Impact of Dairy Wastes on San Joaquin River and Delta Water Quality Issues

Report to As You Sow
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Synopsis of Findings

The long history of inadequate management of dairy waste in the Central Valley of California has contributed to the pollution of the San Joaquin River (SJR) and its tributaries. "As You Sow," an environmental organization in the San Francisco Bay area, requested that we (Drs. G. Fred Lee and Anne Jones-Lee) review the impact of dairies in the San Joaquin River watershed on water quality in the San Joaquin River (SJR) and the Sacramento San Joaquin Delta (Delta). Presented herein are our findings on the current role of dairy wastes in the pollution of surface waters in those areas. Issues concerning pollution of area groundwater by current dairy waste management practices were not a focus of this report, except with respect to pollution of shallow groundwater by constituents of dairy wastes, which, in turn, discharge to surface waters in an SJR tributary and the SJR. References to groundwater in this report refer to shallow groundwaters that discharge to surface waters.

Past Pollution of SJR Watershed by Dairies

In 2003 the state of California Water Resources Control Board (SWRCB) had a private consulting firm, Brown, Vence and Associates, conduct a review of the pollution of waters in the Central Valley by dairies, focusing on groundwaters (BVA, 2003). Their report documented that dairies in the Central Valley were causing significant water pollution due to inadequate management of dairy waste. While the focus of this report was groundwater pollution it has applicability to surface water pollution as well. They noted manure, bedding, hair, spilled feed, and leachate from silage as sources of wastes, and primary pollutants from animal wastes to include nitrogen compounds, salts, organic matter, pathogens, antibiotics, pesticides, and hormones (BVA, 2003). The results of the SWRCB review of the pollution of waters by dairies stimulated the Central Valley Regional Water Quality Control Board (CVRWQCB) to develop improved dairy waste management programs that included discharge requirements for dairy wastes focused on significantly reducing, but not necessarily eliminating, water pollution by manure and liquid wastes from dairies.

Updated Management/Monitoring Program

Based on the findings of Brown, Vence and Associates (BVA, 2003), the CVRWQCB/SWRCB developed regulations for dairy wastes, which were released in 2007. In 2011 the timetable for implementation of the 2007 dairy waste regulations was relaxed to allow greater opportunity for compliance; this change was precipitated by US EPA litigation settlement in matters outside the issue of Central Valley dairy wastes.

Significant water quality degradation of the San Joaquin River and its tributaries, as well as of the Delta, could be due in part to discharges of pollutants by dairies. The potential pollutant

from dairies that has been of greatest concern is nitrogen in the form of ammonia, which is toxic to aquatic life in receiving waters and which, under environmental conditions, converts to nitrate which is an aquatic plant nutrient. More recently, concern has been raised about the presence of hormones, steroids, and pharmaceuticals used to treat dairy herds in dairy wastes and in surface waters receiving dairy waste discharges/runoff. The CVRWQCB's 2007 expanded regulatory approach requires that dairies adopt waste control measures focused largely on the land application of dairy waste so as to control nitrogen runoff/discharges to surface waters. The expanded approach also requires monitoring programs that should, if adequately implemented, be able to demonstrate whether the dairy waste management programs have been effective in detecting and controlling fish toxicity due to dairy-derived ammonia. By 2012/2013 each dairy has to develop a Nutrient Management Plan to establish a mass balance between total nutrients applied to land as part of dairy waste management practices and nutrients taken up by crops in areas of waste application. Further, all surface water runoff from dairies is to be monitored to determine whether it contains elevated concentrations of nitrogen and phosphorus compounds that could stimulate excessive growths of aquatic plants in the waters receiving the runoff.

In establishing the dairy waste management program the CVRWQCB acknowledged that the dairy waste control program was to "balance" the control of impacts of dairy wastes and the costs of additional control of dairy waste discharges to surface and groundwater. The CVRWQCB stated that taking such a "balanced" approach is in the best interest of the people of California. From our perspective the position of the "balance" is somewhat controlled by the limitations on the price of milk; apparently it is not possible to raise the amounts of money that dairies are paid for milk and milk products sufficiently to cover the cost of improved waste management.

Need for More Comprehensive Monitoring

The dairy waste monitoring program adopted in 2007 and updated in 2011 is intended to detect discharges of some of the potential pollutants in dairy wastes. That program, however, is not adequate to quantify the load and the water quality impacts of the discharges of dairy waste-derived pollutants. Since many of the pollutants in dairy wastes are also in other sources such as irrigated agriculture runoff/discharges, a much more comprehensive monitoring program will be needed to distinguish water quality impairments attributable to dairy waste-derived constituents from those caused by other sources of contaminants. It is possible that implementation of existing and potential total maximum daily loads (TMDLs) will provide some of the information needed to evaluate and quantify water quality impacts of the currently allowed dairy waste discharges to surface waters in the SJR watershed.

Impact of Nutrient Discharges

A major problem still exists in evaluating the water quality impacts of the aquatic plant nutrients (nitrogen (N) and phosphorus (P) compounds) in dairy waste discharges because the CVRWQCB/SWRCB has not provided guidance on how to evaluate water quality impacts of a particular discharge of nutrients. While not listed as a cause of Clean Water Act section 303 (d) "impairments" in the SJR and Delta because of a lack of numeric water quality criteria/standards/objectives (WQOs), nutrient discharges and a lack of guidance on implementation of the narrative water quality objectives limiting "Biostimulatory Substances" in the SJR/Delta watershed are significantly impairing the water quality –beneficial uses of the SJR

and Delta through the stimulation of planktonic and attached algae and floating and rooted attached aquatic plants in the Delta. Also of concern is the impact of nutrients in Delta waters on the growth of algae that cause tastes and odors in domestic water supply reservoirs in the San Francisco Bay area and in southern California.

At present, nutrients are to be regulated under narrative WQOs for "Biostimulatory Substances," i.e., substances that stimulate aquatic plant growth. As required by the US EPA under the Clean Water Act, and as an activity independent of concerns about impacts of dairy wastes, the SWRCB recently initiated a program to develop specific WQOs for nutrients in the freshwaters of California. Once those criteria have been developed and implemented to address excessive fertilization of aquatic plants that cause water quality problems in the SJR and Delta (which could likely be at least five years hence, but more likely in 10 to 15 years) and TMDLs have been implemented to control violations of the water quality objectives from all sources of nutrients discharged to SJR tributaries, SJR and the Delta, the role of residual dairy discharges of nutrient to surface waters that are allowed by current regulations can be evaluated. This is because at this time there are no WQOs or TMDLs (regulatory tools) for nutrients against which discharges of nutrients from dairy wastes and other sources can be assessed for regulation. It is possible that the balancing of the cost of controlling nutrients, and for that matter some other residual pollutants, in dairy wastes with income derived from milk and other milk products will be a factor in determining the degree of nutrient control that can be achieved in dairy-waste discharges/runoff. Economic factors will also likely be a consideration in controlling nutrient discharges from irrigated agriculture in the Central Valley.

The CVRWQCB/SWRCB should establish a committee/contract to develop guidance on how the CVRWQCB "Biostimulatory Substances" WQO will be applied to nutrients discharged by dairies and irrigated agriculture in the SJR watershed to adequately consider the excessive fertilization issues in the SJR and Delta.

Impact of Reductions in Phosphorus Loads to the Delta on Fishery Resources
Decreasing the phosphorus loads to the Delta from key sources, including possibly dairy wastes, will likely have adverse impacts on Delta fish populations that rely on the Delta as a nursery area. It will be important to understand and then balance phosphorus load reductions needed to control excessive phytoplankton and other aquatic plant biomass with sufficient phosphorus loading to support desired fisheries in and associated with the Delta.

Groundwater as a Source of Dairy Nutrients for the SJR Waters
Studies by the USGS have demonstrated that nutrients, especially nitrate, that pollute shallow groundwater near the SJR and its tributaries can pollute surface waters. Studies should be conducted of the pollution of shallow groundwaters by dairies located near surface waters to determine if the dairy-polluted shallow groundwater is contributing nutrients and other pollutants to surface waters.

Hormones, Steroids, and Pharmaceuticals
Dairy herds are treated with hormones, steroids, and pharmaceuticals. Those chemicals are of concern in surface waters because they have the potential to be adverse to human health and to aquatic life. A recent study of dairy wastes found that residues of those types of chemicals are

present in dairy wastes. There is need for additional study of all chemicals and their transformation products in the wastes at variety of dairies. ("Transformation products" are products of chemical/biochemical transformation of the original (parent) chemical. They are chemicals that are produced when the original (parent) chemical enters into chemical and biochemical reactions in the environmental systems into which the parent chemical and its transformation products enter. Transformation products can be less hazardous/toxic, equally hazardous/toxic, or more hazardous/toxic than the parent chemical.) The impacts of those chemicals and their transformation products on aquatic life in the receiving waters for dairy runoff should be an area of study focus. Those studies need to be ongoing in order to evaluate the occurrence, transport, fate, and potential water quality impacts of those chemicals in waters receiving discharges/runoff from dairies. Also there is need to establish regulatory programs in the USDA, FDA and the US EPA for controlling the potential water quality impacts of hormones, steroids and pharmaceuticals used in dairy operations prior to their extensive use.

The SWRCB is developing a Recycled Water Policy, http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/, that will define the approach that the SWRCB and Regional Boards will adopt for regulating hormones, steroids, and pharmaceuticals in domestic wastewaters and discharges from other sources including dairies. Of particular concern for the regulation of dairy wastes for the protection of water quality will be how the SWRCB and Regional Boards address the issues of "Recycled Water – Constituents of Emerging Concern (CECs)" in its policymaking. According to C. Rogers of the CVRWQCB that policy, once adopted and implemented, could define the approach that is adopted for managing those chemicals in dairy wastes.

Pesticides and Herbicides

The waters of the SJR and its watershed and Delta channels are on the CWA 303 (d) list of impaired waterbodies due to the presence of legacy organochlorine pesticides and DDT. Many of those waters are also on that list because of organophosphorus and pyrethroid-based pesticides and the herbicide Diuron. Those pesticides/herbicides have been used, and some are likely still being used, at dairies; some of them could be present in discharges/runoff from dairies. The CVRWQCB has not included monitoring for those chemicals in runoff waters from dairies. While not considered to be a dairy waste product, legacy pesticides and currently used pesticides and herbicides should be included in runoff monitoring programs because of their past and current use.

Need for Expanded Monitoring, Research, and Site-Specific Studies

After the current updated dairy waste monitoring as set forth in the 2007 dairy waste regulations (as updated by the 2011 revisions) has been conducted for several years, an independent review by experts should evaluate the adequacy of implementation and efficacy of those monitoring programs. The objectives of that review should be

- the adequacy of the monitoring program,
- how well the monitoring program characterizes the concentrations/loads of potential pollutants and their water quality impacts for regulated pollutants and those chemicals that while not regulated by numeric water quality objectives such as aquatic plant nutrients, and
- defining the modifications of the current monitoring program needed to better estimate the water quality impacts of the currently occurring and allowed potential pollutants discharges.

Of particular concern is the adequacy of the current monitoring program for providing the technical basis for a mass balance of dairy waste nutrients applied to land as part of the Nutrient Management Plan that are to be controlled by plant uptake to prevent water pollution of surface and groundwaters. Within a few years the monitoring program should be expanded to include those hormones, steroids, and pharmaceuticals, as well as pesticides, that are being found in dairy wastes; a set of special focused studies should be conducted to define the presence of such chemicals in dairy wastes and that could be present in dairy discharges to surface waters.

Impact of Dairy Waste Salt Load

The Central Valley groundwaters are being polluted by salts in dairy and other wastes applied to land and by irrigated agriculture. This has caused the CVRWQCB to initiate the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS). The CVRWQCB 2007/2011 dairy waste monitoring program includes monitoring of dairy wastes and runoff/discharges for their salt content. As part of the review of the adequacy of the monitoring program there is need to evaluate the adequacy of the salt monitoring program to defining the salt load that Central Valley dairies are contributing to surface and groundwaters.

Other Potential Pollutants in Dairy Wastes

As discussed herein, the SJR and Delta are experiencing water quality impairments due to a number of regulated as well as thus-far unregulated chemicals. Of particular concern is the organic carbon (measured as total organic carbon (TOC) and dissolved organic carbon (DOC)) that at times causes water utilities that treat Delta waters to experience excessive concentrations that contribute to trihalomethanes (which are carcinogens) in some treated waters. TOC/DOC is derived from many sources in the Delta watershed including the Sacramento River watershed. While the SWRCB/CVRWQCB has not developed WQOs objectives for TOC/DOC, the CVRWQCB is developing a Drinking Water Policy that could include regulations for TOC/DOC. The CVRWQCB Revised Monitoring and Reporting Program Order NO. R5-2007-0035 adopted in February 2011 should be expanded to include TOC and DOC monitoring. If WQOs are developed for TOC/DOC, in time the role of dairy waste discharges/runoff as a source of these chemicals will be able to be evaluated.

Impact of Future Sacramento River Water Diversion on Dairy Waste Impacts

As part of developing a Delta water resource management policy, the California legislature adopted legislation that required the development of the Bay Delta Conservation Plan and Delta Stewardship Council Delta Plan. Information on those plans is available at, http://baydeltaconservationplan.com/Home.aspx , and http://deltacouncil.ca.gov/
Those plans, which are under development, could involve the diversion of up to 15,000 cfs of Sacramento River water upstream of the main part of the Delta around the Delta to the export pumps in the South Delta to pump water to the Central Valley, southern California and the San Francisco Bay area. The current flow of high quality Sacramento River water through the Delta greatly dilutes the concentrations of SJR-associated pollutants and therefore their impacts on Delta water quality. At this time the Sacramento River flows through the Delta to the export pumps. Diverting Sacramento River water around the Delta will have a major effect on the impact of SJR water and its associated pollutants on Delta water quality. The proposed diversion could mean that SJR pollutant loads that now enter the Delta would not be diluted and therefore could have a much greater impact on Delta water quality. This could, in turn, cause the

dischargers of pollutants in the SJR watershed, including dairies, to be under greater pressure to control the discharge of pollutants to try to control their impact on Delta water quality

Economic Affordability Issues
Price controls on milk and milk products in California, coupled with increased dairy feed costs, are placing CA dairies in a low profitability situation. The milk pricing formulas do not necessarily include consideration of the increased costs of waste management associated with meeting increased regulatory requirements. In order for dairies to afford the increased regulation of dairy wastes it may be necessary for the prices of dairy products to be increased to cover the waste management requirements as they are developed and implemented.

Overall Conclusion
The CVRWQCB Order covering the improved regulation of dairy wastes will, in time, significantly reduce the pollution of SJR and the Delta waters. There are, however, a number of implementation issues that the CVRWQCB will need to address including assessing the adequacy of the adopted monitoring programs for defining the pollutant (especially noted at this time: nutrients (N and P), TOC/DOC, hormones, steroids, and pharmaceuticals) discharges/runoff from dairies and, most important, Nutrient Management Plans' allowed discharges of aquatic plant nutrients and other pollutants from areas where dairy wastes are managed. It will be a number of years before the allowed discharges/runoff of pollutants from dairies and areas where dairy waste are managed can be evaluated to determine if the residual discharges of dairy waste-associated pollutants are a significant cause of the pollution of the Central Valley waters. It is recommended that an intensive review of the adequacy of the current dairy waste regulatory be conducted in five years to determine if it is be implemented as required and whether changes in the 2007/2012 regulatory programs should be made to improve the effectiveness of the program.

Overall Recommendations
- The CVRWQCB/SWRCB should establish a committee/contract to develop guidance on how the CVRWQCB "Biostimulatory Substances" WQO will be applied to nutrients discharged by dairies and irrigated agriculture in the SJR watershed to adequately consider the excessive fertilization issues in the SJR and Delta.
- Studies should be conducted of the pollution of shallow groundwaters by dairies located near surface waters to determine if the dairy-polluted shallow groundwater is contributing nutrients and other pollutants to surface waters.
- Legacy pesticides and currently used pesticides and herbicides should be included in runoff monitoring programs because of their past and current use.
- After the current updated dairy waste monitoring as set forth in the 2007 dairy waste regulations (as updated by the 2011 revisions) has been conducted for several years, an independent review by experts should evaluate the adequacy of implementation and efficacy of those monitoring programs.
- As part of the review of the adequacy of the monitoring program there is need to evaluate the adequacy of the salt monitoring program to defining the salt load that Central Valley dairies are contributing to surface and groundwaters.
- The CVRWQCB Revised Monitoring and Reporting Program Order NO. R5-2007-0035 adopted in February 2011 should be expanded to include TOC and DOC monitoring, soluble

ortho P, flow, monitoring during runoff events, and expanded as additional information becomes available concerning currently unregulated and unmonitored potential pollutants.

- It is recommended that an intensive review of the adequacy of the current dairy waste regulatory be conducted in five years to determine if it is be implemented as required and whether changes in the 2007/2012 regulatory programs should be made to improve the effectiveness of the program.
- A comprehensive TMDL should include sufficiently detailed monitoring program to identify all sources of the pollutants that are causing the WQO violations.
- The monitoring program should focus on intensive monitoring of the shallow groundwater and vadose (unsaturated) zone near the source of pollutants at the dairy.
- Monitoring for assessing impacts of dairy waste management practices should include monitoring of the shallow groundwater near the areas of dairy waste management to determine if that groundwater is being polluted by the dairy. Such monitoring will require installation of monitoring wells in the area in which dairy waste management is occurring and downgradient to the point at which it discharges or could discharge into a surface waterbody. Where there is a defined flow path of nitrate from the dairy waste management area to a surface water, studies will need to be conducted to evaluate the amount of denitrification of the nitrate that occurs along the flow path and as it enters the surface water.
- To be useful in assessing and managing nutrient-related water quality issues, those nutrient criteria will need to adequately address and quantify transport, transformation, and impacts of nutrients from all sources on all water quality-related parameters including planktonic algal biomass, low DO conditions, sediment toxicity issues, aquatic plants both floating and attached, bluegreen algae blooms, algal tastes and odors in water supply reservoirs, and increased THM precursors.
- There is need to evaluate the adequacy of the salt monitoring program to determine the salt load that Central Valley dairies are contributing to surface and groundwaters.

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Introduction

"As You Sow," an environmental organization in the San Francisco Bay area, requested that we (Drs. G. Fred Lee and Anne Jones-Lee) review the issues of what is known about the impacts of dairies in the San Joaquin River watershed on water quality in the San Joaquin River (SJR) and the Sacramento San Joaquin Delta (Delta), and associated water quality regulations. As described by BVA (2003),

"Confined animal facility operations typically concentrate animals in feeding areas, milk production areas, and within open corrals. Wastes from the operations include manure, bedding, hair, spilled feed, and leachate from silage. The composition of animal manure depends on a number of factors such as the animal species, size, maturity, health, and composition of animal feed. Generally, the primary pollutants associated with animal wastes with potential to affect groundwater include nitrogen compounds, salts, organic matter, pathogens, and to a lesser extent, antibiotics, pesticides, and hormones."

While the focus of this review is potential impacts of dairy wastes on surface waters of the SJR and Delta, consideration is also given to work that has been done on impacts of dairy wastes on groundwater. This is because there has been more research done on those impacts. Further, shallow groundwaters can discharge to surface waters in an SJR tributary and to the SJR. Thus, contaminants from dairies that enter shallow groundwater can, in those situations, be contributed to surface waters. References to groundwater in this report refer to shallow groundwaters that discharge to surface waters.

According to the California Central Valley Regional Water Quality Control Board (CVRWQCB) Dairy Program webpage, http://www.swrcb.ca.gov/rwqcb5/water_issues/dairies/

"*The Central Valley regulates several types of confined animal facilities, including dairies, feedlots, poultry facilities, and horse facilities. The Confined Animal Facility Program primarily focuses on dairies. Over 1,500 Dairies are located in the Central Valley. On 3 May 2007, the Regional Board adopted Waste Discharge Requirements General Order for Existing Milk Cow Dairies (General Order). The General Order includes requirements for both the dairy production area and land application area and requires each dairy to fully implement their Waste Management Plan by 2011 and Nutrient Management Plan by 2012."*

While there is considerable information on impacts of dairies in the SJR watershed on Central Valley groundwater quality, there is limited quantitative information on impacts of dairy wastes on water quality of surface waters that receive runoff/discharges from areas on which dairy wastes are managed. In addressing impacts of dairies on water quality in the SJR and the Delta, the following issues are discussed in this report: water quality problems in the SJR and Delta that need regulatory attention/control; dairy waste and wastewater discharges to those waters; current information on the transport of dairy waste-associated pollutants to SJR tributaries, the SJR, and the Delta including the discharge of shallow groundwaters that are polluted by dairy wastes to SJR tributaries and the SJR. This report also presents a review of the current regulatory programs intended to control the impacts of dairy-derived pollutants on surface waters and issues of their effectiveness, and recommended changes in the regulatory program structure and implementation.

Constituents Responsible for "Impaired"
Designations in SJR Watershed and Delta

In accord with the requirements of the US EPA Clean Water Act Section 303 (d), states are to prepare a list of waterbodies in which violations of water quality standards/objectives (WQO) exist. For waterbodies on that list, the state must prepare a total maximum daily load (TMDL) to control the sources of contaminants in violation of the WQOs. Recently the state of California SWRCB/CVRWQCB and the US EPA finalized the 2010 updated list of 303 (d) designated waterbodies and associated pollutant-causes for the SJR and its watershed and for the Delta channels. A prepublication copy of that list was examined by the authors for the pollutants that are known to be, or could be, associated with dairy waste discharges in the areas of the SJR and Delta of concern in this review. WQO violations in the SJR its tributaries and in the Delta channels due to ammonia, *Escherichia coli* (*E. coli*), low dissolved oxygen, dissolved oxygen, sediment toxicity, unknown toxicity, bacteria, BOD (biochemical oxygen demand), chloride, electrical conductivity, fecal coliform, organic enrichment/low dissolved oxygen, pathogens, pH (high), salinity, and total dissolved solids could in part in some areas be the caused by dairy waste. For several of the parameters on that list the discharge of a pollutant to a waterbody contributes to conditions in the waterbody that causes the WQO violation such as low dissolved oxygen due to biochemical oxygen demand (BOD) and ammonia discharges.

Included among the pollutants in 2010 CWA 303 (d)-listed waterbodies are a number of pesticides that are used in agricultural and urban areas, some of which could have been used or could currently be used in dairy operations and on agricultural fields in which dairy feed is grown, including organochlorine legacy pesticides such as DDT and dieldrin, and the currently used organophosphorus and pyrethroid-based pesticides and herbicides such as Diuron. Those pesticides, and others, could contribute for the organochlorine legacy pesticides to excessive bioaccumulation of pesticide residues in edible fish that can cause cancer in people who use large amounts of the fish as food and for all pesticides to known aquatic life toxicity that is found in the SJR and the Delta.

All of the waterbodies on the 2010 303(d) list of impaired waterbodies, as well as those on future updated lists, will require total maximum daily loads (TMDLs) to control pollutants that violate WQOs. The 2010 list includes information on the dates by which the TMDLs for the named pollutants should be controlled to eliminate the WQO violations. Generally for the SJR and Delta, those dates are five to ten years in the future

There are several aspects of the 303 (d) list of impaired waterbodies that need to be understood with respect to attributing the current 303(d) listing to the WQO violations by dairies in the SJR watershed. At this time there is limited information on the specific discharges by dairies that cause local WQO violations. Typically the water quality monitoring programs are not sufficiently detailed to identify the specific sources of the pollutant on the 303 (d) list. This situation may be rectified somewhat when the studies are conducted in implementing the TMDLs that will need to be developed for each waterbody where WQO violations have been found. A comprehensive TMDL should include a sufficiently detailed monitoring program to identify all sources of the pollutants that are causing the WQO violation. Based on our experience in developing and implementing TMDLs, considerable larger amounts of funds and

staff will need to be made available to the CVRWQCB to develop comprehensive TMDLs to control the pollution of SJR and Delta waters by to scheduled date.

Another factor that would influence finding that dairies are the cause of current WQO violations is that under the current CVRWQCB regulatory program, surface water discharges from areas where dairy wastes are managed is not allowed. Dairies are required to prevent all ongoing runoff/discharges from areas that could contain dairy wastes. Under these conditions only short term discharges from spills or high rainfall runoff would likely be contributing to the discharge of dairy waste discharge pollutant to surface waters. This issue is discussed further below in the section on the current dairy regulatory program as well as in Appendix B.

In order for a chemical or condition to be placed on the CWA 303 (d) list for a particular waterbody or part thereof, the constituent must have a WQO and there must be sufficient monitoring data to meet the criteria for a 303 (d) listing. Based on our experience in water quality evaluation and knowledge of the SJR and its tributaries as well as the Delta channels, there are several pollutants discharged by dairies in the SJR Delta watershed that are significantly impairing water quality but that are not included on the 2010 303(d) list. Table 1 lists chemicals that we have discussed should be included, or considered for inclusion, on the 303 (d) list for the SJR and/or Delta along with a ranking of importance in terms of water quality significance.

Several of the chemicals listed in Table 1 are present in dairy wastes that, at times, are discharged by dairies to surface waters or pollute shallow groundwater that caries the pollutant to SJR surface waters, which in turn contribute to water quality impairment in the SJR and Delta. The most significant of these chemicals are the N and P compounds that stimulate the growth of algae and other aquatic plants in the SJR and Delta. While the CVRWQCB requires that N and P compounds be monitored in any dairy discharges/runoff, there are no numeric water quality standards/ objectives by which, according to CVRWQCB protocol, to evaluate the water quality implications of concentrations in waters that have been in contact with dairy wastes. Attached to this report is a list of publications on SJR Delta water quality issues. In our comments on the CVRWQCB Irrigated Lands Regulatory Program in the Discharges from Irrigated lands (http://www.swrcb.ca.gov/rwqcb5/water_issues/irrigated_lands/) we provided guidance on the types of information that need to be incorporated into a regulatory program to develop appropriate nutrient-based discharge and waterbody limits for N and P compounds. This issue is discussed further below.

Causes of impairment that lead to a 303(d) listing also do not include total organic carbon/ dissolved organic carbon (TOC/DOC) that adversely impact the use of Delta waters as a domestic water source; those parameters include compounds that form trihalomethanes (THMs) during domestic water supply disinfection. The CVRWQCB/SWRCB have not developed water quality standards for TOC/DOC by which excessive concentrations in discharge waters can be evaluated. We have provided guidance on the issues that need to be considered in developing TOC/DOC discharge limits and water quality standards to control the excessive THM formation in the domestic water supplies that use Delta water as a water supply source. Additional discussion of the TOC/DOC and nutrient management issues is provided below.

Table 1
Delta Impaired Waters Not Listed on CWA 303(d)

Should Be Listed*	Known Impairment	Significance
1 Nutrients – N & P	Excessive growth of algae & macrophytes	contribute to tastes & odors and THM formation in water supply; additional cost for domestic water treatment; contribute to low-DO problems in Delta; impair recreational use; adversely impact fisheries habitat
2 TOC/DOC	Trihalomethanes formed in water treatment	carcinogens; additional cost for domestic water treatment
Could Be Listed - Need Investigation for Potential Impacts	**Sources**	
PBDE - polybrominated diphenylethers	Domestic wastewater discharges	not a known dairy discharge-related issue
PPCP - pharmaceutical & personal care products	Domestic wastewater discharges	not a dairy discharge-related issue
3 Pharmaceuticals, steroids, hormones	Dairy & animal husbandry operations	potential adverse impacts on aquatic life; unknown impact on water supply; need to be investigated
4 Other unregulated chemicals	Various	Unknown; need to be investigated

* Rank of water quality significance

There is also concern about the presence of pharmaceuticals, steroids, and hormones used to treat dairy cows and that could therefore be present in dairy wastes, and in dairy waste waters that are discharged to surface waters. The presence and potential impacts of these chemicals in the waters of the SJR and Delta have not been adequately investigated. With respect to "Other unregulated chemicals" in Table 1, only a small number of the potential pollutants in aquatic systems are regulated compared to the very large number of unregulated, unmonitored, or as yet unrecognized chemicals that are discharged to the environment. We have developed several papers/reports on these issues that are available on our website, including the summary paper Lee and Jones-Lee (2005). There is need to be vigilant in the evaluation of dairy wastes for evidence of the presence of unregulated, unmonitored, or as yet unrecognized chemicals that could be transported in runoff or via shallow groundwaters to surface waters.

Current Dairy Waste Regulations and Management Program

Significant water quality degradation of the San Joaquin River and its tributaries, as well as of the Delta, could have been due in part to discharges of pollutants by dairies. The potential pollutant from dairies that has been of greatest focus is nitrogen in the form of ammonia, which is toxic to aquatic life in receiving waters and which, under environmental conditions, converts to nitrate which is an aquatic plant nutrient. More recently, concern has been raised about the presence of hormones, steroids, and pharmaceuticals used to treat dairy herds in dairy wastes and in surface waters receiving dairy waste discharges/runoff.

To better understand the pollution of waters in the Central Valley by dairies, the California Water Resources Control Board (SWRCB) contracted with Brown, Vence and Associates (BVA), a private consulting firm, to review animal waste regulations for the protection of groundwater quality. The resulting BVA (2003) reports documented that dairies in the Central Valley were causing significant water pollution due to inadequate management of dairy waste. They noted manure, bedding, hair, spilled feed, and leachate from silage as sources of wastes, and primary pollutants from animal wastes to include nitrogen compounds, salts, organic matter, pathogens, antibiotics, pesticides, and hormones. While the BVA reports focused on pollution of groundwater, information on potential pollutants derived from dairy operations has direct bearing on potential pollutants than can be directly contributed to surface waters by runoff from such operations. Further, the pollution of shallow groundwater by dairies is of importance to Central Valley surface waters because in some areas, shallow groundwaters discharge directly into surface waters. Thus chemicals derived from dairy animal wastes (and their transformation products) that are in shallow groundwater can pollute surface water.

In accord with requirements of the Clean Water Act, water quality criteria/standards/objectives are established by the US EPA and state, and all dischargers are to control pollutants to a sufficient extent so as to prevent violations of those criteria/standards/objectives. Based on the findings of Brown, Vence and Associates (BVA, 2003), in 2007 the SWRCB and CVRWQCB released improved dairy waste regulations and management programs that requires the control of toxic discharges, specifically ammonia, in dairy wastes for the protection of fish and other aquatic life in receiving waters. However as is discussed in other sections of this report, there are no numeric water quality criteria/standards/objectives for some of the other components of dairy wastes that are of greatest concern to receiving water quality, including:

- nutrients as they stimulate excessive aquatic plant growth
- TOC/DOC as it affects the treatment of water for domestic water supply use
- Pharmaceuticals, steroids, hormones

As discussed in subsequent sections of this report, the SWRCB and CVRWQCB are working toward the development of numeric water quality standards/objectives for controlling excessive fertilization of surface waters through the development of nutrient criteria. However, there is so little understanding of the occurrence or potential impacts of other types of chemicals in dairy wastes as they enter surface waters that it is not possible to regulate the discharges of those chemicals. The SWRCB is working toward the development of regulations to enable assessment and control of such chemicals in dairy wastes as information becomes available.

As a result of the significant lack of understanding of the occurrence and impacts of certain potential pollutants in dairy wastes, such as nutrients, TOC/DOC, and pharmaceuticals, steroids and hormones, the CVRWQCB has not established an absolute prohibition of discharges of those potential pollutants from dairies, but instead has implemented a requirement for monitoring programs intended to give an indication of the amounts of discharges of these types of chemicals from dairies.

The Monitoring and Reporting Program (MRP) that was adopted in 2007 offers the beginnings of an approach needed to assess the occurrence of pollutants in dairy waste discharges to surface

waters. It contains specific requirements for visual inspections, nutrient monitoring, monitoring of surface runoff including discharge monitoring, stormwater discharges to surface water from the production area, stormwater discharges to surface water from each land application area, and tailwater discharges to surface water from land application areas. The MRP monitoring requirements are, in general, adequate in terms of the parameters monitored for conventional, currently regulated potential pollutants. However, as discussed in another section of this report, in order to quantify the magnitude of discharges of potential pollutants, and most important, their impacts on the beneficial uses of SJR and Delta waters, the surface water quality monitoring program will need to be significantly expanded. Some of the chemicals of potential concern in dairy wastes have regulatory limitation against which concentrations and loads can be evaluated in terms of potential impact on receiving water quality. As more is learned about the presence of currently unregulated potential pollutants in dairy wastes, including TOC/DOC. Hormones steroids and pharmaceuticals, the list of monitored parameters will need to be expanded to cover those parameters as well.

In addition, all surface water runoff from dairies is to be monitored to determine whether it contains elevated concentrations of nitrogen and phosphorus compounds that could stimulate excessive growths of aquatic plants in the waters receiving the runoff but there is no regulatory mechanism in place for determining what constitutes excessive concentrations of nutrients. It is not possible to interpret monitoring data for total phosphorus in terms of impacts on water quality because part of the total phosphorus is not available to stimulate algae and other forms of aquatic plant growth; soluble orthophosphate should be added to the list of parameters measured in discharges and runoff as that is the form of phosphorus that is available to stimulate the growth of algae and other aquatic plants.

The frequency and intensity of monitoring during a discharge/runoff event will need to be increased to adequately characterize the load of pollutants in the discharge. There is also need to reliably monitor the volume of discharge during the course of a discharge/runoff event in order to evaluate the load of pollutants in the discharge. Without this information it will not be possible to evaluate the potential water quality impacts of the monitored parameters in the receiving waters.

In 2011 the timetable for implementation of the 2007 dairy waste regulations was relaxed to allow greater opportunity for compliance; this change was precipitated by US EPA litigation settlement in matters outside the issue of Central Valley dairy wastes. As originally developed by 2012 each dairy has to develop its Nutrient Management Plan (NMP) to establish a mass balance between total nutrients applied to land as part of dairy waste management practices and nutrients taken up by crops in areas of waste application. However, there is no requirement for the CVRWQCB to review, much less act pursuant to, those plans. This is a significant deficiency in the current regulatory program.

In establishing the dairy waste management program the CVRWQCB acknowledged that the dairy waste control program was to “balance” the control of impacts of dairy wastes and the costs of additional control of dairy waste discharges to surface and groundwater. The CVRWQCB stated that taking such a “balanced” approach is in the best interest of the people of California. From our perspective the position of the “balance” is somewhat controlled by the

limitations on the price of milk; apparently it is not possible to raise the amounts of money that dairies are paid for milk and milk products sufficiently to cover the cost of improved waste management. This is the same approach that is currently being followed by the CVRWQCB for controlling runoff/discharges of these types of discharges from irrigated agriculture. While it is recognized that these types of chemicals can be adverse to water quality/beneficial uses of surface waters, it is not technically sound to establish an absolute ban on such discharges. Instead, a monitoring and assessment approach is being used.

With regard to groundwater, not only are there no numeric standards for prevention of groundwater pollution by dairy wastes, but also the current CVRWQCB groundwater quality monitoring program for dairies is not adequate to protect deeper and shallow groundwater quality; pollution of shallow groundwater can lead to pollution of surface water. A fundamental deficiency in the regulations and monitoring requirements is that they do not focus on detection of the initial pollution of groundwater by dairy operations, but rather relies on after-the-fact detection at some point down groundwater gradient from the pollution by a dairy.

Overall, the current regulatory requirements allow discharges/runoff of dairy wastes in the Central Valley that can cause violations of water quality objectives in the SJR and the Delta. Further, currently allowed dairy waste management practices do not address pollutants in dairy wastes that are, at this time, not regulated by WQOs. Because of the inadequacies of current regulatory practice for dairy wastes in the Central Valley that allow their pollution of surface waters in the SJR watershed and Delta, a more rigorous, encompassing, and directed water quality monitoring program should be implemented in areas downstream from dairies.

Additional discussion of regulatory issues and of specific sections of the CVRWQCB 2007 "Dairy Program Regulations and Requirements," and its 2007 "Waste Discharge Requirements General Order" that are of particular significance to understanding and regulating the impact of dairy wastes on water quality in the SJR and Delta is provided in Appendix B.

Groundwater Pollution Issues

As noted in the previous section, the 2003 SWRCB Brown, Vence and Associates report has documented that dairies in the Central Valley are a major, local, source of pollutants, specifically nitrate and salt, in groundwater near the dairies (BVA, 2003). As discussed at the CA/NV American Water Works Association conference in Sacramento, the CVRWQCB and SWRCB have allowed land surface activities, including irrigated agriculture, land disposal of municipal and industrial wastewaters, and landfills, to pollute Central Valley groundwaters (Lee and Jones-Lee, 2007a, b).

The CVRWQCB has begun to develop and implement programs to control groundwater pollution in the Central Valley, including the pollution of groundwater by dairy wastes. However, its approach is largely an after-the-fact monitoring of deep groundwater to determine if the current waste management activities are resulting in groundwater pollution. The environmental organization, "Food and Water Watch," with assistance from the California Sports Fishing Protection Alliance (CSPA) has issued a report entitled, "What's in the Water" (available at http://www.foodandwaterwatch.org/reports/whats-in-the-water/), which is highly critical of the current CVRWQCB program for controlling groundwater pollution by dairies.

Lee and Jones-Lee have extensive expertise and experience in monitoring sources of groundwater pollution from landfills and waste piles; many of their papers and report on these issues are available on their web site in the Landfills-Groundwater section. The issues of concern and approaches for groundwater monitoring to evaluate the effectiveness of a dairy's waste management program for preventing groundwater pollution are very similar to those to evaluate the effectiveness of landfill containment systems for preventing groundwater pollution.

Rather than a passive monitoring of deeper groundwater to determine if it has been polluted by a dairy, the monitoring program must focus on intensive monitoring of the shallow groundwater and vadose (unsaturated) zone near the source of pollutants at the dairy. Additional information on the pollution of shallow groundwater by dairies and other sources that is pertinent to our report on the pollution of surface waters in the SJR watershed by dairies is provided by Domagalski et al. (2008). In their evaluation of the transport and transformation of nitrate from an almond orchard to the Merced River in the Central Valley by measurements of pore-water nitrate and modeling using the root zone water quality model, they found that more than 60% of the applied nitrogen was transported through a 6.5-m unsaturated zone.

They found that some of the nitrate that polluted groundwater from the source was discharge to the Merced River. According to S. Phillips of the USGS, Sacramento, CA (personal communication, December 2011), *"Celia Zamora of the USGS is wrapping up a report on our recent work looking at groundwater inflow to the SJR and associated nutrient loads, etc.*" Phillips also indicated that the USGS is conducting studies of the interaction between groundwater and surface water along the SJR. The results of those studies will help better-define the role of shallow water in the SJR watershed in the transport of pollutants in the watershed to surface waters.

The USGS (Domagalski and Johnson, 2011) also reported on its investigation of the transport of phosphorus in shallow groundwaters. The abstract of that paper stated:
"Concentrations of dissolved orthophosphate (ortho P) in the unsaturated zone, groundwater, tile drains, and groundwater/stream water interfaces were assessed in five agricultural watersheds to determine the potential for subsurface transport. Attenuation of ortho P in these aquifers was attributed primarily to sorption onto iron oxides, and in one location onto clay minerals. Only one location showed a clear indication of phosphorus transport to a stream from groundwater discharge, although groundwater did contribute to the stream load elsewhere."

Domagalski (2012) also reported two additional potential issues with regard to phosphorus transport in shallow groundwater in the San Joaquin Valley: "One is that aquifer sediments in parts of the San Joaquin Valley are nearing saturation with respect to how much phosphorus can be adsorbed. Secondly, the increased flux of DOC from dairies might result in decreases in the amount of iron oxides in the aquifer solids, thereby making them less effective for phosphorus sorption." He also emphasized, "…manure management has to consider phosphorus impacts and not just be managed for nitrogen. In the part of my study in Washington state, manure management has led to high amounts of phosphorus in the unsaturated zone, and near saturation of the iron oxides with respect to phosphorus."

Domagalski (2012) also stated with respect to DOC in dairy wastes, "Excesses of DOC to groundwater can affect the water chemistry by changing the redox conditions as well as supplying a source of carbon to bacteria, in either groundwater or surface water sediments. Some potential issues include changes in denitrification in the aquifers down gradient from the dairies. This could be a positive thing in that nitrate concentrations in groundwater might be lowered. Assuming the extra DOC results in decreased oxygen in the groundwater, iron reduction may occur which could affect subsurface transport of phosphorus."

Drs. Lee and Jones-Lee have been involved in the investigation of the transport of soluble orthophosphate in groundwater such as occurs from septic tank wastewater disposal systems. A paper they published on their findings Jones and Lee (1979). They found, as did Domagalski and Johnson as well as others, and as would be expected based on environmental chemistry of the system, that in general orthophosphate is not transported in groundwaters, especially groundwaters in aquifers whose particles are coated with iron oxide and those in calcareous (hard water) systems. Typically aquifer systems composed of quartz sand without iron oxide coatings allow phosphorous transport in groundwater. In calcareous aquifer systems the phosphate is precipitated on calcium carbonate as hydroxyapatite with the result that hard water aquifer have a high capacity to remove phosphate from groundwaters.

Monitoring for assessing impacts of dairy waste management practices should include monitoring of the shallow groundwater near the areas of dairy waste management to determine if that groundwater is being polluted by the dairy. Such monitoring will require installation of monitoring wells in the area in which dairy waste management is occurring and downgradient to the point at which it discharges or could discharge into a surface waterbody. Where there is a defined flow path of nitrate from the dairy waste management area to a surface water, studies will need to be conducted to evaluate the amount of denitrification of the nitrate that occurs along the flow path and as it enters the surface water.

A key issue that needs to be evaluated is the concentration/load of nitrate in the shallow groundwater that enters a surface water where it can contribute to excessive fertilization of the downstream waterbody. As discussed in another section of this report, at this time the CVRWQCB/SWRCB have not developed guidance on how to implement the applicable CVRWQCB Basin Plan objective, which states:

"*Biostimulatory Substances*
Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses."
page III-3.00 at http://www.swrcb.ca.gov/rwqcb5/water_issues/basin_plans/sacsjr.pdf

This past fall the SWRCB announced in a "Scoping Document-Nutrient Policy" that it will be developing water quality objectives for fresh waters in the state. Further information is available at:
http://www.swrcb.ca.gov/plans_policies/docs/nutrients/scpng_doc.pdf
http://www.swrcb.ca.gov/plans_policies/nutrients.shtml
http://www.swrcb.ca.gov/academy/courses/wqstandards/materials/mod12/12nutn_pca.pdf

We have commented on issues that need to be considered in developing freshwater nutrient criteria in Lee and Jones-Lee (2011).

To be useful in assessing and managing nutrient-related water quality issues, those nutrient criteria will need to adequately address and quantify transport, transformation, and impacts of nutrients from all sources on all water quality-related parameters including planktonic algal biomass, low DO conditions, sediment toxicity issues, aquatic plants both floating and attached, bluegreen algae blooms, algal tastes and odors in water supply reservoirs, and increased THM precursors. Once such guidance is available, and dairy wastes and management practices evaluated for their contributions of N and P, the impacts of those wastes on water quality in the SJR, its tributaries, the Delta, and downstream waterbodies including domestic water supply reservoirs that receive Delta water as a source can be assessed. This assessment will provide a technical basis for limiting N and P compounds discharges from various sources in the SJR watershed and Delta.

In order to develop and implement nutrient criteria/objectives there will be need to conduct intensive research on the sources of N and P to each of the waterbodies, as well as the transport and transformation of those nutrients from their sources to receiving waters. This will require a well-directed and focused study plan and considerable funding over a several-year period.

An issue that needs to be considered in the development of nutrient criteria and the regulation of nutrients in land runoff is that much of the inorganic particulate forms of phosphorus in land runoff is not available to support algal growth and does not become available in the receiving waters for these discharges. This issue is discussed in Lee (2006). As discussed by Lee (2006) and other writings of Lee and Jones-Lee (See Appendix G), as part of developing and implementing nutrient criteria and their application for land runoff, it will be necessary to quantify the relationship between the loading of available nutrients and the eutrophication-related water quality in the receiving waters in order to evaluate the benefit that can be expected to accrue from controlling the loadings of nutrients. The focus needs to be on the control of the loads of available forms of N and P that are responsible for stimulating excessive growths of various forms of aquatic plants that are adversely impacting water quality/beneficial uses of the receiving waterbody and downstream waterbodies. Fulfilling these requirements will mean that it will be a number of years before there will be nutrient criteria that can reliably regulate dairy and other sources of nutrients in the SJR/Delta watersheds.

van Nieuwenhuyse (2007) reported that reductions in phosphorus load to the Delta resulted in decreased planktonic algal chlorophyll. This decreased primary productivity could be adverse to fish productivity in the Delta. In developing a nutrient regulatory program to control excessive growths of aquatic plants in the Delta there will also be need to understand how reducing the loads of N and P to the Delta will adversely impact the aquatic food web especially fish productivity. The nutrient regulatory program will need to balance the positive impacts (reducing excessive algae and aquatic plants that adversely affect water quality) with the negative impacts (reduced fish productivity).

Hormones and Steroid-Related Water Quality Issues
Hormones, steroids, and pharmaceuticals are used in the treatment of cows in dairy operations. This use results in the potential for those chemicals to be present in dairy wastes and thus to pollute surface and groundwaters. Results of a study of the presence of steroid hormones in a dairy waste disposal system were reported by Zheng et al. (2008).

The abstract reported,
"The environmental loading of steroid hormones contained in dairy wastes may cause an adverse effect on aquatic species. To better assess the potential risks of hormone contamination resulting from land application of dairy wastes, various steroid hormones were determined in a typical dairy waste disposal system." "In the dairy wastewater and lagoon water, three endogenous hormones–17a-estradiol, 17B-estradiol, and estrone–were detected. The concentration of 17a-estradiol in fresh milk parlor effluent rapidly decreased along the wastewater disposal route, whereas the concentration of estrone increased along this same pathway. This suggests that 17a-estradiol was readily oxidized to the metabolite estrone. Levels of total steroid hormones in the sequencing lagoon water were approximately 1-3 orders of magnitude lower than those in the fresh dairy wastewaters, indicating significant removal of these hormones during the transport of dairy wastewater from source to field. In solid dairy waste samples, four steroid hormones were identified and quantified. Increasing the piling time of solid wastes and increasing the residence time of wastewater in sequencing lagoons are suggested to be economical and efficient agriculture practices to extend the degradation time of hormone contaminants and thereby reduce the hormone load to the environment."

Clay Rogers, Assistant Executive Officer of the CVRWQCB Fresno office that has the responsibility for Ag Regulatory & Issues, indicated that the SWRCB is developing a Recycled Water Policy http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/ that will define the approach that the SWRCB and Regional Boards will adopt for regulating hormones, steroids, and pharmaceuticals in domestic wastewaters and discharges from other sources including dairies. Of particular concern is the "Recycled Water – Constituents of Emerging Concern (CECs)" http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/recycledwater_cec.shtml. Once adopted and implemented, that policy could define the approach that is adopted for managing these types of chemicals in dairy wastes that may be present in runoff waters.

Pesticides and Herbicides
The waters of the SJR and its watershed, and Delta channels are on the US EPA CWA 303 (d) list of impaired waterbodies due to the presence of legacy organochlorine pesticides (Group A pesticides) and DDT. Many of those waters also are on that list for organophosphorus and pyrethroid-based pesticides and the herbicide Diuron.

While it has not been legal to use organochlorine pesticides for many years, residues from former use are still present in soils in areas where they have been used that are slowly being released to surface waters. Lee and Jones-Lee (2002, 2007c) developed a comprehensive review of the information available on the presence of legacy organochlorine pesticides in fish in the SJR and Delta. As discussed in those reports those legacy pesticides are of concern in water because they bioaccumulate in edible flesh of aquatic organisms that can be used as food; consumption of

excessive levels increases the risk of cancer in humans a threat to the health of those who consume large amounts of some fish taken from these waters.

The CVRWQCB has not included monitoring for those chemicals in runoff waters from dairies. While they are not considered to be a dairy waste product, because of past and legacy pesticides should be included in runoff monitoring along with currently used pesticides and herbicides.

Managing Dairy Manure Pollution

The University of California Committee of Experts on Dairy Manure Management (2005), which consisted of faculty and staff in the UC Cooperative Extension and the UC Water Resources Center, discussed the management of dairy manure in the Central Valley of California. That report is a good source of information on dairy manure composition, and the application of manure to land in crop production to control nitrogen losses to waters. It addresses manure and nitrogen excretion, distribution of manure on dairies, atmospheric N losses from liquid dairy manure prior to land application, developing nitrogen application rate guidelines, phosphorus and potassium in manure applications, and salts in dairy manure and salinity issues in land application.

The development of a Nutrient Management Plan for areas where dairy wastes are applied will be a challenge. Dr. Lee was a member of a Water Environment Federation committee that reviewed the results of a series of field studies designed to evaluate the then-current practice of land application of domestic wastewater sludges (BioSolids) so as to prevent surface and groundwater pollution by pollutants in sewage sludge. The primary issue was the development of loading rates for biosolids that would match the uptake of nutrients by crops grown in the application area. At the time of the initiation of that WEF study it was standard practice to match the nitrogen load application rate with the plant uptake rate to achieve "agronomic" loading. In principle, if the nitrogen loading from biosolids matched the plant crop uptake there should be no nitrogen pollutants in runoff surface waters and no infiltration of nitrogen into groundwater. Those studies demonstrated, however, that achieving an "agronomic rate" of application of sewage sludge (biosolids) did not achieve protection of surface and groundwaters. The problem was that part of the nitrogen in sewage sludge was in an organic form that was not mineralized during a particular growing season but was slowly mineralized over the winter when plant uptake was not occurring. Continuing to apply biosolids at agronomic rates year after year resulted in loss of nitrogen from the land application area. It was also found that a number of site-specific factors, besides nitrogen loads and plant uptake, had to be evaluated and taken into consideration in order to prevent pollution of surface and groundwaters. Jones-Lee and Lee (2001) discussed these issues in detail.

The University of California Committee of Experts on Dairy Manure Management's (2005) guidance on recommended allowed loadings of dairy waste considered many of the issues as addressed in evaluating the allowed loading of biosolids in land application. The Committee of Experts reported:

"*The results presented here undoubtedly are subject to a great number of uncertainties. It nevertheless demonstrates that the upper end of computer-simulated optimal N loading rates of 1.4 to 1.65 times the crop N harvest removal are practical and, based on field observations, achievable if the production field is properly managed.*"

"The combined evidence from laboratory, field, and modeling studies indicates that precise nutrient management, while plausible in principle, may be problematic when implemented in full-scale production systems, as it requires careful timing of the N applications, close monitoring of the amount of N and water inputs, and best management of crop production. More importantly, the growers must show flexibility to make necessary adjustments on N inputs during the course of a growing season to achieve satisfactory results."

As quoted in Appendix B, the Order covering allowed dairy waste application rates is dependent on the development and implementation of a Nutrient Management Plan. Under such a Plan, however, nutrient discharges are allowed from areas where dairy wastes are land-applied. Achieving a Nutrient Management Plan that only allows minimal incidental discharge of nitrogen and other pollutants to surface waters will be difficult to achieve. While large dairies would be able to hire specialized staff to monitor and adjust the applications of dairy wastes to land, this could be well beyond the ability of the average dairy to implement. It could be many years before reliable NMPs are used in controlling dairy wastes so that there is little or no pollutant discharge to surface waters.

Salt Pollution of Central Valley Groundwaters

ASAE (2005) provided detailed information on the chemical composition of manure, including its elevated salt content. A salt that is characteristically elevated in dairy waste is potassium, which is used as part of nutritional feed for dairy cows. According to the CVRWQCB website, http://www.swrcb.ca.gov/rwqcb5/water_issues/salinity/

"*Elevated salinity and nitrates in surface water and groundwater are increasing problems affecting much of California, other western states, and arid regions throughout the world. In California, as surface and groundwater supplies become scarcer, and as wastewater streams become more concentrated, salinity and nitrate impairments are occurring with greater frequency and magnitude.*

In 2006, the Central Valley Water Board, the State Water Board, and stakeholders began a joint effort to address salinity and nitrate problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is a collaborative basin planning effort aimed at developing and implementing a comprehensive salinity and nitrate management program. The goal of CV-SALTS is to maintain a healthy environment and a good quality of life for all Californians by protecting our most essential and vulnerable resource: WATER.

In July 2008, the Central Valley Salinity Coalition (CVSC) was formed. CVSC represents stakeholder groups working with the Board in the CV-SALTS effort. Its purpose is to organize, facilitate and fund efforts needed to fulfill the goals of CV-SALTS. CVSC coordinates the meetings of the CV-SALTS committees, maintains an independent web site, and manages the projects originating from this effort. Information and materials regarding the stakeholder committees and other activity, including the meeting schedule, are posted on their website: www.cvsalinity.org."

Information on the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is available at http://www.swrcb.ca.gov/rwqcb5/water_issues/salinity/.

The pollution of Central Valley surface and groundwaters by salts has adversely impacted the quality of Delta water for use in agriculture, as a source that is adverse of those of domestic water supply, and for use in enhanced groundwater recharge of domestic wastewaters in Southern California. The elevated salts in these domestic wastewaters (the source of some of which is Delta waters) prohibits the recharge of the domestic wastewaters to groundwater due to salinity limitations on groundwater recharge.

Dairy wastes contain elevated salt concentrations that can led to increased salt concentrations in Central Valley surface and groundwaters. There is need to understand the role of dairy waste management practices on the salt pollution of Central Valley waters and to develop approaches for controlling the pollution of surface and groundwaters by salts in dairy wastes. The CVRWQCB 2007/2011 dairy waste monitoring program included monitoring of dairy wastes and runoff/discharges for their salt content. As part of the review of the adequacy of the monitoring program there is need to evaluate the adequacy of the salt monitoring program to determine the salt load that Central Valley dairies are contributing to surface and groundwaters.

Other Potential Pollutants in Dairy Wastes

As discussed herein, the SJR and Delta are experiencing water quality impairments due to a number of regulated as well as thus-far unregulated chemicals. Of particular concern is the organic carbon (measured as total organic carbon (TOC) and dissolved organic carbon (DOC)) that at times causes water utilities that treat Delta waters to experience excessive concentrations that contribute to trihalomethanes (which are carcinogens) in some treated waters. TOC/DOC is derived from many sources in the Delta watershed including discharges/runoff from dairies. The CVRWQCB's Revised Monitoring and Reporting Program Order NO. R5-2007-0035 adopted in February 2011 should be expanded to include TOC and DOC. The Sacramento River watershed also contributes TOC/DOC to the Delta. While the SWRCB/CVRWQCB has not developed WQOs for TOC/DOC, the CVRWQCB is developing a Drinking Water Policy that could include the development of regulations for TOC/DOC. Information on the Drinking Water Policy is available at http://www.swrcb.ca.gov/rwqcb5/water_issues/drinking_water_policy/.

If WQOs are developed for TOC/DOC, in time the role of dairy waste discharges/runoff as a source of these chemicals will be able to be evaluated.

Some of the issues that will need to be evaluated in regulating TOC/DOC have been discussed by Lee and Jones-Lee (2003).

Impact of Future Sacramento River Water Diversion on Dairy Waste Impacts

As part of developing a Delta water resource management policy, the California legislature is developing a Bay Delta Conservation Plan and a Delta Stewardship Council Delta Plan. Information on those plans, which are under development, is available at, http://baydeltaconservationplan.com/Home.aspx , and http://deltacouncil.ca.gov/
Those plans could involve the diversion of up to 15,000 cfs of the Sacramento River upstream of the main part of the Delta, around the Delta to the export pumps in the South Delta, to pump

water to the Central Valley, southern California, and the San Francisco Bay area. At this time the Sacramento River flows through the Delta to the export pumps. Diverting Sacramento River water around the Delta will have a major effect on the impact of SJR water and its associated pollutants on Delta water quality. The current flow of high-quality Sacramento River water through the Delta greatly dilutes the concentrations of SJR-associated pollutants and therefore their impacts on Delta water quality. The proposed diversion could mean that SJR pollutant loads that now enter the Delta would not be diluted and therefore could have a much greater impact on Delta water quality. This could, in turn, cause the dischargers of pollutants in the SJR watershed, including dairies, to be under greater pressure to control the discharge of pollutants to try to control their impact on Delta water quality. It is unclear if the regulations will be adequately implemented to control these problems. These issues are discussed further by Lee and Jones-Lee (2009).

Issues in Improving the Regulation of Dairy Wastes Water Quality Impacts

While the CVRWQCB has established an improved management program for dairy wastes to reduce their water quality impacts, there is need to evaluate the ability of dairies, especially smaller dairies, to fund the increased control and monitoring that will be needed to implement a more effective control program. As discussed in this report, the CVRWQCB has made the decision that the degree of improved regulation of dairy wastes that was adopted in 2007 is a balanced approach for the best overall interest of the people of California. Basically the CVRWQCB has balanced the cost of improved dairy waste management with the residual water quality impacts that will occur as a result of not requiring full control of dairy waste-related water quality impacts. It will be several years before the residual impacts of the allowed dairy waste discharges/impacts are known. If improved monitoring programs for water quality characteristic of the SJR and the Delta are developed and implemented, within a few years – at least 5 and more likely 10 to 15 years – it may be possible to reevaluate the appropriate balance of the cost of improved dairy waste management and the residual water quality impacts. This information may be developed as part of the implementation of pending and to-be-developed TMDLs for the SJR and Delta.

Economic Affordability Issues

Milk and milk products price controls in California, coupled with increased costs for dairy feed, are placing CA dairies in a low profitability situation. The milk pricing formulas do not necessarily include consideration of the increased costs of waste management associated with meeting increased regulatory requirements. Information on dairy pricing is available on the California Department of Food and Agriculture website http://www.cdfa.ca.gov/dairy/prices_main.html. It may be necessary for the price of dairy products to be increased to enable dairies to pay for meeting the waste management requirements.

Overall Conclusion

Significant water quality degradation of the San Joaquin River and its tributaries, as well as of the Delta, could have been due in part to discharges of pollutants by dairies. There are violation of state water quality objectives in the SJR its tributaries and in the Delta channels due to ammonia, Escherichia coli (E. coli), low dissolved oxygen, dissolved oxygen, sediment toxicity, unknown toxicity, bacteria, BOD (biochemical oxygen demand), chloride, electrical

conductivity, fecal coliform, organic enrichment/low dissolved oxygen, pathogens, pH (high), salinity, and total dissolved solids. Dairy wastes could have been contributing to those violations. Further, the waters of some areas of the Delta are listed as "water quality limited" due to a number of pesticides that for the legacy pesticides have been used at dairies and the currently used organophosphorus and pyrethroid-based pesticides and herbicide such as Diuron. Those pesticides, and others, could contribute to known aquatic life toxicity that is found in the SJR and the Delta and the excessive bioaccumulation of the organochlorine legacy pesticides in edible fish tissue that are a threat to cause cancer in those who use large amounts of these fish as food.

While there is considerable information on impacts of dairies in the Central Valley groundwater quality, there is limited quantitative information on impacts of dairy wastes on water quality of surface waters that receive runoff/discharges from areas on which dairy wastes are managed. The potential pollutant from dairies that has been of greatest focus is nitrogen in the form of ammonia, which is toxic to aquatic life in receiving waters and which, under environmental conditions, converts to nitrate which is an aquatic plant nutrient. There is also likely to be contribution of organic carbon (as measured as TOC and DOC) in runoff from dairy facilities to surface waters in the Delta watershed. Those organics adversely impact the quality of Delta water as a domestic water supply. More recently, concern has been raised about the presence of hormones, steroids, and pharmaceuticals used to treat dairy herds in dairy wastes and in surface waters receiving dairy waste discharges/runoff.

The SWRCB and CVRWQCB are working toward the development of numeric water quality standards/objectives for controlling excessive fertilization of surface waters through the development of nutrient criteria. However, there is so little understanding of the occurrence or potential impacts of other types of chemicals in dairy wastes as they enter surface waters that it is not possible to regulate the discharges of those chemicals. The SWRCB is working toward the development of regulations to enable assessment and control of such chemicals in dairy wastes as information becomes available it should provide a basis for developing regulation of these types of chemicals.

The CVRWQCB 2007/2012 Order covering the improved regulation of dairy wastes will, in time, significantly reduce the pollution of SJR and the Delta waters. There are, however, a number of issues that the CVRWQCB will need to address to implement those regulations, including determining the adequacy of the adopted monitoring programs for reliably defining the pollutant discharges/runoff from dairies, and most important the allowed Nutrient Management Plans' allowed discharges of nutrient and other pollutants from areas in which dairy wastes are managed as well as:

- updated management/monitoring program
- more comprehensive monitoring
- impact of nutrient discharges
- impact of reduced phosphorus loads to the delta on fishery resources
- groundwater as a source of dairy nutrients for the SJR waters
- hormones, steroids and pharmaceuticals
- pesticides and herbicides
- expanded monitoring, research and site specific studies

- impact of dairy waste salt load
- other potential pollutants in dairy wastes
- impact of future Sacramento River water diversion on dairy waste impacts
- economic affordability issues

It will be a number of years before the allowed continuing discharges/runoff of pollutants from dairies and areas where dairy waste are managed can be evaluated to determine if the residual discharges of dairy waste-associated pollutants are a significant cause of the pollution of the Central Valley waters. It is recommend that an intensive review of the adequacy of the current dairy waste regulatory approach be conducted in five years to determine if it is being implemented as required and whether changes in the 2007/2012 regulatory programs should be made to improve the effectiveness of the program.

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Appendix B
Additional Discussion of
Current Dairy Waste Regulations and Management Program

The CVRWQCB website "Confined Animal Facilities" at http://www.swrcb.ca.gov/rwqcb5/water_issues/dairies/ provides information on the CVRWQCB dairy wastes management program. On that site is a link to "*Historical Dairy Program Information*" which contains a section entitled, "Review of Animal Waste Regulations." That section describes three reports prepared by Brown, Vence, and Associates (BVA, 2003) under contract with the SWRCB: "*a review of the effectiveness of Title 27 of the California Code of Regulations to protect groundwater quality from confined animal facility waste discharges; a comparison of regulations designed to protect groundwater quality from releases at confined animal facilities; and an evaluation of alternative criteria to protect groundwater quality from releases at confined animal facilities.*" Links are provided to Task 2, Task 3, and Task 4 reports.

The Executive Summary of the Task 2 Report, "Review of Animal Waste Management Regulations, Task 2 Report: Evaluate Title 27 Effectiveness to Protect Groundwater Quality" dated October 2003 (http://www.swrcb.ca.gov/rwqcb5/water_issues/dairies/historical_dairy_program_info/bva_final_task2_rpt_ess_ctns1_6.pdf) states:
"*Executive Summary*
The purpose of this report is to evaluate the effectiveness of California Code of Regulations (CCR) Title 27 requirements intended to protect groundwater quality from confined animal facility waste discharges. Pursuant to Title 27 §22560, the purpose of the regulations is to set minimum standards for the discharge of animal wastes and to specify the general information that should be submitted to the Regional Water Quality Control Board (RWQCB)."

"Confined animal facility operations typically concentrate animals in feeding areas, milk production areas, and within open corrals. Wastes from the operations include manure, bedding, hair, spilled feed, and leachate from silage. The composition of animal manure depends on a number of factors such as the animal species, size, maturity, health, and composition of animal feed. Generally, the primary pollutants associated with animal wastes with potential to affect groundwater include nitrogen compounds, salts, organic matter, pathogens, and to a lesser extent, antibiotics, pesticides, and hormones."

"The minimum standards for confined animal facilities specified in Title 27 provide limited siting, design, and construction requirements designed to protect groundwater quality at confined animal facilities."

"Based on these considerations, in addition to site-specific data from Central Valley dairies, and the information included in published studies, it is reasonable to conclude that current Title 27 requirements are insufficient to prevent groundwater contamination from confined animal facilities, particularly in vulnerable geologic environments."

The pollution of groundwater by dairy animal wastes has been and continues to be under the current updated regulatory program, a chronic problem. As discussed below, the pollution of shallow groundwater by dairies is of importance to Central Valley surface waters because in some areas, chemicals derived from dairy animal wastes pollute shallow groundwater which leads to pollution of surface water.

On December 10, 2010, the CVRWQCB issued a "Staff Report, Consideration of Adoption of General Waste Discharge Requirements and General National Pollutant Discharge Elimination System (NPDES) Permit for Existing Milk Cow Dairy Concentrated Animal Feeding Operations within the Central Valley Region"
http://www.swrcb.ca.gov/rwqcb5/board_decisions/adopted_orders/general_orders/r5-2010-0118.pdf
that was devoted to "Board Order No. R5-2010-0118 NPDES NO. CAG015001," which states:

"*BACKGROUND*
"*There are currently approximately 1440 existing milk cow dairies in the Central Valley. While a small number of these facilities are regulated under individual Waste Discharge Requirements, the majority are regulated under Waste Discharge Requirements General Order for Existing Milk Cow Dairies, Order No. R5-2007-0035 (General Order). The General Order, adopted by the Central Valley Water Board on 3 May 2007 required dairies to submit information on their nutrient management and waste management practices according to a schedule, with all submittals and implementation to be complete by July 2012. The General Order does not serve as a federal NPDES permit, and thus derives its authority solely from state law."*

That staff report provides a discussion of the current regulatory issues for controlling pollution of surface and groundwater by dairy wastes.

In 2007 the CVRWQCB developed an updated "Dairy Program Regulations and Requirements," which is presented at
http://www.swrcb.ca.gov/rwqcb5/water_issues/dairies/dairy_program_regs_requirements/index.shtml in "Waste Discharge Requirements General Order No. R5-2007-0035
http://www.swrcb.ca.gov/rwqcb5/board_decisions/adopted_orders/general_orders/r5-2007-0035.pdf

The key to understanding this order and its impact on dairy operations
"Order No. R5-2007-0035 Waste Discharge Requirements General Order for Existing Milk Cow Dairies" states,
"*The California Regional Water Quality Control Board, Central Valley Region (hereafter, Central Valley Water Board), finds that:*
Scope of Coverage of This Order
1. This Order serves as general waste discharge requirements for discharges of waste from existing milk cow dairies (defined in Finding 7) of all sizes."

According to Charlene Herbst, Unit Chief/Senior Engineering Geologist (personal communication, December 2011) at this time the majority of the dairies in the Central Valley are following that general order.

The Order also states:
"*12. There are approximately 1,600 milk cow dairies within the Central Valley Region (Region) that will be required to operate under the requirements of this Order. Each facility represents a significant source of waste discharge with a potential to affect the quality of the waters of the State."*

"13. For the purposes of this Order, "waste" includes, but is not limited to, manure, leachate, process wastewater and any water, precipitation or rainfall runoff that contacts raw materials, products, or byproducts such as manure, compost piles, feed, silage, milk, or bedding."

"15. This Order does not authorize any further degradation to groundwater and prohibits discharges from production areas to surface waters. This Order also contains many restrictions, including the requirement to comply with a Nutrient Management Plan, for the application of waste to land application areas. However, it is possible that some minor degradation to surface waters from the application of waste to land application areas could occur despite compliance with this Order. That degradation would be limited because any such discharge may not cause or contribute to the exceedance of any water quality objective in the surface water. Such possible minor degradation is consistent with the maximum benefit to the people of the state. This Order would impose significantly more stringent requirements on these existing facilities than has been imposed in the past and as a result, water quality will be improved. While this Order will impose stringent new requirements, it will still accommodate important economic activities in mostly rural areas of the Central Valley Region, which is considered to be a benefit to the people of the State. Given that these are existing facilities, this Order would reduce the impacts that may have occurred under previous regulation of these facilities."

"This Order will assure that pollution or nuisance will not occur and that the highest water quality consistent with maximum benefit to the people of the State will be maintained. For example, the proposed order prohibits discharges to surface water from the production area and prohibits discharges from land application areas unless, among other requirements, the dairy prepares and implements a Nutrient Management Plan. Any authorized discharge from the land application area must not cause or contribute to an exceedance of any applicable water quality objective or federal water quality criteria. The proposed order prohibits any further degradation of groundwater. The Order addresses impacts from future discharges of waste, but does not address the cleanup of existing degraded surface and groundwater from past dairy operations. Any required cleanup would be handled under separate authority under the Water Code."

According to Item 22,
"This Order prohibits:
a. Discharges of waste and/or storm water to surface waters from the production area;

b. Discharges of waste to surface waters which causes or contributes to an exceedance of any applicable water quality objective in the Basin Plans or water quality criteria set forth in the California Toxics Rule or the National Toxics Rule;

c. The collection, treatment, storage, discharge or disposal of wastes at an existing milk cow dairy that results in (1) discharge of waste constituents in a manner which could cause degradation of surface water or groundwater except as allowed by this Order, (2) contamination or pollution of surface water or groundwater, or (3) a condition of nuisance (as defined by the California Water Code Section 13050);

d. Discharges of wastewater to surface waters during or following wastewater application to cropland; and

e. Discharges of storm water to surface water from the land application area where manure or process wastewater has been applied unless the land application area has been managed consistent with a certified Nutrient Management Plan (see Attachment C, which is attached to and made part of this Order).

This Order requires that discharges of waste from existing milk cow dairies shall not cause groundwater to be further degraded 1, to exceed water quality objectives, unreasonably affect beneficial uses, or cause a condition of pollution or nuisance. This Order also requires monitoring of surface water and groundwater to demonstrate reduced impacts to surface water and groundwater upon compliance with this Order."

As discussed in this report this order is significantly deficient in that some of the pollutants of greatest concern in dairy wastes that can be present in surface water runoff, are the aquatic plant nutrients, N and P compounds. Those nutrients can stimulate increased growth of aquatic plants in the SJR and Delta, but are not regulated by WQOs, and no guidance is provided on how a particular nutrient discharge is to be evaluated by the current CVRWQCB narrative WQOs (biostimulatory substances).

With respect to controlling groundwater pollution by dairy wastes this order states,
"*23. Groundwater monitoring shows that many dairies in the Region have impacted groundwater quality. A study of five dairies in a high-risk groundwater area in the Region found that groundwater beneath dairies that were thought to have good waste management and land application practices had elevated levels of salts and nitrates beneath the production and land application areas. The Central Valley Water Board requested monitoring at 80 dairies with poor waste management practices in the Tulare Lake Basin. This monitoring has also shown groundwater pollution under many of the dairies, including where groundwater is as deep as 120 feet and in areas underlain by fine-grained sediments."*

"24. No set of waste management practices has been demonstrated to be protective of groundwater quality in all circumstances. Since groundwater monitoring is the most direct way to determine if management practices at a dairy are protective of groundwater, Monitoring and Reporting Program No. R5-2007-0035, which is attached to and made part of this Order, requires groundwater monitoring to determine if a dairy is in compliance with the groundwater limitations of this Order, unless the Executive Officer determines that an alternative method of environmental monitoring is appropriate and issues an individual monitoring and reporting program to the individual dairy pursuant to Water Code Section 13267."

As discussed below, the current CVRWQCB groundwater quality monitoring program for dairies is not adequate to protect deeper and shallow groundwater quality; pollution of shallow groundwater can lead to pollution of surface water.

"*25. The Central Valley Water Board has documented many discharges of waste from existing milk cow dairies to surface water and has taken appropriate enforcement actions in such cases. This Order prohibits discharges of: waste and/or storm water to surface water from the production area; wastewater to surface waters from cropland; and storm water to surface water from a land application area where manure or process wastewater has been applied unless the land application area has been managed consistent with a certified Nutrient Management Plan. When such discharges do occur, this Order requires the Discharger to monitor these discharges."*

"26. *The milk cow dairies at which this Order is directed were in existence prior to October 2005 and many were constructed several decades ago. The waste management systems at these existing dairies are commonly not capable of preventing adverse impacts on waters of the state either because of their outdated design or need for maintenance or both."*

"The Discharger may be able to make some of these improvements relatively quickly while some improvements may require more time to implement. It is reasonable to allow Dischargers time to phase in elements of the required Waste Management Plan and Nutrient Management Plan in order to adequately design and construct major infrastructure changes needed to comply with all the requirements of this Order.

Since dairy wastes are rich in nutrients and the SJR and Delta are experiencing excessive fertilization due to discharges of nitrogen and phosphorus compounds from the SJR watershed, it is appropriate to examine the required nutrient monitoring program for surface water discharges and runoff and the Nutrient Management Plan that is part of this order.

This order contains a "*Monitoring and Reporting Program NO. R5-2007-0035 General Order for Existing Milk Cow Dairies"* beginning on page 25.
The Monitoring and Reporting Program (MRP) states:

"*Monitoring requirements also include monitoring of nutrients applied to, and removed from, land application areas in order for the Discharger to develop and implement a Nutrient Management Plan that will minimize leaching of nutrients and salts to groundwater and transport of these constituents to surface water."*

This MRP contains specific requirements for *Visual Inspections, Nutrient Monitoring, Monitoring of Surface Runoff including discharge monitoring, Storm Water Discharges to Surface Water from the Production Area, Storm Water Discharges to Surface Water from Each Land Application Area, and Tailwater Discharges to Surface Water from Land Application Areas.* The MRP monitoring requirements are, in general, adequate in terms of the parameters monitored for conventional, regulated potential pollutants; however, soluble orthophosphate should be added to the list of parameters measured in discharges and runoff. Soluble orthophosphate is the form of phosphorus that is available to stimulate the growth of algae and

other aquatic plants. It is not possible to interpret monitoring data for total phosphorus in terms of impacts on water quality because part of the total phosphorus is not available to stimulate algae and other forms of aquatic plant growth.

The frequency and intensity of monitoring during a discharge/runoff event will need to be increased to adequately characterize the load of pollutants in the discharge. There is also need to reliably monitor the volume of discharge during the course of a discharge/runoff event in order to evaluate the load of pollutants in the discharge. Without this information it will not be possible to evaluate the potential water quality impacts of the monitored parameters in the receiving waters. As more is learned about the presence of currently unregulated potential pollutants in dairy wastes, the monitored parameters will need to be expanded to cover those parameters as well.

This Order (page 98) contains *"Attachment C – Contents of a Nutrient Management Plan and Technical Standards for Nutrient Management for Existing Milk Cow Dairies."* The Plan states:

"*Waste Discharge Requirements General Order No. R5-2007-0035 (Order) requires owners and operators of existing milk cow dairies (Dischargers) who apply manure, bedding, or process wastewater to land for nutrient recycling to develop and implement management practices that control nutrient losses and that are described in a Nutrient Management Plan (NMP). The purpose of the NMP is to budget and manage the nutrients applied to the land application area(s) considering all sources of nutrients, crop requirements, soil types, climate, and local conditions in order to prevent adverse impacts to surface water and groundwater quality. The NMP must take the site-specific conditions into consideration in identifying steps that will minimize nutrient movement through surface runoff or leaching past the root zone."*

The "Contents of a Nutrient Management Plan" is to contain a number of *"elements to demonstrate that the Discharger can control nutrient losses that may impact surface water or groundwater quality and comply with the requirements of the Order and the Technical Standards for Nutrient Management (Technical Standards)."* including (page C-4):

"III. Nutrient Budget (see Technical Standard V below)
The Discharger shall develop a nutrient budget for each land application area. The nutrient budget shall establish planned rates of nutrient applications for each crop based on soil test results, manure and process wastewater analyses, irrigation water analyses, crop nutrient requirements and patterns, seasonal and climatic conditions, the use and timing of irrigation water, and the nutrient application restrictions listed in Technical Standards V.A through V.D below. The Nutrient Budget shall include the following:

A. The rate of application of manure and process wastewater for each crop in each land application area (also considering sources of nutrients other than manure or process wastewater) to meet each crop's needs without exceeding the application rates specified in Technical Standard V.B below. The basis for the application rates must be provided.

B. The timing of applications for each crop in each land application area and the basis for the timing (Technical Standard V.C below). The maximum period of time anticipated between land

application events (storage period) based on proper timing and compliance with Technical Standard V.C. below. This will be used in the Waste Management Plan (item II.A of Attachment B) to determine the storage capacity needs.

C. The method of manure and process wastewater application for each crop in each land application area (Technical Standard V.D below).

D. If phosphorus and/or potassium applications exceed the amount of these elements removed from the land application area in the harvested portion of the crop, the soil and crop tissue analyses shall be reviewed by an agronomist at least every five years. If this review determines that the buildup of phosphorus or potassium threatens to reduce the long-term productivity of the soil or the yield, quality or use of the crops grown, application rates will be adjusted downward to prevent or correct the problem."

It also requires that the discharger comply with specific *"technical standards for nutrient management in the development and implementation of the Nutrient Management Plan (NMP)"* (page C-6) including:

"IV. Overall Nutrient Balance
If the NMP shows that the nutrients generated by the dairy exceed the amount needed for crop production in the land application area, the Discharger must implement management practices (such as offsite removal of the excess nutrients, treatment, or storage) that will prevent impacts to surface water or groundwater quality due to excess nutrients.

V. Nutrient Budget
The NMP shall include a nutrient budget which includes planned rates of nutrient applications for each crop that do not exceed the crop's requirements for total nitrogen considering the stage of crop growth and that also considers all nutrient sources, climatic conditions, the irrigation schedule, and the application limitations in A through D below."

Under the current regulatory program dairies have to develop an NMP and have it available for review. However the CVRWQCB does not review those plans. This is a significant deficiency in the current regulatory program.

"VI. Wastewater Management on Land Application Areas"

A. "Prohibition A.3 of the Order: 'The discharge of waste from existing milk cow dairies to surface waters which causes or contributes to an exceedance of any applicable water quality objective in the Basin Plans or any applicable state or federal water quality criteria, or a violation of any applicable state or federal policies or regulations is prohibited.'"

If properly implemented, that "Prohibition" gives the appearance of affording protection of surface water quality from adverse impacts of the discharge/runoff of nutrients and some other potential pollutants in dairy wastes that are applied to land. However, in practice the CVRWQCB does not have a nutrient regulatory approach to effectively implement that Prohibition. In 2002, under contract with the SWRCB/CVRWQCB, we developed the following

report that discussed issues that need to be considered in regulating nutrient discharges from non-point sources, including irrigated agriculture.

> Lee, G. F. and Jones-Lee, A., "Review of Management Practices for Controlling the Water Quality Impacts of Potential Pollutants in Irrigated Agriculture Stormwater Runoff and Tailwater Discharges," California Water Institute Report TP 02-05 to California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 128 pp, California State University Fresno, Fresno, CA, December (2002)

That discussion also has applicability to the proper regulation of nutrients in discharges/runoff from areas that have received dairy wastes.

Between 2003 and 2010 we developed a series of reports on deficiencies in the CVRWQCB Irrigated Lands Regulatory Program. We discussed why simply taking grab samples of runoff waters and/or receiving waters as prescribed by the CVRWQCB is not adequate to define the loads of nutrients discharged or their impacts on receiving water and downstream water quality. Our writings on these issues specifically discuss problems in trying to regulate nutrient discharges from irrigated lands to control the impacts on the SJR and Delta. These discussions include:

> Lee, G. F., and Jones-Lee, A., "Interpretation of Nutrient Water Quality Data Associated with Irrigated Agricultural Ag Waiver Monitoring," Submitted to Central Valley Regional Water Quality Control Board, Rancho Cordova, CA, by G. Fred Lee & Associates, El Macero, CA, November (2005).
> http://www.gfredlee.com/Nutrients/InterprNutrWQData.pdf

Those reports are on our website, www.gfredlee.com, in the Agricultural Impacts on Water Quality section at http://www.gfredlee.com/pwwqual2.htm#agwaiver.

It has been our experience that the CVRWQCB has yet to implement a reliable monitoring program for any non-point-source pollutant in runoff/discharge waters. There is, therefore, concern that the monitoring program that is implemented under these Orders will not be adequately implemented or effectively reviewed unless substantially more funding is made available to the CVRWQCB specifically for that purpose. It is suggested that an independent expert panel be convened to review if the water quality monitoring and nutrient management plans developed under this Order are in fact being implemented adequately for the protection of the SJR watershed waters from pollution by runoff/discharges from areas where dairy wastes are managed.

In February 2011 the CVRWQCB issued a “Revised Monitoring and Reporting Program” that is available at
http://www.swrcb.ca.gov/rwqcb5/board_decisions/adopted_orders/general_orders/r5-2007-0035_mrp_rev.pdf .
The revised MRP is basically the same for surface water issues with minor changes in wording, parameters, dates of compliance, etc. There are several problems in the required monitoring program including the following:

- “Potassium” is listed in Nutrient Monitoring (Table 2, page 3); potassium is not a nutrient in waterbodies.

- Soluble orthophosphate should be included in Nutrient Monitoring since that is the form of phosphorus that is available for algal growth.
- The specification for measurement in manure of “sulfur” should be “sulfide.”

These MRPs are apparently intended to obtain data to provide insight into potential violations of discharge limitations for some of the parameters in dairy wastes that could impact surface water quality. In order to properly characterize potential surface water quality impacts of dairy waste discharges, however, a much more comprehensive monitoring program of the discharges/runoff would need to be conducted. Guidance for developing such a program is provided in:

> Lee, G. F. and Jones-Lee, A., "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA," California Water Institute Report TP 02-07 to the California Water Resources Control Board/ Central Valley Regional Water Quality Control Board, 157 pp, California State University Fresno, Fresno, CA, December (2002).
> http://www.gfredlee.com/SurfaceWQ/Agwaivemonitoring-dec.pdf

Overall, the current regulatory requirements allow discharges/runoff of dairy wastes in the Central Valley that can cause violations of water quality objectives in the SJR and the Delta. Further, currently allowed dairy waste management practices do not address pollutants in dairy wastes that are, at this time, not regulated by WQOs. Because of the inadequacies of current regulatory practice for dairy wastes in the Central Valley that allow their pollution of surface waters in the SJR watershed and Delta, a more rigorous, encompassing, and directed water quality monitoring program should be implemented in areas downstream from dairies.

Appendix C – List of Abbreviations

BOD	Biochemical oxygen demand
CWA	Clean Water Act
CVRWQCB	Central Valley Regional Water Quality Control Board
DOC	dissolved organic carbon
MRP	monitoring and reporting program
NMP	nutrient management plan
N	nitrogen compounds
P	phosphorus compounds
SJR	San Joaquin River
SWRCB	CA State Water Resources Control Board
TOC	total organic carbon
WQO	water quality objective

Appendix D – Acknowledgement

We wish to acknowledge the support given this project by As You Sow. We also appreciate the time taken by the following individuals to discuss with us various aspects of issues covered in this report:
Charlene. Herbst, Unit Chief/Senior Engineering Geologist of CVRWQCB Sacramento Office
Clay Rogers, Assistant Executive Officer, CVRWCB Fresno office
David Sholes, Senior Engineering Geologist CVRWQCB Fresno Office Dairies under Individual WDRs
Dr. Deanne Meyer, UC Davis Department of Animal Science, Associate Livestock Waste Management Specialist
Hyrum Eastman, Economic/Pricing unit California Department of Food and Agriculture
S. Phillips and J. Domagalski of the Sacramento office of the USGS
While the individuals named above provided information that was helpful in the development of this report, no representation is made here as to their support of the conclusions drawn in this report.

Appendix E – List of Tables

Appendix F – Background/Qualifications of Authors

Drs. G. Fred Lee and Anne Jones-Lee are principals/owners of G. Fred Lee & Associates–EnviroQual, a specialty environmental consulting firm located in El Macero, California. They focus their activities on water quality investigation and control for point and non-point sources of pollutants and municipal and industrial solid wastes. Information on G. Fred Lee & Associates is available on their website, www.gfredlee.com, in the section on the homepage entitled, "About G. Fred Lee & Associates," http://www.gfredlee.com/gflinfo.htm.

Dr. Lee earned his BA degree in environmental health science from San Jose State College in San Jose, CA in 1955 He earned a Master of Science in Public Health degree in 1957 from the School of Public Health at the University of North Carolina, Chapel Hill with emphasis on environmental science and environmental chemistry. The focus of his work there was water quality evaluation and management for the protection of public health and environmental quality from chemical constituents and pathogenic organisms. Dr. Lee earned his PhD degree in environmental engineering from Harvard University in 1960. A major area of his specialization there was aquatic chemistry, which focused on the transport, fate, transformation, and control of chemical constituents in aquatic (surface and groundwater) and terrestrial systems, as well as in waste management facilities.

For 30 years Dr. Lee held graduate-level faculty positions, teaching and conducting research in departments of civil and environmental engineering at several major US universities. During that time he conducted more than $5 million in research and published approximately 500 professional papers and reports based on his investigations. In 1989, he relinquished his position as Distinguished Professor of Civil and Environmental Engineering to expand his part-time consulting into a full-time endeavor.

Dr. Jones-Lee earned a BS degree in biology in 1973 from Southern Methodist University in Dallas, TX. She earned MS and PhD degrees (1978) in environmental science from the University of Texas at Dallas where she focused on aquatic toxicology and aquatic biology. Dr. Jones-Lee taught and conducted research in graduate university environmental engineering programs for 11 years prior to relinquishing her tenured Associate Professorship in Civil and Environmental Engineering in 1989 to join Dr. Lee in full-time consulting. She and Dr. Lee have worked together as a team in part-time and full-time consulting activities since the mid-1970s.

Since 1989 Drs. Lee and Jones-Lee have worked as full-time consultants in numerous aspects of water quality evaluation, management, and protection problems and concerns from their base in El Macero, CA, near Sacramento. They have continued to be active in developing professional papers and reports based on their private consulting and public service activities. Many of their papers and reports, which now number over 1,100, are available on their website, www.gfredlee.com, as downloadable files.

Drs. Lee and Jones-Lee began their involvement in water quality issues of the SJR and Delta in 1989. Professional papers and reports developed from their work on those waters are available on their website in the Watershed Studies section San Joaquin River Watershed Program – Delta

subsection at: http://www.gfredlee.com/psjriv2.htm. A summary of their experience on Delta water quality issues is provided in the following paper:

> Lee, G. F., and Jones-Lee, A., "Experience in Reviewing Delta Water Quality Issues," G. Fred Lee & Associates, El Macero, CA, April 3 (2011). http://www.gfredlee.com/SJR-Delta/GFLAJL-Delta-EXP-REV.pdf

Dr. Lee's work on evaluating/managing dairy waste water quality impacts began in the early 1960s when he held the positions of Professor of Water Chemistry and Director of the Water Chemistry Program at the University of Wisconsin Madison. Dr. Lee also served as the vice chair of the Lake Mendota Problems Committee. Lake Mendota is a large urban lake in Madison, WI which experienced large blooms of planktonic bluegreen algae and severely degraded water quality; the Lake Mendota Problems Committee was responsible for examining the sources of phosphorus to the lake that stimulated and sustained the excessive growths of algae. With the assistance of University of Wisconsin Soil Chemistry faculty it was found that the primary source of phosphorus that was the cause of the algal blooms was runoff from agricultural fields. Particularly problematic was the widely practiced spreading of dairy cow manure during the winter on frozen land; with the spring snowmelt and rainfall that occurred while the soil was still frozen came a large flux of phosphorus to the lake. The Lake Mendota Problems Committee worked with the US Department of Agriculture to obtain funding for dairies to construct large tanks to hold all winter manure, which could then be spread after the ground had thawed. The phosphorus in the manure that was spread on the ground in the spring, summer, and fall infiltrated the soil and, except for periods of intense rainfall, did not runoff from the land.

In the 1980s Dr. Lee had a contract with the US Army Construction Engineering Research Laboratory to conduct a review of the sources of phosphorus to Lake Champlain, VT that stimulated large blooms of planktonic algae. Working with the Vermont environmental protection agency, Dr. Lee found that dairies in the lake's watershed spread manure on frozen soil during the winter, which resulted in large fluxes of phosphorus into the lake during spring runoff while the soil was still frozen.

In the 1980s Drs. Lee and Jones-Lee presented an invited paper and expanded discussion on water quality impacts of P in runoff from agricultural lands:

> Lee, G. F. and Jones-Lee, A., "Assessing the Water Quality Impacts of Phosphorus in Runoff from Agricultural Lands," IN: Hall, W. L. and Robarge, W. P. (eds.), Environmental Impact of Fertilizer on Soil and Water, American Chemical Society Symposium Series 872, Oxford University Press, Cary, NC, pp. 207-219 (2004). http://www.gfredlee.com/Nutrients/P_Runoff_Ag_ACS.pdf
>
> Lee, G. F. and Jones-Lee, A., "Assessing the Water Quality Impacts of Phosphorus in Runoff from Agricultural Lands: Expanded Discussion," Presented in part at American Chemical Society Agro Division Symposium, "Environmental Impact of Fertilizer Products in Soil, Air and Water," Chicago, IL, August (2001). (Published in part in Symposium Proceedings (Lee and Jones-Lee, 2004) [http://www.gfredlee.com/Nutrients/P_Runoff_Ag_ACS.pdf]) (http://www.gfredlee.com/ ag_p-1_012002.pdf)

http://www.gfredlee.com/Nutrients/ag_p-1_012002.pdf

Those papers included a section devoted to "Development of Appropriate Agricultural Nutrient Runoff Control BMPs" that stated in part:
"*The experience in controlling nitrogen and/or phosphorus in rural land runoff has not been highly successful. Sharpley (15) has reviewed the experience in achieving a 40-percent nitrogen and phosphorus control in the Chesapeake Bay watershed. He has indicated that, after 15 years or so of control efforts, limited progress is being made in achieving the 40-percent reduction goal for phosphorus and nitrogen control from agricultural lands.*

Similarly, Logan (16), in a review of the experience of phosphorus control in the Lake Erie watershed, has indicated that little progress has been made in achieving effective phosphorus control in agricultural runoff."

Sharpley, A. N. (ed). Agricultural and Phosphorus Management – The Chesapeake Bay. CRC Press: Boca Raton, FL, 2000.

Logan, T. Nonpoint Sources of Pollutants to the Great Lakes: 20 Years Post PLUARG. In: Nonpoint Sources of Pollution to the Great Lakes Basin. Great Lakes Science Advisory Board, International Joint Commission Workshop Proceedings, February 2000.

Based on the experience in other areas of the US it will likely be difficult to achieve effective control of phosphorus in irrigated agriculture runoff/discharges in the Central Valley of CA. That finding has important implications for the control of phosphorus in runoff from lands that have received dairy wastes. This issue is discussed further below in connection with the review of the Nutrient Management Plans that are required under the current dairy waste regulations.

Since moving to California in 1989 Drs. Lee and Jones-Lee have been involved in evaluating the sources of aquatic plant nutrients (N and P compounds) in the Delta watershed and their impacts on Delta water quality. The nutrients that are stimulating excessive growth of aquatic plants in the Delta are derived primarily from runoff/discharges from agricultural lands in the SJR watershed. One of the key issues of concern is whether reducing the phosphorus load to the Delta by realistic amounts would reduce the excessive aquatic plant growth in the Delta to a meaningful extent. Concentrations of algal-available phosphorus in the SJR and the Delta are above growth-rate-limiting levels; this means that there is more available P in the water than can be used by algae. However, it has been documented, as part of the OECD Eutrophication Study program conducted by Dr. Lee and his graduate students, that the planktonic algal chlorophyll in waterbodies having significantly surplus algal-available P can, in fact, be reduced by reducing P load/concentration. These findings are summarized in:

Lee, G. F., and Jones-Lee, A., "Application of Vollenweider OECD Modeling: Limiting Nutrient Issues," Report of G. Fred Lee & Associates, El Macero, CA, February (2009). http://www.gfredlee.com/Nutrients/LimitingNutrientIssues.pdf

van Nieuwenhuyse also reported that reductions in phosphorus load to the Delta have resulted in decreased planktonic algal chlorophyll in his paper:

van Nieuwenhuyse, E., "Response of Summer Chlorophyll Concentration to Reduced Total Phosphorus Concentration in the Rhine River (Netherlands) and the Sacramento–

San Joaquin Delta (California, USA)," Can. J. Fish. Aquatic, Sci. 64(11):1529-1542 (2007).
[http://www.ingentaconnect.com/content/nrc/cjfas/2007/00000064/00000011/art00006]

Those findings indicate that it can be expected that decreasing phosphorus discharges in the SJR watershed will contribute to decreasing the excessive fertilization of SJR and the Delta. The implication of these findings should be carefully considered in the management of land application of dairy wastes that can contribute P to runoff to surface waters.

As part of their efforts to improve the management of nutrient-related water quality problems in the Delta, and on behalf of the California Water and Environmental Modeling Forum (CWEMF), Drs. Lee and Jones-Lee developed a "Workshop on Overview of Delta Nutrient Water Quality Problems: Nutrient Load - Water Quality Impact Modeling" held on March 25, 2008 and attended by about 100 professionals. Background to the development of that workshop was provided in the following report:

Lee, G. F., and Jones-Lee, A., "Delta Nutrient Water Quality Modeling Workshop — Background Information," Report of G. Fred Lee & Associates, El Macero, CA, September (2007). http://www.gfredlee.com/Nutrients/NutrWorkshopRev4.pdf

Information on the technical content of the workshop, as well as a synopsis of the workshop presentations developed by Dr. Lee with his PowerPoint slides, are available at: http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/Nutrientworkshop_files/CWEMF_WS_synopsis.pdf

Over the past 20 years Dr. Lee has followed closely the activities of the Central Valley Regional Water Quality Control Board (CVRWQCB) in its development of water quality programs for the SJR and Delta, including its assessment of the impacts of dairy wastes on water quality and the development of the CVRWQCB Dairy Program. They have developed several papers/review of SJR and Delta water quality issues including:

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 (2004). http://www.gfredlee.com/SJR-Delta/Delta-WQ-IssuesRpt.pdf

Lee, G. F., Jones-Lee, A., "San Joaquin River Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA, June (2006). http://www.gfredlee.com/SJR-Delta/sjr-WQIssues.pdf

Additional papers and reports that serve as background to this report are listed in an appendix to this report.

Appendix G – Additional Lee and Jones-Lee Papers/Reports That Provide Technical Background Information on Issues Discussed

In addition to the papers and reports cited in the text of this report we have developed several papers/reports that provide information that is background to this report. These are listed below.

Delta Water Quality Issues

Lee, G. F., and Jones-Lee, A., "Overview—Sacramento/San Joaquin Delta Water Quality," Presented at CA/NV AWWA Fall Conference, Sacramento, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, October (2007). http://www.gfredlee.com/SJR-Delta/DeltaWQCANVAWWAOct07.pdf

Lee, G. F., and Jones-Lee, A., "Overview—Sacramento/San Joaquin Delta Water Quality," Presented at CA/NV AWWA Fall Conference, Sacramento, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, October (2007). http://www.gfredlee.com/SJR-Delta/DeltaWQCANVAWWAOct07.pdf

Lee, G. F., and Jones-Lee, A., "Comments on the DSC Staff Fifth Draft of Chapter 6 Devoted to Delta Water Quality Issues in the Delta Plan," Comments Submitted to Delta Stewardship Council, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, August 21 (2011). http://www.gfredlee.com/SJR-Delta/DeltaPlan5DraftCh6Comm.pdf

Lee, G. F., and Jones-Lee, A., "Comments on the Adequacy of C. Dahm's Discussion of Delta Eutrophication Issues & Delta N/P Rations as a Cause of Adverse Impact on Delta Fish," Comments to Delta Stewardship Council, Report of G. Fred Lee &Associates, El Macero, CA, November 17 (2011). http://www.gfredlee.com/SJR-Delta/DSC-Comments-Dahm-Eutroph.pdf

Lee, G. F., and Jones-Lee, A., "San Joaquin River Water Quality Issues,"(PowerPoint Slides) Invited Paper Presented at Great Valley Conference, "At the Tipping Point," Sacramento, CA, Sponsored by Great Valley Center, Modesto, CA, May 11 (2006). http://www.gfredlee.com/SJR-Delta/SJR-April2006.pdf

Review of SJR Irrigated Agriculture Impacts on Water Quality

Lee, G. F. and Jones-Lee, A., "Agriculture-Related Water Quality Problems in the San Joaquin River," Proceedings of 2006 International Conference on The Future of Agriculture: Science, Stewardship, and Sustainability, Center for Hazardous Substance Research, Kansas State University, Manhattan, KS (2006). http://www.gfredlee.com/SJR-Delta/SJRAgAug06Paper.pdf

Lee, G. F. and Jones-Lee, A., "Agriculture-Related Water Quality Problems in the San Joaquin River," PowerPoint slides presented at 2006 International Conference on "The Future of Agriculture: Science, Stewardship, and Sustainability," Sacramento, CA, August 7 (2006). http://www.gfredlee.com/SJR-Delta/SJRAgAug06Sli.pdf

Lee, G. F., and Jones-Lee, A., "Potential Water Quality Impacts of Agriculture Runoff/Discharges in the Central Valley of California," Presented at Central Coast Agricultural Water Quality Coalition's 2007 National Conference on Agriculture & the Environment, Monterey, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, November (2007).
http://www.gfredlee.com/SJR-Delta/SJRAgImpactsMontereyNov2007.pdf

Lee, G. F., and Jones-Lee, A., "Water Quality Issues of Irrigated Agricultural Runoff/Discharges—San Joaquin River, Central Valley, California," Presented at Agriculture and the Environment - 2007 Conference, Central Coast Agricultural Water Quality Coalition, Monterey, CA, November (2007).
http://www.gfredlee.com/SJR-Delta/SJR-WQ-Ag-Monterey.pdf

Lee, G. F., and Jones-Lee, A., "Potential Water Quality Impacts of Agriculture Runoff/Discharges in the Central Valley of California," Presented at Central Coast Agricultural Water Quality Coalition's 2007 National Conference on Agriculture & the Environment, Monterey, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, November (2007).
http://www.gfredlee.com/SJR-Delta/SJRAgImpactsMontereyNov2007.pdf

Current Delta Water Quality Issues

Lee, G. F., and Jones-Lee, A., "Delta Nutrient-Related Water Quality Problems," PowerPoint Slides Presented at CALFED Science Conference, Sacramento, CA, October 24 (2008). http://www.gfredlee.com/SJR-Delta/CALFED_SciConf10-08.pdf

Lee, G. F., and Jones-Lee, A., "Delta Water Quality Standards Violations" and "Comments on Water Quality Sections of the Delta Vision Strategic Plan, Third Staff Draft – dated August 14, 2008," Submitted to Delta Vision Blue Ribbon Task Force, Sacramento, CA. Report of G. Fred Lee & Associates, El Macero, CA, September 1 (2008). http://www.gfredlee.com/SJR-Delta/DeltaVisionWQViolations.pdf

Lee, G. F., "Comments on Developing Nutrient Criteria for SJR Delta," email to Christine Joab, Central Valley Regional Water Quality Control Board, Rancho Cordova, CA, March 29 (2011).
http://www.gfredlee.com/SJR-Delta/Delta-Nutr-Criteria-Com.pdf

Lee, G. F., and Jones-Lee, A., "Discussion of Water Quality Issues That Should Be Considered in Evaluating the Potential Impact of Delta Water Diversions/Manipulations on Chemical Pollutants on Aquatic Life Resources of the Delta," Report of G. Fred Lee & Associates, El Macero, CA, February 11 (2010).
http://www.gfredlee.com/SJR-Delta/Impact_Diversions.pdf

Appendix H – As You Sow Objective and Activities

As You Sow is a nonprofit organization dedicated to increasing environmental and social corporate responsibility. Founded in 1992, As You Sow envisions a safe, just, and sustainable world in which environmental health and human rights are central to corporate decision making. Its Energy, Environmental Health, Waste, and Human Rights programs create positive, industry-wide change through corporate dialogue, shareholder advocacy, coalition building, and innovative legal strategies. www.asyousow.org provides information on the activities of As You Sow.