Supplement to Synthesis Report on the Low-DO Problem in the SJR DWSC[1]

G. Fred Lee, PhD, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
27298 E. El Macero Drive, El Macero, CA 95618
Ph: (530)753-9630 Fx: (530)753-9956 Em: gfredlee@aol.com
www.gfredlee.com

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In March 2003 Lee and Jones-Lee (2003a) completed a Synthesis Report covering the four years of studies that had been conducted on the San Joaquin River (SJR) Deep Water Ship Channel (DWSC) low-DO problem. In July 2003 Lee and Jones-Lee (2003b) published a summary of sections of the Synthesis Report in the Interagency Ecological Program *IEP Newsletter*. In November 2003 Lee and Jones-Lee (2003c), in a presentation to the California Lake Management Society annual conference devoted to Delta drinking water quality issues, summarized the issues pertinent to managing the low-DO problem in the DWSC.

Since completion of the Synthesis Report, Lee and Jones-Lee have continued to develop information pertinent to further defining the causes of the low-DO problem and the approaches that need to be evaluated to control this problem in a technically valid, cost-effective manner. Presented herein is a summary of the additional studies that have been conducted by Lee and Jones-Lee during the past year. For each of the issues mentioned below, there is a backup report which provides additional detail on the issue. The various reports developed by Lee and Jones-Lee over the past year are available as downloadable files from the Lee and Jones-Lee website, www.gfredlee.com, in the San Joaquin River Watershed section. The link to this section is near the bottom of the first page of the website.

As discussed in the Synthesis Report (Lee and Jones-Lee, 2003a), the Department of Water Resources (DWR), as part of the DWR Delta D-1641 Compliance Monitoring, has been conducting monitoring cruises (Hayes cruises) at about two-week intervals over the late summer and fall on the SJR DWSC from Prisoners Point to the Port of Stockton. A summary of all of these cruises from 1995 through 2002 is presented in the Synthesis Report. Giovannini, et al. (2003) have published the results of the fall 2002 cruises.

Impact of Flow of the SJR through the DWSC on DO

The CALFED-supported SJR DWSC studies focused on gathering data during 1999, 2000 and 2001. Lee and Jones-Lee, in an unsupported effort, continued the DWR Rough and Ready Island (RRI) monitoring station DO data and USGS SJR DWSC flow data review for 2002 and early 2003. The data through February 2003 were presented in the Synthesis Report. The complete 2003 data into early winter 2004 have been presented and discussed in a series of small reports by Lee and Jones-Lee, discussed below.

In June 2003 G. F. Lee attended a CBDA (formerly CALFED) workshop on the impact of water management projects on Delta and Delta tributary fisheries. It was found that both

[1] Reference as 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).

fisheries and water managers (DWR, Department of Fish and Game, USBR and CALFED/CBDA) apparently did not understand that the operation of the federal and state export projects were responsible for causing significant low-DO problems in the DWSC.

In a report, Lee (2003a) discussed what was known in July 2003 about the impact of SJR DWSC flow on DO in the DWSC and discussed how the federal and state export pumps' drawing of SJR Vernalis water into the South Delta through Old River contributed to the low-DO problems in the DWSC. This report was distributed to the various agencies' management and staff as part of an effort to educate them that the development of future management plans for controlling Delta tributary and Delta channel flows should consider how the flow management/manipulations impact DO in the DWSC.

In July 2003 Lee (2003b) issued a summary report updating the information on the impact of SJR flow through the DWSC on DO at the RRI monitoring station. This report showed that in the early summer of 2003, as had occurred in previous summers, low DO starts to occur in the DWSC shortly after the termination in mid-May of the Vernalis Adaptive Management Program (VAMP) flows. This is coincident with the increased federal and state project export pumping that occurs at the end of VAMP and with the removal of the Head of Old River (HOR) barrier. Further information on the impact of VAMP flows on the low-DO problem is provided in a subsequent section of this report.

When the SJR DWSC studies were first initiated, it was thought by those conducting the studies that the low-DO problem was primarily an August-September problem. Lee and Jones-Lee (2000), as part of developing the Issues Report for the CVRWQCB and the SJR DO TMDL Steering Committee, showed, through examination of the RRI monitoring station data, that the low-DO problem occurred in June and persists through October, November and often December. The summer 2003 data showed that during June and early July 2003 there were severe low-DO problems in the DWSC off of Rough and Ready Island that occurred whenever the SJR flow through the DWSC was a few hundred cfs or less. As in the past, Lee and Jones-Lee's examination of the SJR Vernalis flows showed that the problem was not a deficiency in flow in the SJR at Vernalis, but the diversion of most of the SJR Vernalis flows into Old River in order to feed the federal and state export pumps.

Additional reports on the SJR DWSC flow, RRI DO and SJR Vernalis flow relationships through the remainder of the summer, fall and winter of 2003 have been developed by Lee and Jones-Lee (2003d,e).

Lee and Jones-Lee (2003a) reported on the extremely low DO that was found in the DWSC near RRI during late January through mid-February 2003. As they reported, there were periods of several weeks during February when the DO at RRI was at or near zero in the surface waters each day. During late afternoon it might get up to 1 mg/L. When put in the context of impact on fisheries, any DO below about 3 mg/L is lethal to most fish.

The winter 2003 low-DO situation was during a period of low SJR DWSC flow and appeared to be caused almost exclusively by the ammonia in the city of Stockton's wastewater effluent discharge to the SJR just upstream of the DWSC. Examination of the January, February and March 2004 RRI DO data (no report developed) shows that, while there were a few days of DO below the water quality objectives, there was not the severe low DO that had occurred in the DWSC near RRI in the winter of 2003.

The primary differences between February 2003 and February 2004 were that the extreme low flows that occurred in 2003 did not occur to the same extent in 2004. Also, for part of this period, the city of Stockton's wastewater effluent ammonia was not at the mid-20 mg/L levels in 2004 as it had been in 2003. When the ammonia concentrations in the City's wastewater effluent reached the mid-20s in February 2004, the flows of the SJR through the DWSC were not at their extreme low values as they had been in 2003.

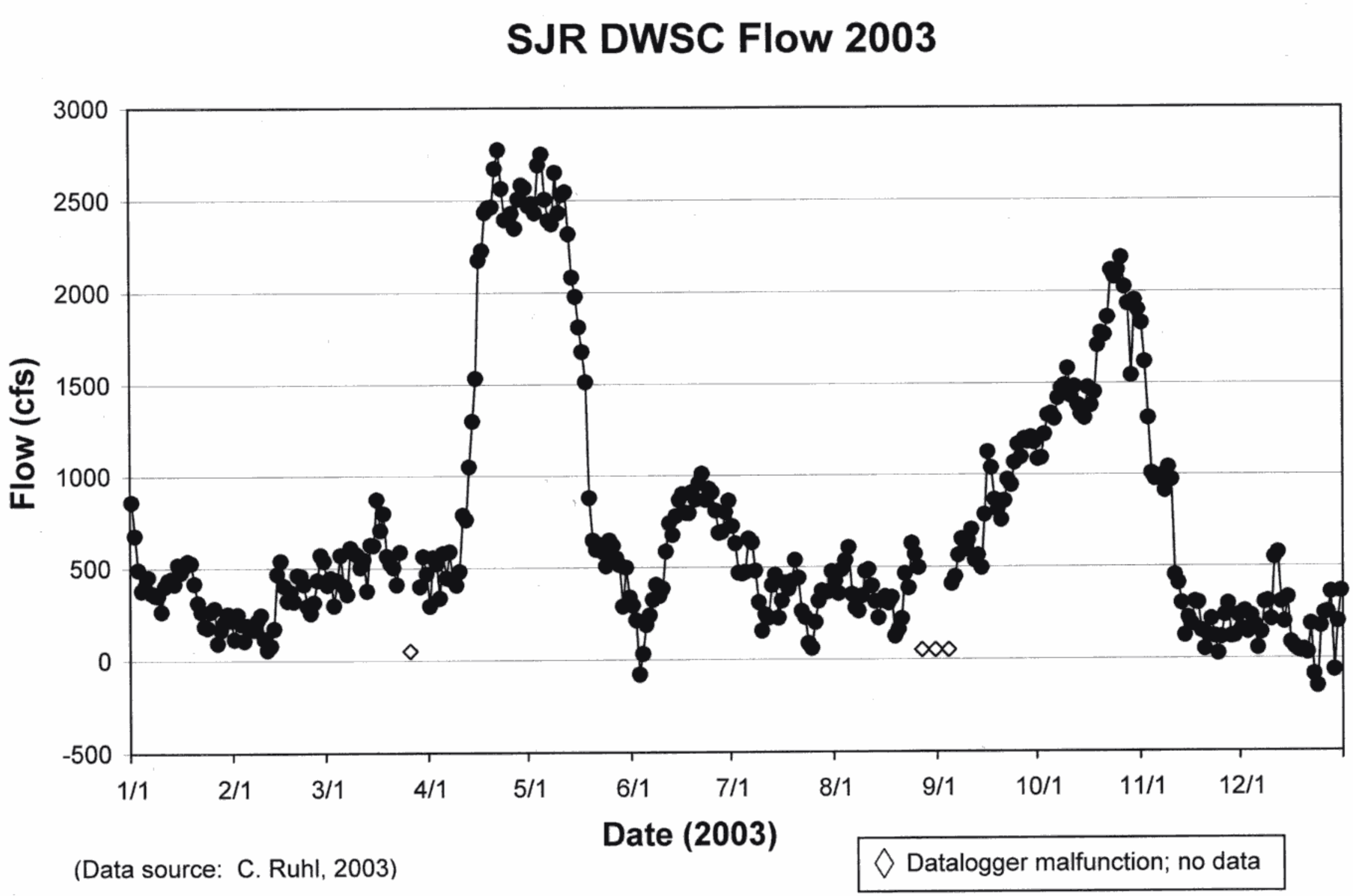
The efforts of Lee and Jones-Lee were successful in gaining the attention of the Delta export project managers to understand the impact of export pumping when the HOR barrier is not in place on the low-DO problem in the DWSC, in that a representative (T. Quinn) of the Metropolitan Water District of Southern California announced at several CBDA meetings that efforts were underway, as part of developing a Delta Improvement Package (see Lee and Jones-Lee, 2004a), to provide about 1,500 cfs of flow through the SJR DWSC. This issue is still under review.

Impact of Vernalis Adaptive Management Program. In 1999 the Vernalis Adaptive Management Program (VAMP) was initiated. This program is designed to assist the outmigration of juvenile salmon from the San Joaquin River eastside tributaries. Between about mid-April through mid-May, the operators of the water projects located on the eastside tributaries manage reservoir releases to provide a uniform flow of the San Joaquin River at Vernalis. At the same time, the Head of Old River barrier is closed so that the SJR flow at Vernalis primarily passes through the DWSC, rather than into the South Delta. The HOR culverts allow sufficient SJR Vernalis water to pass into the South Delta to protect South Delta channel water levels.

During VAMP operations in 2003 and projected for 2004, the SJR Vernalis flows were/are on the order of 3,200 cfs. Figure 1 shows the SJR DWSC flows during 2003, where the VAMP SJR DWSC flows during mid-April through mid-May were on the order of 2,500 to 2,700 cfs. During the 2003 VAMP, approximately 600 cfs of the VAMP flow at Vernalis of 3,200 cfs passed through the Head of Old River barrier into the South Delta.

During 2003 VAMP, the state and federal projects exported an average of 1,446 cfs (SJRGA, 2004a). During the 2004 VAMP, the state and federal water projects are projected to maintain an average pumping rate of 1,500 cfs (SJRGA, 2004b). Normally the combined export pumping by the state and federal projects is from 10,000 to 14,000 cfs. The greatly reduced export pumping during VAMP operations is designed to reduce the influence of the state and federal export projects' drawing of Sacramento River water and associated small fish to the South Delta.

Figure 1


SJR DWSC Flow 2003
Flow (cfs)
3000
2500
2000
1500
1000
500
0
-500
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
12/1
Date (2003)
(Data source: C. Ruhl, 2003)
◇ Datalogger malfunction; no data

During the VAMP flows, studies are conducted by fisheries biologists from the California Department of Fish and Game, US Fish and Wildlife Service and the San Joaquin River Group Authority (SJRGA) on salmon smolt responses and survival. These studies are designed to evaluate the survival of salmon smolt outmigrating the San Joaquin River watershed in relationship to flow and export conditions with the Head of Old River barrier in place. Annual VAMP reports on the results of these studies are, in accordance with State Water Resources Control Board (SWRCB) D-1641, published by the SJRGA. Further information on VAMP is available at their website, www.sjrg.org.

By June 1, 2003, with the removal of the HOR barrier, the South Delta export project pumps took all of the SJR flow at Vernalis into the South Delta, where on one day there was a negative (upstream) flow of the SJR to the Head of Old River. There was a several-week period following 2003 VAMP when the SJR DWSC flows were less than 500 cfs (see Figure 1).

During the VAMP flows of the SJR through the DWSC, there are no low-DO problems in the DWSC. However, as discussed by Lee and Jones-Lee (2003a), after the cessation of VAMP flow, the SJR flow through the DWSC can be a few hundred cfs. This has been accompanied by low-DO problems in the DWSC. Concern has been expressed by A. Hildebrand (pers. comm., 2004) about VAMP contributing to the low-DO problem in the DWSC. The release of large amounts of flow during VAMP from the eastside reservoirs potentially reduces the amount of flow that could be present in the SJR DWSC during the summer months. However, Johnson (pers. comm., 2004) has questioned whether waters associated with the VAMP flows would be available to increase the flow through the DWSC during the summer if they were not used for VAMP. Hildebrand (pers. comm., 2004) has stated,

> *"New Melones releases to meet the salinity standard at Vernalis tend to increase summer flow at Vernalis. However, the spring releases from New Melones for fish have been greatly increased. It will not be feasible to continue those fish releases and also meet the New Melones obligation for salinity control. The Bureau of Reclamation has acknowledged that this is the case and proposes that the fish releases have priority. Proposals are also underway to export water from the Stanislaus watershed to western and northeastern San Joaquin County.*
>
> *The net effect of all this on inflow to the Ship Channel is difficult to predict or quantify. I see no point in considering the flow regime that would exist without either the dams or the Ship Channel. However, it seems clear that the inflow to the Ship Channel during June through September is reduced by the effort to restore the April-May fish flows at Vernalis that have been depleted by exports from the SJ watershed and by increased consumptive use within the watershed. There is no provision by the SWRCB or any other entity that summer flows at Vernalis will be kept above some minimum level. We can therefore only provide a minimum inflow to the Ship Channel by augmented flow through the barriers."*

The issue of the impact of VAMP on SJR DWSC flows needs to be evaluated.

Operations of the COE Aerator

The Port of Stockton has proposed to change the navigation depth of the DWSC from the current 35 feet to 40 feet. This would further aggravate the low-DO problem that exists in the DWSC near the Port of Stockton. As discussed by Lee and Jones-Lee (2003a), the development of the Port of Stockton and its associated deep water navigation channel is one of the primary causes of the low-DO problem in the SJR DWSC near the Port of Stockton. The DWSC in this region has converted the SJR from a fast-flowing river that has a depth of 10 to 15 feet to a slow-moving, long, thin lake, with a depth of 35 feet. This change in the physical characteristics of the channel greatly increases the hydraulic residence time of water in the channel beginning at the Port, with the result that oxygen-demanding materials, such as ammonia discharged by the city of Stockton wastewater treatment plant and algae that develop on nutrients derived primarily from agricultural sources in the SJR DWSC watershed, exert oxygen demand to a greater degree in the SJR DWSC than would occur if the dredged navigation channel to the Port of Stockton did not exist. Increasing the navigation depth of this channel to 40 feet will further aggravate this situation.

While the Corps of Engineers (COE) was required to mitigate the impact of the increased channel depth on the oxygen demand assimilative capacity associated with the past deepening of the channel from 30 feet to 35 feet which occurred in the late 1980s by installing an aeration device located at the Port of Stockton near Channel Point, a critical review of the approach that the Corps of Engineers was allowed to adopt with respect to evaluation of the aerator design to mitigate for the decreased assimilative capacity of the DWSC and the required operation of this aerator shows that the aerator is not achieving design specifications. This issue has been addressed by Brown (Jones & Stokes, 2003).

Further and most importantly, the Corps' current approach for operating the aerator does not require the Corps to operate the aerator whenever the oxygen concentrations in the DWSC near the Port of Stockton are below the water quality objective for this reach of the Channel. As discussed by Lee and Jones-Lee (2003a), there have been several periods over the last couple of years when the dissolved oxygen concentrations in the DWSC just downstream of the Port of Stockton were at or near zero mg/L. Associated with these periods were fish kills. However, in accordance with the current operations plan for the aerator adopted as part of mitigation for increasing the channel depth from 30 feet to 35 feet, the aerator was not operated during all times that the DO was below the water quality objective. Lee (2003c) has discussed the need to change the characteristics and operations of the aerator so that it more appropriately mitigates for the deepening of the channel that took place in the late 1980s from 30 feet to 35 feet. Further, associated with any additional deepening of the channel, such as that proposed by the Port of Stockton, more appropriate review of mitigation measures as they may impact the oxygen demand assimilative capacity of the SJR DWSC should be conducted.

Impact of City of Stockton Stormwater Runoff on the Low DO-Problem

Lee and Jones-Lee, as part of examining the relationship between SJR DWSC flow and DO as measured at the DWR RRI monitoring station, observed that following a major stormwater runoff event in Stockton in November 2002 the DO in the DWSC at the RRI station decreased below the water quality objective. Coincident with this situation, the DeltaKeeper found that large-scale fish kills were occurring in city of Stockton sloughs that are connected to the DWSC, which were apparently caused by low DO in the sloughs. That situation has been known for many years – that rainfall runoff events cause fish kills in the city of Stockton sloughs, which is apparently related to the discharge of oxygen-demanding materials that accumulate in the City's storm sewer system. These materials are flushed into the sloughs in a rainfall runoff event, which then rapidly deplete the oxygen through abiotic (non-biological) reactions between sulfides, ferrous iron and DO.

In September 2003, a somewhat unusual large rainfall runoff event occurred in Stockton, where again the DO in the DWSC decreased below the water quality objective following the runoff event, and there were fish kills in city of Stockton sloughs that were coincident with low DO in the sloughs. A separate report on this issue was developed by Lee (2003d).

It is now clear that there is a coincidence between low DO in the DWSC and at least some, especially early season, rainfall runoff events in Stockton. Lee and Jones-Lee (2003a), in their review of the November 2002 runoff event, showed that the BOD load in city of Stockton stormwater was sufficient to lead to low-DO conditions in the DWSC. This is an issue that will need further evaluation as part of establishing a control program for low DO in the DWSC.

South Delta

In connection with the potential for increasing the SJR flow through the DWSC, where water could be taken from the South Delta, Lee and Jones-Lee (2003a) have provided information on the water quality characteristics of the South Delta. As they discuss, DWR has monitoring stations on each of the major South Delta channels. The data gathered over the past several years show that several of these channels have low-DO problems. Further, these channels are rich in algal nutrients (nitrogen and phosphorus compounds).

As part of an effort to become more familiar with the South Delta channels and the water quality problems therein, Lee and Jones-Lee, with the support of the DeltaKeeper, conducted a tour of the South Delta channels on August 5, 2003. Lee et al. (2004a) developed a report covering the results of this tour. As discussed by Lee et al. (2004a), Old River near the Tracy Boulevard bridge was found to be experiencing a large-scale fish kill at the time of the tour. Thousands of threadfin shad were found floating in Old River near the Tracy Wildlife Association facilities. Near this location DWR maintains a continuous-recording water quality monitoring station for DO, EC, and several other easily measured parameters. It was found, upon review of the data from this station, that the DO on the evening before the tour was at or near zero for four to six hours. It is likely that the fish kill was related to the low DO during the previous night.

A review of the EC data obtained on the South Delta channels showed that the EC in Old River and the other channels that were toured on the DeltaKeeper boat, was near or above the 700 µmhos/cm water quality objective. It became apparent, through examination of the data taken on the tour, as well as from the DWR monitoring data for the South Delta channels, that the primary source of salt for the South Delta channels was the SJR upstream of Vernalis. The state and federal projects' drawing of SJR Vernalis water into the South Delta as part of the export pumping brings with it large amounts of salt into the South Delta, which causes the high EC found in the channels. As discussed by Lee et al. (2004a), the CVRWQCB's proposed

TMDL for solving the problem of excessive salt content of the SJR, where the objective of this TMDL is to achieve 700 µmhos/cm in the SJR at Vernalis, will not be adequate to protect South Delta agriculture from excessive salt. Hildebrand (pers. comm., 2004) has stated,

> *"In regard to water quality, there was extensive testimony that led to the need for a 700 µmhos/cm salinity standard to prevent losses in crop yield. The salinity was almost always better than 700 µmhos/cm pre CVP. Furthermore, even when the salinity standard is met at Vernalis it is not met downstream, particularly when flows are low and the salt load is high. Manteca, Tracy, Lathrop, and Mountain House wastewater enters the channel system. Furthermore, agricultural use of water necessarily concentrates whatever salt load is in the diverted water. The tributaries are not responsible for the salinity problem, but they aggravate the problem when they manipulate the time of flow from what it would be in the absence of VAMP."*

The CVRWQCB Basin Plan objective and TMDL to control excessive salts in the SJR will need to be significantly revised, so that the total concentrations of salt in the SJR water that is brought into the South Delta, when coupled with the salts added to the South Delta channels by irrigated agriculture, are controlled so that the total EC during the irrigation season does not exceed 700 µmhos/cm. This means that the SJR Vernalis EC will have to be decreased significantly below 700 µmhos/cm.

One of the issues of particular concern in developing an oxygen demand control program for the SJR DWSC is the potential impact of the agricultural interests in the Mud and Salt Slough watersheds in controlling their salt discharges to the SJR. As Lee (2003e) discussed, the approach that is used there will likely impact the oxygen demand loads that are received by the SJR from the Mud and Salt Slough watersheds. Lee, as part of commenting on the upstream monitoring proposal submitted by SJR watershed agricultural interests, has indicated that this situation means that the upstream monitoring should be delayed until such time as the salt and boron TMDLs have been established and the agricultural interests have initiated programs to control the salt load. Failure to properly consider this situation would mean that the upstream monitoring and modeling efforts that are conducted in the near term may have little or no applicability to the conditions that will exist at the time when efforts are made to relate oxygen demand loads present in the SJR where Mud and Salt Sloughs discharge to the SJR and those that are present at Mossdale.

The information available now on South Delta water quality indicates that the reverse-flow low-head pumping over the permanent barriers, discussed by Lee and Jones-Lee (2003a), in which Sacramento River water that is being drawn to the export pumps is pumped into the South Delta and ultimately into the San Joaquin River through the Head of Old River, could be a major factor in improving South Delta water quality and overcoming the significant water quality problems that occur in the South Delta channels because of the federal and state export pumps' drawing SJR Vernalis water into the South Delta.

Central Delta

Lee and Jones-Lee, as part of developing the Issues Report (Lee and Jones-Lee, 2000) and Synthesis Report (Lee and Jones-Lee, 2003a), in which they suggested that consideration be given to increasing the flow through the SJR DWSC, indicated that there is need to evaluate whether the oxygen demand load associated with the increased flow through the critical reach of the DWSC could result in water quality problems in the Central Delta. As part of an effort to investigate this situation, G. F. Lee arranged with the DeltaKeeper to conduct two tours of Central Delta channels during the summer 2003. The first of these tours took place on July 17, 2003, and the second on September 17, 2003. They both involved proceeding from the Calaveras River where the DeltaKeeper boats are moored down the SJR DWSC to Turner Cut, down Turner Cut to Middle River, and, on the July 17 tour, down Middle River to Victoria Canal and then back up Old River, eventually reaching Columbia Cut and then the DWSC. The September 17 tour included going down Whiskey Slough to the end, turning around and heading out Turner Cut to Old River, and then up Old River to Columbia Cut. A report covering both tours has been developed by Lee et al. (2004b).

The results of the tours confirmed that Sacramento River water mixes with San Joaquin River DWSC water at Turner Cut to significantly dilute the concentrations of salts and other constituents in the SJR DWSC. On both tours the DO in the mixture of Sacramento and San Joaquin River DWSC water was above the water quality objective. Neither tour, however, was conducted on what would be the worst-case situation of high SJR DWSC flow (in excess of 1,500 to 2,000 cfs) and high algal concentrations. Lee et al. (2004b) recommended that further studies specifically directed to worst-case conditions be conducted to examine Turner Cut and especially Whiskey Slough for low-DO conditions. They also discuss the variety of factors that can influence the mixing of Sacramento River water with SJR DWSC water and the resultant impacts from this mixture on Central Delta and South Delta water quality.

Upstream Monitoring Studies

As part of developing an understanding of the sources of oxygen demand from the SJR DWSC watershed, with particular emphasis on the origin of the algal oxygen demand load that, at times, is a major factor in causing low DO in the DWSC, it was recommended that follow-on studies to those conducted in 2001 be conducted to better define the potential for control of oxygen demand sources in the Mud Slough and Salt Slough watersheds and in the SJR at Lander Avenue watershed. While this was to be the focus of further studies, agricultural interests in the SJR watershed shifted the emphasis to an effort focused on gathering additional data on sources of oxygen demand in the SJR DWSC watershed, and chose to not do the recommended studies on the origin of the oxygen demand in the Mud and Salt Slough watersheds that would be useful to determining whether it would be feasible to control the low-DO problem that originates primarily from the growth of algae in these watersheds.

Beginning in December 2002, Lee pointed out that the proposed studies by Stringfellow, Quinn, and others in the SJR watershed were not focused on the key issues that needed to be addressed in order to better define the potential for controlling the upstream oxygen demand sources in the SJR watershed. When the draft proposal for the proposed studies was finally made available for public review in January 2003, both Dr. G. F. Lee and Dr. Chris Foe independently commented on the significant deficiencies in the proposed studies. These comments are on the SJR DO TMDL website (www.sjrtmdl.org). While Stringfellow claimed at a January 2003 SJR DO TMDL Steering Committee meeting that the issues raised by Foe and Lee would be addressed in the finalization of the proposal, in fact the final proposal, which was made available in March 2003, did not address these issues and continued with the inappropriate focus on issues that will provide little in the way of determining the ability to control the upstream oxygen demand sources. This upstream monitoring proposal was written as though there had not been two years of data collection on the oxygen demand loads of each of the tributaries to the SJR and along the SJR, which showed how the oxygen demand changed from Mud and Salt Sloughs downstream to Mossdale.

In response to a request from the DeltaKeeper regarding the appropriateness of supporting the Stringfellow et al. proposal, Lee (2003e) prepared a critique of the proposal based on what was known in the fall of 2003 about the issues that needed to be addressed. Several of the key issues discussed by Lee (2003e) as deficiencies in the proposed upstream monitoring studies are nevertheless included in the project approved by CALFED. It is possible, however, that the final studies that will be conducted under this project will be modified to more appropriately address issues that need to be addressed in implementing the upstream monitoring program.

There are several aspects of the proposal that were supported by Lee, including the HydroQual modeling, where additional guidance was provided in his comments on how this modeling should proceed to better understand the transformations in oxygen demand along the SJR. It is important to note, however, that the HydroQual modeling is not going to change the overall conclusions about load-response from the major tributaries to the SJR and the resultant loads downstream. All it can hope to do is to possibly develop an approach that would predict how changing the loads of oxygen demand from Mud and Salt Sloughs would result in a change in oxygen demand at Mossdale. One of the problems with the modeling, however, is that there is an inadequate database on some of the key parameters that could influence the coupling between Mud and Salt Slough discharged loads of oxygen demand and those at Mossdale. The upstream monitoring project approved by CALFED did not address these issues, with the result that the modeling will have to be done with “literature” values, which may, because of the character of the SJR, not be reliable. Of particular importance are the surplus nutrients and the light-limited growth of algae along the SJR.

Lee, in his comments on the upstream monitoring proposal, and again this spring in comments to Gowdy and Marcotte following a meeting in which the HydroQual modeling was reviewed, urged that HydroQual change the focus of its initial efforts from the DWSC DO depletion to tuning the model of algal growth/oxygen demand along the SJR from Mud and Salt Sloughs to Mossdale to the 2000 data and determining how well the model, without adjustment of coefficients, predicts the 2001 results. The model could then be retuned so that it considers both 2000 and 2001, and see how well it predicts 2002 and 2003 data that have been collected by Dr. Randy Dahlgren. This effort would lead to defining the additional studies that need to be done on characterizing oxygen demand load transformations along the SJR. Based on these results, it could be possible to define the additional upstream studies that are needed to improve the ability to relate oxygen demand loads from Mud and Salt Slough and the SJR at Lander Avenue watersheds to loads that enter the DWSC.

One of the issues of concern in the upstream monitoring project is the continued work on attempting to use isotope tracers to provide definitive information on issues pertinent to the low-

DO problem. Several reviewers, including Dr. Lee, commented that the isotope work cannot succeed in yielding the kind of information needed for solving the low-DO problem, since it is not possible to distinguish between isotopes in the water that are not related to oxygen-demanding materials and those that are. The predictions on this situation were demonstrated by the Kratzer et al. (2004) report, where part of this report was devoted to isotope studies.

While Kratzer et al., in a press release, attempted to demonstrate the value of the isotope work, in fact, this press release and the report itself demonstrated what some individuals, including Dr. Lee, have been saying all along – that the isotope work cannot be of value in this situation. The major conclusion of the Kratzer et al. study, which was the focus of the press release, was that nitrate measured in the SJR was derived from upstream manure and domestic wastewater discharges. Further, there were implications that this, in some way, was of importance to the low-DO problem in the DWSC. As discussed by Lee (2004a,b), the isotope study results, which, according to Kratzer et al. indicated that manure and domestic wastewaters were a major source of nitrate in the San Joaquin River, even if reliable, are not relevant to the low-DO problem.

It is clear, from a review of the press release and the Kratzer et al. report, that those responsible for developing this report did not adequately consider the information that is available on the relationship between nitrate in the SJR and the low-DO problem. As discussed in the Synthesis Report (Lee and Jones-Lee, 2003a) regarding algal growth dynamics in the SJR, the isotopic signature of nitrate in the SJR has no relevance to the low-DO problem. Neither domestic wastewaters nor animal manure is the source of the nitrogen that is responsible for the algal loads that are contributed to the SJR by Mud and Salt Sloughs and are present in the SJR at Lander Avenue. The removal of all animal manure and domestic wastewater nitrate downstream of this point will have little or no impact on the low-DO problem because of the massive surplus nitrogen that is already incorporated into the algal biomass at the point where Mud and Salt Sloughs discharge to the SJR. With respect to the future upstream studies, there is need for critical review of any future isotope work, to be sure that the same kinds of mistakes that were made in the Kratzer, et al., report are not repeated.

It is recommended that a critical review be conducted of how the funding made available by CBDA for upstream studies should be used to develop the information needed in light of the current degree of understanding of the upstream sources of oxygen demand and the factors that influence the amount of this oxygen demand that can reach the DWSC. Of particular concern are the impacts of the implementation of the salt TMDL for control of salts derived from Mud and Salt Slough watersheds.

Impact of South Delta Export Pumping on Fall Run Chinook Salmon Homing through SJR DWSC Watershed Waters

As discussed by Lee and Jones-Lee (2003a, 2004b) and Lee et al. (2004b), the state and federal projects' export of South Delta water creates a strong Sacramento River water flow through the Central Delta on its way to the pumps. The flow of Sacramento River water through the Central Delta is typically on the order of 8,000 to at times 12,000 cfs. This water is drawn across the SJR DWSC beginning at Turner Cut/Columbia Cut and downstream at other locations where there are channels by which Sacramento River water can be drawn to the export pumps through Middle River and Old River. As discussed by Lee and Jones-Lee (2004b,c), one of the consequences of the export pumping of water from the South Delta by the state and federal projects is the essential elimination of any homing signal that the fall run Chinook salmon may have upon entering the western Delta from San Francisco Bay. Any chemical signal in the San Joaquin River would be drawn to the South Delta as part of the export pumping, either through Old River at the Head of Old River, or through Turner Cut/Columbia Cut. The full significance of this situation needs to be evaluated with respect to its adverse impacts on Chinook salmon returning to their home stream waters for reproduction.

Overview of Delta Water Quality

Lee and Jones-Lee (2004a) have developed a comprehensive review of Delta water quality issues. This review includes information that is pertinent to the SJR DWSC low-DO situation, in that they discuss a number of the factors that influence DO depletion in the DWSC.

As Lee and Jones-Lee (2004a) have summarized, Delta fisheries have been declining over the past 20 years or so. Lower trophic levels – the zooplankton and phytoplankton that make up the lower level of the food web – have declined one to two orders of magnitude since the 1980s. While the cause of this decline is not understood, part of this decline may be due to reduced lower trophic level food supply associated with decreased algal populations in the Delta, which could be caused by invasive species (Asian clams) that consume algae and zooplankton. Reductions in the algal input associated with nutrient control in the Delta watershed could lead to further reductions in the lower trophic level food supply for zooplankton and larval and small fish.

Another factor that leads to lower algal productivity in the Central Delta is that the export pumps draw large amounts of low-nutrient Sacramento River water through the Central Delta thereby reducing the amount of nutrients available to support algal growth in this region. As Lee and Jones-Lee (2004b) point out, the Sacramento River water drawn through the Central Delta mixes with nutrient-rich South Delta water near Clifton Court Forebay to provide increased nutrient concentrations in the mixture of water that is pumped at the Banks pumping station. There are sufficient nutrients in the water at this location to lead to the algal-related water quality problems in Clifton Court Forebay and in the State Water Project reservoirs, which were discussed by DWR staff at the California Lake Management Society (CALMS, 2003) conference that was held in November 2003. There is need to better understand the food web in the Delta to evaluate how manipulation of nutrients and algal loads to the Delta as part of managing the low-DO problem will impact Delta aquatic life resources.

Lee (2003f) has discussed the potential for pesticides and herbicides that are present in the SJR upstream of the DWSC and within the DWSC to impact the low-DO problem in the DWSC. Some of the commonly used pesticides, such as the organophosphorus pesticides, are toxic to some zooplankton that graze on algae, and some of the commonly used herbicides are toxic to algae. As Lee (2003f) discussed, this is an area that needs further investigation as it may impact the low-DO problem in the DWSC.

Lee and Jones-Lee (2004a) provided information on the Clean Water Act section 303(d) listings of impaired Delta channels. Many of these channels have listings for aquatic life toxicity, excessive bioaccumulation of organochlorine pesticides and PCBs in edible fish, mercury, excessive EC (salt) and low dissolved oxygen (in the South Delta), pathogen indicator organisms, and dioxins (near the Port of Stockton). Lee and Jones-Lee (2004a) have reviewed the current water quality monitoring programs in the Delta, noting that they are deficient in adequately defining the water quality problems and in serving as a basis for beginning to control the constituents responsible for the 303(d) listings. Further, there is growing recognition that there are a variety of other unrecognized pollutants in urban and agricultural wastewater discharges and stormwater runoff that are not now monitored, which may be having adverse effects on fish and other aquatic life within the Delta. Solving the low-DO problem in the DWSC will not solve all of the water quality problems of the DWSC, since the reach of the SJR within the Delta (i.e., Vernalis to the DWSC) and the DWSC have a number of 303(d) listings as impaired waterbodies due to one or more constituents that are present at concentrations above water quality objectives.

Evaluation of Non-Aeration Alternatives for Managing the Low-DO Problem in the SJR DWSC

Lee and Jones-Lee (2003a), as part of developing the Synthesis Report, included discussions of the various approaches for solving the low-DO problem in the DWSC that had evolved out of the four years of studies. These approaches were largely based on Dr. Lee's experience in working on similar problems over the past 40 years in various parts of the US and in other countries. They included extensive review and comment by Dr. Chris Foe of the CVRWQCB. The discussion of alternative approaches was made available to the SJR DO TMDL Steering Committee and email listees in the spring 2002 external peer review version of the Synthesis Report. In the winter 2003, with the update of the Synthesis Report, the Steering Committee and email listees were provided with an additional opportunity to comment on the Synthesis Report's discussion of alternative approaches for solving the low-DO problem. The final Synthesis Report of March 2003 incorporated reviewers' comments on these issues.

The Lee and Jones-Lee (2003a) Synthesis Report and the Lee (2003g) review of alternative approaches concluded that there are only a few alternative approaches that should be evaluated further, such as increased flow of the SJR through the DWSC, controlling ammonia-caused oxygen demand from the city of Stockton's wastewater effluent and controlling oxygen demand from the Mud and Salt Slough watershed-derived algae. Even with respect to the latter, there are significant questions as to whether it will be technically feasible to control the algae that develop in Mud and Salt Sloughs, which are the source of the algae that ultimately are a significant oxygen demand source for the SJR DWSC. The approach that Lee and Jones-Lee (2004d) recommend is to first establish the maximum minimum SJR DWSC flow that can be relied on during normal year hydrology. If, as has been discussed, 1,500 cfs can be assured as the minimum flow through the DWSC during most years, then the control of the low-DO problem needs to focus on selective aeration to eliminate low-DO situations that are not eliminated by the elevated flow.

A key aspect of evaluating the feasibility of an altered flow alternative approach is an evaluation of potential secondary impacts, with particular concern about effects on fisheries and water quality in the Central Delta. These are issues that should be the focal point of the alternative approach evaluation.

References

CALMS, DWR Staff Presentations at the California Lake Management Society Annual Meeting, November (2003). http://wwwomwq.water.ca.gov/PublicationsPage/index.cfm

Giovannini, P.; Giulianotti, J. C. and Hayes, S. P., "Dissolved Oxygen and Flow in the Stockton Ship Channel, Fall 2002," *IEP Newsletter* 16(4): 30-34, Fall (2003).

Jones & Stokes, "Evaluation of Aeration Technology for the Stockton Deep Water Ship Channel," Report by R. L. Brown prepared for San Joaquin River DO TMDL Steering Committee and TAC, Jones & Stokes, Sacramento, CA, January (2003). Available from www.sjrtmdl.org.

Kratzer, C. R.; Dileanis, P. D.; Zamora, C.; Silva, S. R.; Kendall, C.; Bergamaschi, B. A. and Dahlgren, R. A., "Sources and Transport of Nutrients, Organic Carbon, and Chlorophyll-*a* in the San Joaquin River Upstream of Vernalis, California, during Summer and Fall, 2000 and 2001," Water-Resources Investigations Report 03-4127, US Geological Survey, Sacramento, CA (2004).

Lee, G. F., "Impact of San Joaquin River Deep Water Ship Channel Watershed and South Delta Flow Manipulations on the Low-DO Problem in the Deep Water Ship Channel," Submitted to the US Bureau of Reclamation OCAP Biological Assessment, Sacramento, CA, Report of G. Fred Lee & Associates, El Macero, CA, July 10 (2003a). http://www.members.aol.com/duklee2307/FlowImpact.pdf

Lee, G. F., "Review of 2003 SJR DWSC Flow and Dissolved Oxygen Data," Report of G. Fred Lee & Associates, El Macero, CA, July (2003b). http://www.gfredlee.com/SJR.Jan.July.DO.Flow.2003dl.pdf

Lee, G. F., "Need to Change the Operation Requirements of the COE Aerator Located at the Port of Stockton near Channel Point," Report of G. Fred Lee & Associates, El Macero, CA (2003c). http://www.gfredlee.com/COEaerator9-4-03.pdf

Lee, G. F., "Additional Studies on the Impact of City of Stockton Stormwater Runoff on Low DO in the SJR DWSC," Report of G. Fred Lee & Associates, El Macero, CA (2003d). http://www.gfredlee.com/stockton-storm-sept03r.pdf

Lee, G. F., "Review of 'CALFED Directed Action Proposal: Monitoring and Investigations of the San Joaquin River and Tributaries Related to Dissolved Oxygen,' Proposal Number 262DA," Comments submitted to the DeltaKeeper, Report of G. Fred Lee & Associates, El Macero, CA, October 28 (2003e). http://www.members.aol.com/duklee2307/deltakeeper-ups-mon.pdf

Lee, G. F., "Potential Impact of Pesticides (Insecticides & Herbicides) on Low DO in the SJR DWSC and South Delta," Report of G. Fred Lee & Associates, El Macero, CA (2003f). http://www.members.aol.com/duklee2307/Potential-Impact-Pesticides.pdf

Lee, G. F., "Suggested Approach for Defining Non-Aeration Alternatives for Managing the Low-DO Problem in the SJR DWSC," Report of G. Fred Lee & Associates, El Macero, CA (2003g). http://www.gfredlee.com/AlternativeApproaches.pdf

Lee, G. F., "Comments on the Kratzer, et al. Press Release: 'San Joaquin River/Fisheries Animal Wastes or Sewage Contribute to Salmon Migration Barrier in San Joaquin River' News Release, U. S. Geological Survey – 2/24/04," Report of G. Fred Lee & Associates, El Macero, CA, May (2004a).

Lee, G. F., "Comments on the Kratzer, et al. Report, 'Sources and Transport of Nutrients, Organic Carbon, and Chlorophyll-a in the San Joaquin River Upstream of Vernalis, California, during Summer and Fall, 2000 and 2001,'" Report of G. Fred Lee & Associates, El Macero, CA, May (2004b).

Lee, G. F. and Jones-Lee, A., "Issues in Developing the San Joaquin River Deep Water Ship Channel DO TMDL," Report to Central Valley Regional Water Quality Board, Sacramento, CA, August (2000). http://www.gfredlee.com/sjrpt081600.pdf

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 and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003a). http://www.gfredlee.com/SynthesisRpt3-21-03.pdf

Lee, G. F. and Jones-Lee, A., "Update on the Understanding of the Low-DO Problem in the San Joaquin River Deep Water Ship Channel," *IEP Newsletter* 16(3):12-15, Summer (2003b). http://www.gfredlee.com/IEPnewsletterSummer2003-GFL.pdf

Lee, G. F., and Jones-Lee, A., "Managing Oxygen Demand in the San Joaquin River Deep Water Ship Channel," PowerPoint slides presented at the California Lake Management Society annual conference, Sacramento, CA, November (2003c). http://www.gfredlee.com/CALMSli.pdf

Lee, G. F. and Jones-Lee, A., "August and September 2003 SJR DWSC Flow and DO," Report of G. Fred Lee & Associates, El Macero, CA (2003d). http://www.gfredlee.com/Aug-Sept.2003.SJR.DWSC.Flow.DO.pdf

Lee, G. F. and Jones-Lee, A., "SJR DWSC Flow and RRI DO Data for 2003," Report of G. Fred Lee & Associates, El Macero, CA (2003e). http://www.members.aol.com/apple27298/DWSC-Flow-DO-2003.pdf

Lee, G. F. and Jones-Lee, A., "Overview of Sacramento-San Joaquin River Delta Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA, May (2004a). http://www.members.aol.com/duklee2307/Delta-WQ-IssuesRpt.pdf

Lee, G. F. and Jones-Lee, A., "Comments on the CBDA Delta Improvements Package," Comments submitted to California Bay-Delta Authority by G. Fred Lee & Associates, El Macero, CA, June (2004b). http://www.members.aol.com/apple27298/DIPcomments.pdf

Lee, G. F. and Jones-Lee, A., "SJR Deep Water Ship Channel Water Not SJR Watershed Water below Columbia Cut," Submitted to *IEP Newsletter* for publication, Report of G. Fred Lee & Associates, El Macero, CA (2004c). http://www.gfredlee.com/IEP-SJR-Delta7-24-03Final.pdf

Lee, G. F. and Jones-Lee, A., "Recommended Approach for Controlling the Low-DO Problem in the SJR DWSC," Report of G. Fred Lee & Associates, El Macero, CA, May (2004d). http://www.members.aol.com/apple27298/SJR-Rec-Approach.pdf

Lee, G. F.; Jones-Lee, A. and Burr, K., "Results of the August 5, 2003, Tour of the South Delta Channels," Report of G. Fred Lee & Associates, El Macero, CA (2004a). http://www.members.aol.com/duklee2307/South-Delta-Tour.pdf

Lee, G. F.; Jones-Lee, A. and Burr, K., "Summary of Results from the July 17, 2003, and September 17, 2003, Tours of the Central Delta Channels," Report of G. Fred Lee & Associates, El Macero, CA (2004b). http://www.members.aol.com/duklee2307/Central-Delta-Tours.pdf

SJRGA, "2003 Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan," Prepared for the California Water Resources Control Board in compliance with D-1641, by the San Joaquin River Group Authority, Sacramento, CA, January (2004a). www.sjrg.org

SJRGA, "San Joaquin River Agreement Vernalis Adaptive Management Program Update Report," San Joaquin River Group Authority, Sacramento, CA, April (2004b).