Water Quality Issues That Could Influence Aquatic Life Resources of the Delta[1]

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The significant decline in the population of several species of pelagic fish and zooplankton in the Delta during the past three years has raised the issue of whether toxic chemicals in the Delta water and/or sediments could be the cause of, or contribute to, this pelagic organism decline (POD). In the summer of 2005 the POD investigation team (Armor et al., 2005a) conducted a "screening level" investigation that included a very limited-scope monitoring of aquatic life toxicity in the Delta. While a report presenting and discussing this toxics monitoring program is not available for review, the recent draft report by the IEP POD investigation management team (Armor et al., 2005b) indicated, as expected, that some samples of Delta water and sediments were toxic to US EPA standard test organisms. The CA Bay Delta Authority's (CALFED) independent technical review panel concluded that toxics, export of South Delta water by the State (SWP) and Federal (CVP) export projects, and invasive species need further study to determine what, if any, role each of these factors, as well as other factors, play in the POD. Presented herein is information on issues that need to be considered in evaluating the role of toxics and toxicity as factors contributing to the POD.

Review of Known Toxics Issues in the Delta

Lee and Jones-Lee (2004) developed a 150-page report entitled, "Overview of Sacramento-San Joaquin River Delta Water Quality Issues." That report evolved from Drs. G. Fred Lee and Anne Jones-Lee's work on Delta water quality issues beginning in the summer of 1989. A summary of Drs. G. Fred Lee and Anne Jones-Lee's Delta water quality experience is presented in Appendix C. Appendix A presents the "Abstract and Summary of Existing Delta Water Quality Problems" from the Lee and Jones-Lee (2004) report. During the course of the year of its development, that report has been through several drafts and circulated to numerous individuals for review and comment. Lee and Jones-Lee reported that IEP, DWR, USBR, DFG and CALFED have devoted inadequate attention to assessing and managing the impacts of toxic chemicals in the waters and sediments of the Delta on the Delta's aquatic life resources. Evaluation of the impacts of toxic chemicals on Delta water quality could show that significant adverse effects to the aquatic life resources of the Delta have been occurring.

Lee and Jones-Lee (2004) pointed out that many of the Delta channels have been listed for several years by the Central Valley Regional Water Quality Control Board

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(CVRWQB)/State Water Resources Control Board (SWRCB)/US Environmental Protection Agency (US EPA) as Clean Water Act Section 303(d) water quality impaired due to the presence of toxic chemicals and other chemicals in the water column at concentrations above the US EPA water quality criteria/state water quality objectives (WQOs). The exceedance of a WQO for many of the Delta 303(d) listings are based on aquatic life toxicity, excessive bioaccumulation of hazardous chemicals that are a threat to human health to those who use Delta fish as food, as well as measured aquatic life toxicity using the US EPA standard aquatic life toxicity test organisms. Lee and Jones-Lee (2004) summarized the Delta water quality issues as follows,

- **Pesticides.** Currently used agricultural and urban area pesticides cause aquatic life toxicity. According to Kuivila (2000) of the USGS there are over 150 pesticides used in the Delta and its tributaries. Some of those pesticides have the potential to cause toxicity to Delta fish, zooplankton, and/or algae.
- **Legacy Pesticides** such as DDT, chlordane, toxaphene, dieldrin and formerly used organochlorine chemicals such as PCBs and dioxins have accumulated in fish tissue to sufficient levels to cause some Delta fish to be unsafe to eat. There is also the potential for the organochlorine residues to be adverse to the host organism.
- **Low Dissolved Oxygen.** San Joaquin River (SJR) Deep Water Ship Channel (DWSC), South Delta channels, and Stockton Sloughs experience low DO that leads to fish kills, decreased fish growth rates and greater susceptibility of fish to disease and toxics. Also the low DO in the DWSC potentially blocks fall-run salmon homing migration to spawning areas in SJR watershed Sierra rivers.
- **Heavy Metals** from former mining and other sources are potentially toxic to aquatic life. Of particular concern are copper, cadmium, and nickel.
- **Excessive Selenium** in Delta waters/sediments may be adverse to sturgeon.
- **Mercury**, derived from former mercury mining and gold mining, is found in excessive amounts in some Delta fish causing them to be unsafe to eat.
- **Nutrients (nitrogen and phosphorus compounds)** lead to excessive aquatic weeds, water hyacinth, egeria, and planktonic algae. The excessive growth of aquatic plants interferes with recreational uses – boating, swimming, water skiing -- and also causes tastes and odors in domestic water supplies. On the other hand, the SWP/CVP export projects that draw large amounts of low-nutrient Sacramento River water through the Central Delta to the export pumps in the South Delta reduce the phytoplankton primary production in the Northern and Central Delta.
- **Pathogen** indicator organisms in water near urban areas, marina and beaches cause waters to be unsafe for contact recreation (swimming, water skiing, wading).
- **Salt/EC** in South Delta channels impairs the use of Delta waters for irrigated agriculture and impairs the ability to use waters derived from the Delta for groundwater recharge as part of wastewater reuse.

- **Sediment** accumulation causes shoaling of Delta channels and causes Delta waters to be turbid (cloudy).
- **Total Organic Carbon** (TOC) leads to excessive trihalomethanes (THMs) in disinfected water supplies. THMs are potential carcinogens that cause increased cost of domestic water supply treatment.
- **Aquatic life toxicity** to zooplankton, algae, and benthic invertebrates has been found in Delta waters. Some of this toxicity has been caused by currently used pesticides. In addition, toxicity is caused by unidentified chemicals.
- **Unregulated Chemicals** are present in domestic and animal wastewater discharges to the Delta. Among these chemicals are excreted and discarded pharmaceuticals and personal care products (PPCPs). These discharges represent an emerging area of aquatic life toxicity concern since some of these chemicals, in very low concentrations, have been found to be highly toxic to some forms of aquatic life; they could be affecting aquatic life especially near wastewater discharges.

Inadequate Delta Water Quality Monitoring is being conducted to define the magnitude and areal extent of water quality impairments from known pollutants, or to define the magnitude of water quality problems from yet-to-be-identified pollutants. At this time only 100 to 200 chemicals are regulated, while thousands of chemicals are in use including,

- PPCPs, endocrine disrupters and other unregulated chemicals
- New pollutants that have been in the environment for years but are only now being identified – e.g., perchlorate and PBDEs

There is need to search for unidentified pollutants and become pro-active in managing water quality in the Delta.

Appendix B presents a summary of the current situation for monitoring potentially toxic chemicals nationally and in the Delta, that was developed by Dr. Christian Daughton, Chief of the Environmental Chemistry Branch (ECB), Environmental Sciences Division, US Environmental Protection Agency. Daughton (2002) discussed the fact that the current approach for monitoring pollutants associated with domestic wastewaters and landfill leachate measures only a very small number of the many thousands of chemicals commonly present in homes that are a threat to human health and wildlife in the environment. Daughton (2004a, b) highlighted the growing concern about unrecognized, unregulated pollutants, indicating that there are over 22 million organic and inorganic substances, with nearly 6 million commercially available. The current water quality regulatory approach addresses fewer than 200 of these chemicals. There could readily be yet-to-be-recognized, unregulated chemicals in the many thousands of chemicals that are discharged to and occur within the Delta that are contributing to the POD. Lee and Jones-Lee (2004) summarized several recent studies that demonstrate that traditional aquatic life toxicity testing is not adequate to detect adverse impacts to fish, zooplankton or benthic invertebrates due to currently unrecognized pollutants.

An issue that needs to be understood is that aquatic life toxicity testing as currently practiced with the US EPA standard test organisms is not sufficiently sensitive to detect some of the adverse impacts to aquatic life. While that testing approach can detect some aspects of acute toxicity, it is not necessarily adequate to detect all aspects of chronic toxicity and sublethal impacts on aquatic life resources of the Delta.

There is increasing evidence that the lack of an exceedance of a WQO is not a reliable approach for assessing water quality impacts of a specific chemical on aquatic life due to the potential for additive and synergistic toxicity to aquatic life. Such toxicity does not necessarily result in death, deformed growth or impaired reproduction, i.e., readily observable impacts. Some of the impacts are far more subtle such as impaired ability to capture food or avoiding being captured.

Delta Water Export Impacts

Lee and Jones-Lee (2004) discussed the fact that the federal (USBR) Central Valley Project-CVP and state (DWR) State Water Project-SWP export large amounts of South Delta water to Central and Southern California and San Francisco Bay Region for agricultural and domestic water supply. At times these projects have exported as much as about 13,000 cfs. This South Delta water export totally changes the flow of water in the Delta channels. Impacts of these exports on water quality have not been adequately evaluated. However, these exports impact the magnitude, location and extent of existing water quality problems such as aquatic life toxicity, excessive bioaccumulation of hazardous chemicals, low-DO problem areas. It is likely that the adverse impacts of toxics and the export of South Delta water are linked. This linkage needs to be evaluated.

Funding Issues

Lee and Jones-Lee (2004) summarized the recent and current water quality monitoring programs in the Delta. They pointed out that the IEP monitoring program that is carried out to comply with SWRCB Water Rights Decision 1641, discontinued toxic chemical monitoring in the mid-1990s. At the most recent review of the IEP D-1641 monitoring program DWR and USBR representatives claimed that the South Delta export projects do not impact toxic chemical impacts and aquatic life toxicity. That statement was not based on study results.

CALFED started to develop a comprehensive water quality monitoring/management program in the late-1990s. That program included a proposed comprehensive water quality monitoring program that was not funded/activated apparently due to lack of funding. This situation has led to the current lack of information on the potential role of toxics in the POD as well the need for this information to justify increasing Delta water exports by DWR as proposed in the SDIP.

The Delta POD situation has led to the creation of a limited-scope, “crash” monitoring program. The past summer’s monitoring, and the monitoring program apparently proposed for 2006 are, however, inadequate to reliably define the roles of toxics and aquatic life toxicity on the POD, as well as the impacts of Delta water exports on the toxicity. It is important that future monitoring/management be conducted without the

politics of Delta water exports that has influenced the funding and the conduct of adequate water quality monitoring in the Delta.

Additional information on these and related issues is available upon request from G. Fred Lee at gfredlee@aol.com.

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Additional information on Delta water quality issues is provided on www.gfredlee.com in the Watershed Studies section, San Joaquin River Program subsection. http://www.gfredlee.com/psjriv2.htm

Appendix A
Abstract and Summary of the
Overview of Sacramento-San Joaquin River Delta Water Quality Issues

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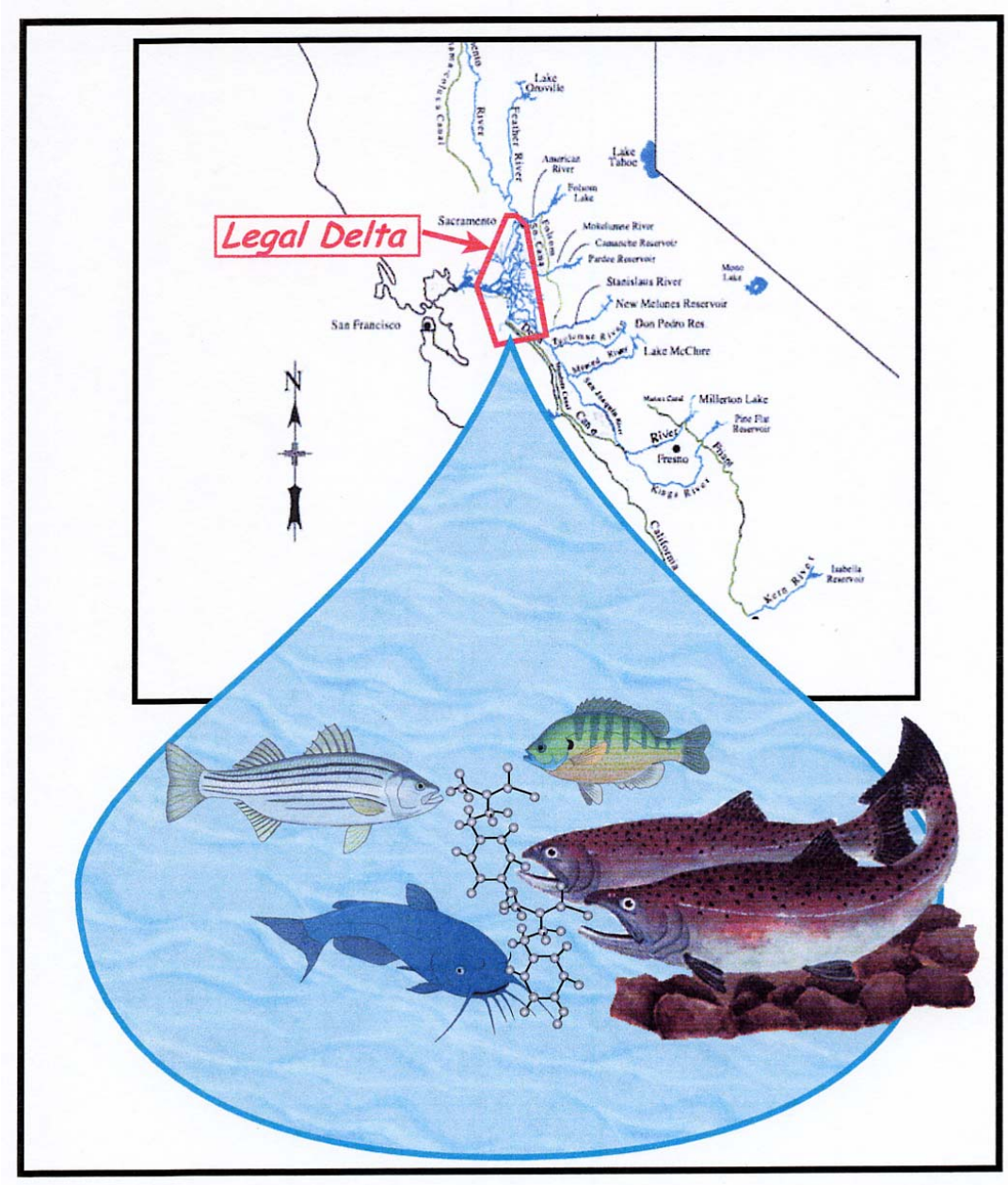

Adapted in part from images in SJRGA (2000)

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Abstract

The Sacramento-San Joaquin River Delta is a unique and valuable resource and an integral part of California's water system. It is a tidal freshwater system, which receives runoff from over 40 percent of the State's area, including the Sacramento River and San Joaquin River watersheds. It covers 738,000 acres with hundreds of miles of interlaced waterways. Its land and waterways support communities, agriculture and recreation, and provide essential habitat for wildlife. The Delta also serves as a water supply source for about 23 million people in California. The legal Delta extends northward to just upstream of the city of Sacramento, eastward into the city of Stockton, southward to Vernalis, and westward to Chipps Island just downstream of Pittsburg (DWR, 1995).

Delta waters have been found to contain sufficient concentrations of various pollutants to be in violation of water quality objectives, and hence experience legal, as well as actual, impairments of beneficial uses. These violations of the US EPA Clean Water Act have led to the need to develop Total Maximum Daily Load (TMDL) programs in an effort to control the input of these pollutants from their sources, which include municipal, domestic, industrial and agricultural wastewater and stormwater.

For example, the water quality/beneficial use of Delta waters is impaired by excessive bioaccumulation in fish of organochlorine "legacy" pesticides (DDT, chlordane, dieldrin, etc.), PCBs, dioxins/furans, and mercury that is a threat to the health of those who use some types of Delta fish as food. Organophosphorus-based pesticides used in agriculture, such as diazinon and chlorpyrifos, are causing aquatic life toxicity to fish food organisms in the Delta. Further, pyrethroid-based pesticides are being found in aquatic sediments downstream of agricultural fields where these pesticides have been used. Some of those sediments have been found to be toxic to sediment organisms. Herbicides used to control roadside and other vegetation have been found to be present in Delta waters at sufficient concentrations to be toxic to algae. Also, Delta waters have been found to be toxic to aquatic life due to unidentified substances (i.e., exhibit toxicity of unknown cause). The current US EPA and California Department of Pesticide Regulation registration of pesticides does not ensure that following label restrictions for the use of a pesticide will prevent aquatic life toxicity in waters receiving runoff/discharges from areas of pesticide use.

An issue that is not being considered in regulating pesticides/herbicides in the Delta and elsewhere is the potential additive and synergistic toxicity of multiple pesticides and/or the interaction of pesticides with other chemicals in the water. Such interactions could cause adverse impacts to Delta aquatic life without there being an exceedance of current water quality objectives for the individual regulated pesticides.

Delta waters contain sufficient concentrations of total organic carbon (TOC) and nutrients (nitrogen and phosphorus compounds) to cause those water utilities that use Delta water as a domestic water supply source to have to provide additional treatment, at additional cost, to control excessive trihalomethanes (THMs) (carcinogens) in the treated

waters. The nutrients in Delta waters stimulate algal growth which causes tastes and odors in the water supply.

The total salts (TDS/EC) in the San Joaquin River (SJR) as it enters the South Delta via Old River are at times in violation of the South Delta TDS/EC water quality objective (WQO). Several of the South Delta channels, such as Old River, Middle River and Grant Line Canal, have excessive levels of TDS/EC compared to water quality objectives. This situation has important and restrictive implications for South Delta agriculture. Further, the level of total salts in Delta waters restricts the ability of water management agencies to recharge domestic wastewaters to groundwater as part of wastewater reuse.

The nutrients in Delta waters cause excessive growths of water weeds such as water hyacinth that interfere with recreational use of Delta waters for boating, swimming, and water skiing. Further, the nutrients cause the growth of algae and aquatic weeds in Delta and Delta tributary waters that are used as agricultural water supply. Such growth requires the use of aquatic herbicides to prevent problems with water transport and the plugging of screens on irrigation canals and drip irrigation systems. There is concern about the toxicity of the aquatic herbicides to non-target aquatic life in the Delta and Delta tributary waters. The California State Water Resources Control Board (SWRCB) recently adopted a water quality order for a statewide general NPDES (National Pollutant Discharge and Elimination System) permit for the discharge of aquatic pesticides used for aquatic weed control. However, this permitting framework does not provide adequate protection of non-target organisms from toxicity caused by the aquatic pesticides alone or in combination with other chemicals in the water.

Excessive growth of algae in the San Joaquin River watershed waters and the South Delta channels also contribute to the problems of low dissolved oxygen in these waters. The decomposition of dead algae creates sufficient oxygen demand to cause or significantly contribute to violations of dissolved oxygen (DO) water quality objectives. At times the DO depletion is sufficient to cause fish kills. The export of South Delta water at the federal and state project pumps at Tracy and Banks greatly aggravates the low dissolved oxygen problem in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC). Also, the export pumps at Tracy and Banks have altered the flow of South Delta channels so that low-DO problems and excessive salts are encountered in some of those channels as well. Another source of oxygen demand at times is the ammonia that is discharged in the city of Stockton domestic wastewater. This discharge to the SJR just upstream of the DWSC is a major source of oxygen demand that leads to low DO in the DWSC. The ammonia in the city of Stockton's wastewater discharges also has the potential to be toxic to aquatic life in the DWSC.

The fisheries and other aquatic life resources of the Delta have declined significantly over the past 20 years. This decline appears to be related to entrainment of fish at the export pumps and to the decline of fish food organisms (phytoplankton and zooplankton) in the Delta aquatic food web. The decline in phytoplankton in some parts of the Delta appears to be caused by the harvesting of algae by invasive species such as

clams. The decline in zooplankton could be caused, in part, by aquatic life toxicity. The Delta water export projects may also contribute to these declines by drawing large amounts of low-nutrient Sacramento River water to the South Delta.

There is a lack of information on the significance of Delta sediments in causing aquatic life toxicity and contributing to excessive bioaccumulation of chemicals in edible organisms. The SWRCB's current work toward development of sediment quality objectives should be expanded to cover Delta sediments, in accordance with the Bay Protection and Toxic Cleanup Program requirements.

The sanitary quality of Delta waters has been found to violate water quality objectives for contact recreation such as swimming, water skiing and wading. This means that those who have body contact with Delta waters are at increased risk of contracting disease. The sanitary quality of Delta waters is also of concern to the water utilities that use Delta waters as a water supply. The violations of the sanitary quality WQOs mean that without adequate treatment the use of Delta waters for domestic water supply poses a threat of disease for those who drink the water.

Heavy metals such as mercury, selenium, cadmium and nickel are potentially causing adverse impacts to Delta and San Francisco Bay organisms through food web bioaccumulation.

There is a variety of other potentially hazardous and deleterious chemicals discharged to Delta tributaries and the Delta channels. Several of the Delta tributaries are listed as 303(d) impaired due to heavy metals from former mining activities in the Delta watershed. Other hazardous and deleterious chemicals enter Delta tributaries and Delta channels via domestic and commercial wastewater discharges and stormwater runoff from Stockton, Tracy, Manteca, Sacramento, West Sacramento, etc., and from agricultural activities. These potentially hazardous and deleterious chemicals include pharmaceuticals and personal care products (PPCPs), pesticides, endocrine disruptors, etc., that have not been evaluated with respect to their impacts on Delta water beneficial uses. Further, current regulatory approaches do not adequately address the additive and synergistic impacts of multiple stressors on aquatic life and other beneficial uses of waterbodies.

There is also need for a more systematic and comprehensive approach to the examination of Delta waters and wastes discharged to the Delta for their implications for public health and aquatic life. The recent finding of perchlorate as a widespread water pollutant which is toxic to humans is an example of the inadequate approach for investigating potentially hazardous chemicals in water. Further, the finding of the polybrominated diphenyl ethers (PBDEs) (which bioaccumulate) as water contaminants in San Francisco Bay aquatic life demonstrates the inadequacy of the current approach for the protection of water quality. While both perchlorate and PBDEs have been in the aquatic environment for many years, they have only recently been discovered there.

The Delta water monitoring program associated with the State Water Resources Control Board (SWRCB) D-1641 water rights decision allowing Delta water export via the State Water Project (SWP) to Central and Southern California is substantially deficient compared to that which is needed to properly evaluate the impact of the water exports from the South Delta via the federal (Central Valley Project – CVP) and state export projects on Delta water quality-beneficial uses. Inadequate attention has been given to the water quality impacts of San Joaquin River water exports and the large amounts of Sacramento River water and its associated pollutants that are drawn to the South Delta by the federal project pumps at Tracy and the State Water Project pumps at Banks. The current water quality monitoring that focuses on TDS/EC is not an adequate surrogate for defining the full range of important Delta water quality problems.

There is an urgent need to significantly expand Delta water quality monitoring/evaluation to define the magnitude and extent of known and yet-to-be-defined water quality problems. This information is essential to developing water quality management programs to restore Delta water quality that has been degraded due to discharge of pollutants to the Delta channels, and the export of Delta waters by the federal and state projects. The funding for this program should be provided by the water exporters, those who discharge potential pollutants to the Delta and its tributaries, and those who use Delta aquatic resources. The current situation where decreasing funding is available for water quality monitoring is strongly contrary to protecting Delta water quality.

Summary of Existing Delta Water Quality Problems

This comprehensive review of the current understanding of Delta water quality issues has been developed in response to increased interest in Sacramento-San Joaquin River Delta water quality because of current South Delta water exports by the federal (Tracy) and state (Banks) water projects and proposed expanded Delta water exports by the State Water Project. This review discusses the currently recognized Delta water quality issues as assessed based on violations of Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan water quality objectives (WQOs). These violations have resulted in the listing of Delta channels as US EPA Clean Water Act (CWA) 303(d) impaired. This means that chemicals and pathogen indicator organisms in Delta waters are at least legally impairing the beneficial uses of Delta waters. In accordance with the Clean Water Act, this listing requires that the CVRWQCB conduct TMDL programs to control the WQO violations.

As discussed below, in addition to the exceedances of WQOs, there are several known water quality problems – beneficial use impairments in Delta waters that are not listed by the CVRWQCB, State Water Resources Control Board (SWRCB) or US EPA as 303(d) impairments. These include excessive growth of aquatic weeds due to nutrients, TOC that leads to impairment of the use of Delta waters for domestic water supply, certain heavy metals that are toxic to aquatic life, and sediment accumulation that impairs the uses of Delta waters. These problems are primarily identified through the CVRWQCB Basin Plan "narrative" water quality objectives rather than by exceedances of numeric WQOs. There is need to conduct studies to implement the narrative water quality objectives for these and other constituents that are or potentially are causing beneficial use impairment.

This Delta water quality review also addresses deficiencies in current water quality monitoring programs that impede the ability to properly define the full range of Delta water quality problems-beneficial use impairments as well as to serve as the basis to begin to develop a TMDL program to control the WQO violations. This review also presents a summary of characteristics of current Delta water quality problems and suggests the approach that should be followed to control these problems. The current US EPA Clean Water Act and state of California water quality regulatory approach, which is based on defining violations of water quality standards/objectives and then developing a program to control those violations, fails to address the many thousands of chemicals that are present in urban and industrial wastewaters and stormwater runoff as well as discharges/runoff from agricultural areas, which can be adverse to the water quality-beneficial uses of waterbodies.

Periodically, significant environmental pollutants that have been in the environment for many years are discovered to represent a threat to water quality and/or public health. Two recent examples of this type of pollutant are perchlorate and the polybrominated diphenyl ethers (PBDEs). While these chemicals have been present in wastewaters and ambient waters for many years, they are now being recognized as widespread water pollutants. There are likely many other chemicals of this type which

are a threat to water quality through adverse impacts to aquatic life or people who drink the water or who eat fish and other aquatic life derived from waterbodies, but which are not being adequately addressed in water quality evaluation and management programs. The issue of inadequate definition of water pollutants is discussed in more detail below.

Hazardous Chemicals in Edible Fish

A map of the Delta is presented in Figure S1. Various Delta channels/waterways are listed as CWA 303(d) impaired because of the excessive bioaccumulation in fish of mercury, organochlorine "legacy" pesticides (DDT, dieldrin, toxaphene, chlordane, etc.), PCBs, and, near Stockton, dioxins and furans. These organochlorine compounds can cause cancer and neurological damage in humans who eat Delta fish and other organisms that contain elevated levels. The organochlorine pesticides are called "legacy" pesticides because they had been used in agriculture and urban areas but have been banned for use for about 20 years because of their threat to human health. Since these chemicals are highly resistant to degradation in the environment, they are still present in soils and in water sediments downstream of areas where they were applied/used.

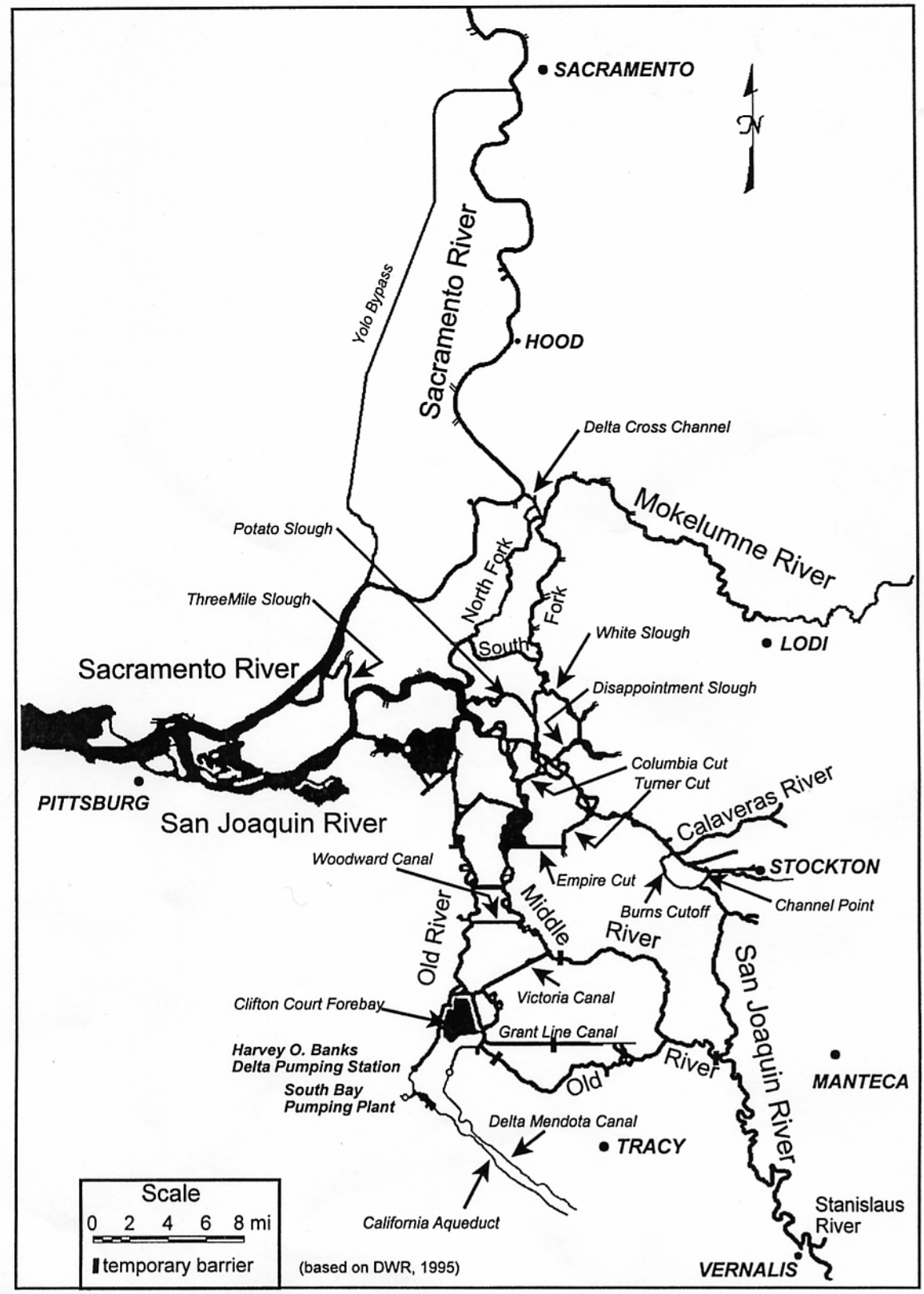
Even though excessive bioaccumulation of organochlorine compounds represents one of the most significant water quality problems in the Delta, at this time there are no funds available to the CVRWQCB or other agencies to evaluate the full extent of excessive bioaccumulation of the organochlorine chemicals that accumulate in Delta edible organisms. Further, no funds are available to define current sources of organochlorine hazardous chemicals or to begin to develop programs for control of the excessive bioaccumulation problem in Delta channels and near-Delta tributaries.

Also of concern is the excessive bioaccumulation of mercury in some types of Delta fish. Consuming mercury-contaminated fish can cause neurological damage in unborn and young children. The excessive bioaccumulation of mercury is also a threat to birds that feed on aquatic life. California Bay-Delta Authority (CBDA) is funding research to evaluate mercury bioaccumulation and its control in order to protect the CBDA Ecosystem Restoration Program's development of shallow water habitat to help restore Delta fisheries.

The chemicals that bioaccumulate to excessive levels in edible fish and other organisms tend to be associated with sediments. Therefore, work needs to be done to determine the role of Delta sediment-associated pollutants as a source of hazardous chemicals that bioaccumulate in edible organisms to levels that are a threat to the health of those who use Delta fish as food.

Overall, there are no funds available in CBDA or the State and Regional Water Boards to address several significant the human health problems of bioaccumulation of hazardous chemicals in Delta fish. This is a significant deficiency in the water pollution control programs in the Delta, Central Valley and California.

Figure S1
Map of the Delta



Toxicity of Currently Used Pesticides

With the banning of the organochlorine pesticides, new pesticides were developed to control agricultural and urban pests. Organophosphorus-based pesticides were developed and have been widely used in agriculture and in urban areas for about 20 years. The most commonly used organophosphorus pesticides are diazinon and chlorpyrifos. While the organophosphorus pesticides are less persistent in the environment than the organochlorine pesticides, they are sufficiently persistent so that runoff from the areas where they have been applied can contain sufficient concentrations to be toxic to aquatic life in the receiving waters for this runoff.

Beginning in the late 1980s the CVRWQCB staff and University of California, Davis (UCD) faculty/staff found that diazinon and chlorpyrifos – two of the most commonly used organophosphorus pesticides – while not highly toxic to fish, are highly toxic to zooplankton (small water animals) that serve as food for young and small fish. This in turn can be detrimental to larger fish that are desirable to fishermen and are important to the Delta aquatic ecosystem. The CVRWQCB staff, with support of the UCD staff, found that waters in many areas of the Central Valley are toxic to zooplankton after organophosphorus pesticide application to agricultural and urban areas.

The presence of zooplankton toxicity in Central Valley waterbodies and Delta channels due to organophosphorus pesticides violates the CVRWQCB Basin Plan WQO controlling aquatic life toxicity. This has led to a CWA 303(d) listing for diazinon- and chlorpyrifos-caused aquatic life toxicity in the Delta channels. It is possible that this toxicity is in part responsible for the decline in the fisheries resources of the Delta. While the CVRWQCB is developing TMDLs to control organophosphorus pesticide toxicity in the Sacramento River and San Joaquin River watersheds, no work is being done to control the diazinon- and chlorpyrifos-caused toxicity in Delta channels. There are insufficient funds to enable the CVRWQCB to initiate work in this area.

With the reduced use of diazinon and chlorpyrifos, pyrethroid-based pesticides are being used increasingly in agricultural and urban areas. Some of these pesticides are as toxic or more toxic to zooplankton than the organophosphorus pesticides, and are also toxic to fish. One important difference between the organophosphorus and pyrethroid pesticides is that the pyrethroid pesticides tend to accumulate in aquatic sediments and are potentially toxic to sediment organisms. These sediment-associated organisms are important as fish food and to the aquatic ecosystem. At this time very little work is being done on investigating pyrethroid pesticide-caused water and sediment toxicity in the Central Valley and the Delta.

The current pesticide registration process used by the US EPA and the California Department of Pesticide Regulation (DPR) allows the use of pesticides that are highly toxic to aquatic organisms without evaluation of whether the pesticide can be present in stormwater runoff and irrigation water discharges at concentrations that are toxic to aquatic life in the receiving waters for the discharges/runoff. This is a significant deficiency in the federal and state of California pesticide registration process. Another deficiency in the current approach used for regulating pesticides is the failure to properly

control aquatic life toxicity associated with additive or synergistic interactions among multiple pesticides in the water or between the pesticide and other chemicals in the water. It is well known that the toxicities of the organophosphorus pesticides diazinon and chlorpyrifos are additive. There is recent evidence that the combination of organophosphorus pesticides with triazine herbicides in water has a synergistic effect on aquatic life toxicity – i.e., the magnitude of the toxicity found is greater than the sum of the toxicities of the pesticide and herbicide. Additive or synergistic toxicity could lead to situations in which a pesticide could be present in concentrations below a water quality objective, yet be causing toxicity to aquatic life through interactions with other pesticides and/or other chemicals.

Sediment Toxicity

Organisms that live in or on aquatic sediments are important to the aquatic food web. A variety of chemicals can cause aquatic sediments to be toxic to aquatic organisms. While Delta sediments are known to contain several potential pollutants (heavy metals and organics) that have the potential to be toxic to aquatic life, there is limited information on the occurrence of toxicity in Delta sediments. This is an area that needs attention to determine where Delta sediments are toxic, and where toxic, the cause of the toxicity. This information is required to begin to remediate the polluted Delta sediments and to control the input of pollutants that accumulate in Delta sediments and cause the sediments to be toxic.

There is need to develop reliable sediment quality objectives to regulate real, significant water quality problems caused by sediment-associated pollutants. Recently the SWRCB staff responsible for developing sediment quality objectives has indicated that it has abandoned trying to use chemical concentration-based objectives in favor of a weight-of-evidence (WOE) approach. The WOE approach involves an integrated use of aquatic life toxicity, organism assemblage and appropriate chemical information to evaluate water quality impairment and causes, and remediation of the impairment. Sediment quality objectives should be based on biological effects, such as aquatic life toxicity, with the toxic substances properly identified through toxicity identification evaluations. Co-occurrence-based approaches, such as those that have been proposed in the past by the SWRCB staff, are well-known to be unreliable for this purpose. Adoption of a WOE approach by the SWRCB will be a significant advance toward properly regulating chemical pollutants in aquatic sediments. One of the major deficiencies of the current SWRCB sediment quality objectives development is the failure to include developing sediment quality objectives (SQOs) for Delta sediments, even though the Bay Protection and Toxic Cleanup Program (BPTCP) requires that SQOs be developed for Delta sediments.

Unknown-Caused Toxicity

Studies by the CVRWQCB staff, UCD Aquatic Toxicology Laboratory staff and others have found that many Central Valley waters, including the Delta, exhibit aquatic life toxicity for which the cause is unknown. The CVRWQCB staff, with support of others, has initiated a program to identify the cause of toxicity in such situations and develop management programs for this toxicity. A draft Strategy for Control of Toxicity

of Unknown Cause is under development. This strategy will be used to support a proposal to CBDA to fund the implementation of a control program. Funding of this effort by CBDA would be in accord with the CALFED Record of Decision (ROD) which requires work to control the cause of unknown-caused toxicity in the Delta.

Heavy Metals

Several of the Delta tributaries are listed as 303(d) impaired due to heavy metals from former mining activities in the Delta watershed. Mercury from former Coast Range mercury mining operations and from gold mining operations in the Sierra-Nevada Mountains has been found to bioaccumulate in fish of the Delta and its tributaries. This accumulation is of sufficient magnitude to cause the fish to be hazardous to fetuses and young children when the contaminated fish are eaten by the mother or the child.

Selenium is another metal that is potentially causing water quality problems in the Delta. It bioaccumulates in the Delta food web and is potentially causing adverse impacts to certain higher trophic-level fish, notably sturgeon. This situation could cause even greater restrictions on the discharge of selenium to Delta tributaries in the San Joaquin River watershed than exist today.

There is a potential for food web accumulation of cadmium and nickel that is toxic to aquatic life. The bioaccumulation of these metals, as a cause of aquatic life toxicity, is not regulated under the current US EPA water quality criteria or CVRWQCB Basin Plan water quality objectives.

Some Delta sediments, such as in marinas, have been found to contain elevated concentrations of copper, possibly due to the use of copper in antifoulant paints on boat hulls.

In summary, past mining operations and current sources of heavy metals require that studies be conducted to determine the water quality significance of several heavy metals in Delta and Delta tributary water and sediments.

Drinking Water Quality Problems

From 10,000 to 13,000 cfs of Delta water is exported from the Central and South Delta for use for domestic water supplies in the San Francisco Bay area (Contra Costa and Santa Clara Water Districts) and Southern California (Metropolitan Water District of Southern California), and for agriculture in the Central Valley. About one-half of the exported water is used for domestic water supply. Delta water contains several constituents (TOC, bromide, nutrients and TDS/EC) that cause domestic water supply water quality problems that increase the cost of treatment. Of particular concern are the constituents – notably total organic carbon (TOC) and bromide – that form trihalomethanes (THMs) during water supply disinfection. THMs are chloroform and chloroform-like compounds that are regulated as carcinogens. The TOC is derived from runoff from agricultural and urban areas, wetlands, and Delta island peat soils; terrestrial plants and higher forms of aquatic plants. The bromide is derived from sea water intrusion into the Delta from San Francisco Bay.

The CBDA Drinking Water Subcommittee is developing a drinking water quality management strategy. The CVRWQCB is also reviewing drinking water quality problems in the Delta, associated with developing a Drinking Water Policy. There are major water quality management issues that will need to be addressed as part of developing a technically valid, cost-effective drinking water quality policy for the Delta, such as whether it is more appropriate to try to control TOC in agricultural runoff and urban stormwater and wastewater discharges at the source, or to treat the part of the export waters that are used for domestic water supply purposes to control the TOC/THM problem at the water treatment works.

The total salts (measured as total dissolved solids (TDS) and electrical conductivity (EC)) in Delta waters are of concern to the Southern California drinking water utilities, since elevated TDS/EC in the water supply restricts the ability of water management agencies to recharge the treated wastewaters to groundwaters for future use as a domestic water supply.

Aquatic plant nutrients (nitrogen and phosphorus compounds) are derived from runoff and discharges from agricultural areas (including dairies and feedlots), wetlands discharges, urban wastewater discharges and stormwater runoff. The nutrients cause excessive growth of algae that cause tastes and odors in drinking water and decrease the length of filter runs for water utilities that use Delta waters as a water supply source. These water quality problems are controlled with increased water treatment at an increased cost. Efforts are being made by water utilities and regulatory agencies to control the constituents responsible for such impairments at their sources in the watershed. This could lead to significantly increased of cost of pollution control to agricultural and urban interests in the Delta watershed.

Impact of Salts on Agriculture in the South Delta

The San Joaquin River water that flows into the South Delta via Old River at times contains sufficient salts (TDS/EC) to cause violations of the CVRWQCB Basin Plan water quality objective for TDS/EC for the South Delta channels. The first phase of the currently proposed CVRWQCB Basin Plan Amendment to limit TDS discharges to the SJR upstream of Vernalis will not address this problem since the TDS/EC TMDL target that has been proposed by the CVRWQCB staff is the TDS/EC WQO for the South Delta channels. This means that South Delta irrigated agriculture tailwater discharges to the South Delta channels will at times cause violations of the WQO. These violations will be the result of the high salt loads to the Delta via the SJR that currently occur and are proposed to be allowed by the CVRWQCB as part of the initial phase of the San Joaquin River TDS/EC TMDL. There is need to control the TDS/EC discharges in the SJR watershed to a greater degree than that proposed by the CVRWQCB, so that the SJR waters that enter the South Delta will not be in violation of TDS/EC WQOs and will be suitable to South Delta agriculture that does not impair crop production and restrict tailwater discharges..

Nutrient Impact on Delta Aquatic Resources and Agricultural Water Supplies

Delta waters experience excessive growths of aquatic plants such as water hyacinth and *Egeria densa*. These water weeds interfere with recreational use of Delta waters for boating, swimming, water skiing, fishing, etc. The water weeds develop on nutrients added to Delta tributaries from urban, agricultural and wetlands sources in the Delta watershed, and from Delta island discharges. The California Department of Boating and Waterways spends several hundred thousand dollars per year to apply chemicals for controlling water weeds. There is concern about the potential toxic and other impacts of these chemicals on non-target organisms, such as fish food organisms, in the water column and sediments.

The excessive nutrients in Delta, Delta tributary and Delta export waters lead to the growth of sufficient algae and other aquatic plants to interfere with the transport of the waters in irrigation systems, including canals, by Delta watershed and in-Delta irrigation districts. The algae and water weeds plug irrigation system screens and drip-irrigation systems. Many irrigation districts treat these waters with herbicides to prevent aquatic plant growth in the irrigation water supply system. There is concern that the herbicides are toxic to non-target organisms and thereby impair aquatic life resources of the waters receiving the irrigation waters. While, in the past, irrigation districts could apply aquatic herbicides without evaluating the potential for adverse impacts on non-target organisms, the SWRCB has been developing a permit system that could require monitoring of the treatment area for adverse impacts to aquatic resources in the area of treatment and downstream. However, the recently adopted Statewide General NPDES permit for application of aquatic herbicides falls short of providing adequate protection of non-target organisms from toxicity impacts of herbicides. It is essential that the NPDES permit covering aquatic herbicide application include comprehensive aquatic life toxicity testing and bioassessments to determine if the herbicides used and their transformation products, either alone or in combination with other chemicals in the water through additive or synergistic effects, are adverse to non-target organisms.

Low Dissolved Oxygen Problems

The nutrient-rich waters of the SJR upstream of the Deep Water Ship Channel (DWSC) lead to the development of sufficient algae in the SJR as it enters the DWSC to be a major contributor of oxygen demand that leads to the low-DO problem in the DWSC. The algae in the SJR do not cause low-DO water quality problems in the SJR upstream of the DWSC. However, the decomposition of algae that die in the DWSC is at times a major cause of oxygen depletion there which causes DO concentrations to fall below the WQO.

One of the recently documented problems caused by the export of South Delta water by the federal and state projects is the reduction of the flow of the SJR through the Deep Water Ship Channel near Stockton. The export pumping of South Delta water by the federal and state project pumps at Tracy and Banks causes most of the water in the SJR at Vernalis to be drawn into the South Delta via Old River, leaving little of the SJR flow to pass through the DWSC. This diversion of SJR flow into the South Delta is at times a major cause of severe low dissolved oxygen problems in the DWSC. If most of

the SJR flow at Vernalis were allowed to pass through the DWSC before being exported to Central and Southern California, there would typically be sufficient flow to reduce/prevent the development of the low-DO problem in the DWSC.

The DeltaKeeper-supported studies conducted by the authors in the summer 2003 on South Delta channels showed severe DO depletion in Old River near the Tracy Boulevard bridge. At the time of the tour of this area on August 5, 2003, a fish kill had just occurred; many thousands of fish were seen floating on the water surface there. Data from DWR's continuous water quality monitoring station in the area of the fish kill showed that the DO there had been at or near zero for about six hours the previous night. Thus, the fish kill was likely due to low DO. A review of the DWR 2003 data obtained for Old River showed that there was a period of about six weeks beginning in late July when the DO in that channel was below the WQO. There were many days when the DO was less than 1.0 mg/L, compared to the 5 mg/L WQO. Similar situations have been recorded in that channel and some other South Delta channels over the past three years, and likely occurred before then as well. The severe low-DO problems in some of the South Delta channels are apparently the result of the decay of excessive algal growths.

The DeltaKeeper also supported two tours by the authors of Central Delta channels during the summer 2003 to investigate the mixing of Sacramento River water with San Joaquin River water that is present in the Deep Water Ship Channel. The SJR DWSC water enters the Central Delta through Turner Cut and Columbia Cut where it mixes with Sacramento River water that is drawn to the South Delta via Middle River by the state and federal export projects. This mixing of Sacramento River water with SJR water in Turner Cut dilutes the oxygen demand, EC and other pollutants in the SJR DWSC waters, and thereby reduces the impact of introduction of SJR DWSC water into the Central Delta on Central Delta water quality. This is important because it means that the increased flow of the SJR through the DWSC which has been proposed as a means to help solve the low-DO problem will not in general have adverse impacts on Central Delta water quality. There may, however, be adverse impacts under certain flow and seasonal conditions. Specific studies need to be conducted to evaluate this situation.

Another major source of oxygen demand in the DWSC is the ammonia in the city of Stockton's domestic wastewater discharges. At times, the ammonia in the City's wastewater discharge to the SJR just upstream of the DWSC represents about 90 percent of the oxygen demand load to the DWSC. Under the revised CVRWQCB NPDES wastewater permit conditions designed to control ammonia toxicity to aquatic life, the city of Stockton's discharge of ammonia will need to be significantly reduced. This reduction will significantly reduce the oxygen demand load of Stockton's wastewater ammonia to the DWSC.

Delta fisheries have been declining over the past 20 years or so. Populations of lower trophic-level fish-food organisms (the zooplankton and phytoplankton that make up the lower level of the food web) have also declined one to two orders of magnitude since the 1980s. While the cause of this decline is not understood, it may be due in part to a decrease in algal populations in the Delta which could be caused by invasive species

(Asian clams) that consume algae and zooplankton. Another potential cause of reduced algal growth in the Central Delta is the export pumps' drawing of large amounts of low-nutrient Sacramento River water through the Central Delta to the South Delta. 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. There is need to better understand the food web in the Delta to evaluate how manipulation of nutrients and algal loads to the Delta will impact Delta aquatic life resources.

Sediment Oxygen Demand

Studies of the bedded sediment oxygen demand (SOD) of the DWSC sediments have shown that it is not unusually high. It appears that the tidal currents cause the dead algae that would normally settle to the bottom and exert an SOD to be suspended in the water column near the bottom of the channel where the oxygen demand of the particulate matter (principally dead algae) is exerted.

Sanitary Quality of Delta Waters

The sanitary quality indicators in Delta waters have been found in some Delta waters to be in violation of water quality objectives for contact recreation, including swimming, water skiing, wading, etc. Studies on Delta waters have shown that they contain fecal coliforms at concentrations that have been associated with the presence of enteric (intestinal) pathogens (disease-causing organisms). As a result, those who have contact with some Delta waters are exposed to disease organisms that can cause a variety of enteric and other illnesses.

The sanitary quality of Delta waters is also of concern to the water utilities that use Delta waters as a water supply. The violations of the sanitary quality WQOs mean that the use of Delta waters for domestic water supply is a threat to cause diseases in those who drink the water without adequate treatment.

Sediment Accumulation

Some South Delta channels are experiencing shoaling (loss of water depth) due to the accumulation of sediment in the channels. The sediment accumulation is also detrimental to benthic (bottom-dwelling) organisms' habitat. The excessive sediments are apparently derived from erosion of agricultural lands in the watersheds of the westside tributaries of the San Joaquin River. Erosion in the San Joaquin River watershed also causes increased turbidity, which reduces light penetration and algal growth.

Managed Wetlands as a Source of Pollutants

The Delta watershed contains several federal and state wildlife refuges and private migratory waterfowl gun clubs. Many of these areas are managed to produce crops for wildlife. Runoff/discharges from managed wetlands contain several chemical constituents (TOC, salts and nutrients) that impair Delta water quality. As part of its agricultural waiver program, the CVRWQCB is requiring that the owners/managers of managed wetlands investigate the discharge of potential pollutants to Delta tributaries.

This could lead to requirements for managing these discharges to protect Delta water quality.

Impact of Invasive Species

The Delta has been polluted by a variety of invasive species, such as the Asian clam, which are significantly adversely impacting the beneficial uses of Delta waters. It appears that the consumption of phytoplankton and zooplankton by this clam could be responsible for at least part of the decline in the lower trophic-level food web in the Delta.

Several types of aquatic plants (such as water hyacinth, *Elodea* and *Egeria densa*) are invasive plant species that are impairing the beneficial uses of Delta waters.

Impact of Export Projects on Chinook Salmon Home Stream Water Signal

The South Delta export projects that have changed the flow of Sacramento and San Joaquin River water through the Delta have also changed the transport of the home stream chemical signal which guides Chinook salmon to their spawning areas. Prior to the export projects, the San Joaquin River tributary home stream water chemical signal could be transported, during low-flow conditions, to San Francisco Bay, providing a home stream signal to fall-run Chinook salmon proceeding to their San Joaquin River tributary home stream. The export-project-caused drawing of large amounts of Sacramento River water to the South Delta has eliminated the San Joaquin River tributary home stream water signals from occurring in the Central and northern Delta, downstream of Columbia Cut. During the summer, fall and early winter the water in the San Joaquin River channel downstream of Columbia Cut is Sacramento River water, not San Joaquin River water. This means that when the fall-run Chinook salmon enter the Delta from San Francisco Bay during the fall and winter they have no home stream water signal to help them migrate through the Delta to their home stream waters.

Inadequate Water Quality Monitoring/Evaluation

As part of SWRCB water rights decision D-1641, several agencies, through the Interagency Ecological Program (IEP), conduct an Environmental Monitoring Program (EMP) that is to provide information on the impacts of Delta water exports to central and Southern California on Delta resources and water quality. A critical review of the IEP EMP shows that it falls short of adequately defining the full range of water quality impacts of the export of Delta water by the federal project (Central Valley Project – CVP) and state project (State Water Project – SWP). These exports are having major adverse impacts on DO concentrations in the SJR Deep Water Ship Channel and in several South Delta channels. They are also causing pollutants – such as mercury; organochlorine, organophosphorus and pyrethroid pesticides; and other pollutants such as TOC and heavy metals – that enter the Delta from tributary and in-Delta sources to be transported to areas of the Delta where they would not occur at the same concentrations if the South Delta exports did not occur.

The large amount of Sacramento River water that flows through the central Delta to the South Delta export pumps significantly changes the flow of water and pollutants in

the Delta. For example, mercury present in Sacramento River water is transported to the central and South Delta via the Central Delta Old River and Middle River channels as a result of the export of South Delta water by the projects. This export changes the occurrence of mercury in Delta channels, which potentially impacts the excessive bioaccumulation of mercury in Delta fish. There has been essentially no evaluation of the impact of the export of South Delta waters at the Tracy and Banks pumps on a variety of Delta water quality problems. Particular attention should be given in an expanded monitoring/evaluation program to defining the full impact of the export of Delta waters by the federal and state projects.

There is need for a significant expansion of the water quality monitoring/evaluation program in the Delta. This expanded water quality monitoring should be focused on an evaluation of the current extent and magnitude of the 303(d) impairments in the currently listed Delta channels. Also, where the expanded monitoring/evaluation program shows water quality use impairment, the sources of the pollutants responsible for the impairment should be defined. This information is essential to begin to develop a TMDL management program for the 303(d)-listed Delta channels.

The Clean Water Act of 1972 required that the US EPA develop a list of the Priority Pollutants and develop water quality criteria for them. The Agency was not given sufficient funding by Congress to accomplish this requirement, and therefore did not meet the congressionally established deadline. Litigation by an environmental group led to an agreement which established 129 Priority Pollutants. The list was developed by attorneys and was not peer-reviewed by the US EPA staff who were experts in this area or by professionals outside the Agency. It is recognized that the Priority Pollutant list did not and does not represent an appropriate listing of the wide variety of chemicals that are a threat to cause water pollution. It is also recognized that the currently regulated pollutants, such as the Priority Pollutants, represent a very small portion of the chemicals that are present in municipal, industrial and agricultural wastewaters and stormwater runoff that are a potential threat to water quality-beneficial uses of waterbodies. Unfortunately, however, the focus of water pollution control programs has been largely devoted to the Priority Pollutants, while ignoring many of the other chemicals used by urban populations, industry and agriculture that are a threat to cause water pollution. For example, more than 150 pesticides are used in the Central Valley, yet fewer than half a dozen receive any regulatory attention by the CVRWQCB. Even though there are significant problems with using the Priority Pollutant list as a primary list of hazardous chemicals of concern in the Delta and discharges to the Delta, there is inadequate monitoring of the Priority Pollutants in Delta waters.

There are more than 22 million organic and inorganic substances, with nearly 6 million commercially available. One hundred thousand of these are produced in large amounts. The current water quality regulatory approach addresses fewer than 200 of these chemicals. Another component of an expanded monitoring/evaluation program for the Delta should include a substantial program for searching for yet-unidentified water quality beneficial use impairments of Delta waters. Where found, the magnitude and extent of the impairment and the source of the pollutants should be defined. In addition

to monitoring/evaluating potential water quality problems caused by conventional pollutants and Priority Pollutants, attention should be given to pharmaceuticals and personal care products (PPCPs) and endocrine disruptors that are present in domestic and other wastewaters and stormwater runoff that are discharged to the Delta and its tributaries, especially by the cities of Stockton, Tracy, Sacramento and West Sacramento. Also of potential concern are the wastewater discharges from Modesto, Merced and other San Joaquin River watershed municipalities and agricultural activities.

The PPCPs are a diverse group of chemicals, including human and veterinary drugs that are available over the counter and by prescription, food supplements, consumer chemicals such as fragrances and sunscreen agents, and the wastes from the manufacture of these and other materials. In general PPCPs and many other chemicals are not regulated with respect to causing water quality impairment. With increasing urban population and industrial activities in the Central Valley, there will be increasing significance of PPCPs and other pollutants derived from urban and industrial activities as a cause of water quality problems in the Delta. This is an area that needs attention in a Delta water quality monitoring/evaluation program. Additional information on PPCPs is available at www.epa.gov/nerlesd1/chemistry/pharma/index.htm.

Another significant deficiency in the current regulatory approach in defining water quality problems in the Delta and elsewhere is that chemical impacts are assessed based on individual chemicals without consideration of additive or synergistic effects. It is well established that the aquatic life toxicities of some combinations of pesticides are additive. Further, the toxicity of certain pesticide combinations show synergistic effects – i.e., the toxicity of a mixture of the pesticides is greater than the sum of the toxicities caused by the individual pesticides.

Another area that needs attention in an expanded water quality monitoring/evaluation program is the potential for various chemicals in domestic and commercial wastewater discharges and agricultural and urban stormwater runoff to be adverse to the migration of anadromous fish through the Delta to their home stream waters in the San Joaquin and Sacramento River watersheds. It is known that low concentrations, below those that are known to be toxic to fish and other forms of aquatic life, of a variety of chemicals – such as heavy metals, pesticides, PPCPs, etc. – can adversely impact the olfactory sensitivity and homing ability of anadromous fish such as Chinook salmon. There is need to determine if there are pollutants in Delta waters that are adverse to the homing of anadromous fish.

The funding for an expanded monitoring/evaluation program should be provided by the Delta water exporters, those who discharge wastewaters and contribute stormwater runoff to the Delta and its tributaries, and the users of Delta aquatic resources. The recent cuts in SWRCB water quality monitoring funding should be immediately reversed, and funding should be significantly expanded to cover defining current water quality problems, the sources of the constituents responsible for these problems, and the efficacy of water pollution control programs in controlling these problems, and to define yet-unidentified pollutants in the Delta and its tributaries.

The recently proposed CBDA Delta water exporters' "Delta Improvements Package" (DIP), in which additional Delta water would be exported to Central and Southern California by the State Water Project, is significantly deficient in defining the potential water quality impacts of additional Delta water exports. Before the proposed DIP is implemented with respect to increased Delta water exports, a comprehensive understanding of the current impacts of the existing exports should be developed. This information should then be used to predict the potential impacts of increased Delta water export, in order to provide a technically reliable basis upon which to establish appropriate mitigation measures for the Delta water quality problems caused by the export pumping of Delta water.

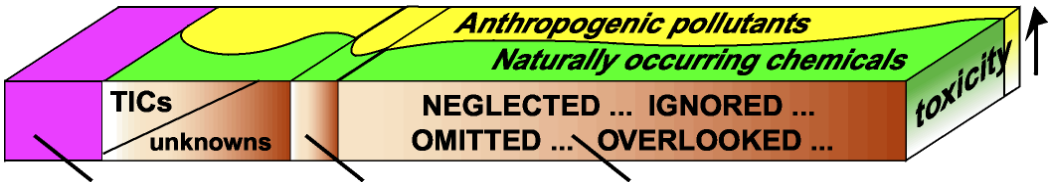
Appendix B
Inadequate Scope of Water Quality Monitoring

The inadequacy of current regulatory programs in defining hazardous chemicals has been discussed by Dr. Christian Daughton, Chief of the Environmental Chemistry Branch, National Exposure Research Laboratory, Office of Research and Development, US EPA, Las Vegas, Nevada, in his presentation, "Overview of Science Involved with Pharmaceuticals," that was made on August 23, 2005. Daughton stated in one of his PowerPoint slides,

> *"Further Truisms Regarding Environmental Monitoring*
> - *What one finds usually depends on what one aims to search for.*
> - *Only those compounds targeted for monitoring have the potential for being identified and quantified.*
> - *Those compounds not targeted will elude detection.*
> - *The spectrum of pollutants identified in a sample represent but a portion of those present and are of unknown overall risk significance."*

He presented a diagram of this situation, which is presented in Figure 1. Dr. Daughton's presentation at the Las Vegas workshop is available from gfredlee@aol.com upon request. While this presentation focused on pharmaceuticals, as he has discussed in other presentations and his writings, it is applicable to the full arena of hazardous chemicals that are not adequately identified, monitored and regulated.

Figure 1
Chemical Analysis Output for a Typical Environmental Sample



TICs = tentatively identified compounds

This figure is cited from the following web page:
Daughton, C. C., "The Critical Role of Analytical Chemistry," July (2002)
http://www.epa.gov/nerlesd1/chemistry/pharma/critical.htm

Appendix C
Drs. G. Fred Lee and Anne Jones-Lee's Background Pertinent to Assessment of Delta Water Quality

Dr. G. Fred Lee is President of G. Fred Lee & Associates, which consists of Drs. G. Fred Lee and Dr. Anne Jones-Lee (Vice President) as the principals in the firm. This discussion of San Joaquin River and Delta water quality is based on G. Fred Lee's academic background and professional experience, which includes a BA degree from San Jose State College in environmental health sciences in 1955, a Master of Science in Public Health focusing on water quality issues from the University of North Carolina in 1957 and a PhD in environmental engineering/environmental science from Harvard University in 1960. Beginning in 1960 for a period of 30 years he held university graduate-level professorial teaching and research positions at several major US universities, including the University of Wisconsin, Madison, the University of Texas system and Colorado State University. In 1989 he retired from university teaching and research as a Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology, where he also held the position of Director of the Site Assessment and Remediation division of a multi-university hazardous waste research center and, for a several-year period, Director of the Water Quality Program for the State of New Jersey Sea Grant Program. During his 30-year university teaching and research career he conducted in excess of five million dollars of research and published over 500 papers and reports on these efforts.

Dr. Anne Jones-Lee was a university professor for a period of 11 years in environmental engineering and environmental sciences. She has a BS degree in biology from Southern Methodist University and obtained a PhD in Environmental Sciences in 1978 from the University of Texas at Dallas focusing on water quality evaluation and management. At the New Jersey Institute of Technology she held the position of Associate Professor of Civil and Environmental Engineering with tenure. She and Dr. Lee have worked together as a team since the mid-1970s.

Dr Lee's areas of expertise include work on fate, effects and impacts of chemical constituents and pathogens on various aspects of water quality-beneficial uses of waterbodies. He has frequently served as an adviser to local, state, national and international governmental agencies and other entities on a variety of aspects of water quality, including water quality criteria and standards development and their appropriate implementation. This activity included serving as an invited peer reviewer for the National Academies of Science and Engineering "Blue Book" of water quality criteria in 1972, a member of the American Fisheries Society Water Quality Committee that reviewed the US EPA's "Red Book" water quality criteria of 1976, and a US EPA invited peer reviewer in the early 1980s for the approach that the Agency then proposed and finally adopted for developing water quality criteria for protection of aquatic life. This is the same criteria development approach that is in existence today. Further, Dr Lee was involved as a US EPA invited peer reviewer for several criteria documents. His work on water quality issues is somewhat unusual, in that, in addition to having a strong background in the chemical and biological sciences pertinent to water quality evaluation,

he also has an engineering background in developing control programs for chemical constituents in point and nonpoint source discharges. I am familiar with how national water quality criteria are develop and how they should be implemented to protect the water quality related beneficial uses of waterbodies without significant unnecessary expenditures for potential pollutant control.

In 1989, Dr Lee retired from university teaching and research and expanded his part-time consulting activities that he conducted while a university professor into a full-time activity. While living in New Jersey he became involved in three different consulting jobs in California, one of which was concerned with Delta water quality issues. Another was concerned with Lake Tahoe water quality, and the third was on behalf of the Metropolitan Water District of Southern California, on groundwater quality protection in the San Gabriel Basin. It was at that time that Dr. Anne Jones-Lee and he moved from New Jersey to El Macero, which is adjacent to Davis, CA about 11 miles from Sacramento. Since 1989 they have maintained a two-person specialty consulting firm, working on water supply water quality, water and wastewater treatment, water pollution control for both fresh and marine surface waters, and solid and hazardous waste impact evaluation and management, with particular emphasis on groundwater quality protection. They have continued to be active in publishing the results of their studies, where in the last 15 years they have added another 600 papers and reports covering work they have done in their various areas of activity. One of these areas is San Joaquin River and Delta water quality.

Dr. Lee's initial work on Delta water quality occurred in the summer of 1989, where he was asked to be a consultant to Delta Wetlands on water quality issues associated with the development of in-Delta storage reservoirs. As part of this effort he became familiar with Delta water quality issues. Dr. Lee's work on Delta water quality issues has included participating in various CALFED (now California Bay-Delta Authority – CBDA) committees, subcommittees, working groups, etc., concerned with water quality issues in the Delta and its tributaries.

Beginning in the mid-1990s Dr. Lee became involved in the details of water quality issues in both the Sacramento and San Joaquin River watersheds. Beginning in the 1990s he began to work with William Jennings (the DeltaKeeper) as a volunteer technical adviser to help the DeltaKeeper focus its activities on technically correct positions on water quality management. This approach has provided Dr. Lee with an opportunity to become involved in a variety of areas that are of particular significance to the DeltaKeeper's efforts to improve the quality of science and protection/enhancement of water quality of the Delta and its tributaries. Dr. Lee's work with the DeltaKeeper included addressing such issues as managing aquatic life toxicity in the Central Valley and Delta due to pesticide runoff/discharges from agricultural and urban areas, reviewing and managing excessive bioaccumulation of organochlorine legacy pesticides and PCBs in Central Valley waterbodies and the Delta, review of the potential environmental impacts of aquatic pesticides used for aquatic weed control in the Central Valley and Delta, impact of flow management in and from the South Delta on water quality, and

providing guidance on environmental aspects of dredging and dredged sediment management in the Delta.

One of Dr. Lee's major areas of work has been on the San Joaquin River Deep Water Ship Channel low-DO problem. Beginning in 1999, Dr. Lee worked closely with the SJR DO TMDL Steering Committee as well as the Central Valley Regional Board staff in helping to formulate and implement higher quality science and engineering in the San Joaquin River low-DO TMDL program. This included Dr. Lee being awarded a contract with the CVRWQCB, to develop an "Issues" report of the issues that need to be addressed as part of formulating a TMDL to control the low-DO problem in the San Joaquin River DWSC. This issues report is available as,

> 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

Dr. Lee worked closely with the Central Valley Regional Water Quality Control Board lead staff (Dr. Chris Foe) in developing a coherent two-million-dollar proposal, which was funded by CALFED. Dr. Lee served as the coordinating PI for 12 projects that were conducted under this proposal. This work resulted in a 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 and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003).
> http://www.gfredlee.com/SynthesisRpt3-21-03.pdf

This report presents a summary/synthesis of approximately four years and four million dollars of studies on the SJR DWSC low-DO problem. Since completion of the synthesis report in March 2003, Drs. Lee and Jones-Lee have continued to be active in Delta water quality issues. They have developed a series of reports on these issues that are available from their website, www.gfredlee.com, in the San Joaquin River Watershed section. They have developed a synthesis report supplement that presents a review of the various studies that they have conducted over the past two years that are pertinent to investigating and managing Delta water quality issues. This work has included detailed review of San Joaquin River and South Delta water quality.

Drs. G. F. Lee and Anne Jones-Lee have developed several reports on Delta and its tributaries water quality. These papers and reports are available on their website, www.gfredlee.com.

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Further information on Drs. Lee and Jones-Lee's experience pertinent to assessment of Delta water quality issues is available on their website, www.gfredlee.com, or upon request.