Charge to Modeling Science Work Group.

Background

In 2009 the California legislature passed the Delta Reform Act creating the Delta Stewardship Council. The mission of the Council is to implement the coequal goals of the Reform Act and provide a more reliable water supply for California while protecting, restoring, and enhancing the Delta ecosystem. The Council wrote and adopted a Delta Plan in 2013 to implement these goals. Chapter 6 of the Delta Plan deals with water quality and contains recommendations to implement the coequal goals of the Delta Reform Act. Recommendation # 8 states, in part,

> *"…the State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards should prepare and begin implementation of a study plan for the development of objectives for nutrients in the Delta … by January 1, 2014. Studies needed for development of Delta… nutrient objectives should be completed by January 1, 2016. The Water Boards should adopt and begin implementation of nutrient objectives, either narrative or numeric, where appropriate, in the Delta… by January 1, 2018.*

The potential problems identified in the Delta Plan includes assessing whether (1) decreases in algal abundance and shifts in algal species composition, (2) increases in the abundance and distribution of macrophytes, including water hyacinth and Brazilian waterweed, and (3) increases in the magnitude and frequency of cyanobacteria blooms are the result of changes in ambient nutrient concentrations in the Delta. White papers are being prepared on each of these topics assessing whether long term changes in ambient nutrient concentrations have contributed to these conditions and whether future changes in nutrient management might remedy the situation.

In the spring of 2014 Water Board staff wrote a new five-year Delta Strategic Work Plan to help prioritize Delta activities. The five-year plan was presented as an information item at the February 2014 Board meeting. Item five in the Strategic Plan lays out tasks, schedule and deliverables to begin implementing the nutrient recommendations in the Delta Plan (Figure 1). The Strategic Plan included the formation of a Technical Advisory

Committee and a Stakeholder Advisory Group (which was later combined into the Stakeholder and Technical Advisory Group or STAG) to help respond to Delta Plan recommendations and to identify additional issues of concern. The Water Board also formed several Science Work Groups to help develop white papers on the three potential nutrient related problems. White papers will include recommendations for research to resolve outstanding questions about the efficacy of nutrient management to control these problems. These recommendations will be incorporated into a Nutrient Research Plan. Draft white papers and a draft Nutrient Research Plan will be available for review by the STAG and the State Board's Independent Science Review Panel in 2015. A final Nutrient Research Plan addressing all review comments is anticipated to be completed and presented as an information item to the Central Valley Regional Water Board and, if requested, the Delta Stewardship Council in 2015.

Need for a Model

The STAG, a CALFED independent Science Review Panel and Water Board staff all recommend that the Research Plan include development of a hydrodynamic model linked to a suite of environmental modules for the Delta. The previously described white papers and associated research will provide valuable information on whether ambient nutrient concentrations in the Delta contribute to present problems and can be managed in the future to remedy them. However, these one dimensional nutrient centric results cannot provide a holistic understanding of the relative effect of nutrient loads acting in combination with other physical and environmental factors on water quality and food webs in the Delta. Only robust hydrodynamic models coupled with a suite of water quality modules can accomplish this.

In 2009 CALFED assembled an independent science review panel to recommend a research plan to determine the role of ammonia in the Delta[1]. The panel prepared a final document entitled, "*A Framework for Research Addressing the Role of Ammonia/Ammonium in the Sacramento San Joaquin Delta and the San Francisco Bay Estuary Ecosystem*". A high priority recommendation of the panel was development of a coupled hydrodynamic water quality model. The authors state, "*We believe that the most important gap to be filled in the Bay-Delta research program is the development of an overarching, integrative model of the major drivers controlling the Bay-Delta Ecosystem. This modeling effort is especially needed because a wide variety of non-*

[1] http://www.science.calwater.ca.gov/events/workshops/workshop_ammonia.html

convergent perspectives remain about the major controls on POD species and the Bay-Delta food web". The 2014 Delta Stewardship Council's Workshop on *Delta Outflow and Related Stressors* Panel[2] also recommended development of a hydrodynamic biological model to tease apart the effect of nutrients, grazing, and outflow on algal species composition and biomass. Unfortunately, limited progress has been made in developing such models for the Delta, although model development has started for Suisun Bay as part of the San Francisco Bay Nutrient Management Strategy.

Investment in a suite of environmental models will provide multiple benefits. First, such models would allow an understanding of the ecological significance of changes in nutrients from an ecosystem perspective. For example, an ecosystem perspective is essential to compare and understand the relative importance of clam and zooplankton grazing, transport (flow and settling, routing), light limitation, residence time, water temperature, introduced species and nutrients on algal biomass and algal species composition. A second benefit of such models is that they would allow researchers to build and test management planning scenarios, based in part on future reductions in nutrient loads already "baked into" the system as the result of past regulatory and management decisions. For example, the models could be used to inform questions like, "*what will be the effect on blue green algal biomass if reductions in nutrients and global warming (increased water temperature, intensification of spring discharge and decreased summer/fall flows) simultaneously occur*"? Finally, the models will help in the design of field experiments and in the interpretation of their results. All this information will be essential for evaluation, and if needed, the development of a robust nutrient management plan and associated nutrient objectives for the Delta. Development of such models may also be useful for other researchers as they investigate non-nutrient related issues. At present there are no environmental models being used to perform these functions.

The suite of water quality models will depend on the types of questions being asked. A potential framework for how the hydrodynamic/water quality models might be linked and an initial set of questions are included in Figure 2 and Table 1. Both the figure and list of questions will likely be revised and expanded upon by the Modeling Work Group, other science work groups and STAG. For example, each of the other three science

[2] http://deltacouncil.ca.gov/sites/default/files/documents/files/Delta-Outflows-Report-Final-2014-05-05.pdf

work groups has been asked to review Table 1 and provide additional questions for the modeling group to consider. The present list has been divided into questions that are of immediate and longer term significance. Information on both time scales is important as development of a nutrient management plan and adoption of nutrient objectives for the Delta are intended to protect aquatic resources now and in the future.

A preliminary list of hydrodynamic models that might be coupled with water quality modules is included as Table 2. Some important criteria for the preferred suite of hydrodynamic and water quality modules are listed in Table 3. The STAG and Modeling Science Work Group should review and expand on both Tables 2 and 3.

Charge to the Modeling Science Work Group.

The purpose of the Modeling Science Work Group is to provide advice to the Water Board on the important criteria for models to inform nutrient management questions and on the characteristics of the institution(s) where such models would be housed. The deliberations and recommendations of the work group will be captured in a white paper. The white paper will not recommend the preferred suite of models nor the institution responsible for housing and maintaining the model. Instead, the Modeling Science Work Group will (1) examine and expand upon the types of questions that the model(s) will need to inform, (2) assemble a list of important criteria the models should meet, (3) assemble a list of available hydrodynamic and water quality models, (4) evaluate available models against these criteria, discussing the pros and cons of each suite of models and the improvements that would need to be made to develop hydrodynamic-water quality models to inform management questions, (5) provide advice, if possible, on the cost and amount of time required to successfully develop linked hydrodynamic water quality models. Finally, (6) integrating the various models, validating and calibrating them is likely to be an expensive, multi-year, multi-phased effort. The work group should provide advice on how to successfully phase model development and identify key tasks that should be included at each phase of the project. Actual model selection would be left to the funding authorities to determine in a competitive bid process.

Similarly, the Modeling Science Work Group will not recommend the institution(s) responsible for developing and housing the model(s). The work group will (1) assemble a list of potential institutions interested in being responsible for developing and maintaining the model(s) and (2) assemble a list of criteria the preferred institution(s) should possess. Again, selection of the institution(s) responsible for developing and maintaining the model would be left to the funding institutions.

It is likely that multiple models will be needed to inform all of the nutrient management questions listed in Table 1. Models that can provide high spatial and temporal detail cannot also provide multi-year simulations of the whole Delta with reasonable computational processing times. Therefore, the work group is not expected to recommend one single type of model to inform all of the management questions.

Stakeholder Comments

At the last STAG meeting Stakeholders reviewed the charge and had a suggestion for the Modeling Work Group. One Stakeholder commented, "*My experience with the development and application of such models in the Delta ecosystem makes me concerned that more effort will be devoted to producing a model than will be dedicated to validating and calibrating that model. Predictions from quantitative models should not be used to inform management or make recommendations until the model has been tested to verify that it can accurately predict outcomes of scenarios that were not used to develop the model.*

This may be a bit premature, since the charge of the STAG is to identify a process for developing the model. But this appears to be the most funding-challenged of the proposed projects, and at a minimum, we'll want to ensure that the work plan and budget for model development includes sufficient resources to calibrate the final model".

The Modeling Work Group should attempt to achieve the charge while being mindful of Stakeholder recommendations.

Work Group Process

Mike Deas of Watercourse Engineering will serve as the Chair of the Modeling Work Group. Philip Trowbridge, San Francisco Estuary Institute, and Water Board staff will attend all meetings, take notes and be responsible for drafting the white paper. The white paper will summarize the deliberations and recommendations of the group (see Attachment A for a draft outline of the white paper). All materials sent to the Modeling Work Group will be made available on the Water Board's project webpage and will also be shared with the STAG.

The Modeling Work Group will meet three times in 2015. The approximate schedule and desired outcomes from each meeting are summarized below. Note: This schedule may need to be adjusted if pre-identified Science Work Group members decline to participate and replacements cannot be readily identified and confirmed.

Work Group Meeting #1 (Mid-June 2015)

Desired Outcomes:

- Review and comment on the outline for the white paper (Attachment A).
- Review and comment on the nutrient management questions prepared by the Regional Board, Stakeholders and other work groups (see Table 1 for initial list) to determine whether they can be practicably addressed through modeling.
- Review and comment on the draft list of important criteria for the preferred suite of models (Table 3).
- Review and comment on the draft list of available hydrodynamic and water quality models (Table 2).
- Gather information from the Modeling Work Group to initially populate a table with the following information for each different management question:
  a) the important criteria for a model(s) to inform the specific question;
  b) the existing hydrodynamic and water quality models that meet or can reasonably be adapted to meet the criteria from step (a);
  c) the pros and cons of the existing model(s) from step (b); and
  d) the estimated time and cost to modify existing models or to develop new models to inform the management question.

Work Group Meeting #2 (Early September 2015)

Desired Outcomes:

- Review and comment on the first draft of white paper. The white paper will contain tables of the important criteria and existing models that were discussed at the first meeting. The group will carefully review these tables. Any items in the tables that do not have concurrence from the group will be identified as a data gap or area of uncertainty. (Note: the draft white paper will be distributed to the STAG for comments at the same time.)
- Provide recommendations for phasing the development of hydrodynamic and water quality models over multiple years.
- Provide recommendations on the characteristics for institution(s) to house and maintain the model(s).
- Provide recommendations for developing coordination among modeling efforts across agencies/institutions.

Work Group Meeting #3 (Early October 2015)

Desired Outcomes:

- Review and comment on the final draft of the white paper.
- Polish language in the executive summary.

A final session may be scheduled to review suggested changes to the white paper after comments from the STAG and from the State Board Independent Science Review Panel (tentatively scheduled for late fall) have been received.

Products of the work group process will include:

1. Science Work Group white paper and prioritized research recommendations.
2. STAG comments and recommendations.
3. State Board Independent Science Panel comments and recommendations.
4. Final white paper and research plan after comments from the State Board Independent Science Panel and STAG have been received and addressed.

This package is intended to support the transparency of the process and ensure that Regional Water Board staff and other interested parties have a complete suite of information needed for their consideration and decision making.

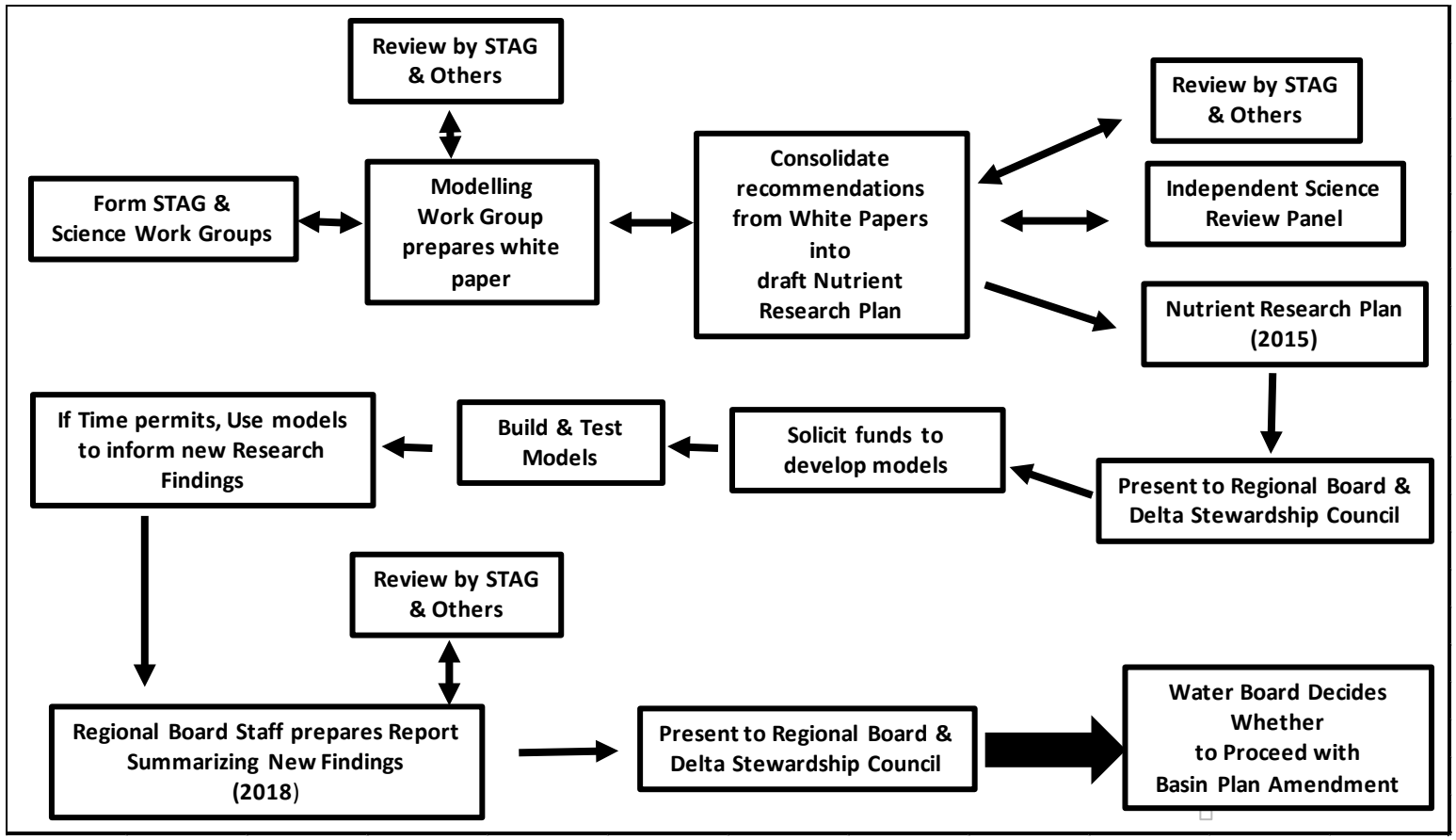

Figure 1. Tasks and schedule for developing and implementing the Nutrient Research Plan as outlined in the 2014 Delta Strategic Work Plan. Staff will solicit input at a 2018 Regional Board meeting whether nutrient objectives are needed for the Delta and whether staff should begin their development.

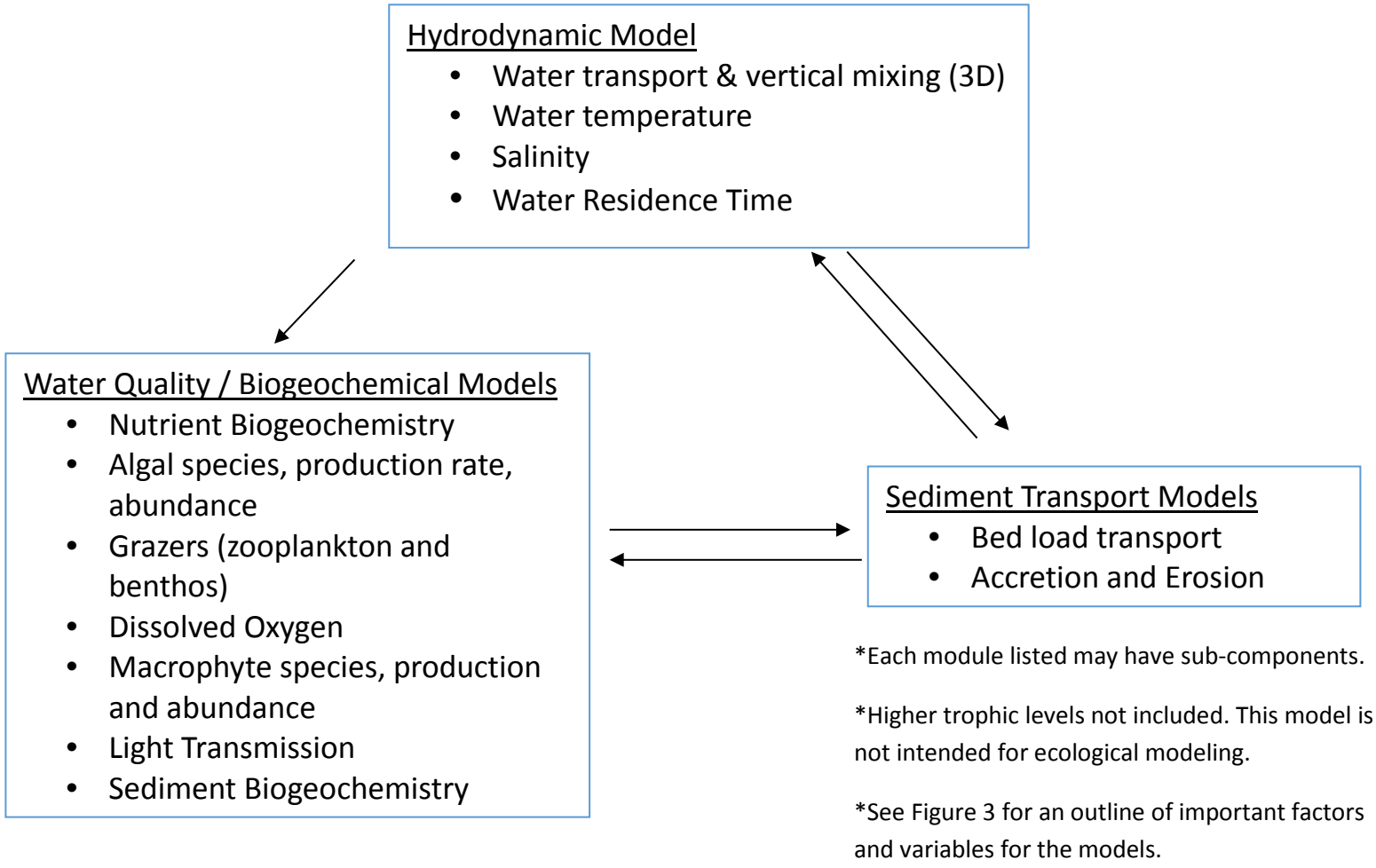

Figure 2. Preliminary framework for the hydrodynamic, water quality/biogeochemical, and sediment transport models and sub-models needed to inform nutrient-related questions. Others researchers may use the model to investigate non-nutrient related issues.

Table 1. Potential list of the types of questions that a linked suite of hydrodynamic and environmental models might inform. The Science Work Groups and STAG should review and propose additional questions for evaluation. Purpose of compiling a list of questions is to ensure that the appropriate hydrodynamic model(s) and suite of water quality modules are selected for use in the Delta.

Current Nutrient Sources, Hydrodynamic Transport and Rates of Transformation	
1	What are the main sources and loads of nutrients to the Delta now?
2	How much do nutrient loads from known sources contribute to ambient nutrient concentrations in different sections of the Delta by season?
3	Do the models indicate that all the major sources of nutrients to the Bay are accurately being measured?
4	What are the important processes that transport and transform nutrients in the Delta and what are the rates at which these processes occur?
Which Factors are Most Important	
5	What are the main factors* affecting: • The algal biomass and primary production rates; • The algal species composition; • The distribution and abundance of macrophyte species; • The magnitude and frequency of cyanobacteria and diatom blooms. How does the relative importance of these factors vary with space & time?
Effects of Nutrient Load Reductions	
6	After the already permitted reductions in nutrient loads from NPDES dischargers have been implemented: a) What will be the main sources of nutrients in the Delta? b) What will be the new ambient nutrient concentrations in different sections of the Delta in each season? c) How much will nutrient loads from known sources contribute to ambient nutrient concentrations in different sections of the Delta by season?

7	After the already permitted reductions in nutrient loads from NPDES dischargers have been implemented, what changes and what magnitude of beneficial response are expected for: • The algal biomass and primary production rates; • The algal species composition; • The distribution and abundance of macrophyte species; • The magnitude and frequency of cyanobacterial and diatom blooms. How will these changes vary with space and time?
Effects of Long-Term Climate and Hydrology Changes	
8	What effect will predicted climate change, changes in Delta hydrology, and wetland restoration have on the following effects (1) under current nutrient loads and (2) under a future predicted nutrient load scenario: • The algal biomass and primary production rates; • The algal species composition; • The distribution and abundance of macrophyte species; and • The magnitude and frequency of cyanobacterial and diatom blooms?

*see Figure 3 for a list of some, but not necessarily all, of the important factors and variables relevant to the types of questions that a linked suite of hydrodynamic and environmental models for the Delta might inform.

Figure 3. Driver-Pressure-State-Impact-Response (DPSIR) model outlining some, but not necessarily all, of the important factors and variables relevant to the types of questions that a linked suite of hydrodynamic and environmental models for the Delta might inform

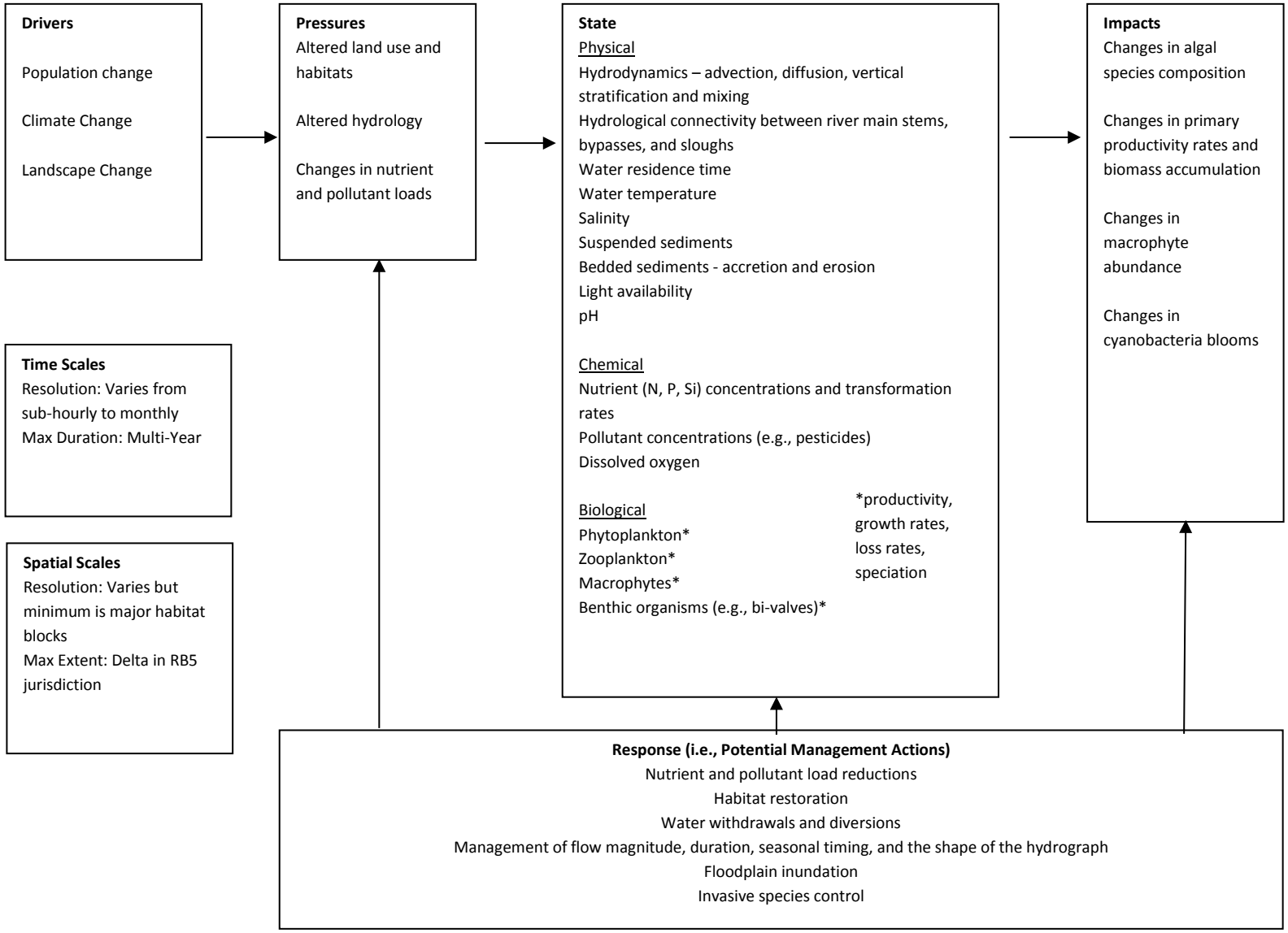

Table 2. Partial List of available hydrodynamic models.

Model	Description
SCHISM	3-dimensional, unstructured grid, hydrodynamic model. Has compatible water quality modules. DWR involved in model development and calibration. Open source.
Suntans	3-dimensional, unstructured grid (horizontally but not vertically), hydrodynamic model calibrated for Delta. Developed by Stanford University and funded by CALFED. Open source.
Deltares Flexible Mesh	3-dimensional, unstructured grid, hydrodynamic model. Has compatible sediment and water quality modules. Developed by Deltares in collaboration with USGS Menlo Park. Open source.
DSM2	Calibrated 2-dimensional hydrodynamic model for Delta. Has nutrient, chlorophyll and dissolved oxygen modules. Developed and maintained by DWR. Open source
Delta EFDC Water Quality Model	Calibrated 3-dimensional, structured grid, hydrodynamic model for Delta. Has compatible water quality and sediment models. Developed at Virginia Institute of Marine Sciences, local calibration supported by the U.S. Army Corps of Engineers. Open source
UnTRIM Bay-Delta model	3-dimensional hydrodynamic and sediment model of the Bay-Delta Estuary. Not in the public domain

Table 3. Preliminary list of desirable criteria for the linked hydrodynamic and water quality modules.

1	Public domain
2	Open source
3	Model successfully employed elsewhere or otherwise peer-reviewed
4	Compatible* with other hydrodynamic and water quality models selected by the San Francisco Regional Board for use in Suisun and San Pablo Bays and with watershed models of river loads to the Delta
5	Calibration for the Delta preferred
6	Model technical support and training available for end users
7	Spatial Extent - Model covers the majority of the legal Delta
8	Temporal Extent - Model can be applied to short duration studies, or long-term (e.g., decadal) analyses.
9	Hydrodynamic model results need to support environmental models representing water quality, sediment biogeochemistry, and sediment transport modeling.
10	Spatial scalability—model can be started at a simple, coarse grained, large-cell version, with finer scale resolution and complexity added as the need arises and data allow.
11	Temporal scalability—model can accommodate time scales from short (e.g., hourly, daily) to long-term (e.g., monthly, annually).
12	Development status – model could potentially start to be used to inform preliminary nutrient management questions as early as mid-2018.

*Different options for evaluating compatibility: Basic ability to pass loads of nutrients and other constituents between models; using the same space and time steps; using the same period of analysis; and modeling the same processes.

Table 4. List of Individuals for the Modeling Science Work Group.

Individual	Agency	Modeling Work Group
David Senn	San Francisco Estuary Institute	X
Joe Domagalski	US Geological Survey	X
Chris Enright	Delta Stewardship Council	X
Lisa Thompson	Sac Regional County Sanitation District	X
Bill Fleenor	UC Davis	X
Phil Trowbridge	San Francisco Estuary Institute	X
Edward Gross / Marianne Guerin	Resource Management Associates	X
Michael Deas	Watercourse Engineering, Inc	X
Eli Ateljevich	Department of Water Resources	X
Paul Hutton	Metropolitan Water District	X
Eric Danner	NOAA Fisheries	X

Key: X = Individual agrees to participate in work group.

Attachment A: Draft Outline of White Paper

Expected Length: 10-20 pages of text plus detailed tables and figures. Text from the "Charge" document, as modified by the Modeling Work Group, will be used for sections 1, 2, and 3a.

1. Introduction

a. Background

b. Need For Models

c. Charge to the Modeling Science Work Group

2. Nutrient Management Questions to be addressed by Modeling in the Delta

Table: Nutrient management questions that a linked suite of hydrodynamic and environmental models might inform (based on Table 1 of the Charge document)

3. Desired Characteristics of Models

a. Important Criteria for Nutrient Models

Table: Important criteria for hydrodynamic and water quality models to address nutrient management questions in the Delta (based on Table 3 of the Charge document)

Characteristic	Explanation

Table: Existing hydrodynamic models meeting the important criteria (based on Table 2 of the Charge document)

Model	Description

Table: Existing water quality models meeting the important criteria and the hydrodynamic models for which they are compatible.

Model	Description

b. Important Criteria for Nutrient Models Relevant to Specific Management Questions

Table: Important criteria for models to address each nutrient management question

Mgmt Question	Spatial domain	Temporal extent	Spatial resolution	Temporal Resolution	Modules Needed	Accuracy of Key Variables	Other Criteria

3. Costs and Schedule to Adapt or Build Models for the Delta

Table: The strengths, weaknesses, costs, and schedule for possible models to inform each management question. If no existing models reasonably meet criteria, the estimated cost and time to build new models is shown.

Mgmt Question	Model	Strengths	Weaknesses	Cost to Adapt	Time to Adapt	Cost to Build	Time to Build
1	e.g. DSM2						
2	New model						

*Note: cost and time estimates may be qualitative

4. Recommendations

a. Phasing the development of nutrient models over multiple years.

b. Characteristics for institution(s) to house the model(s).

c. Developing coordination among modeling efforts across agencies/institutions.