Review of Potential for Controlling P Discharges from Mud and Salt Sloughs for Reducing Algal-Related Oxygen Demand Load to SJR DWSC

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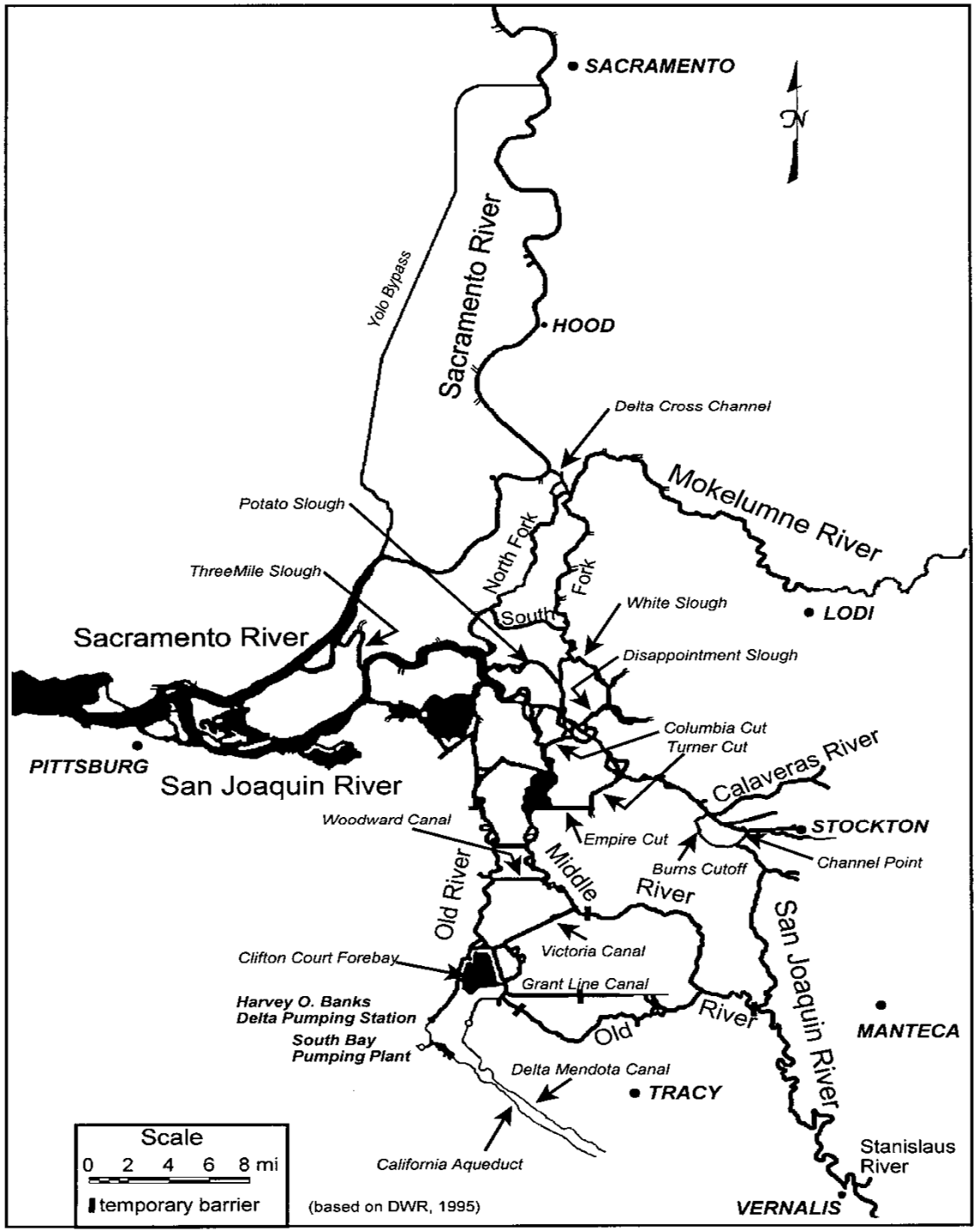
Issues

- Dissolved Oxygen (DO) in San Joaquin River (SJR) Deep Water Ship Channel (DWSC) near Stockton Falls below Water Quality Objective (WQO)
  - Inhibits Homing Migration of Fall Run Chinook Salmon to SJR Watershed Rivers for Spawning
- Requires Development of TMDL to Control Low-DO Conditions

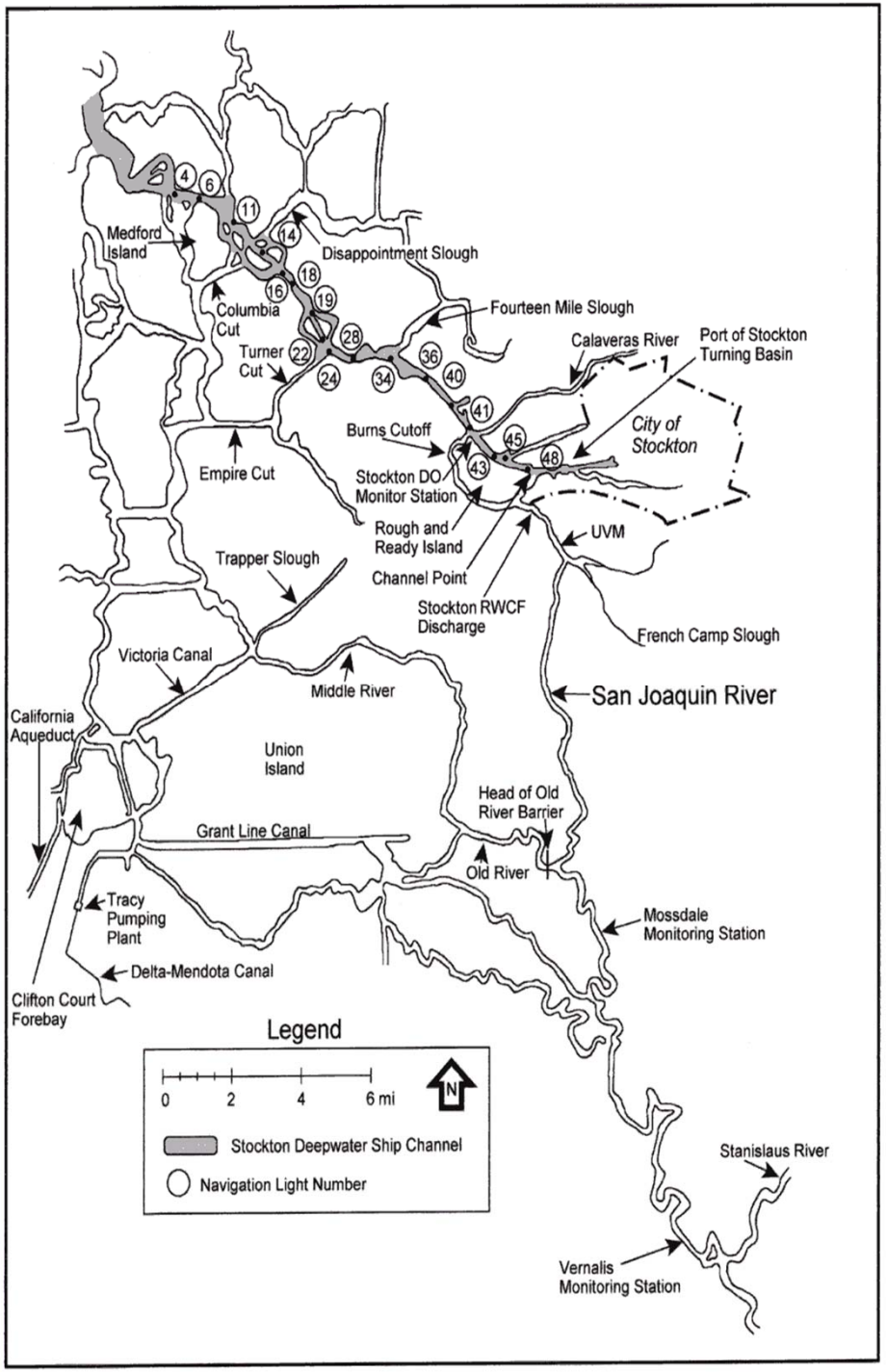
Presented at Bay-Delta Science Conference, Sacramento, CA, September 29 (2010)
[Slides available at: http://www.gfredlee.com/SJR-Delta/SJR-DO-BayDeltaConf.pdf]

Sacramento River
San Joaquin River
Delta

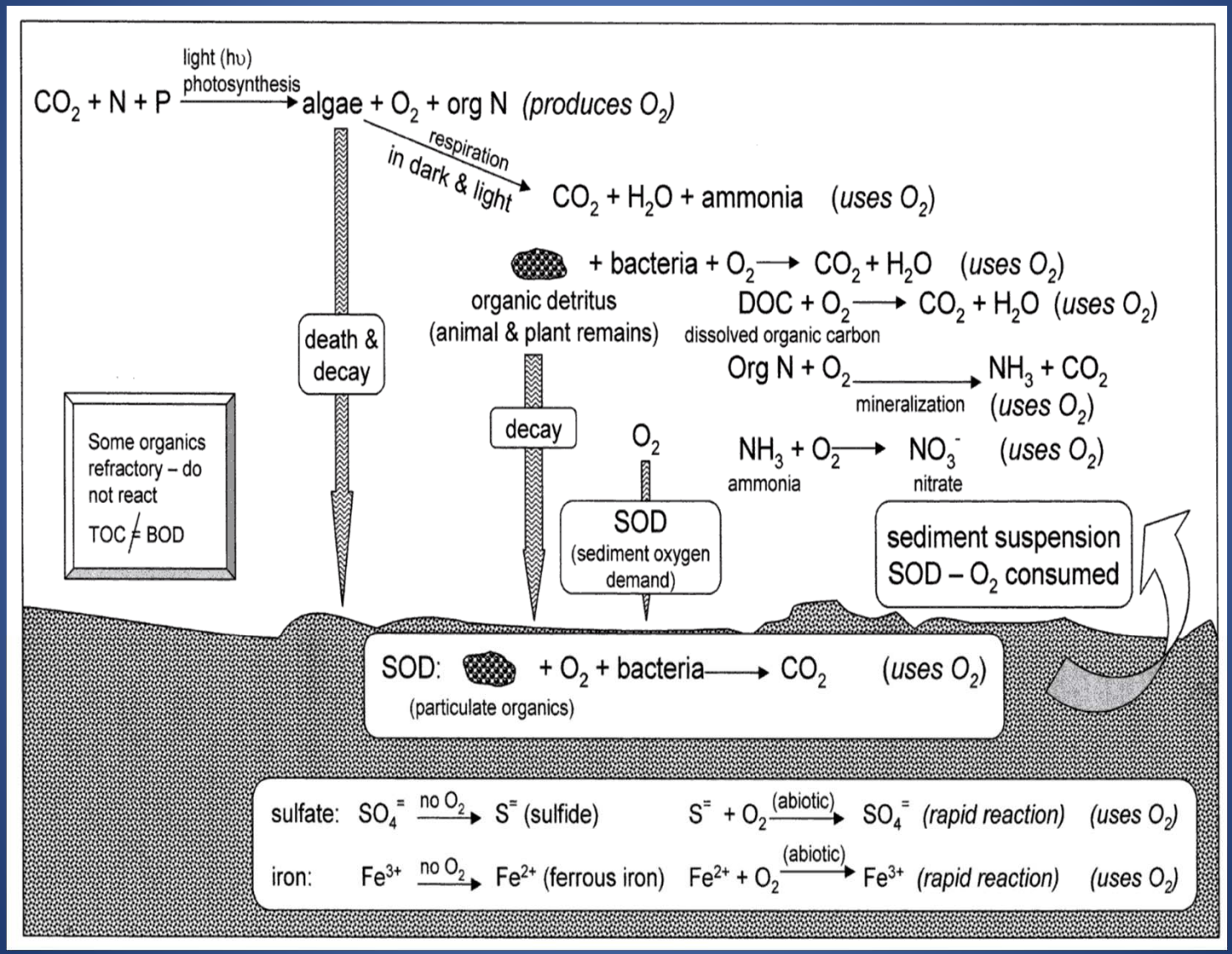


San Joaquin River Deep Water Ship Channel

Critical Low-DO Reach



Oxygen Demand Reactions and Processes



CALFED Study of Low DO in SJR in Early 2000s

- $2-million, 12-Investigator Effort to Study Characteristics of Low-DO in SJR & Delta
  - Where & When Low DO Occurs
  - Causes of Low DO
  - Sources of Chemicals & Other Factors That Cause Low-DO
  - Factors Influencing Low-DO Conditions
- Lee & Jones-Lee Co-PIs

  Developed Synthesis Report: Lee. G. F., and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee/Technical Advisory Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003). http://www.gfredlee.com/SJR-Delta/SynthesisRpt3-21-03.pdf

  Other Papers & Reports: See SJR Watershed Section of Our Website: http://www.gfredlee.com/psjriv2.htm

Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data

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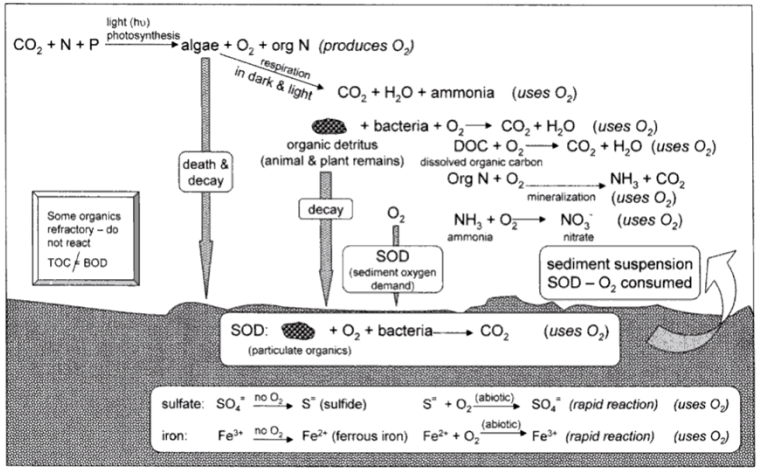


Conceptual Model of DO Depletion Reactions in the SJR DWSC

Report Submitted to
SJR DO TMDL Steering Committee/Technical Advisory Committee
and
CALFED Bay-Delta Program
March 2003

Causes of Low-DO Conditions in DWSC

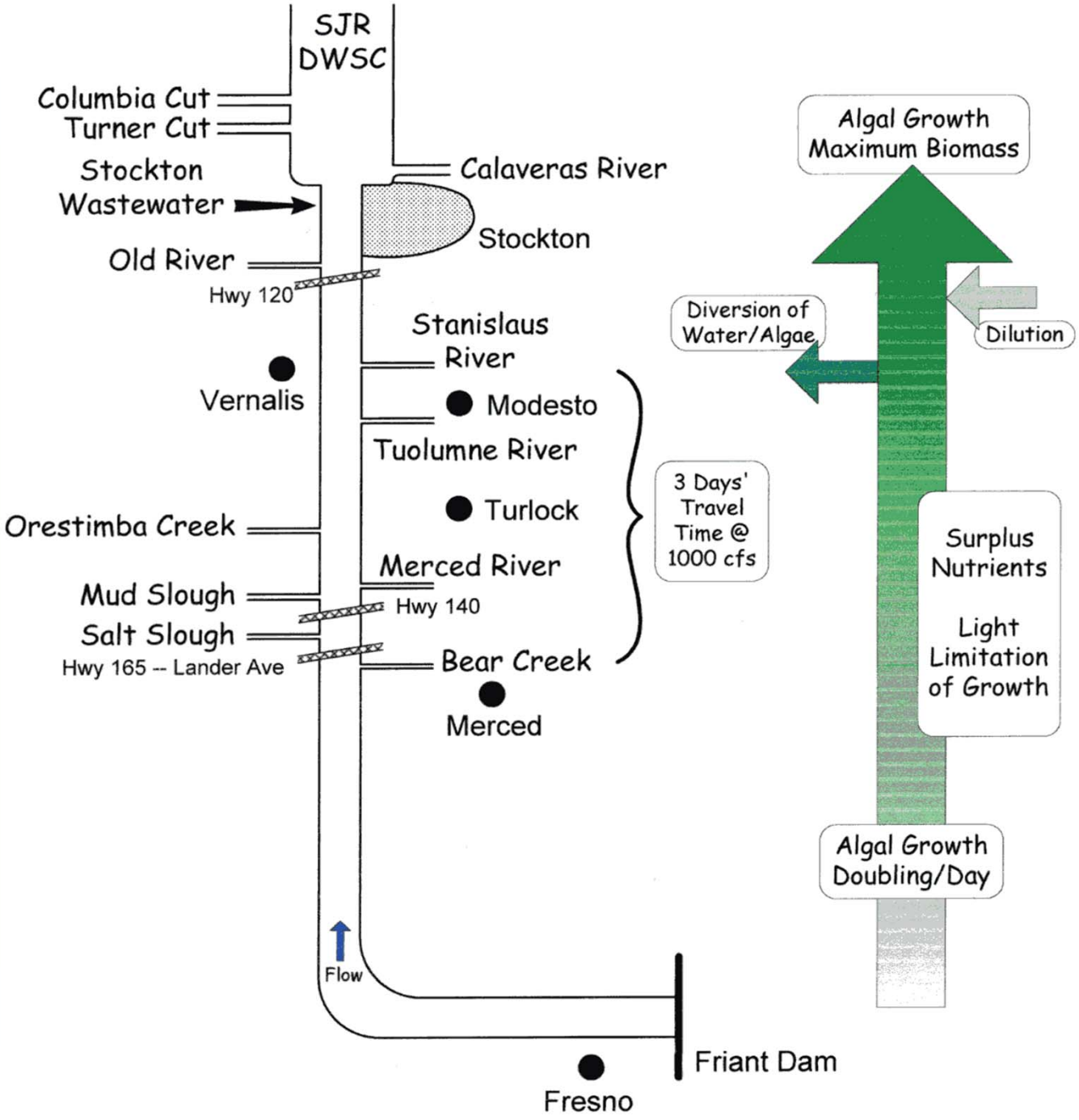
- Ammonia Discharged in City of Stockton Domestic Wastewaters
  - Ammonia Nitrified (Converted to Nitrate) in DWSC – Uses DO
- Algae That Develop in SJR Upstream of DWSC
  - Die & Undergo Bacterial Decomposition in DWSC – Uses DO
- Relative Significance Depends on Loads of Oxygen Demand & SJR Flow through DWSC
  - Flow Impacts Hydraulic Residence Time of Water in DWSC – a Few Days to a Month
- Key Factor Impacting Flow of SJR in DWSC: Diversion of SJR Flow to USBR & DWR South Delta Export Pumping of South Delta Water

Upstream

Algal

Oxygen

Demand



Control of Low-DO Conditions

- CVRWQCB Required City of Stockton to Nitrify Its Domestic Wastewater Effluent
  - Has Greatly Reduce Ammonia-Related Low DO
- Aeration of DWSC in Attempt to Control Remaining Low-DO Associated with Algal Decomposition in DWSC
  - Pilot Aeration Studies Show Aeration Potentially Effective in Controlling Most of Low-DO Conditions
- May Not Eliminate All Violations of DO WQOs (No More Than 1 Violation of Any Magnitude Every 3 yrs)
- Who Will Pay for Operation of Aerators?
  - Upstream Dischargers of Nutrients (N & P) That Led to Growth of Algae, Decomposition of Which Led to Low DO in DWSC?

TMDL Requirements

- TMDL Requires That Programs Be Developed to Control Cause of WQO Violations
- CVRWQCB Needs to Determine If Possible to Control Nutrients from Ag Runoff/Discharges
  - CALFED Studies Determined That Primary Source of Nutrients is discharges from the Grasslands Bypass Agricultural Area
  - C. Foe (CVRWQCB) Determined That Algae That Lead to High Algal Load to DWSC Develop in Grasslands Mud & Salt Sloughs
    - Independently Confirmed by Lee and Jones-Lee
    - Further Confirmed by Follow-on Studies
  - Amount of Algal Biomass (“Seed”) in Mud & Salt Sloughs Impacts Biomass of Algae That Develop in SJR & Enter DWSC

Issues in Control of Nutrients That Control SJR Algal Biomass

- Concentrations of Available N & P in Mud & Salt Sloughs
  - Surplus Compared with Growth-Rate Limiting Levels
    - P: few tenths mg/L , N: few mg/L
- Planktonic Algal Chlorophyll Decreases with Decrease in P Load, Even with Surplus P Concentrations
  - Rast et al. – Lakes in Several Areas of World
  - E. Van Nieuwenhuyse – Rhine River (Europe) and Sacramento San Joaquin Delta
- Major Source of P in Mud & Salt Sloughs: Discharge from Subsurface Tile Drains and other sources
- Control of Algal-Available P in Head Waters of Mud & Salt Slough Could
  - Reduce Algal Growth in Sloughs, Which Could
    - Reduce Algal "Seed" Biomass for High SJR Algal Biomass That Enters DWSC, Which Could
      - Reduce Incidence of Low-DO in DWSC

Treatment to Control P

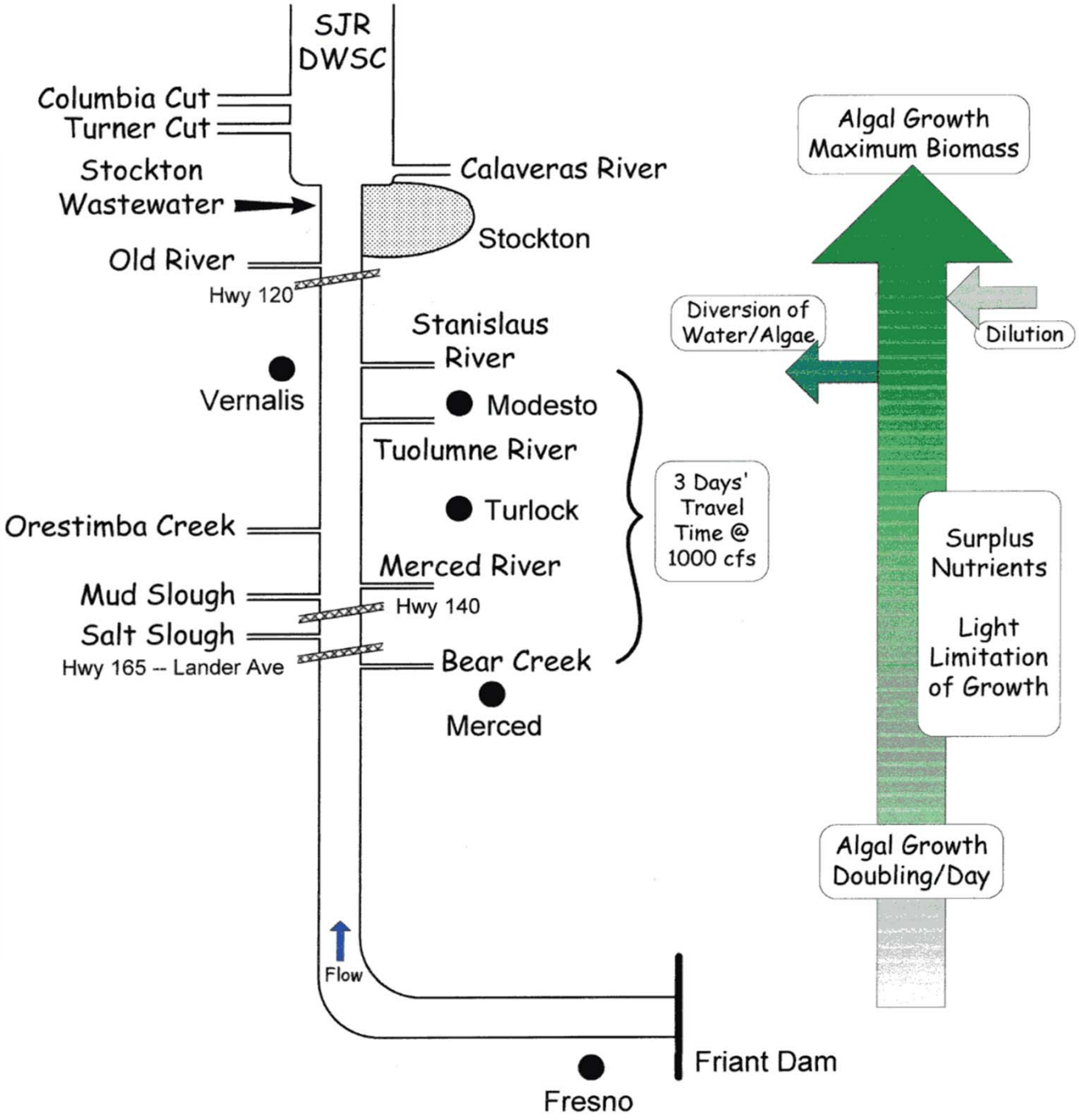
- Alum (Aluminum Sulfate) Added to Domestic Wastewaters to Reduce P in Effluent
- Studies in 1960s in Sweden & Wisconsin: Adding Alum to Lakes Reduced P and Algae
- Possible to Add Alum to Tile Drain Discharges to Immobilize P as Alum Precipitate
  - In This Form, P Not Available to Support Algal Growth & Does Not Convert to Algal-Available Form
- Need Pilot Studies in Mud & Salt Sloughs to Better Understand Specific Sources of P That Leads to Algal “Seed” That Develop into High Algal Biomass in SJR at DWSC
- Evaluate Potential Use of Alum Treatment and other Approaches to Control Algal-Available P
- Studies on Further Controlling Selenium in Ag Discharges from Grasslands Area Should Be Expanded to Include P Control as Well

Upstream

Algal

Oxygen

Demand



Issues
Need to Be Addressed

- Need Model to Describe Relationship between Changes in Algal-Available P Load from Grasslands Area Agriculture and DO Depletion in DWSC
  - How Impacts of P Control on Achieving DO WQO in DWSC Are Affected by Flow in:
    - Mud & Salt Sloughs
    - SJR Upstream of DWSC
    - SJR Flow into DWSC
- How Much of Algal-Available P Discharged by Agriculture in Mud & Salt Sloughs Is Potentially Amenable to Control by Alum Addition and by other means?
- How Does A Given Change in Algal-Available P in Mud & Salt Sloughs Impact Algal Biomass That Enters SJR at Confluence with Mud & Salt Sloughs?
  - Factors Controlling That Relationship

Issues
Need to Be Addressed

- How Does Change in Algal Biomass in SJR at Confluence with Mud & Salt Sloughs Impact Algal Biomass at Vernalis?
  - Factors Influencing That Relationship
- How Much of the Algal Biomass in SJR at Vernalis Enters DWSC
  - Factors Influencing That Relationship
- Relationship between Algal Biomass in SJR as It Enters DWSC and DO Depletion below WQO in DWSC
  - Factors Influencing That Relationship
- Impact of Flow of SJR into DWSC on DO Depletion
- What Are the Potentially Controllable Factors – e.g., Flow – That Can Be Used to Control
  - Algal Oxygen Demand Load to DWSC
  - DO Depletion below WQO in DWSC

Proper Model

- Benefits: Provides Technical Base for
  - Evaluation of Potential to Substantially Reduce Upstream Algal Load
  - Evaluation of Impact of Reducing Upstream Algal Load on DO Depletion in DWSC
  - Estimation & Comparison of Costs & Effectiveness of Control Approaches for Algal Oxygen Demand
- Model Development: Can Be Based on
  - Information from Past Studies, to Some Extent
  - Some Highly Focused Studies to Provide Additional Key Information
- Important to Incorporate Changes in Flow of SJR That Can Result from Flow Manipulations Associated with Current BDCP Development

Lee, G. F., and Jones-Lee, A., “Background Information on SJR Upstream Oxygen Demand Control Issues,” Prepared for San Joaquin River Technical Work Group, Report of G. Fred Lee & Associates, El Macero, CA, July 11 (2010).
http://www.gfredlee.com/SJR-Delta/Bkgrnd-SJR-DO.pdf

Further Information

Consult Website of
Drs. G. Fred Lee and Anne Jones-Lee
http://www.gfredlee.com

Click on “Watershed Studies” Section, “San Joaquin River Watershed Program—Delta”
http://www.gfredlee.com/psjriv2.htm