Issues in Controlling Residual Oxygen Demand in SJR DWSC That Leads to Violations of DO WQO

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Topics

- Current Issues in Controlling Residual Oxygen Demand in SJR DWSC
- Nitrification of Stockton WWTP in Mid-2000s
  - Greatly Reduced Occurrence & Magnitude of DO WQO Violations
- Need to Also Control Some of Algae-Related Oxygen Demand in DWSC

Discussion of Issues

- Lee, G. F., and Jones-Lee, A., "Issues in Controlling the Residual Oxygen Demand in the SJR DWSC That Leads to DO WQO Violations," Report of G. Fred Lee & Associates, El Macero, CA, November 3 (2010).

  http://www.gfredlee.com/SJR-Delta/Residual-Ox-Demand-DWSC.pdf

Definitions

- SJR — San Joaquin River
- DWSC — Deep Water Ship Channel
- DO — Dissolved Oxygen
- WQO — Water Quality Objective
- CVRWQCB — Central Valley Regional Water Quality Control Board
- TMDL — Total Maximum Daily Load
- CWA — Clean Water Act
- DIP — Delta Improvement Package

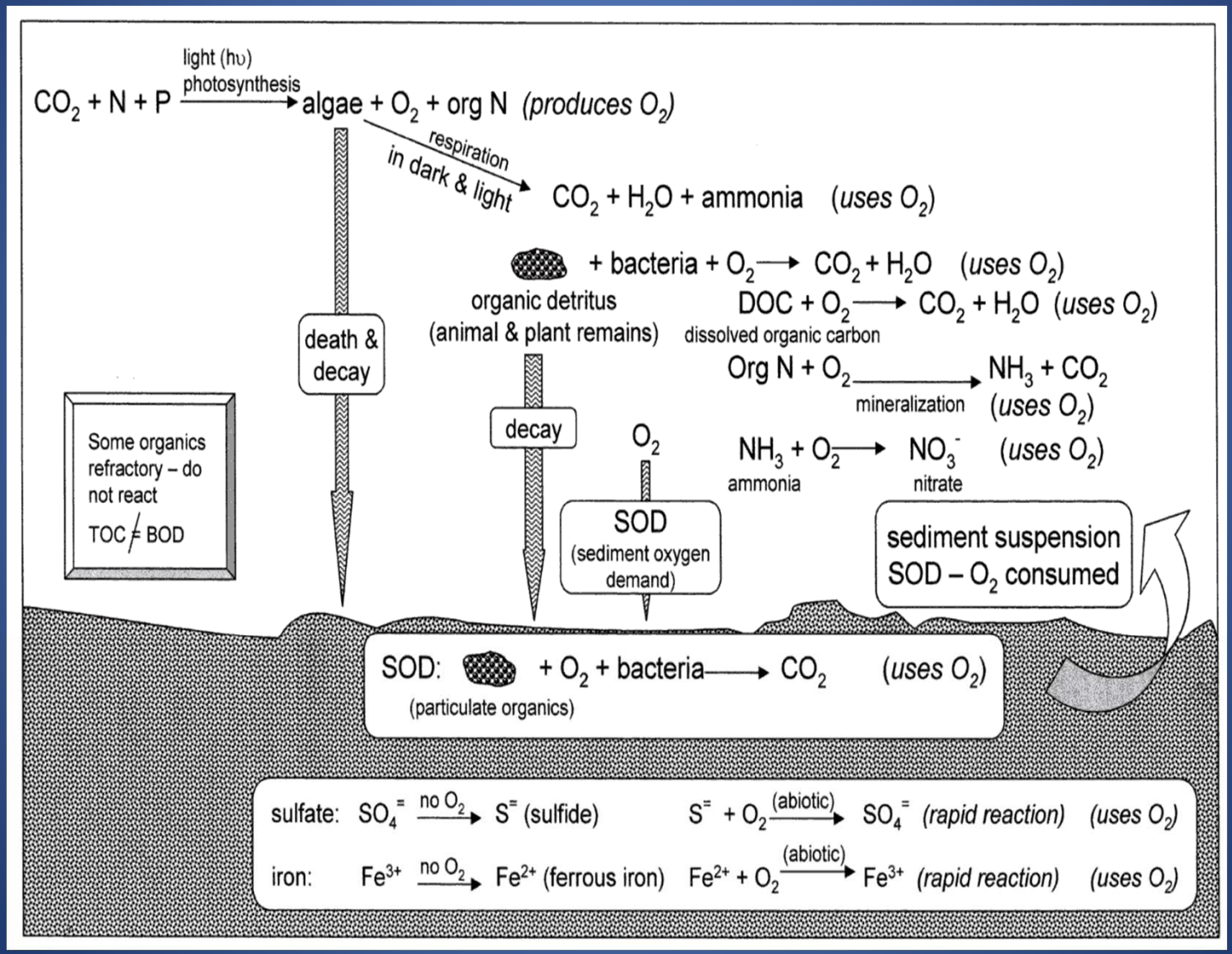
CALFED-Supported Investigation of Causes of Low-DO Problems in DWSC

- Lee and Jones-Lee, PIs, Reported Study Findings:
  - 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
  - Lee, G. F. and Jones-Lee, A., “Supplement to Synthesis Report on the Low-DO Problem in the SJR DWSC,” Report of G. Fred Lee & Associates, El Macero, CA, June (2004).
    http://www.gfredlee.com/SJR-Delta/SynthRptSupp.pdf
- Additional Information Available
  - www.gfredlee.com

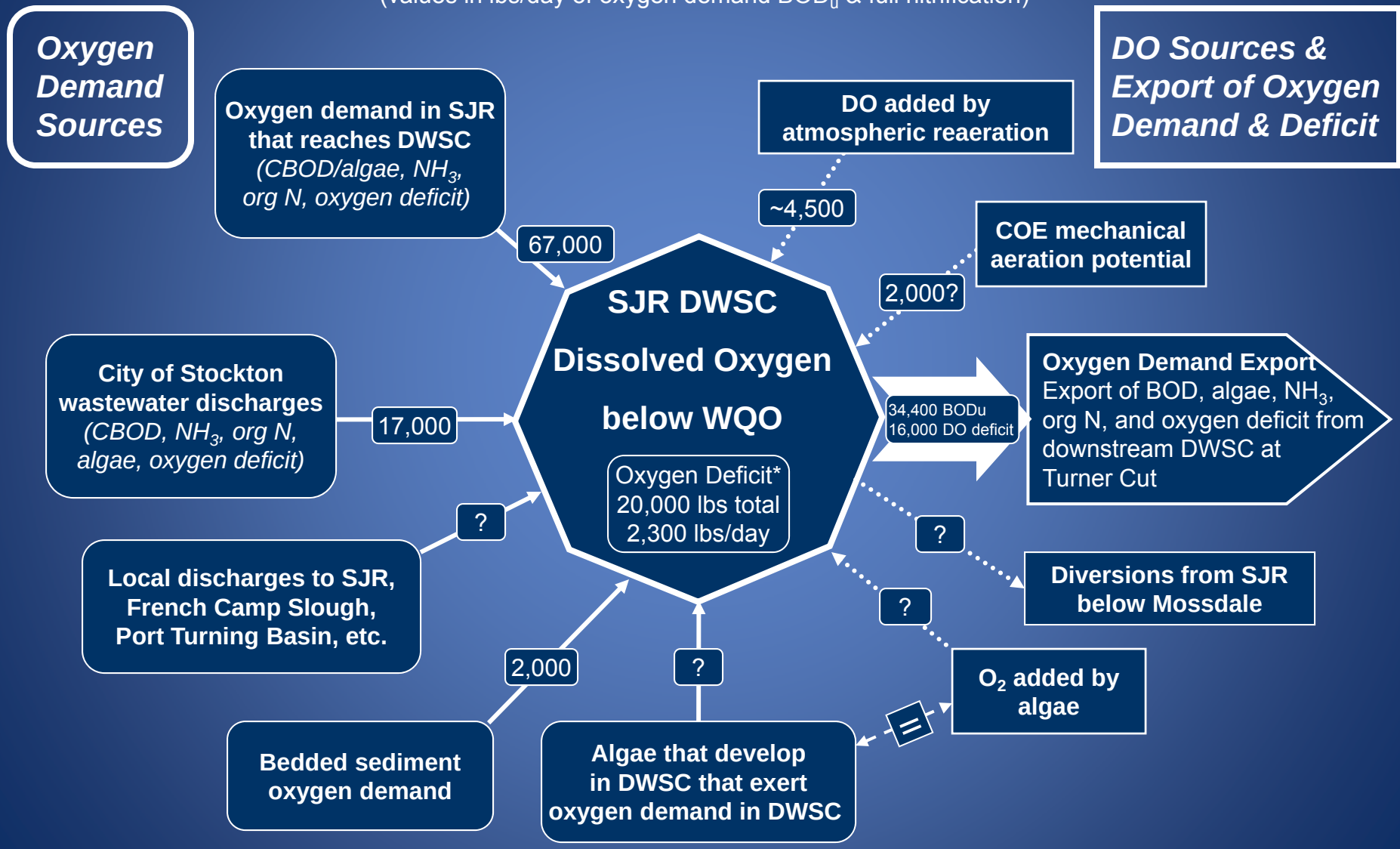
    Watersheds Studies section, San Joaquin River Watershed Program-Delta subsection http://www.gfredlee.com/psjriv2.htm

Oxygen Demand Reactions and Processes



Box Model of Estimated DO Sources/Sinks in SJR DWSC
"Average" Summer/Fall 1999—2001
SJR DWSC Flow: 930 cfs; Travel Time: 8.6 days

(values in lbs/day of oxygen demand BOD_u & full nitrification)



* Total oxygen deficit below oxygen saturation ≈120,000 lbs; 14,000 lbs/day

Controlling Impacts of P on Excessive Fertilization

- Lee: More than 5 Decades' Experience Investigating & Developing Control Programs for Excessive Fertile Waterbodies
- Comprehensive Report for CVRWQCB on Controlling Pollutants, Including P, in Ag Discharges
  - Lee, G. F. and Jones-Lee, A., "Review of Management Practices for Controlling the Water Quality Impacts of Potential Pollutants in Irrigated Agriculture Stormwater Runoff and Tailwater Discharges," California Water Institute Report TP 02-05 to California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 128 pp, California State University Fresno, Fresno, CA, December (2002).

    http://www.gfredlee.com/SurfaceWQ/BMP_Rpt.pdf

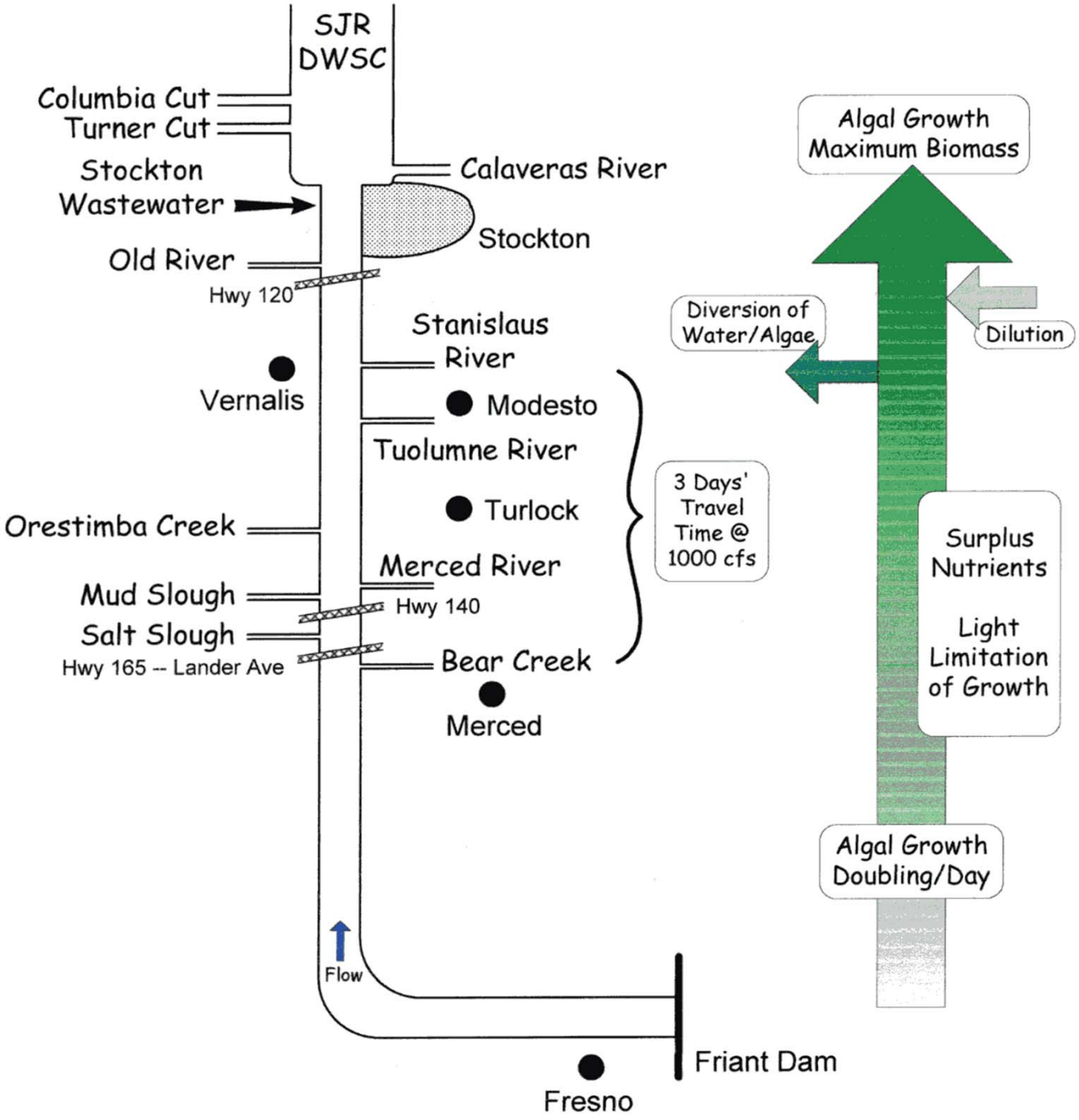
- Examples of Well-Known, Proven Treatment Options Discussed
  - Treatment of Domestic Wastewater with Alum (Aluminum Sulfate) to Bind Algal-Available P into Unavailable Forms
  - Treatment of Waterbodies with Alum to Control Algal-Available P
    - Can Be Effective in Controlling Excessive Planktonic Algal Growth Depending on Location/Situation

Upstream

Algal

Oxygen

Demand



Control of “Seed Algae”

- “Seed Algae”
  - C. Foe Found that Seed Algae Develop in Mud & Salt Sloughs
  - Grow as Transported in SJR to DWSC Where They
  - Die & Exert Oxygen Demand
- Control Algal-Available P (Largely Soluble Ortho P) Discharged by Ag Sources in Mud & Salt Slough Watersheds
  - Need for Study: Potential Efficacy & Reliability of Treating Ag Discharges with Alum to Convert Algal-Available P to Unavailable Forms
  - Discussed in:

    Lee, G. F., and Jones-Lee, A., "Review of Potential for Controlling P Discharges from Mud and Salt Sloughs for Reducing Algal-Related Oxygen Demand Load to SJR DWSC," PowerPoint slides presented at Bay-Delta Science Conference, Sacramento, CA, September 29 (2010). http://www.gfredlee.com/SJR-Delta/SJR-DO-BayDeltaConf.pdf

Efficacy of P Load Reductions for Controlling Algal Growth

- Planktonic Algal Chlorophyll Is Reduced in Predictable & Quantifiable Way after P Load Reduction

  Rast, W., Jones, A., and Lee, G. F., "Predictive Capability of US OECD Phosphorus Loading-Eutrophication Response Models," Journ. Water Pollut. Control Fed. 55(7):990-1003 (1983). http://www.gfredlee.com/Nutrients/PredictiveCapabilityOECD.pdf

- P Load Reductions Effected Decreases in Planktonic Algal Chlorophyll Levels in Rhine River (Europe) & Sacramento—San Joaquin Delta
  - Dr. Erwin Van Nieuwenhuyse (Fishery Biologist, US Bureau of Reclamation Div. Environmental Affairs, Sacramento) Discussed Impact of Altering P Loads to Delta on Phytoplankton Biomass at CWEMF Delta Nutrient Water Quality Modeling Workshop – "Impact of Sacramento River Input of Phosphate to the Delta on Algal Growth" [http://cwemf.org/Calendar/index.htm]
  - Van Nieuwenhuyse, E., "Response of Summer Chlorophyll Concentration to Reduced Total Phosphorus Concentration in the Rhine River (Netherlands) and the Sacramento–San Joaquin Delta (California, USA)," Can. J. Fish. Aquat. Sci. 64:1529-1542 (2007).

Evaluation of Potential Effectiveness of P Control in Ag Discharges to Mud & Salt Sloughs

- Review Existing Data & Necessary Targeted Studies
- Quantify Export of Algal-Available Nutrients from Watershed
  - Purpose:
    - Enable Targeted P Management
    - Enable Ongoing Assessment of Efficacy of Control Measures
  - Develop Reliable Nutrient Export Coefficients
    - Mass P Discharged per Unit Area Farm Land per Unit Time (e.g., g P/m2/day)
  - Focus on
    - Total & Soluble Ortho P in Ag Discharges at Edges of Fields, before Entrance to Drainage Waterways
    - Flow at Time of Sampling
    - Types of Crops & Farming Practices in Drainage Area at Time of Sampling

Evaluation of Potential Effectiveness of P Control in Ag Discharges to Mud & Salt Sloughs

- Critical Period: May – October
  - Algal Biomass in SJR Constitutes Significant Component of the Residual Oxygen Demand Load Entering DWSC
- Identify Inadequacies in Data
- Conduct Targeted Studies to Gather Missing/Inadequate Data
- Description of Approach
  - Rast, W., and Lee, G. F., "Nutrient Loading Estimates for Lakes," Journ. Environ. Engr. 109(2):502-518 (1983). http://www.gfredlee.com/Nutrients/NutrientLoadingEstRast.pdf
- Rast & Lee Study
  - Examined ~100 Watersheds across US
  - Found Ag Lands Typically Export ~0.05 gP/m^2/yr

Evaluation of Potential Effectiveness of P Control in Ag Discharges to Mud & Salt Sloughs

- Mud & Salt Slough Watershed P Export Likely Somewhat Different
  - Different Types of Farming Practices
  - Discharge from Subsurface Drains
    - Filamentous Algae in Grasslands Bypass Drainage Ditches Just Downstream of Subsurface Drain Indicates Large Amount of Algal-Available P
- Use of Watershed-Specific P Export Coefficients
  - Determine P Export Coefficients for Various Major Types of Farming Activities/Settings
  - Based on Area Devoted to Each Activity, Estimate Total & Soluble P Load to Mud & Salt Sloughs
  - Compare Estimates with Total P Loads Measured at Downstream Stations in Mud & Salt Sloughs
  - Work with J. McGahan, Drainage Coordinator for Grasslands Farmers to Select Sampling Sites, Estimating Discharge Flows, etc.

Previous Studies on Controlling Excessive Algal Growth with Alum

- 1960s-1970s – Number of Studies US & Abroad
  - Wisconsin Department of Natural Resources (WDNR) Studies on Lake Rehabilitation
    - Use of Alum for Whole-Lake Treatment for P Inactivation
    - Dunst, R., et al., "Survey of Lake Rehabilitation Techniques and Experiences," Technical Bulletin no. 75, Wisconsin Dept. Natural Resources, Madison, WI (1974).
- 1980s – US EPA Office of Water
  - Series of Annual Conferences on Lake Restoration Techniques
  - Summary of Studies:
    - Funk, W., and Gibbons, H., "Lake Restoration by Nutrient Inactivation," In: Lake Restoration, Proc. Int. Conf., EPA 440/5-79-001, US EPA Office of Water, Washington, DC, March (1979).

      http://www.gfredlee.com/SJR-Delta/Funk-Gibbons-Lake-Restor.pdf

Impact of Flow & Other Factors on DWSC DO Depletion

- SJR Technical Work Group (TWG) June 2010 Meeting
  - Lee Raised Number of Issues That Could Impact Control of Algae-Related DO Depletion in DWSC
  - Summary of Issues:
    - 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

Review CA SWRCB Development of Delta Flow Criteria

- How Flow through SJR DWSC Impacts DO in DWSC
- Impact of Flow into & through Delta Channels on Water Quality in Delta
- Lee, G. F., and Jones-Lee, A., "Discussion of Water Quality Issues That Should Be Considered in Evaluating the Potential Impact of Delta Water Diversions/Manipulations on Chemical Pollutants on Aquatic Life Resources of the Delta," Report of G. Fred Lee & Associates, El Macero, CA, February 11 (2010).

  http://www.gfredlee.com/SJR-Delta/Impact_Diversions.pdf
- Lee, G. F., and Jones-Lee, A., "Comments on Water Quality Issues Associated with SWRCB's Developing Flow Criteria for Protection of the Public Trust Aquatic Life Resources of the Delta," Submitted to CA State Water Resources Control Board as part of Public Trust Delta Flow Criteria Development, by G. Fred Lee & Associates, El Macero, CA, February 11 (2010).

  http://www.gfredlee.com/SJR-Delta/Public_Trust_WQ.pdf

Need to Control Flow of SJR Through DWSC

- Low DO Problem in DWSC Essentially Restricted to Reach: Port of Stockton to Turner Cut (~ 7 mi)
  - Restriction Due to DWR & USBR South Delta Export Projects' Drawing Sacramento River Water into Turner Cut
- Lee & Jones-Lee (2003): SJR DWSC Flows > ~ 1,200 cfs Reduced Hydraulic Residence Time Sufficiently to Eliminate DO WQO Violations in DWSC
  - Less Time for Exertion of Oxygen Demand in DWSC before Dilution with Sacramento River Water
- Changes in Sacramento River Flow through or around Delta Will Impact DO Depletion in DWSC
- CVRWQCB/SWRCB Should Work with BDCP & Delta Stewardship Council to Establish Flow Conditions in SJR DWSC That Will
  - Reduce/Eliminate Violations of DO WQO in DWSC
  - Improve Water Quality in Delta
  - Enable Passage of SJR Watershed Home-Stream Signal for Fall-Run Chinook Salmon to San Francisco Bay

SJR Watershed Home-Stream Chemical Signal

- During Summer & Fall USBR & DWR South Delta Export Projects Draw All SJR DWSC Flow down Turner Cut (~ 7 mi down SJR DWSC from Port of Stockton)
- Diversion of SJR Flow down Turner Cut Prevents Home-Stream Chemical Signal from Reaching San Francisco Bay Where It Would Otherwise Guide Fall Run Chinook Salmon to Their Home-Stream Waters for Spawning in SJR Watershed from Which They Originated
- Such Homing Interference
  - Increases “Straying” of Chinook Salmon
  - Inhibits Spawning
- Lee, G. F., and Jones-Lee, A, “Review of Impacts of Delta Water Quality and Delta Water Exports on the Decline of Chinook Salmon in the SJR Watershed,” Comments submitted to NMFS Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, by G. Fred Lee & Associates, El Macero, CA, August (2008).

  http://www.gfredlee.com/SJR-Delta/Salmon-NOAAcom.pdf

SJR TWG Review of SJR Aeration

- Lee & Jones-Lee (2003): Selective Monitoring & Modeling Could Be Useful to Guide Aerator Operation
- October 21, 2010 SJR TWG Meeting: R. Brown Presented Results of His Modeling Work on Relationships between Algae-Related Oxygen Demand Load to DWSC and DO Depletion
  - Brown, R., "Possible SJR DO TMDL Implementation Procedures," Prepared for CA Dept. Water Resources, ICF International Sacramento, CA December (2010) http://www.sjrdotmdl.org/library_folder/01-11/Appendix-A.pdf
  - Provided Guidance on the Use of Aeration in Implementation of TMDL to Control Violations of DO WQOs in DWSC

Other Factors Influencing DO Depletion in DWSC

- Current DO Water Quality Objective for DWSC
  - At Any Location in Channel, ≤ 1 Violation Every 3 yrs:
    - 5 mg/L December – August
    - 6 mg/L September – November
- Objective Difficult to Achieve
- Implications of Exceedances of DO WQO Concentrations by ~ 1 mg/L for Aquatic Life Resources of Delta Discussed:
  - Lee & Jones-Lee Synthesis Report
  - US EPA (& Several States) Allows Averaging of DO Concentrations for Evaluating Compliance with DO WQO

Need for Evaluation of Chinook Salmon Migration Through DWSC under Depressed DO Conditions

- Impetus for SJR DWSC DO TMDL: Report by CA Department Fish & Game Staff That Fall-Run of Chinook Salmon Passage Through DWSC Inhibited by DO Concentrations < 5 mg/L
- Lee & Jones-Lee Synthesis Report: Questioned Whether Inhibition of Migration through DWSC Due to Depressed DO Alone, or Due at Least in Part to Elevated Temperatures in DWSC
- There Is Reason to Question Whether DO Depression of about a mg/L Is Real, Significant Factor Inhibiting Migration of Chinook Salmon through DWSC (Discussions with A. Mearns, NOAA, Expert on Chinook Salmon Homing Migration Issues)
- DFG Should Consider: Does DO of 4 – 5 mg/L for Short Duration (e.g., Early Morning &/or near Sediment) Significantly Influence Chinook Salmon Migration to Home-Stream Waters?

Development of Nutrient Criteria for SJR

- US EPA Aggressively Pursuing Requirement for States to Develop Nutrient Criteria to Be Implemented into Numeric Water Quality Standards for N and P
  - In Effort to Control Excessive Fertilization of Waterbodies
- Summary of Some Key Activities Being Undertaken in Various Areas of US toward Development of Nutrient Criteria
  - Volume 13, no. 3 Lee and Jones-Lee Stormwater Runoff Water Quality Newsletter http://www.gfredlee.com/Newsletter/swnewsV13N3.pdf
- SJR Experiences Excessive Growth of Algae Compared to Normally Allowed Planktonic Algal Chlorophyll (20 ug/L)
- Appropriate Nutrient Criteria for SJR Could Limit P Discharge to Mud & Salt Sloughs
- SJR Algae Also Cause Low-DO Problems in South Delta Channels

Phosphorus vis-à-vis Selenium

- CVRWQCB Requires Significant Reductions in Selenium Discharged to Mud & Salt Sloughs
  - Selenium Control Can Result in Reduction in P Loads
- P Should Also Be Monitored as Part of Meeting CVRWQCB Requirements for Selenium Load Reduction to Mud & Salt Sloughs
  - Could Provide Insight for Guiding Development of P Control Programs for Controlling Algal “Seed” in Mud & Salt Sloughs

Issues Needing Attention/Evaluation

- Evaluation of impact of algae-related oxygen demand load to DWSC on DO depletion below WQO in the DWSC as function of SJR flow through DWSC.
- Determination of how the cost of aerator operation changes with reductions in algae-related oxygen demand load.
- Relationship between reduction of algal biomass in Mud & Salt Sloughs and reduction of algae-related oxygen demand load to DWSC – as function of SJR through the DWSC.
- Relationship between phosphorus control in agricultural discharges in Mud & Salt Slough watersheds and algal “seed” that develops in discharges of sloughs to SJR.
- Relationship between cost of controlling phosphorus discharges and cost of aerator operation.

Issues Needing Attention/Evaluation

- CVRWQCB/SWRCB should work to have BDCP/Delta Stewardship Council allocate sufficient SJR DWSC flow to eliminate violations of DO WQO in DWSC.
- CVRWQCB should adopt a Basin Plan amendment to allow averaging of the DO concentration with depth and over the diel (night/day) cycle.
- SWRCB should remove the 6 mg/L DO WQO during September through November and adopt a daily average over depth in the DWSC of 5 mg/L.
- DFG should reevaluate whether a daily diurnal average with depth of DO of 5 mg/L is a significant barrier to homing migration of Chinook salmon through DWSC.
- SWRCB should work to allow a substantial part of the SJR DWSC flow to continue down the SJR channel to the confluence with the Sacramento River in Western Delta to enable home-stream water signal to be transported to the upper parts of San Francisco Bay.

Adoption of These Recommendations

- Could Significantly Influence Compliance with DO WQO in DWSC
- Could Significantly Reduce Amount of Algae-Related DO Depletion below Current WQO or WQO Ultimately Adopted
- Could Significantly Reduce Cost of Aeration of DWSC

- CVRWQCB/DFG Should Appoint Advisory Committee to Work with Agency Staff to Formulate Approach to Address These & Other Emergent Issues

Summary

- DWR & ICI/Brown Reports on Evaluation of Aerator
  - Operation of Aerator Can Significantly Reduce Occurrence & Magnitude of DO Depletion below WQO in DWSC
  - Cost: $2,400 – $2,500/day of Operation
  - Will Not Prevent DO Depletion below WQO in DWSC under Current Regulatory Requirements
- Proper Revision of Specific Regulatory Requirements Can Greatly Reduce Need/Cost for
  - Operation of Aerator
  - Control of Upstream “Seed” Algae from Mud & Salt Sloughs

  Allow Appropriate DO WQO Averaging

  Maintain Adequate Flow through SJR DWSC
- Changes in Flow of Sacramento River into/around Delta (Peripheral Canal) Can Impact
  - DO Depletion in DWSC
  - Aerator Operation
- Major Factor Needing Consideration: Future Appropriate Nutrient Criteria for SJR to Control Algae

Questions?

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Further Information

Consult Website of

Drs. G. Fred Lee and Anne Jones-Lee

http://www.gfredlee.com