OFFICE MEMO

TO: Paul Hutton	**DATE:** November 26, 2001
FROM: Tara Smith	**SUBJECT:** In Delta Storage: CALSIM Water Quality Operating Rules to Meet Delta Wetlands WQMP:DRAFT

Introduction

CALSIM2 requires operating rules to release flows to meet water supply demands and water quality standards. For the Delta water quality standards, CALSIM2 uses the Artificial Neural Network (ANN) to determine if salinity standards are being met and adjusts water supply in the Delta to meet those standards.

The operation of the In Delta Storage islands will affect water quality in a way that cannot currently be addressed by the ANN. ANN is trained using rimflows, exports, and cross channel gate operations and provides salinity water quality results at select locations. The ANN has not been trained to provide salinity water quality results using a Delta hydrology that includes flows being taken and released from In Delta Storage islands.

Additionally, there are other water quality criteria that have been listed in the Water Quality Management Plan (2000) for the In Delta Storage project that are not addressed in CALSIM2. These include criteria for Total Organic Carbon (TOC), Chloride (Cl), Total Trihalomethanes (TTHM), Bromate (BRM), Disolved Oxygen (DO) , and temperature. The attached table (Table 1) shows a summary of the criteria and these constraints are described in greater detail in Hutton (2001).

The water quality criteria for the In Delta Storage project requires that the water releases from the project islands do not adversely impact the ecosystem (temperature and DO) and do not degrade drinking water quality (TOC, Cl, TTHM, BRM). This paper will address the preliminary work done in determining operating rules for CALSIM2 that will address the In Delta Storage Water Quality criteria. Developing these water quality rules will be an iterative process.

CALSIM2

Since CALSIM2 is not designed for water quality modeling, determining if water quality standards are violated in the Delta is not an easy task. As previously discussed, CALSIM2 uses ANN to determine salinity at selected locations based on flows and Delta Cross Channel operation. Other water quality constraints would require using information available from CALSIM2 such as flows or the time of year and would require implementing water quality modules within the code. In these situations, the processes affecting water quality would be simplified and would be a gross estimate of the effects of project operations.

Also included in this puzzle of operating the reservoir islands are several possible combinations of factors that can influence the operation of the projects. The various possible operations of the project to limit Total Organic Carbon at the urban intake locations is used to illustrate this point. To reduce the amount of TOC released from the islands the following operations could be considered;

1. Water diverted onto the island could not only be based on available water supply but also on the

quality of intake water.

2. The time the water is stored on the island, the temperature of the water and its depth will affect the quality of the water. The amount of release and when it is released could be based on these island storage factors.
3. When the water is released from the project islands, it will have to meet water quality criteria at the urban intake locations. This meeting of the criteria could be addressed in the previous steps but could also be addressed by adjusting the amount of water that can be released.

Determining the operation that will optimize the quality and quantity of water released from the project islands will require iterations and analysis with DSM2.

Discussed below are the various water quality criteria and factors that should be considered in determining operating rules.

Chloride

Diversions onto the project islands and releases from the islands will affect the hydrodynamics of the Delta system and could affect the transport of ocean salinity. This transport would affect the Chloride levels. To address this issue, the ANN would be trained with project island releases and diversions.

The amount of flow diverted onto the reservoir islands should be inversely proportional to the Chloride levels at Old River at Rock Slough (the closest station that ANN determines quality at). As the Chloride levels increase the amount of diversion decreases. Since not all water may be diverted at one time, CALSIM2 will need to calculate the changing concentration in the project reservoirs due to inflows and evaporation/precipitation.

The amount of water released will be determined by the effect on quality that the release water has. If the water has low levels of chloride, then the chloride quality won't be a controlling factor. If releasing the water results in a violation of the 150 mg/l or 250 mg/l standard at Rock Slough, then the amount of water released will be less. To prevent the standard from being violated, the following equation could be used as a preliminary estimate (Wang,2001).

Definintions:

Q_1 = Background flow rate, cfs
Q_2 = Project island release flow rate, cfs
C_1 = Chloride concentration of Q_1, mg/l
C_2 = Chloride concentration of Q_2, mg/l

To Determine Maximum Q_2:

Assuming Q_1 is not changed.

$$\frac{(Q_1 - Q_2)C_1 + Q_2 C_2}{Q_1} \leq 150 \qquad (1)$$

Rearranging the equation gives:

$$Q_2 \leq \frac{(150 - C_1)Q_1}{C_2 - C_1} \qquad (2)$$

Total Organic Carbon

There are three areas that have to be considered when looking at Total Organic Carbon quality and its effects on drinking water quality. The first is the quality of the water diverted onto the project islands, the second is the increase in TOC in the project reservoirs due to the interaction with the peat soil and bioproductivity, and the third area is the release quality and quantity from the project islands.

Diversion of water onto the reservoir islands takes place in excess flow conditions. TOC levels tend to be high during the first big precipitation event. Water diverted to the reservoir island during this time will have higher TOC than the water in the channels during times of reservoir island release. Operating rules may need to consider limiting the amount of water diverted during these events.

While the water stays in the project island reservoir, it interacts with the peat soil and the TOC levels increase (Jung, 2001). Additionally TOC increases due to bioproductivity (Duvall,2001). This increase depends on the length of time the water is there, the depth of the water, and the temperature of the water, among other factors. Operating rules may need to consider these factors in determining when and how much water can be released. A possible operating rule to limit the increase of TOC would be to release the project island water first to meet south of Delta demands instead of releasing from upstream reservoirs. Additionally, a rule to retain a small amount of water in the project island may be made to limit bioproductivity.

Since CALSIM2 does not model the changing Total Organic Carbon or Dissolved Organic Carbon (DOC) levels in the Delta Channels, an attempt was made to correlate DOC with Delta island consumptive use (DICU) with the intention of using the relationship to develop project island diversion rules. No strong correlation was found (Anderson, May 2001).

Using a relationship developed by Jung (Nov 2001), the interaction between the peat soil and the water can be modeled in CALSIM2 (Nader-Tehrani, Nov 2001).

Similar to the rules for chloride, the amount of water released will be determined by the effect on TOC that the release water has. If the water has lower levels of TOC, then the TOC quality won't be a controlling factor. If releasing the water results in a violation of the 1 mg/l criteria, then the amount of water released will be less. As a preliminary estimate of release flows that will not violate the TOC criteria, equation 4 could be used.

Definintions:

Q_1 = Background flow rate, cfs
Q_2 = Project island release flow rate, cfs
C_1 = TOC concentration of Q_1, mg/l
C_2 = TOC concentration of Q_2, mg/l

To Determine Maximum Q_2:

Assuming Q_1 is not changed.

$$\frac{(Q_1 - Q_2)C_1 + Q_2 C_2}{Q_1} \leq C_1 + 1 \qquad (3)$$

Rearranging the equation gives:

$$Q_2 \le \frac{Q_1}{C_2 - C_1} \qquad (4)$$

Bromate

Using the Ozekin equation in attachment 3 of the Water Quality Management Plan (2000) which was further derived and simplified in Hutton (2001), Bromate can be described as a function of Dissolved Organic Carbon and Bromide.

$$BRM = C2 \times DOC^{0.31} \times Br^{0.73} \qquad (3)$$

When water is diverted, stored and released, the combination of DOC and Bromide will also have to be incorporated into the operating constraints. Both DOC and Bromide can be determined using relationships between TOC (Hutton, 2001) and Electrical Conductivity and Chloride (Suits, 2001)

Total Trihalomethanes (TTHM)

Using the Malcolm Pirnie equation in attachment 3 of the Water Quality Management Plan (WQMP) which was further derived and simplified in Hutton (2001), TTHM can be described as a function of Dissolved Organic Carbon, and Bromide, Ultraviolet Absorbance (UVA), and temperature (T).

$$TTHM = C1 \times DOC^{0.228} \times UVA^{0.534} \times (Br + 1)^{2.01} \times T^{0.48} \qquad (4)$$

Temperature and DO

Adequate temperature and DO rules in CALSIM2 will be difficult to implement due to some precise release rules criteria. Even accurately modeling temperature and DO changes due to diversions and releases in DSM2 will be difficult due to inadequate amounts of observed data to calibrate DSM2.

Analysis of the effects of releases on temperature and DO levels is currently being accomplished by using a spreadsheet model to evaluate the local effects (Yokoyama, 2001).

Table 1: Water Quality Criteria, In-Delta Storage Program

WATER QUALITY CRITERIA, IN-DELTA STORAGE PROGRAM												
CRITERIA	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
TOTAL ORGANIC CARBON (TOC)												
All export Locations (14-day average) (1)						<4.0 mg/L limit						
All export locations and Water TP intakes (14-day average) (2)					Incremental Increase <1.0 mg/L							
If TOC of stored water > TOC of channel water (3)		Discharge from Webb Tract or Bacon Island ranges from 40 cfs to 1,500 cfs depending on TOC										
CHLORIDE												
CCWD's intake and any urban water intake in the Delta (4)					< 10 mg/L Chloride							
Any urban intake in the Delta (5)					< 90% of salinity std.							
Limit discharge from Webb Tract and Bacon Island (6)			For chloride 0 - 250 mg/L, discharge 3,000 - 80 cfs									
DISINFECTION BYPRODUCTS (TTHM)												
Urban intake or treatment plant outlet (7)					< 64 µg/L TTHM							
BROMATE												
Urban intake or treatment plant outlet (8)					< 8 µg/L Bromate							
DISOLVED OXYGEN (DO)												
No discharge if DO in stored water is less than: (9)						< 6 mg/L						
No discharge if depressesDO of channel water to less: (10)						< 5.0 mg/L						
No discharge if DO in San Joaquin (Turner Cut to Stockton) (11)									< 6.0 mg/L			
TEMPERATURE												
No discharge if temperature differential (12)						>20º F						
For channel temp. 55º F to 66º F, limit increase to (13)						< 4º F						
For channel temp. 66º F to 77º F, limit increase to (14)						< 2º F						
For channel temp. > 77º F, limit increase to (15)						< 1º F						

FOOTNOTES

(1) Releases from storage reservoir ahould not cause the TOC concentration at any of the intakes of SWP, CVP, CCWD pumping plant, or urban water treatment plant (ALL INTAKES) to exceed 4.0 mg/L (14-day average).

(2) Incremental increase of TOC concentration at ALL INTAKES should not exceed 1.0 mg/L (14-day average).

(3) Discharge from Bacon Island and Webb Tract is limited to a declining scale if TOC concentration of stored water is higher than TOC of channel water

(4) Chloride concentrations at ALL INTAKES shall not ecxeed 10.0 mg/L.

(5) Operation of Delta Wetlands Project should not cause or contribute to salinity increase at ALL INTAKES if salinity at the intake is at 90% of an adopted standard.

(6) If chloride concentration of stored water is higher than of the channel water, the conbined discharge from storage islands will be limited depending on the incremental differencial.

(7) Modeled or predicted TTHM concentration at ALL INTAKES or the outlet of a water treatment plant should be caused by the Project to exceed 64 µg/L.

(8) Modeled or predicted bromate concentration at ALL INTAKES or the outlet of a water treatment plant should be caused by the Project to exceed 8 µg/L.

(9) Stored water will not be discharged if DO is less than 6 mg/L.

(10) Stored water will not be discharged if it would cause the DO of the mixture with channel water to drop less than 5.0 mg/L.

(11) Stored water will not be discharged if the operation would decrease the DO of San Joaquin River between Turner Cut and Stockton to less than 6.0 mg/L.

(12) Stored water will not be discharged in the channels if the temperature differential is more than 20º F .

(13) No discharge of stored water if it will increase the channel water temperature by more than 4º F when the channel water temperture is between 55º F and 66º F.

(14) No discharge of stored water if it will increase the channel water temperature by more than 2º F when the channel water temperture is between 66º F and 77º F.

(15) No discharge of stored water if it will increase the channel water temperature by more than 1º F when the channel water temperture is higher than 77º F.

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