exist for the outcome indicator?

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the outcome indicator? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to this outcome indicator. Discuss data availability.
- b. To the extent possible, evaluate the quality of the data to use as an outcome indicator. What field methods are used for sampling, what methods for lab analysis (if applicable). In general, what is known about the Quality Assurance program and the quality of the data to be used?

The California Department of Health Services (CDHS) collects monitoring data electronically related to regulatory compliance for drinking water standards; local drinking water utilities collect additional data to support their operations. Data not in the CDHS database that is present at drinking water systems may be in different formats, depending on the system.

22. Do any data exist for the driver indicators? (See list generated in number 6).

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the major driver indicators? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to the driver indicators. Discuss data availability. Also see answer to 21
- b. To the extent possible, evaluate the quality of the data for the major driver indicators. What field methods are used for sampling, what methods for lab analysis (if applicable)? In general, what is known about the Quality Assurance program and quality of the data to be used.

Review the list of drivers and outcome indicators. **Are there linkages** for environmental justice concerns, working landscapes, or watershed management (affected by local decisions)? Linkages are defined as affecting the indicator or being affected by the indicator. Discuss the linkages for each of those topics.

Water systems operate at different levels of sophistication and complexity, depending on the economic situation, which reflects the community they serve. Hence, communities having lower socioeconomic status may have water systems that are smaller and simpler, and that have fewer options for operations improvement, given economic constraints.

23. What are the significant data and information gaps? The purpose of this is to help prioritize the monitoring and research needs for gathering and synthesizing the information. Provide a list of significant gaps related to the conceptual or quantitative models or the data and data analysis needed related to the outcome and driver indicators. Rank each item on this list as one of the following:

- A: information needed for reporting on outcomes (monitoring data)

- B: information needed for better understanding of the linkages between drivers and outcomes and improvements in the conceptual model. (research)
- C. information needed for reporting on drivers (monitoring data)

24. Provide a **ballpark estimate** of how much it would cost (provide a cost basis – per year, or one time) **to fill the significant information gaps**. Try to provide an separate estimate for each line item and then add them together for each category (A,B,C).
25. With a target date of spring 2007, **estimate how much staff time** would be needed to develop a web-based information organization of conceptual models and data related to outcome and driver indicators (including data acquisition and analysis). What staff time is currently available to work on this (break it out by agency)? What are the resource needs to complete this?

CALFED (USBR) is currently contracting support for the final assessment, which will support these goals as well. Currently 3 CBDA staff people (Lisa Holm, Sam Harader, and Patricia Fernandez) are working on the data compilation and analyses full-time. An additional \$1M grant is providing support for some Regional Board staff and CUWA staff to also participate. Three additional full-time staff people – one from each of the state implementing agencies: SWRCB, CVRWQCB, and DHS – would greatly benefit this effort and allow the data collection analyses and reporting to be completed in a more timely manner.

Table Key:

ID: Used to organize and link to table in main report

Key phrase: Short phrase or word to describe outcome indicator (e.g. Water quality at the tap)

Type of indicator: Use key below to select outcome, intermediate outcome or driver type

Key for type of indicator:

OI- Outcome indicator

D/IOI – Driver / Intermediate outcome indicator

D/UF = Driver / Uncontrollable factor

D/MA = Driver / Potential management action

For the next 5: provide a ranking of how much information is currently available related to the indicator:

Key for information ranking

--: Not applicable

0 = no information available

1 = minimal information available

2 = some information available but major gaps

3 = lot of information available but minor gaps

4 = information is fairly complete

- **Conceptual model:** Characterize how much information is available in the conceptual model that documents the understanding of how the outcomes and drivers are related.
- **Quantitative model:** If a quantitative model is available, estimate how much information is available to explain the relationship of the outcomes and drivers, including some assessment of the applicability and quality of the model.
- **Drivers identified:** How much information is available about the drivers that are affecting this outcome? If there are no drivers, use –not applicable.
- **Past monitoring data:** How much historic data are available to evaluate the status and trend of this outcome indicator?
- **Current / future monitoring data:** Are there current or planned monitoring programs or studies that will collect data on the outcome indicator in the short-term future?

Linkages: (check if yes)

EJ: Does this indicator have linkages to environmental justice concerns?

WL: Does this indicator have linkages to working landscapes issues?

WM: Does this indicator have linkages to watershed management such as local land use decisions and land management?

Comments: Provide any brief additional comments to clarify. The main text of the appendix should be used for explanations of any length.

Break-out table for indicator: Water Quality for the tap

Key for type of indicator:

- OI- Outcome indicator
- D/IOI – Driver / Intermediate outcome indicator
- D/UF = Driver / Uncontrollable factor
- D/MA = Driver / Potential management action

Key for information ranking

- : Not applicable
- 0 = no information available
- 1 = minimal information available
- 2 = some information available but major gaps
- 3 = lot of information available but minor gaps
- 4 = information is fairly complete

Indicator description			Conceptual basis			Monitoring data		Linkages			Comments
ID	Key phrase for indicator	Type of indicator	Conceptual Model	Quant. model	Drivers identified	Past indicator data	Current indicator data	EJ	WL	WM	
WQ2	Water quality for the tap	OI	2	2	2	3.5	3.5	Y	—	Y	Summarization of water quality for 4 constituent areas
WQ2.A	Disinfection byproducts	OI	2	2	2	4	4	Y	—	Y	Lot of information in some areas, no info for some treatment areas
WQ2.B	Salinity	OI	2	2	2	4	4	Y	—	Y	
WQ2.C	Taste and odor	OI	2	2	2	2	2	Y	—	Y	
WQ2.D	Level / type of disinfection	OI	2	2	3	4	4	Y	—	Y	
WQ2.a	Raw water quality	D/MA	2.5	2.5	3	3	3.5	Y	Y	Y	Summarization of water quality at intakes, other sources, storage and conveyance
WQ2.a.1	Water Quality at intakes (see other indicator)	D/MA	2.5	2	2	2	3	Y	Y	Y	Summarization of the 4 constituent areas
WQ2.a.2	Water quality through conveyance, storage	D/MA	2	2	3	3	3	Y	Y	Y	
WQ2.a.3	Quality of Other water sources	D/MA	3	3	3	4	4	Y	Y	Y	Data exists, but we don't have it
WQ2.b	Treatment plant characteristics		4	4	4	4	4	Y			
WQ2.b.1	Treatment plant technology	D/MA	4	4	4	4	4	Y	—	—	Relates to current utilized technologies

WQ2.b.2	Treatment plant operations	D/MA	4	4	4	4	4	Y	—	—	Relates to current operated treatment plants
WQ2.c	Socioeconomic considerations		2	2	2	2	2				
WQ2.c.1	Economics	D/MA	2	2	2	2	2	Y	—	—	Rating relates to program's knowledge of local utility decision making processes
WQ2.c.2	Institutional capacity of the water system	D/MA	3	3	3	3	3	Y	—	—	
WQ2.d	regulations	D/UF	4	4	4	4	4	—	—	—	

II Toxicity of Unknown Cause (TUC)

A. Overall questions for subgroup

1. Criteria for selection of core indicators and associated strategic objectives

Water quality indicators and targets were selected based on recommendations in the following documents:

- CALFED ROD (pg. 18)
- CALFED Water Quality Program Plan (Table 1, pg. 8)
- Strategy to Address Toxicity of Unknown Cause
- Comprehensive Monitoring, Assessment, Research Program (CMARP, pg. 54)

2. Strategic objectives for first round (those that will be assembled for the Phase 2 analysis and report)

Proposed topics for indicator development:

- **Water column and sediment toxicity to laboratory test organisms in Delta and upstream tributary watersheds**
- **Determination of degree to which contaminants contribute to population level impacts**
- Copper, cadmium and zinc concentrations at Sacramento R. above Hamilton City and below Shasta Dam
- Organophosphorus (OP) pesticide concentrations in the Delta and upstream tributary watersheds

Indicators for the topics highlighted in bold text above will be the initial focus for indicator development. The remaining topics may be included in the future.

3. Other efforts relevant to these core indicators and coordination strategy

- State Water Board Surface Water Ambient Monitoring Program
- Regional Water Board Irrigated Lands Waiver Program
- Sacramento River Watershed Program Toxicity Monitoring and Focus Group
- Strategy to Address Toxicity of Unknown Cause
- State Water Board Sediment Quality Objectives Development and Sediment Monitoring
- Interagency Ecological Program Contaminants Work Team (Pelagic Organism Decline)

4. Identify which indicators are linked to other CALFED program elements and other non-CALFED efforts.

See list in preceding question.

5. Identify which indicators have linkages for environmental justice, working landscapes or citizen involvement and education.

Toxicity indicators are linked to working landscapes in as much as working landscapes are sources of contaminants that cause toxicity to aquatic life (i.e., pesticides). Likewise, watershed management can affect the fate and transport of contaminants in water bodies. However, there is no obvious link between toxicity to aquatic life and environmental justice.

B1. Water Column and Sediment Toxicity: Outcome indicator questionnaire and breakout table (Fill out for each core outcome indicator or strategic objective.)

1. Short description or key phrase:

Toxicity of unknown cause (TUC) – Toxicity observed but the toxicant could not be identified.

2. What goal(s) and objective(s) are the outcome indicator related to? What is the rationale or supporting information for how this indicator relates to the goal and objective. (Please provide a reference in the CALFED documents for specific objectives).

The CALFED ROD and Water Quality Program Plan goal is: *Through research and monitoring, identify parameters of concern in the water and sediment and implement actions to reduce their impacts to aquatic resources.*

3. Document any long-term performance objectives in the CALFED documents that related to this goal and indicator. Document any **short-term performance goals or targets** in the CALFED documents related to this goal and indicator. (provide references) How does this indicator relate to performance goals and targets in the documents?

- Successful identification of causal agents of toxicity in the Delta, Bay, Sacramento River and San Joaquin River regions.
- Significant reduction (or elimination) of the amount of toxicity present in rivers and sediments due to successful implementation of control measures for toxicants identified in the CMARP.
- Determination of degree to which contaminants are a causal factor in the decline of pelagic organism species in the Delta.

4. If there is a lack of performance measures or targets in CALFED documents for this indicator – draft a qualitative (non-numeric) long-term performance objective related to the goal and indicators. The long-term performance objective should describe what success would “look like” for this goal and indicator. Provide any supporting reasoning or rationale. If quantitative targets or performance goals are needed – note in the table.

- Indications through TIEs that toxicity is attributable to known sources in the Delta Region.
- No likely significant toxicity to aquatic test organisms in sediment or aquatic toxicity tests.
- Establish whether contaminants are a significant factor in the decline of pelagic organisms in the Delta and if so, identify which contaminants and their sources.

5. Document any conceptual or quantitative models that are related to this outcome indicator and describe what factors are or may be influencing the outcome. How complete are they for documenting linkages between the outcome and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix.

Two conceptual models have been developed to describe toxicity impacts in the Delta and upstream tributaries (see attached figures). One was developed for the strategy to address toxicity of unknown cause and the other for investigating whether and to what degree contaminants/toxicity is a factor contributing to the decline of pelagic organisms in the Delta. These models could be combined to provide a complete picture of drivers of toxicity at the

watershed scale and impacts at the species level. Neither model is complete. There is need to compile and summarize references from the literature to support the models. Neither model has been subjected to scientific peer review.

6. Provide a list of the major drivers in the conceptual model that are likely to influence the outcome. Note which ones are uncontrollable factors (by this program) and which are management actions (or potential management actions). For each one, list whether it also has a related conceptual and/or quantitative model related to it. Add to the list any drivers that are identified in the driver conceptual models.

The major drivers for toxicity in the Delta and upstream tributaries are:

- Toxicant transport and fate as effected by:
 - Land use and land use practices
 - Landscape properties
 - Toxicant Properties
 - Water column/matrix properties
 - Hydrology
- Instream impacts to the aquatic community are determined by:
 - Water column/matrix properties
 - Magnitude, duration, and frequency of contaminant exposure
 - Geographic extent of contaminant exposure
 - Resident community composition (i.e., tolerant v. sensitive species)
 - Non-toxicant stressors (i.e., habitat, flow, temperature)

7. Document any conceptual or quantitative models associated with the drivers.

Similar to question 5. How complete are the conceptual or quantitative models for documenting linkages between the driver (intermediate outcome) and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix. Provide a reference list of key documents or scientific papers that would be useful to managers and decision makers who would like more detailed information about the topic.

Fate and transport models for specific constituents do exist but there is a lack of models for the general parameter "toxicity".

8. Do any data exist for the outcome indicator?

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the outcome indicator? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to this outcome indicator. Discuss data availability.
 - b. To the extent possible, evaluate the quality of the data to use as an outcome indicator. What field methods are used for sampling, what methods for lab analysis (if applicable). In general, what is known about the Quality Assurance program and the quality of the data to be used?
- Toxicity monitoring data available through 2001 is summarized in the Strategy to Address Toxicity of Unknown Cause. Additional toxicity monitoring efforts since 2001 include: State Water Board's Surface Water Ambient Monitoring Program,
 - Regional Water Board's Irrigated Lands Waiver Program,
 - Sacramento River Watershed Program's main stem Sacramento River monitoring, and

- Interagency Ecological Program's toxicity monitoring associated with investigation of the pelagic organism decline in the Delta.

NPDES permittees (wastewater treatment plants and stormwater permittees) All of these monitoring programs collect high quality and comparable data and much of it will be stored in the California Data Exchange Network database, which is available online. The major exception is the NPDES permit monitoring, which is largely only available in hard copy format.

- 9. Do any data exist for the driver indicators?** (See list generated in number 6).
- c. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the major driver indicators? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to the driver indicators. Discuss data availability.
 - d. To the extent possible, evaluate the quality of the data for the major driver indicators. What field methods are used for sampling, what methods for lab analysis (if applicable)? In general, what is known about the Quality Assurance program and quality of the data to be used.

Data for driver indicators exist for specific constituents (i.e., pesticides). However, in many cases the driver causing toxicity could not be determined (see discussion of data gaps) making it impossible to identify needed analyses.

- 10. Review the list of drivers and outcome indicators. Are there linkages for environmental justice concerns, working landscapes, or watershed management (affected by local decisions)?** Linkages are defined as affecting the indicator or being affected by the indicator. Discuss the linkages for each of those topics.

Working landscapes and watershed activities are linked to toxicity because they are the sources of constituents that cause toxicity.

- 11. What are the significant data and information gaps?** The purpose of this is to help prioritize the monitoring and research needs for gathering and synthesizing the information. Provide a list of significant gaps related to the conceptual or quantitative models or the data and data analysis needed related to the outcome and driver indicators. Rank each item on this list as one of the following:

- A: information needed for reporting on outcomes (monitoring data)
- B: information needed for better understanding of the linkages between drivers and outcomes and improvements in the conceptual model. (research)
- C: information needed for reporting on drivers (monitoring data)

A. Toxicity of unknown cause essentially is a data gap. In many cases in which the cause of toxicity was not identified, standard USEPA toxicity identification evaluation (TIE) procedures were applied, but were inconclusive. If the issue of TUC is to be resolved, TIE or analytical chemistry procedures need to be refined, or new ones developed. Furthermore, if toxicity is detected, several other parameters, like the duration, magnitude, frequency and geographic extent of the toxicity, must be determined prior to implementation of control strategies. The specific contaminants responsible for toxicity should be documented (by including TIEs or other identification procedures in monitoring projects) so that a focused control program can be developed. Further, identification of sources and the practices or actions that result in the toxicants entering surface waters would be helpful in designing control strategies.

B. Knowledge regarding ecological impacts of TUC is extremely limited. Some toxicity testing has been conducted with native species. While some argue that toxicity tests with indigenous species enhance the 'predictiveness' and ecological relevance of results,

there is little evidence to support this claim. Given the large number of resident aquatic species in the Sacramento/San Joaquin systems, surrogate species may not encompass the range of sensitivities of indigenous populations. In this regard, de Vlaming and Norberg-King reported that laboratory tests with indicator species more frequently underestimate, rather than overestimate, impacts on resident populations. Instream ecological surveys or bioassessments seldom have been performed in conjunction with ambient toxicity testing projects. Bioassessments and resident species toxicity testing could contribute to a weight-of-evidence assessment of impacts on aquatic ecosystem populations.

B. Aquatic life toxicity measurements are an effective screen for pesticide-caused aquatic life toxicity at high levels of toxicity. However, at low levels of toxicity, the standard laboratory tests do not have the sensitivity needed to detect adverse effects to aquatic organisms. For example, pesticides, such as diazinon and chlorpyrifos, can be present in water at toxic levels and not cause toxicity to aquatic life in the standard tests specified in the monitoring requirements.

A & C. In recent years toxicity monitoring has been sporadic, infrequent, and incomplete in coverage of the Sacramento and San Joaquin watersheds and Bay-Delta waterways. For the most part, toxicity testing projects have focused on major tributaries and downstream of major reservoirs. To gain a better understanding of toxicity in these watersheds, monitoring programs (that include TIEs) must be expanded and focused on critical events (e.g., storms, land use activities, etc.). For example, only recently has toxicity monitoring (albeit with limited sampling sites) been resumed in the San Joaquin River watershed, and virtually no toxicity monitoring is being conducted in the Delta. In addition, ambient toxicity monitoring associated with NPDES permit discharges has largely been ignored. Analysis of these data could assist in understanding toxicity in Central Valley and San Francisco Bay water bodies.

Break-out table for indicator: _____

Key for type of indicator:

OI- Outcome indicator
 D/IOI – Driver / Intermediate outcome indicator
 D/UF = Driver / Uncontrollable factor
 D/MA = Driver / Potential management action

Key for information ranking

--: Not applicable
 0 = no information available
 1 = minimal information available
 2 = some information available but major gaps
 3 = lot of information available but minor gaps
 4 = information is fairly complete

Indicator description			Conceptual basis			Monitoring data		Linkages			Comments
ID	Key phrase for indicator	Type of indicator	Conceptual Model	Quant. model	Drivers identified	Past indicator data	Current indicator data	EJ	WL	WM	
WQ 3	Water column toxicity	OI	2	0	2	2	2	-	Y	Y	
	Sediment toxicity	OI	2	0	2	2	2	-	Y	Y	

III. Mercury effects on the ecosystem and human health

A. Overall questions

1. Criteria for selection of core indicators and associated strategic objectives

Considering recent activities such as the development of a CALFED Program mercury strategy and total maximum daily loads for mercury in the Delta and Bay by the Central Valley and San Francisco Bay Regional Water Quality Control Boards (RWQCB) respectfully, mercury ranks high among water quality issues for the Bay-Delta system.

The CALFED Water Quality Program Plan, Ecosystem Restoration Program Plan, Mercury Strategy, mercury TMDL for the Delta, and mercury TMDL for the Bay support the strategic objectives for this constituent.

Fish tissue indicators for the ecosystem and human health are consistent with the approach recommended in the Regional Board's Draft Delta TMDL for mercury. Additional human health and fish consumption indicators and targets were selected based on information from applicable studies and advice from persons knowledgeable in this field.

2. Strategic objectives for first round (those that will be assembled for the Phase 2 analysis and report):

The strategic objective relating to for mercury is:

- Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife and people. (Ecosystem Restoration Program Plan, Goal 6)

A long-term objective specific to mercury is:

- Reduce mercury in water and sediment to levels that do not adversely affect aquatic organisms, wildlife, and human health (Water Quality Program Plan, p. 4-2).

In later phases of work, performance measures may address other bioaccumulative substances, such as selenium and PCBs. This is particularly important for appropriate risk communication to be able to recommend healthy alternatives to those fish that bioaccumulate mercury.

3. Other efforts relevant to these core indicators and coordination strategy.

Key efforts currently being conducted on mercury include but are not limited to:

- Fish Mercury Project (FMP; CALFED-funded)
 - Fish mercury sampling coordinated by San Francisco Estuary Institute (SFEI)
 - Development of two fish consumption advisories by Office of Environmental Health Hazard Assessment's
 - Outreach and educational activities conducted by DHS
 - Fish biosentinel work by UC Davis
- CALFED-funded study: Mercury and Methylmercury Processes in North San Francisco Bay Tidal Wetland Ecosystems (managed by SFEI)

- CALFED-funded study: Mercury Release from Delta Wetlands: facilitation and fluxes (managed by USGS)
- CALFED-funded study: Mercury in the Birds of the San Francisco Bay-Delta: Trophic Pathways, Bioaccumulation, and Ecotoxicological Risk to Avian Reproduction. (managed by USFWS)
- CALFED-funded study: Evaluation of Mercury Transformations and Trophic Transfer in the San Francisco Bay/Delta: Identifying Critical Processes for the Ecosystem Restoration Program (managed by USGS)
- CALFED-funded study on atmospheric deposition.
- CDHS Blood sample collection (funded by CVRWQCB)
- Office of Environmental Health Hazard Assessment's (OEHHA) CA Fish Consumption Advisories
- CDHS educational activities on fish consumption: surveys on fish consumption.
- Sacramento River Watershed Program: Identification and Assessment of Candidate Targets for the Mercury Strategic Planning Effort
- Localized Mercury Bioaccumulation Study by Sacramento Regional County Sanitation District by Larry Walker and Associates and UC Davis
- San Francisco Estuary Institute, Regional Monitoring Program
- National Health and Nutrition Examination Survey (NHANES)
- Sacramento Regional County Sanitation District (SRCSD): field angler surveying and provision of risk information to anglers and community members/groups by Fraser Shilling, UC Davis
- State Water Resources Control Board's proposed Holistic Mercury Management Strategy
- Central Valley RWQCB, Mercury TMDL (revised draft June 2006)
- Central Valley RWQCB, Cache Creek, Bear Creek, Sulphur Creek and Harley Gulch Mercury TMDL (draft)
- San Francisco Bay RWQCB, San Francisco Bay Mercury TMDL (draft)
- USGS ongoing studies in upper watersheds and the Yolo Basin.

4. Identify which indicators are linked to other CALFED program elements and other non-CALFED efforts.

The human health / risk communication indicator is related to CDHS and OEHHA programs; the tissue concentration indicators track the Central Valley RWQCB TMDLs.

Mercury effects (associated with tissue and egg concentration indicators) can be drivers for efforts to restore and maintain sensitive species (see Ecosystem Restoration Program, documentation).

Wetlands restoration (ERP) has the potential to affect mercury methylation (i.e., can contribute drivers for methylation and uptake, which would be measured in terms of tissue and egg concentrations).

Water management, including conveyance and storage could affect water chemistry and methylation potential.

5. Identify which indicators have linkages for environmental justice, working landscapes or citizen involvement and education.

Public health effects of mercury accumulation in fish and shellfish have a direct linkage to environmental justice and citizen involvement and education. Certain ethnic groups of people are disproportionately exposed to contaminants in fish due to higher rates of fish consumption and, generally, more fish consumption within the community. Within the Delta, Southeast Asian and African American populations seem to be the most affected.

Part B : Mercury outcome indicators for effects on fish and wildlife

1. Short description or key phrase:

Indicators to characterize the effects of mercury on fish, wildlife and humans within the Delta and Bay-Delta tributaries.

The outcome indicator for **fish and wildlife effects** are:

- Mercury concentrations in the tissue of biosentinels (species considerations include wide distribution, site fidelity, trophic level linkages; delta and lower river reaches may require different species than upper tributaries). Mercury concentrations in eggs or feathers of key bird species could be an indicator for avians.

Outcome indicators for **human health** relate to public awareness (effective risk communication) and human consumption. Suggested measures are:

- Public health benefits (risk reduction)
- Mercury concentrations in tissue of representative sport fish species eaten by humans.

2. What goal(s) and objective(s) are the outcome indicators related to? What is the rationale or supporting information for how this indicator relates to the goal and objective. (Please provide a reference for specific objectives.)

The CALFED Ecosystem Restoration Program Plan, Water Quality Program Plan, and Central Valley RWQCB documents all identify objectives related to the outcome indicators:

- Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife and people. (ERP Strategic Plan, Goal 6 of Ecosystem Restoration Program, p.43)

Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, humans and wildlife. (ERP Strategic Plan, Strategic objective 1 under Goal 6, page 43)

- Reduce mercury in water and sediment to levels that do not adversely affect aquatic organisms, wildlife, and human health (Water Quality Program Plan, p. 4-2).
- Decrease biotic exposure to methyl mercury (draft Delta Mercury TMDL, p. 20)

3. Document any long-term performance objectives in the CALFED documents that relate to the goals and indicators. Document any short-term performance goals or targets in the CALFED documents related to this goal and indicator. (provide references) How does this indicator relate to performance goals and targets in the documents?

Long-term performance objectives:

- Reduce mercury exposure through consumption of harvested fish, wildlife, and invertebrates in the Delta and tributaries to levels that protect public health (Mercury Strategy).
- Reduce mercury and methyl mercury in the Bay-Delta ecosystem to levels where fishery resources, wildlife, and human health are not adversely affected.

Shorter-term and more specific objectives include:

Assess ecological risk (Wiener, et al, p.32).

Assess effects of ecosystem restoration on methyl mercury exposure (Wiener, et al).
Identify and test methods of reducing methyl mercury production and ecosystem exposure (Wiener et al, p. 32; Draft Delta Mercury TMDL)

Manage landscapes to reduce methyl mercury (Wiener, et al; Draft Delta Mercury TMDL)

Control methyl mercury loads resulting from sediment flux. (Delta Mercury TMDL)

Remediate mercury sources. (Wiener, J.G.; Gilmour, C.; and Krabbenhoft, D. Mercury Strategy for the Bay-Delta Ecosystem. Final Report to the California Bay Delta Authority. December 31, 2003; Regional Water Quality Control Boards. San Francisco Bay, Delta, and Cache Creek TMDLs.)

Reduce the discharge of mercury and methyl mercury into the Delta and its tributaries. [Central Valley RWQCB, Sacramento-San Joaquin Delta TMDL for Methyl and Total Mercury, Staff Report, Revised Draft June 2006 (Delta Mercury TMDL)]

Protect human health by assessing human exposure to methyl mercury, and by developing and communicating advice for reducing exposure to methylmercury, the dominant form of mercury in fish. (p. 25, Wiener et al., 2003)

Assess health risks of consuming contaminated fish and communicate these risks to appropriate target audiences. (p. 2, Fish Mercury Project Scope of Work, 2002)

Reduce risk to human populations through effective risk communication and management of exposure. (Mercury Strategy)

Targets:

The CALFED Program Plan does not have quantitative targets for mercury. "Targets," numeric criteria for specified beneficial uses, and water quality standards and objectives are addressed by the Regional Water Quality Control Board, U.S. EPA, and U.S. FWS, among others.

The US EPA criterion for human health is a tissue residue concentration (TRC) of 0.3 mg/kg wet weight (fresh water and estuarine fish and shellfish tissue). A USFWS study has advised that this criterion would not be adequately protective of sensitive fish and wildlife species and has recommended a "highest trophic level" approach. (Russell, Daniel. Evaluation of the Clean Water Act Section 304(a) Human Health Criterion for Methylmercury: Protectiveness for Threatened and Endangered Wildlife in California. U.S. FWS, Sacramento, CA. October 2003, p. ix.) More protective criteria may be adopted by the State in setting objectives for specific areas within the Bay-Delta system.

Objectives in the Delta and Cache Creek TMDLs/Basin Plan Amendments are forthcoming and could be used as long-term targets. The Sacramento-San Joaquin Delta TMDL for Methylmercury - Draft Report, Revised June 2006, proposes species-specific muscle tissue targets based on fish at different trophic levels, as well as a .24 mg/kg methylmercury concentration in largemouth bass.

The draft Delta TMDL describes various actions to achieve these objectives, including reductions in methyl and total mercury loads. Needed reductions vary by location and source type. For example, to ensure protection of human and wildlife health in the Delta it will be necessary to reduce fish methyl mercury levels from zero to 73 % in the peripheral Delta subareas (draft Delta Mercury TMDL, p. 19)

The Delta Mercury TMDL sets a goal of .06 ng/L aqueous methylmercury (Draft Report, revised June 2006, p. 57).

4. If there is a lack of performance measures or targets in CALFED documents (or related agency documents, such as the RWQCB Basin Plan, or measures required pursuant to the Endangered Species Act) for this indicator – draft a qualitative (non-numeric) long-term performance objective related to the goal and indicators. The long-term performance objective should describe what success would “look like” for this goal and indicator. Provide any supporting reasoning or rationale. If quantitative targets or performance goals are needed – note in the table.

The following are examples of potential quantifiable measures of performance:

- Mercury levels in biosentinel species and fish consumed by humans decrease to safe levels (long-term)
- Total mercury and methylmercury discharges are reduced
- Ecosystem restoration sites that may be designed to reduce both total and methyl mercury loads are identified and monitored for changes in methylmercury production and ecosystem uptake (short-term)
- Actions are taken at restoration sites to avoid increased methylmercury export to the food chain or other biota (short-term)
- Proposed restoration sites be assessed with respect to methylmercury loads such that management strategies that reduce methyl mercury loads be identified for potential methylmercury production (short-term).
- At risk human populations receive and understand advisory information (short-term)
- At risk populations decrease consumption of mercury-laden fish to safe levels (short-term)

5. Document any conceptual or quantitative models that are related to this outcome indicator and describe what factors are or may be influencing the outcome. How complete are they for documenting linkages between the outcome and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix.

Numerous papers and conceptual models address different aspects of mercury. The following are representative, generalized conceptual models:

Sources and cycling processes—Central Valley RWQCB. Powerpoint: Board Workshop on Methylmercury Basin Plan Amendment for the Sacramento-San Joaquin River Delta Estuary. November 28, 2005. Relative importance of drivers not identified. Limited treatment of ecosystem uptake and food web processes.

Conceptual model of mercury sources and cycling in the San Francisco Bay-Delta ecosystem. Figure 3 (p. 7) of the Mercury Strategy. More detail on chemical forms and processes, according to source and biotic environment.

The Delta methylmercury budget (quantified inputs by source, and exports from the Delta). (Draft Delta Mercury TMDL, August 2005, p. vii). This approach contributes to future monitoring and management of mercury, as the Regional Board's TMDL is concerned with characterizing and reducing loads of mercury and methylmercury from specific sources.

More specialized models include:

- Biomagnification- p. 17 of Delta Methylmercury Scoping Meeting Powerpoint (http://www.waterboards.ca.gov/centralvalley/programs/tmdl/Delta_hg/delta-mmhg-ceqa.pdf).
- Human Health, Basis for Reference Dose: p. 28 of Appendix 2. Sacramento River Watershed Program: Identification and Assessment of Candidate Targets for the Mercury Strategic Planning Effort
- Conceptual Model for Mercury Concentration Target Derivation: p. 16 of Appendix 2. Sacramento River Watershed Program: Identification and Assessment of Candidate Targets for the Mercury Strategic Planning Effort. Model provides mercury concentration targets and relates concentrations to reference doses.
- Conceptual model for bioaccumulation in the lower Sacramento River. Cited in Shilling, 2006; Source: Phase II work plan for the "Localized Mercury Bioaccumulation Study" by the Sacramento Regional County Sanitation District, Larry Walker Associates, and UC Davis; plan and model have been peer-reviewed).

6. Provide a list of the major drivers in the general conceptual models that are likely to influence the outcome. Include major drivers identified in the "drivers conceptual models" (question 7). Note which are uncontrollable factors (UF) and which are controllable (current or potential management actions-- MA). For each driver, identify (*) whether it also has a related conceptual and/or quantitative model related to it..

Drivers for mercury (total and/or methyl mercury):

Sources of mercury:

- Abandoned mercury mines (MA)
- Mine process wastes (e.g., gold mine tailings) (MA)
- Bed and bank sediments (UF/ MA)
- Natural sources (geothermal springs, background mercury in soil) (UF/ MA)
- Atmospheric sources (e.g., fuel combustion, industrial airborne sources) (MA)
- Discharges (e.g., wastewater treatment plants), urban stormwater, and irrigated lands runoff (MA)

Transport / movement of mercury into the ecosystem:

- Natural hydrology (UF)
- Water management (e.g., operation of reservoirs and conveyance facilities (MA)
- Sediment traps (reservoirs, settling basin, floodplains) (MA)
- Sediment disturbance

Methylation / Demethylation: Transformation of mercury to methylmercury (MA/ UF)

Water depth

Tidal or seasonal rewetting of habitat edges
Water chemistry

Food web bioaccumulation and biomagnification (UF/potential MA)

Exposure of aquatic organisms (UF/ potential MA)

Exposure of wildlife (UF/ MA)

Effectiveness of advisories (MA) – human health

Fish consumption (UF/MA) – human health

Mercury concentrations in key sport fish species (MA) – human health

7. Document any conceptual or quantitative models associated with the drivers. Similar to question 5: How complete are the conceptual or quantitative models for documenting linkages between the driver (intermediate outcome) and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Summarize the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix. Provide a reference list of key documents or scientific papers that would be useful to managers and decision makers who would like more detailed information.

No formalized driver conceptual models for human health / risk communication were identified. A number of research projects have developed conceptual models addressing hypothesized drivers for mercury processes and ecosystem uptake. (For example, as of 2006 the CBDA had funded 19 mercury-related projects.) The conceptual framework for these projects generally is not formalized into a “conceptual model.” Research subjects include:

Mercury transport and cycling

Trophic pathways

Mercury flux in wetlands

Mercury mass budget

Human health risk of fish consumption in the Delta (considered comprehensively)

8. Do any data exist for the outcome indicators (see B1)?

a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate each outcome indicator. Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to this outcome indicator. Discuss data availability.

b. To the extent possible, evaluate the quality of the data to use as an outcome indicator. What field methods are used for sampling, what methods for lab analysis (if applicable). In general, what is known about the Quality Assurance program and the quality of the data to be used?

Mercury concentration in tissue is being used as an indicator (proxy) for human health and ecosystem effects. There are a number of sources of such data, some of which are listed in the following “data driver” question.

A report is pending on past monitoring of bioaccumulants, including mercury, within California: The San Francisco Estuary Institute (Jay Davis) has conducted a review of historical data from bioaccumulant monitoring for the SWRCB Surface Water Ambient Monitoring Program (SWAMP).

There are several CALFED-funded projects that have collected, or are collecting, data on mercury in biosentinels, sport fish, and other measures of exposure and toxicity effects.

For the last year Fraser Shilling, UC Davis, has been conducting field angler surveying (lower Sacramento River-Delta) and providing risk information to anglers and community members/groups; the project ends in February 2007.

There are three current risk assessment and advisory efforts being conducted through the Fish Mercury Project (projects to assess risks of consuming methylmercury-contaminated sport fish, and develop an advisory for the San Joaquin River, Sacramento River, and Delta regions).

Other Fish Mercury Projects working on human health involve communicating with community leaders, better targeting specific communities or populations, involving community-based organizations, developing risk communication messages, and local training and capacity-building.

CDHS is continuing educational activities on fish consumption. In the fall, CDHS will be conducting blood tests on a small sample of low-income, pregnant women. Surveys about fish consumption will be compared with blood mercury levels to assess exposure in this population and conduct education.

National Health and Nutrition Examination Survey (NHANES) conducts a continuous survey of the health and nutritional status of the US civilian, non-institutionalized population. This provides national data (not California-specific) for blood and hair mercury levels.

CALFED funded mercury projects that are collecting water, sediment, and tissue concentrations of mercury are all participating in a Quality Assurance program. Regarding QA/QC for the CALFED projects, see annual report on "Programmatic Quality Assurance and Quality Control for California Bay-Delta Authority Mercury Research and Monitoring Projects," Van Buuren Consulting, LLC and the California DFG.

9. Do any data exist for the driver indicators?

Sources include:

- 2005 National Forum on Contaminants in Fish – Proceedings
- Mercury in fish database developed by Michelle Wood at the Central Valley Regional Water Quality Control Board
- Summaries of fishing activity and fish tissue mercury data, recommendations for action (Shilling, UC Davis, 2003 and 2004)
- California Department of Fish and Game Creel surveys from 1999-2001
- Fish Mercury Project and CALFED mercury projects, generally (http://www.calwater.ca.gov/Programs/EcosystemRestoration/Ecosystem_MercuryAnnualReport2005.asp).

10. Review the list of drivers and outcome indicators. Are there linkages for environmental justice concerns, working landscapes, or watershed management (affected by local decisions)? Discuss the linkages for each of those topics.

Mercury is most directly linked to environmental justice concerns through contaminated fish consumption of contaminated fish from the Bay-Delta and tributaries. High rates of fish consumption disproportionately expose certain ethnic and socioeconomic groups to contaminants in fish. Working landscapes and watershed management activities can affect mercury inputs to waterways; onsite wetland habitats could create conditions susceptible to methylmercury production and wildlife exposure.

11. What are the significant data and information gaps? The purpose of this is to help prioritize the monitoring and research needs for gathering and synthesizing the information. Provide a list of significant gaps related to the conceptual or quantitative models or the data and data analysis needed related to the outcome and driver indicators.

Rank each item on this list as one of the following:

- a: information needed for reporting on outcomes (monitoring data)**
- b: information needed for better understanding of the linkages between drivers and outcomes and improvements in the conceptual model. (research)**
- c. information needed for reporting on drivers (monitoring data)**

For mercury processes and ecosystem uptake key information gaps and uncertainties include:

- Lack of an over-arching conceptual model characterizing the overall processes of bioaccumulation/exposure in the geographic context of the Delta watershed. (This could help prioritize and focus research.)
- Lack of integration of environmental drivers (e.g., amount and form of inorganic mercury, organic carbon, nutrients, temperature) that can affect year-to-year bioaccumulation. Better understanding of how conditions facilitate or inhibit methylation, applicable to site-specific analysis.
- Species feeding habits amount and form of inorganic mercury, trophic transfer and trophic level.

Relationship between mercury concentrations in various environmental compartments (air, sediment, aqueous, tissue).

- Need to prioritize drivers for relative influence on different aspects of the environmental and social systems involved in mercury exposure.
- Data on key environmental drivers of bioaccumulation

Additionally, gaps related to human health / risk communication are:

- Fish tissue monitoring for primary fish species consumed by people and wildlife in areas consumption/capture occurs
- Effectiveness of communication methods used by state and other organizations to convey risk information
- Fish consumption rates and amounts

Break-out table for indicator: Mercury—ecosystem and human health

Table Key:

ID: Used to organize and link to table in main report

Key phrase: Short phrase or word to describe outcome indicator (e.g. Water quality at the tap)

Type of indicator: Use key below to select outcome, intermediate outcome or driver type

Key for type of indicator:

OI- Outcome indicator

D/IOI – Driver / Intermediate outcome indicator

D/UF = Driver / Uncontrollable factor

D/MA = Driver / Potential management action

For the next 5: provide a ranking of how much information is currently available related to the indicator:

Key for information ranking

--: Not applicable

0 = no information available

1 = minimal information available

2 = some information available but major gaps

3 = lot of information available but minor gaps

4 = information is fairly complete

- **Conceptual model:** Characterize how much information is available in the conceptual model that documents the understanding of how the outcomes and drivers are related.
- **Quantitative model:** If a quantitative model is available, estimate how much information is available to explain the relationship of the outcomes and drivers, including some assessment of the applicability and quality of the model.
- **Drivers identified:** How much information is available about the drivers that are affecting this outcome? If there are no drivers, use –not applicable.
- **Past monitoring data:** How much historic data are available to evaluate the status and trend of this outcome indicator?
- **Current / future monitoring data:** Are there current or planned monitoring programs or studies that will collect data on the outcome indicator in the short-term future?

Linkages: (check if yes)

EJ: Does this indicator have linkages to environmental justice concerns?

WL: Does this indicator have linkages to working landscapes issues?

WM: Does this indicator have linkages to watershed management such as local land use decisions and land management?

Comments: Provide any brief additional comments to clarify. The main text of the appendix should be used for explanations of any length.

Break-out table for indicator: _____

Key for type of indicator:

- OI- Outcome indicator
- D/IOI – Driver / Intermediate outcome indicator
- D/UF = Driver / Uncontrollable factor
- D/MA = Driver / Potential management action

Key for information ranking

- : Not applicable
- 0 = no information available
- 1 = minimal information available
- 2 = some information available but major gaps
- 3 = lot of information available but minor gaps
- 4 = information is fairly complete

Indicator description			Conceptual basis			Monitoring data		Linkages			Comments
ID	Key phrase for indicator or driver	Type of indicator	Conceptual Model	Quant. model	Drivers identified	Past indicator data	Current indicator data	EJ	WL	WM	
	ECO INDICATORS										
WQ4B	Mercury in biosentinels-- fish species	OI	2	1	2	1	2				<u>Work underway by UCD on biosentinel fish , funded until '07.</u>
WQ4B	Mercury in biosentinels— bird species	OI	2	1	2	1	3				Work underway by USFWS and USGS to look at 3 different bird guilds, grant funded until '07
	DRIVERS										
WQ4	Sources of total mercury and methylmerc.	D/MA	2	1	2	1	2		✓	✓	Summary of subcategories below
WQ4	Abandoned mines	D/MA	1	0	2	1	1				Preliminary site assessments of abandoned mines have been done in a few watersheds for public land only – virtually nothing on private land
WQ4	Mine process wastes (e.g., dredge tailings)	D/MA	1	0	2	1	2				Some studies done on Clear Creek, Yuba/Bear, and Merced. Clear Creek and Merced are grant funded, not continuous monitoring

WQ4.	Natural sources (e.g., hot springs)	D/some MA	1	1	2	1	1				Cache Creek geothermal springs only. Sac Regional Wastewater Treatment Plant's mercury offset feasibility study looked into mitigating mercury from Sulfur Springs (Cache Creek watershed)
WQ4.	Stormwater / wastewater discharges	D/MA	3	1	2	1	2		✓	✓	Some NPDES historic data for total mercury. Little or no data on methylm. or stormwater inputs.
WQ4.	Atmospheric deposition	D/MA	2	1	2	1	1				Substantial work at the national level but little info on regional/local deposition. Several monitoring sites have been added with CALFED grant funding. Models exist (CA Air Board) for estimates of deposition. Mercury from air deposition may be highly bioavailable. Some controllable drivers but limited CALFED role.
WQ4.	Bed & bank sediments; Delta and Bay sediments	D/MA	1	0	2	1	1				Little info on mercury stored in beds, banks and terraces.
WQ4.	Transport of mercury	D/MA	2	1	3	1	2		✓		Summary of subcategories below
WQ4.	Retention and discharge from sediment traps: reservoirs, basins	D/MA	2	1	3	1	2				Some info on reservoirs and settling basins related to mercury
WQ4	Sediment disturbance (via floods, tidal flow, e.g.)	D/ MA and UF	1	0	1	1	1				Limited information on the transport of mercury with sediments, particularly bed load during flood events. Natural: large storm events move the majority of total and methyl Hg (sediment-related) into the <u>Delta</u> . Tidal flow

											can promote continual erosion, transport and redeposition of contaminated sediment which provides the substrate for methylating .
WQ4.	Managed flows (e.g., through reservoir operations and Delta exports)	D/MA	1-2	1	2	1	1		✓		Limited information on effects of some types of water management actions.
WQ4.	Natural hydrology	D/UF	2	1	3	1	2				E.g., uncontrolled flows (e.g., flood events) transport mercury with sediments (see sed. disturbance).. For the most part, "natural" hydrology is mediated by human activities/projects. E.g., flows in the Bay-Delta system are highly regulated. The instances of "natural" hydrology are limited.
WQ4	Methylation / Demethylation	D/MA/UF	2+	0	2	1	2				A number of studies are underway to better understand the methylation/demethylation processes – may know more in a another year.
WQ4	Food web bio-accumulation	D/ some MA	2	1	2	1	2+				Some studies are underway (USGS, USFWS)
WQ4	Effects of mercury exposure on aquatic organisms	D/UF	2	1	2	2	2+				Information is needed on sublethal effects.
WQ4	Effects on wildlife	D/UF	2	1	2	2	2				Limited information on mammals; sublethal effect information is limited.
	HUMAN										

	HEALTH INDICATORS										
WQ4A	Public health effects	OI	2	0	1	1	1	✓			There is some info on consumption rates. There is no information in this region on the actual public health effects from fish caught, but there is information on effectiveness of risk communication.
WQ4A	Concentration in key sport fish species	OI	2	1	3	2	3		✓	✓	Quite a bit of data are being collected from SFEI project – grant funded ends in '07. Some historic data.
	HH DRIVERS										
WQ4.	Awareness of advisories	D/MA	1	0	3	1	1.5	✓		✓	Very limited surveying done.
WQ4	Effectiveness of advisories for limiting fish consumption	D/MA	1	0	2	0	1	✓		✓	Very limited surveying done.
	Bay-Delta fish consumption	D/UF, MA	1	0	3	2	2	✓			Some pilot consumption studies by DHS, UCD
WQ4	Concentration in key sport fish species	D/UF, MA	2	1	3	2	3		✓	✓	Same as outcome indicator

IV. Levees System Integrity: Breakout table and questionnaire

A. Overall questions for subgroup

8. List the criteria for selection of core indicators and associated strategic objectives (SOW #4)

Previous efforts identified 5 general areas for levee outcome indicators:

Levee Base Level Protection

Levee Structural Integrity and Seismic stability
Resources at risk
Habitat benefits and impacts
Emergency response

In this effort, 2 indicators related to Levee Base Level Protection have been chosen for reporting over the next year. Indicators for the other categories may be developed as part of other efforts, such as the Delta Risk Management Strategy (DRMS) – or will be further developed in future phases. These two indicators were chosen for the first round because there will be data available to compile and evaluate in early 2007.

9. List of strategic objectives for first round (those that will be assembled for the Phase 2 analysis and report) (SOW#4)

Delta Levees Base Level Protection:

- Resistance to overtopping– KIM (Kilo Inch Mile) is a measure of how much material is needed for the levees to meet PL84-99 standards or other relevant standards (100-year flood elevation, HMP)
- Levee structural integrity - # of anomalies detected and repaired.
Electromagnetic surveys will be done to detect anomalies and potential levee weak spots. Anomalies will be investigated further and repaired if appropriate.

10. List of other efforts relevant to these core indicators and coordination strategy (SOW #3)
Delta Risk Management Strategy (DRMS)

11. Develop more detailed questionnaire and table of information for each strategic objective / core indicator. (See section B below)

12. Identify which indicators are linked to other CALFED program elements and other non-CALFED efforts. (SOW #8)

13. Identify which indicators have linkages for environmental justice, working landscapes or citizen involvement and education.

14. Compile information and prioritize information gaps and resource needs to complete monitoring, data acquisition, data analysis, information organization and presentation. (SOW# 10) Detailed analysis from Section B to be summarized.

B. Outcome indicator questionnaire and breakout table (Fill out for each core outcome indicator or strategic objective.)

26. **Short description** or key phrase:

Levee base level protection

Measure of protection from overtopping– KIM: This measurement is
Levee internal integrity - # of high-risk anomalies

27. What **goal(s) and objective(s)** are the outcome indicator related to? What is the rationale or supporting information for how this indicator relates to the goal and objective. (Please provide a reference in the CALFED documents for specific objectives).
28. Documents any **long-term performance objectives** in the CALFED documents that related to this goal and indicator. Document any **short-term performance goals or targets** in the CALFED documents related to this goal and indicator. (provide references) How does this indicator relate to performance goals and targets in the documents?
29. If there is a lack of performance measures or targets in CALFED documents for this indicator – **draft a qualitative (non-numeric) long-term performance objective related** to the goal and indicators. The long-term performance objective should describe what success would “look like” for this goal and indicator. Provide any supporting reasoning or rationale. If quantitative targets or performance goals are needed – note in the table.
30. **Document any conceptual or quantitative models that are related to this outcome indicator** and describe what factors are or may be influencing the outcome. How complete are they for documenting linkages between the outcome and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix.

As part of the development of the Delta Risk Management Strategy (DRMS), a series of white papers are being developed and reviewed. The DRMS will also be developing a risk assessment model. Some preliminary work has been done to document an overall conceptual model for levees – but it needs further development.

31. **Provide a list of the major drivers** in the conceptual model that are likely to influence the outcome. Note which ones are uncontrollable factors (by this program) and which are management actions (MA) (or potential management actions). For each one, list whether it also has a related conceptual and/or quantitative model related to it. Add to the list any drivers that are identified in the driver conceptual models.

Levee maintenance / enhancement	(MA)
Structural integrity of levee	(MA)
Flood management operations	(MA)
Population growth	(UF)
Subsidence	(UF)
Land use	(MA)
Erosion	(MA)
Accidents and animals	(MA)
Earthquakes	(UF)
Natural hydrology (flood events)	(UF)
Sea level rise	(UF)
Emergency response	(MA)

32. **Document any conceptual or quantitative models associated with the drivers.** Similar to question 5. How complete are the conceptual or quantitative models for documenting linkages between the driver (intermediate outcome) and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the

conceptual model to be included in the appendix. Provide a reference list of key documents or scientific papers that would be useful to managers and decision makers who would like more detailed information about the topic.

33. Do any data exist for the outcome indicator?

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the outcome indicator? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to this outcome indicator. Discuss data availability.
- b. To the extent possible, evaluate the quality of the data to use as an outcome indicator. What field methods are used for sampling, what methods for lab analysis (if applicable). In general, what is known about the Quality Assurance program and the quality of the data to be used?

For KIM – LIDAR survey of elevation data will be done in February 2007 by Department of Water Resources. Raw data will need to be processed and analyzed by contractor and DWR staff. KIM values can be reported for 100 year flood elevation, Hazard Mitigation Plan level (100 year elevation + 1 foot), and PL84-99 (100-year elevation + 1.5 feet). The KIM values can also be broken out geographically per island or summed up Delta-wide. Existing data on levee height is limited to a few islands and some of it is not current.

For Levee structural integrity, electro magnetic anomaly data will be collected in some of the reclamation districts in 2006-2007, with cost-sharing (FEMA + DWR providing 90%, local reclamation districts providing 10%) In the government cost share, FEMA is providing 75% of funding, DWR is providing 25% of funding). Depending on participation from the reclamation districts, DWR expects that about 60% of the levees could be inspected using electromagnetic tools. There will be two phases: Phase 1 – detection, Phase 2 - further investigation.

34. Do any data exist for the driver indicators? (See list generated in number 6).

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the major driver indicators? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to the driver indicators. Discuss data availability.
- b. To the extent possible, evaluate the quality of the data for the major driver indicators. What field methods are used for sampling, what methods for lab analysis (if applicable)? In general, what is know about the Quality Assurance program and quality of the data to be used.

35. Review the list of drivers and outcome indicators. **Are there linkages** for environmental justice concerns, working landscapes, or watershed management (affected by local decisions)? Discuss the linkages for each of those topics.

36. What are the significant data and information gaps? The purpose of this is to help prioritize the monitoring and research needs for gathering and synthesizing the information. Provide a list of significant gaps related to the conceptual or quantitative models or the data and data analysis needed related to the outcome and driver indicators. Rank each item on this list as one of the following:
A: information needed for reporting on outcomes (monitoring data)
B: information needed for better understanding of the linkages between drivers and outcomes and improvements in the conceptual model. (research)
C. information needed for reporting on drivers (monitoring data)

37. Provide a ballpark estimate of how much it would cost (provide a cost basis – per year, or one time) **to fill the significant information gaps.** Try to provide an separate estimate for each line item and then add them together for each category (A,B,C).

38. With a target date of spring 2007, **estimate how much staff time** would be needed to develop a web-based information organization of conceptual models and data related to outcome and driver indicators (including data acquisition and analysis). What staff time is currently available to work on this (break it out by agency)? What are the resource needs to complete this?

The implementing agencies for the CALFED Levee program (CA Dept. of Water Resources, US Army Corps of Engineers, and CA Dept. of Fish and Game) do not have the staff capacity to work on the development and reporting of indicators and performance measures for the program. Work will not progress in a timely manner unless additional resources are provided and staff dedicated to this effort.

The resources being requested are one full-time person that could do most of the work and coordinate with other efforts, advised by a multi-agency technical advisory team. The technical advisory team would meet approximately ½ day per month, with some additional time for reviewing and commenting on materials. Therefore, each member of the technical advisory team would need to contribute about 10 days per year toward this effort – over the next year. The suggested make-up of the technical team should be 4 state staff (2-DWR, 1-CBDA, 1-DFG), 3 federal staff (2-USACE, 1-USBR) and 3-4 representatives of the reclamation districts (3 consultants). Funds would be needed to pay the Reclamation District consultants for their participation in the effort (approx 10 days per year). In the future, funds would be needed for a long-term monitoring program and staff for data compilation, analysis and reporting.

Tasks to be completed in 2006-2007 with additional resources:

- o Use relevant information from the DRMS study to apply toward indicators and performance measures
- o Refine conceptual / quantitative models needed to link drivers and outcomes
- o Develop measurable meaningful indicators to improve our understanding of the system and report on progress towards goals.
- o Evaluate and analyze existing data and monitoring programs – identify gaps
- o Develop a long-term monitoring program needed to report on indicators, including funding needs and methods
- o Identify key research needs to improve our understanding of the levee system and risks
- o Develop a web-based information report that includes any existing data, conceptual or quantitative models, relevant research and white papers, including GIS-based data.

Summary of resources needed for Fiscal year 2006-2007 for Levees

Agency	Description	PY	Approx cost
DWR	Team Leader	1	
DWR	Technical Advisors (2 @ 10 days ea)	.08 PY	
USACE	Technical Advisors (2 @ 10 days ea)	.08 PY	
DFG	Technical Advisor (1 @ 10 days)	.04 PY	
USBR	Technical Advisor (1 @ 10 days)	.04 PY	
CBDA staff	Technical Advisor (1 @ 10 days)	.04 PY	
Reclamation Districts	Technical Advisor (3 @ 10 days ea)	.12 PY	
	Total	1.4 PY	

Break-out table for indicator: _____

Key for type of indicator:

OI- Outcome indicator
 D/IOI – Driver / Intermediate outcome indicator
 D/UF = Driver / Uncontrollable factor
 D/MA = Driver / Potential management action

Key for information ranking

--: Not applicable
 0 = no information available
 1 = minimal information available
 2 = some information available but major gaps
 3 = lot of information available but minor gaps
 4 = information is fairly complete

Indicator description			Conceptual basis			Monitoring data		Linkages			Comments
ID	Key phrase for indicator	Type of indicator	Conceptual Model	Quant. model	Drivers identified	Past indicator data	Current indicator data	EJ	WL	WM	
Levees 1	KIM – Levee base level protection	OI	2		4	1	4				LIDAR data will be collected in 06-07
Levees 2	# anomalies detected and repaired – levee structural integrity	OI	2			0	2				Magnetic anomaly data is expected for about 60% of levees in 06-07

V. Water Supply Reliability

A. Overall questions for subgroup

15. List the criteria for selection of core indicators and associated strategic objectives (SOW #4)

There were strategic objects, sub-objectives and descriptions for Water Supply Reliability in the Calfed ROD, PEIR/EIS, and supporting documents. The record review is summarized in Table 4-WSR-1. Based on this record decisions were made based on the availability of data, predictive models and efforts already underway to express Water Supply Reliability and its drivers.

16. List of strategic objectives for first round (those that will be assembled for the Phase 2 analysis and report) (SOW#4)

The CALFED programs fundamental Strategic Objective that describes Water Supply Reliability focuses specifically on the Delta and the State and federal water systems as a whole. That is:

Reduce the mismatch between Bay Delta water supplies and current and projected beneficial uses dependent on the Bay –Delta system.

Table 4-WSR-2 displays the two selected Outcome Indicators and their relationship to the Strategic Objectives.

17. List of other efforts relevant to these core indicators and coordination strategy (SOW #3)

WSR-1 Outcome Indicator – Meeting environmental and water quality demands of the Delta system.

The Water Supply Reliability Workgroup will coordinate with the Ecosystem Restoration and Water Quality Workgroups to incorporate the environmental and water quality demand targets developed by these groups. It is crucial that the WSRW receive these targets in a form that the CALSIM and DSM2 mathematical models can use to predict the WSRW outcome indicators.

WSR-2 Outcome Indicator –Improving export water supplies from the delta.

The WSRW will meet and coordinate with the ongoing Bulletin 160 effort to define export demands from the Delta. In the absence of final results from this effort within Phase 1, CVP and SWP total contract amounts will be used to report results. The storage program studies are ongoing and are not schedule to be completed until the end of 2008. Interim studies and modeling runs will be periodically reported using the best data available at that time.

18. Develop more detailed questionnaire and table of information for each strategic objective / core indicator. (See section B below)

The Water Supply Reliability Workgroup will need more guidance on this request before it can finish this work.

19. Identify which indicators are linked to other CALFED program elements and other non-CALFED efforts. (SOW #8)

For the WSR -1 outcome indicator the WSR Workgroup will need the Ecosystem Restoration and Water Quality Workgroups to provide environmental and water quality demand targets for tributaries to the Delta, in-Delta and Delta outflow. These targets will need to be a form and detail to allow inclusion into the existing CALSIM and DSM2 models. Once included the outcome indicators can be predicted and reported for each storage project currently under review. These environmental demand targets will allow the storage program to better allocate benefits of each project. Coordination with the EWA program will also take place. It is assumed that the current "gamed" water supply targets for EWA will remain the same and can be used for our analysis.

For WSR-2 the WSR Workgroup will need to define the demand for Delta exports in coordination with ongoing Bulletin 160 efforts. In the absence of any additional demand calculations the contract demands of state and federal contractors will be used as a baseline. Export capability will be estimated from ongoing Storage Program planning studies and periodically reported. All linkages to other programs and the correct usage of coordinated data will be assembled and incorporated into the CALSIM , DSM2 and other models used in these studies thru the Common Assumptions effort. The Common Assumptions effort is and established peer review process with experts representing the public, private and local, State, and federal agencies.

20. Identify which indicators have linkages for environmental justice, working landscapes or citizen involvement and education.

None.

21. Compile information and prioritize information gaps and resource needs to complete monitoring, data acquisition, data analysis, information organization and presentation. (SOW# 10) Detailed analysis from Section B to be summarized.

The ongoing Common Assumption effort has prioritized and will continue to identify data gaps, collection of data and use of surrogate data for the Storage Planning Studies. This information and plan will be made available to agencies and the public as necessary. See the current plan attached.

B. Outcome indicator questionnaire and breakout table (Fill out for each core outcome indicator or strategic objective.)

39. **Short description** or key phrase:

WSR -1 – Acre feet of water supply made available for and dedicated to Bay –Delta system for fish restoration and water quality improvements.

WSR -2 –Delta system Export capability (Acre feet) –export demand. This could be reported in percent of export demand supplied.

40. What **goal(s) and objective(s)** are the outcome indicator related to? What is the rationale or supporting information for how this indicator relates to the goal and objective. (Please provide a reference in the CALFED documents for specific objectives).

The PEIR/S and attachments and Rod were reviewed for Strategic Objectives, Goals and specific Targets. The purpose and need statements in the PEIR/S and some guidance documents defined the Water Supply Reality Primary Objective as: Reducing the mismatch between Bay Delta water supplies and current and projected beneficial use dependent on the Bay-Delta system. Additional main and sub objectives were set out also –all centered on the needs on the Bay Delta system as a whole.

These objectives set out in various CALFED background documents and their relationship to one another is displayed on the attached Table 4-WSR-1.

Table 2 sets out the Outcome Indicators chosen for WSR-1 and WSR-1 performance measures and their relationship to the primary strategic objective of the CALFED WSR program. The actual outcome will be expressed in either; 1) the amount of water made available and dedicated to fish restoration purposes and water quality improvement or 2) our ability to reduce the gap between supply and demands on the delta.

41. Document any **long-term performance objectives** in the CALFED documents that related to this goal and indicator. Document any **short-term performance goals or targets** in the CALFED documents related to this goal and indicator. (provide references) How does this indicator relate to performance goals and targets in the documents?

See Tables 4-WSR-1 & 2.

42. If there is a lack of performance measures or targets in CALFED documents for this indicator – **draft a qualitative (non-numeric) long-term performance objective related** to the goal and indicators. The long-term performance objective should describe what success would “look like” for this goal and indicator. Provide any supporting reasoning or rationale. If quantitative targets or performance goals are needed – note in the table.

See Tables 4-WSR-1 & 2.

43. **Document any conceptual or quantitative models that are related to this outcome indicator** and describe what factors are or may be influencing the outcome. How complete are they for documenting linkages between the outcome and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix.

A first draft of a conceptual model and the cause and effects of drivers and outcomes is depicted on the attached Figures 1 and 2.

Further work will be required to define these relationships more closely using the CALSIM, DSM2 and related peer reviewed mathematical models that predict Bay-Delta system supply and demand. The ongoing Common Assumptions effort to standardize and collaborate on modeling assumptions strives to provide a commonly accepted and fully coordinated amongst the Calfed Agencies approach to modeling state wide hydrology and hydraulic capabilities of the state and federal water systems dependent on the Bay-Delta system.

44. **Provide a list of the major drivers** in the conceptual model that are likely to influence the outcome. Note which ones are uncontrollable factors (by this program) and which are management actions (or potential management actions). For each one, list whether it also has a related conceptual and/or quantitative model related to it. Add to the list any drivers that are identified in the driver conceptual models.

See five above and Figures 1 and 2 attached.

45. **Document any conceptual or quantitative models associated with the drivers.** Similar to question 5. How complete are the conceptual or quantitative models for

documenting linkages between the driver (intermediate outcome) and the controlling factors? Does the conceptual model have references from peer-reviewed literature? Has the conceptual model had independent review? If using a quantitative model, has it been validated and verified? Provide a discussion on the quality and completeness of the conceptual or quantitative model. Provide a graphic (with a reference) of the conceptual model to be included in the appendix. Provide a reference list of key documents or scientific papers that would be useful to managers and decision makers who would like more detailed information about the topic.

Attached is a current report that explains the Common Assumptions modeling effort underway that seeks to assemble and use the best data and models available for use in the storage planning studies.

46. Do any data exist for the outcome indicator?

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the outcome indicator? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to this outcome indicator. Discuss data availability.
- b. To the extent possible, evaluate the quality of the data to use as an outcome indicator. What field methods are used for sampling, what methods for lab analysis (if applicable). In general, what is known about the Quality Assurance program and the quality of the data to be used?

For WSR -1 – the data will need to come from the Ecosystem and Water Quality workgroups.

For WSR- 2 – There is great past and predicted future data on the supply of water to the Bay –Delta system. The future demand will need to be coordinated with the Bulletin 160 effort and ongoing State and federal environmental documentation efforts to maintain consistency and use the most up to date and generally accepted accurate data.

47. Do any data exist for the driver indicators? (See list generated in number 6).

- a. To the extent possible, determine what data exist in past and current monitoring programs that can be used to evaluate the major driver indicators? Who collects the data and where is it stored? Discuss spatial and temporal extent of data related to the driver indicators. Discuss data availability.
- b. To the extent possible, evaluate the quality of the data for the major driver indicators. What field methods are used for sampling, what methods for lab analysis (if applicable)? In general, what is known about the Quality Assurance program and quality of the data to be used.

Yes, most if not all this data is being assembled by the Common assumptions Effort and contain and described in detail in the two reports attached.

48. Review the list of drivers and outcome indicators. Are there linkages for environmental justice concerns, working landscapes, or watershed management (affected by local decisions)? Discuss the linkages for each of those topics.

No.

49. What are the significant data and information gaps? The purpose of this is to help prioritize the monitoring and research needs for gathering and synthesizing the information. Provide a list of significant gaps related to the conceptual or quantitative

models or the data and data analysis needed related to the outcome and driver indicators. Rank each item on this list as one of the following:

- A: information needed for reporting on outcomes (monitoring data)
- B: information needed for better understanding of the linkages between drivers and outcomes and improvements in the conceptual model. (research)
- C: information needed for reporting on drivers (monitoring data)

50. Provide a **ballpark estimate** of how much it would cost (provide a cost basis – per year, or one time) **to fill the significant information gaps**. Try to provide an separate estimate for each line item and then add them together for each category (A,B,C).
51. With a target date of spring 2007, **estimate how much staff time** would be needed to develop a web-based information organization of conceptual models and data related to outcome and driver indicators (including data acquisition and analysis). What staff time is currently available to work on this (break it out by agency)? What are the resource needs to complete this?

The ongoing storage and conveyance planning studies and projects will not have final results available by the end of Phase 1. However, there will be periodic progress reports of studies and predictions of how these projects can contribute to these outcome indicators.

Conceptual Model of Delta Supply
 NOD Supply

