EXPERT REPORT OF EDGAR A. IMHOFF,

WATER RESOURCES PLANNER & GEOHYDROLOGIST

I. ASSIGNMENT

In recent reports submitted for the remedy phase of *NRDC v. Rodgers,* several experts retained by the Friant defendants, and in particular Mr. McKusick, have given opinions about the economic effects of restoring flows to the San Joaquin River (SJR) from Friant Dam to the Delta. These reports, however, do not acknowledge or analyze one of the most significant effects of restoring flows to the SJR: water quality in the downstream river corridor and in the Delta. I was asked by NRDC to assess the water quality effects of increased flows from Millerton Reservoir on beneficial water uses other than salmon restoration, including the potential impact of what Dr. Kondolf has termed "Restoration Flows" on current water quality impairments and efforts to improve water quality in the Lower San Joaquin River and the Delta, and how this relates to the U.S. Bureau of Reclamation's (USBR) efforts and the efforts of others to address discharge issues involving Westside irrigators.

II. SUMMARY OF OPINIONS

- "Restoration flows" released from Millerton Reservoir for the benefit of salmon and native fish, as proposed by Dr. Kondolf, will benefit many other categories of users of river water by increasing the capacity of the Lower San Joaquin River (LSJR) to safely assimilate waste discharges and by generally improving water quality conditions in the Lower River and Delta.

- Restoration flows would recreate a San Joaquin River in some 60 miles of stream channel that now are often dry and would have the potential of providing water quality and flow benefits along some 200 river miles, from Friant Dam to the San Joaquin River's junction with the Stanislaus River. This would be in sharp contrast to the current situation in which a comparatively few miles of water quality and flow benefits are derived from periodic releases of New Melones water into the LSJR via the Stanislaus River.

- Restoration flows could help Westside San Joaquin water districts meet current and pending water quality objectives (WQOs) for selenium, salt and boron in the LSJR. Irrigators will face more stringent regulations in the near future when current numerical standards are applied to more sections of the LSJR.

- Beyond the direct benefits of increased assimilative capacity from restoration flows, re-connecting the San Joaquin River between Friant Dam and the Merced River introduces a significant water management tool for greater operational flexibility for the USBR and others grappling with water quality problems in the LSJR and the Delta. To meet water quality and flow objectives in the LSJR and the Delta, additional water from the Friant Division of the Central Valley Project could be released in conjunction with current flow augmentation programs involving SJR tributaries.

- The Bureau of Reclamation (USBR) should look upon restoration flows as an opportunity not only to reduce the impacts of current surface and subsurface discharges of salt, boron and selenium into the San Joaquin River—which would reduce the frequency and severity of violations of WQOs—but also to hedge on the possibility of failures in the performances of key components of USBR planning alternatives. The USBR's in-valley alternatives to address Westside drainage problems rely upon advancements in technology that are expensive and have not been demonstrated as feasible and/or environmentally safe at full scale. Furthermore, the USBR plans rely upon a long time frame that may be over-taken by water quality regulations that are becoming increasingly stringent, whereas restoration flows would provide immediate benefits. (In the USBR plans, the on-farm tile drainage system, essential to collect water from drainage problem lands, is scheduled to be completed over a fifty-year project period.)

- Through increasing assimilative capacity, restoration flows would ameliorate the harmful effects of other substances that are impairing use of the LSJR water for domestic and industrial water supply, recreation, fish and wildlife, and other purposes. For example, other substances of concern include pesticides and herbicides, mercury, oxygen-demanding materials, and total organic carbon.

- The full range of water quality benefits is undoubtedly broader than what I have summarized in this report. That is because I have focused on just a few key parameters, and the increased volumes of high quality restoration flows in the SJR will provide water quality improvements for all parameters.

- The water quality improvements from restoration flows will provide significant economic benefits. The lower SJR and the Delta are highly impaired, ecologically important water bodies that are intensively used by millions of people for purposes ranging from recreation to agriculture to drinking water. Many millions of dollars have been spent, and continue to be spent, on improving water quality (and ecological values relating directly or indirectly to water quality) in these water bodies. While we cannot forecast with precision all of the water quality improvements from restoration flows, the factors discussed herein strongly suggest that the ancillary water quality benefits from restoration flows will be broad and economically meaningful.

III. ANALYSIS AND DISCUSSION

A. Meeting Water Quality Objectives for the Lower SJR

I have reviewed and am familiar with the water quality parameters for which Central Valley Regional Water Quality Control Board programs are current, pending, or potential for the Lower San Joaquin River (LSJR) and the Delta. In this report I concentrate on three current parameters—selenium, salinity, and boron—because of their large impacts, environmental and economic, in the LSJR and the Delta. However, later in this report, I will discuss other water quality parameters and related water problems that could be ameliorated by increasing the assimilative capacity of the LSJR with restoration flows.

1. CWA (Sec. 303d) Impairments of the Lower San Joaquin River (LSJR) By Selenium, Salt and Boron

Water quality impairments of the LSJR because of elevated concentrations of selenium, salt and boron, are a matter of record.[i] Principal sources of these major contaminants are identified as waters applied to[ii], flowing from, or drained from Westside agricultural lands.

The current water quality objective (WQO) set by the Central Valley Board (CVRWQCB) for selenium in the LSJR is 5µ/L, four-day average, waterborne concentration. It is applied to a 50-mile stretch of the LSJR, from Salt Slough to Vernalis (which includes Reach 5 as defined in the Background Report.[iii]) In the year 2010, the Board proposes to extend the 5µg/L objective upstream to Sack Dam, thus applying the objective to all of Reach 4 and, de facto, to inflow into Reach 4 from Reach 3.[iv]

The present management target for selenium in water released from the Mendota Pool is 2 µg/L.[v], a level of concentration that accommodates the Central Valley Board's water objective for wetlands. Because of water deliveries to wildlife refuges from Reach 3 (Mendota Pool to Sack Dam),[vi] the effective WQO for wetlands becomes the attainment objective for Reach 3, during times of diversion of flows to wildlife refuges.

It is important to note that monitoring of the canals that supply water to wetlands shows that the 2 µg/L selenium numeric has been exceeded in various places at various times due to such factors as: flood events, seepage from gates and canals, elevated selenium in the Delta

Mendota Canal and Mendota Pool, inflows from farmland drains, ground water seepage and surface return flows.[vii]

The WQOs for salinity vary seasonally from 700 to 1,000 µS/cm, at the compliance point near Vernalis. The WQOs for boron are differentiated by section of the LSJR. From Sack Dam to Merced River, the numerical standards vary seasonally from a low of 0.8 mg/L to an allowable high of 5.8 mg/L; from Merced River to Vernalis, the numerical standards vary seasonally from a low of 0.8 to a high of 2.6. (Allowance for the inflow of water from the Merced River accounts for the more restrictive standard below the Merced.)

In the Basin Plan Amendments[viii] underway by the Central Valley Board, no significant changes are proposed in the existing numerical standards for salt and boron in the LSJR. However, the Board is in the processs of addressing the exceedance of salinity and boron objectives at Vernalis, and the salt/boron impairment upstream of Vernalis, by extending control programs upriver into the area that contributes the major loads of salt and boron to the LSJR, namely the Westside of the San Joaquin Valley. The control program includes a plan and schedule to establish WQO's and implement Total Maximum Daily Loads (TMDLs) for the SJR upstream of Vernalis to Mendota Pool. Salt and boron control will be applied for both point and nonpoint sources in the Lower San Joaquin River Basin. Controls will also be applied to limit or mitigate the salt imported into the Westside area through the Delta Mendota Canal.

Because of the general direct correlation between boron and salinity concentrations in irrigated lands in the LSJR Basin, and the similar conservative behavior of these substances in water, the Central Valley Board asserts that the boron WQOs will be met if the salinity WQOs are met.

2. Considering the Costs of Implementation of the Basin Plan Amendments:

The Central Valley Board has evaluated several possible measures for implementing the revised WQOs. The proposed Basin Plan Amendments allows flexibility in means to accomplish objectives. But, the extension upriver of the selenium objective and the implementation of a definite plan for control of salt and boron loads in the LSJR have the potential to effect major changes in the operations of many Westside irrigation districts.

Testifying to the U.S. House of Representatives on July 28, 2005, on behalf of the SJR Exchange Contractors, Christopher L. White[ix] said:

> *"Farmers in the northern area of the San Luis Unit and adjacent areas within the Exchange Contractors face a crisis. The California Regional Water Quality Control Board is in effect terminating agricultural drainage to the San Joaquin River by 2009. Without drainage, the land will become water logged and unusable and farming will be extinguished within the area."*

Whether or not that dire prediction holds true, Mr.White is certainly correct that meeting WQOs—without additional freshwater flows in the LSJR—will be difficult. Detailed estimates of costs are available from two sources: the Central Valley Board and the Bureau of Reclamation. Because of different purposes and assumptions these estimates are not equivalent, but both estimates are related in showing high costs for control of salinity and selenium.

In determining the costs of implementing its Resolution R5-2004-0l08, the Central Valley Board estimates[x] that the annual equivalent costs of implementing the salt and boron control program of non-point sources in the Lower San Joaquin River will range from $27 to $38 million (2003 dollars, present worth basis, 20-year period). This cost estimate applies to 1.2 million acres, of which the Westside San Joaquin is by far the primary contributor of salt and boron. These estimates also assume that real-time management will be used to synchronize waste discharges beneficially with the assimilative capacity of the LSJR. The staff of the Central Valley Board did not identify specific cost estimates for selenium control but did note that the constraint of having high selenium content in subsurface drainage from the Grasslands area prevents utilizing a salt and boron control option that would range from $15 to $21 million/year rather than $27 to $38 million.

In developing alternative plans to provide "drainage service"[xi] to the Westside San Joaquin Valley, the USBR has estimated Federal project costsxii and non-federal expenditures for a project area of some 730,000 acres of land. Though drainage service entails more than meeting WQOs, the bulk of the costs and expenditures can be attributed to measures taken to meet WQOs.

The annualized costs of the USBR's alternatives for drainage service range from $34 to $52 million (2002 dollars, present worth, 50-year period). The USBR's estimate of the costs of the most likely alternative, the “In-Valley/Water Needs Land Retirement” alternative, is $47 million. Estimated annual costs of biotreatment of selenium and operation of related evaporation basins comprise only $7.4 million of this value, but this $7.4 estimate does not include mitigation for possible adverse effects on habitat and wildlife or costs for the ultimate disposal of selenium-laden materials from evaporation basins.

In analyzing impact of the likely alternative on non-Federal payees of costs, the USBR estimates that nonrecurring expenditures for onfarm and in-district measures will be $92 million.[xiii] Annualizing this value by proportioning, gives $7 million local expenditures to be added to the $47 million Federal costs. Adding the USBR’s estimate of $2 million local operation and maintenance expenditures results in $9 million/year onfarm and in-district costs of the USBR alternative.

Thus, hypothetically, if the USBR plan works as intended, then for an estimated total annualized cost of $56 million/year, combined Federal and non-federal costs, irrigators on the Westside San Joaquin Valley would meet current WQOs for salt, boron and selenium, in the LSJR, and related wetlands, while addressing Westside drainage problems.

The USBR is scheduled to publish a feasibility level report in 2006 to include refinements of costs and benefit. To date, the USBR has not considered how restoration flows would affect the various strategies under consideration for meeting WQOs. Currently, when the assimilative capacity of the San Joaquin River is insufficient to meet WQOs for salinity at Vernalis, water is released from New Melones Reservoir on the Stanislaus River to boost river flow.[xiv] That is one example of a cost defrayment that could be taken into account by the USBR in considering the potential benefits of restoration flows.

There is no question that the cost of managing the Westside agricultural drainage problems so that WQOs will be met in the LSJR will be high. And as discussed below, there are good reasons to question whether USBR’s drainage service plans will be successful in the absence of high quality flows being restored to the San Joaquin River below Friant Dam.

B. Westside Drainage Problems and Restoration Flows

In response to a federal court order regarding the provision of drainage service to lands on the Westside of the San Joaquin Valley, the Bureau of Reclamation (USBR) has identified several alternatives, each of which would theoretically provide drainage service while meeting California water quality objectives.[xv]

Testifying to the HR Subcommittee on Water and Power, on July 28, 2005, USBR Commissioner John Keys stated the USBR is leaning toward an alternative (the In-Valley/Water Needs Land Retirement Alternative) that would collect 45,000 AF of drainage water from lands showing high concentrations of salts and selenium in shallow ground waters. (An onfarm drainage systems that growers would be responsible for installing—part of what the USBR terms "on-farm and in district actions"—would not be completed until the end of the 50-year planning period.) Collected waters would be conveyed to sequential processes of reuse and treatment that would produce two separate types of effluent: (1), water suitable for blending with CVP water for irrigation, and (2), a concentrate reject water of some 6,800 AF/yr., which would then undergo treatment for selenium removal before discharge to evaporation basins (a.k.a.,"ponds").[xvi] Construction costs of evaporation basins, not including mitigation for adverse effects on wildlife, are estimated as $81,000,000 (present worth basis). Under this alternative, 194,000 acres of presently irrigated lands would be retired from irrigation and would not be included in the integrated drainage/treatment/disposal system.

Treatment technologies for selenium have improved greatly since the original investments in treatment research and field trials by the SJVDP and by water districts such as Panoche and Westlands; however, attaining effluent target levels sufficiently safe for discharge to evaporation ponds has not been demonstrated over any significant period of time at the pilot stage, and has never been demonstrated at full scale.[xvii]

But, let us assume that all the problems that over the years have beset other technologically sensitive biological treatment processes can be overcome; and that 6,800 AF of effluent, in which selenium does not exceed 10 µg/L, will be discharged to some 2,000 total acres of evaporation ponds.

We are left with another uncertainty. Evaporation pond technology has advanced since the days of the SJVDP, but not to the point that credible wildlife biologists who have made their careers a study of ponds are assured that, based on peer-reviewed scientific investigations, the ponds can be operated “bird free” or “bird safe”—which has been the basic performance standard.[xviii]

Currently, on the Westside San Joaquin Valley there are about 4,000 acres of evaporation ponds in operation, or in the process of being closed. The USFWS points out that only one of these ponds has been approved as meeting the requirements of the Central Valley Board as “bird safe.” Most ponds are rich in invertebrates that provide abundant, selenium-laden food for resident, migratory, and wintering birds. In view of the problems with existing ponds, despite great efforts by irrigators and water districts, it is difficult to conceive of large ponds that will not take on some of the hazardous characteristics of a Kesterson Reservoir.[xix]

Though attention focuses on the risk aspects of evaporation facilities, reuse facilities are not free of risk. Biomonitoring of birds attracted to a reuse site showed deformation of bird embryos and avian eggs containing selenium in dry-weight body concentrations that were four times the threshold level for embryo toxicity.[xx]

Simply put, the alternative plan the USBR is apparently leaning toward—or any other in-valley alternative of USBR—may not provide drainage service that meets the WQOs of the LSJR.

If the reuse/treatment/ evaporation pond combination does not perform as expected, what is the fallback position, other than wholesale land retirement (which has not been an objective of the SWRCB or the Central Valley Board)? And anyone who has spent time—as I have—on the ground in the Westside drainage areas, realizes that in the maze of canals, ditches, and drains in those tens of thousands of acres of irrigated lands, there have been and are situations in which selenium discharges get into the LSJR and cause exceedance of WQOs in the River.[xxi]

Time is not an ally of the USBR drainage service plan. Water quality objectives are becoming stricter in the near term—within five years—and more complex in the long-term. The USBR plan will likely not be completed for several decades: the build-out of the onfarm drainage system essential to collect drainage water is forecasted to be complete in the year 2056.

Quoted previously in this report, Mr. White spoke for the Exchange Contractors in declaring that without drainage service a lot of irrigated lands will be shut down when the Central Valley Board's regulations tighten up in 2010. The timing of the USBR drainage service alternative that appears most likely to be selected is not in sync with the timing of necessary water quality regulations.

The salmon restoration flows proposed by Dr. Kondolf range from 184,000 AF/dry year to 356,000 AF/normal wet year. As proposed, these releases of high quality water from Millerton Reservoir are distributed over the year in a manner that would appear to provide considerable assimilative capacity benefits and have the potential to help Westside drainers meet water quality objectives in the LSJR. Specifically, in addition to year-round base flows for restoration, Dr. Kondolf calls for peak monthly flows from March through the April/May timeframe (depending on year type), which will coincide for at least a few months with peak drainage flows, occurring from February through August.[xxii] There is a synergism between the needs for higher flows for salmon and the needs for higher flows to assimilate waste discharges from agriculture.

Because restoration flows can be put on line long before USBR's proposed drainage service plan can be adopted and implemented, and because augmented flows of high quality water may be needed in both an initial phase and as a long-term element of any successful drainage service plan, the USBR should welcome restoration flows as complementary, and arguably essential, to its efforts to resolve the longstanding water quality problems caused by Westside agricultural drainage.

Moreover, in addition to the assimilative capacity benefits provided directly by restoration flows, Dr. Kondolf's proposed flow regime would produce a significant additional benefit for parties such as the USBR who are working to solve chronic water quality and flow issues in the LSJR. Restoration flows would serve as a new source of water and conveyance that could be managed for water quality purposes. For example, water is currently acquired and released from eastside tributaries as part of the VAMP process. However, the California Department of Fish and Game and other stakeholders are requesting, as part of the State Board's (SWRCB) periodic review, that flows be increased above present levels. The General Manager of the Friant Water Authority was recently quoted on these renewed efforts to increase VAMP flows: "Now there are those who want to revisit VAMP and double San Joaquin River fish flows—and Friant is the only possible source for that amount of water."[xxiii] Having the additional management tool of a re-connected SJR that could convey flows from Millerton Reservoir would indeed be critical to any effort to augment flows in the LSJR and the Delta.

Finally, it is important to re-emphasize that restoration flows would provide USBR with a new water quality management tool that could be used to provide water quality benefits along the whole course of the river from Friant Dam to the Delta, in contrast with the current practice of increasing flows from New Melones and only improving water quality downstream of the confluence of the Stanislaus and San Joaquin Rivers.

C. Enhancing the Assimilative Capacity of the LSJR

1. Greater Capacity to Assimilate Salt and Boron Loads

In the Central Valley Board's staff report of July 2004, real-time monitoring of quantity and quality of flows in the LSJR is recommended as a means of allowing agricultural drainers to time their discharges to use the assimilative capacity of the river. Quoting from page 2 of that report: "*…this control program includes opportunities for dischargers to use real-time allocations…Real-time load allocations will generally allow more loading to the LSJR…The benefit of real-time management can be expanded through drainage re-operation…[which] involves the timing of releases to the LSJR to coincide with periods of assimilative capacity…*"

The Central Valley Board will allow the USBR to: "*a) Meet DMC load allocations: or b) Provide mitigation and/or dilution flows to create additional assimilative capacity for salt in the SJR equivalent to salt loads in Delta Mendota Canal supply water in excess of their allocation.*"

The ability to increase assimilative capacity by adding higher quality flow to the SJR was demonstrated in a field study conducted, August 19-30, 2004 when DMC water, containing relatively low salinity compared to base flows in the LSJR, was released down Newman Wasteway with the effect of lowering salt concentrations in the LSJR from a range of 1,500 to 2,000 EC to about 1,000 EC (μS/cm). Dilution flows of 250 to 300 cfs augmented base SJR river flows ranging from 200 to 600 cfs in this USBR experiment.

The Central Valley Regional Board has commented on how flows from Friant Dam could be used in coordination with re-circulation in the Newman Wasteway and flows on other tributaries to provide broad water quality benefits: "Increasing instream flow in the LSJR would provide dilution and mixing options. ...For example, more releases of water from Friant Dam and eastside tributary reservoirs to the LSJR, and recirculation of Delta Mendota Canal water back to the LSJR via Newman Wasteway, would supplement flows and provide benefits to multiple LSJR beneficial users." (Appendix 2, of Draft Final Staff Report, July 2004, CVRWQCB).

In analyzing the beneficial effects on the LSJR of the high-quality water released at Friant Dam, we can also look to the change in water quality during periods when extended flood releases from Friant Dam have re-connected the LSJR with its mainstem headwaters. Such conditions were present in 1998. That year, when Friant releases were flowing by the Landers gage (just upstream of the Merced River) the salinity of the SJR was measured at 50 to 55 EC. However, in other years when there were no Friant releases to the River—and the LSJR contained only waters flowing or drained from irrigated lands—the salinity of the SJR at Landers was twenty times as high.[xxiv]

This dramatic illustration from 1998 is not surprising. The mean EC of SJR water directly below Friant Dam is 52.[xxv] Though some increases in salt concentration may occur in transit down the river, this high quality base flow will obviously provide major improvements in the river's ability to assimilate salt and many other constituents, which is why it will be a great asset in helping Westside drainers meet WQOs in the LSJR.

Moreover, some thousands of acres of irrigated lands in Grasslands—in what the SJVDP classified as zone C of Grasslands in The Rainbow Report[xxvi]—do not contain high concentrations of selenium in the shallow ground water. These lands would seem to be prime candidates for real-time management of matching salinity discharges to an increased assimilative capacity of the LSJR.

2. Dilution of the Concentrations of Selenium in Agricultural Discharges to the LSJR

TMDLs for river bodies are based on the assimilative capacity of the receiving waters. Scientists acknowledge the beneficial effects of dilution of water to lower the potential for bioconcentration of selenium in biota. (Bioconcentration is the process by which living organisms can retain and concentrate chemical present in their surrounding medium, which is usually water.) Lowering the concentration of selenium in water through augmented flows from

Millerton Reservoir has the potential to lessen bioconcentration of selenium in organisms in the LSJR.[xxvii] Eastside streams generally contain amounts of selenium so low as to be undectable (associated with low concentrations of salt and boron, compared to Westside streams and agricultural water discharges.)

Dr. Theresa Presser of the USGS, one of the most experienced and esteemed selenium scientists in California, comments on past difficulties of Grassland Drainers in meeting WQOs under low flow conditions in the San Joaquin River:

> *"…the project [Grasslands Bypass] was not protective of the San Joaquin River during low flow months because Se loads were in excess of those modeled to meet a 5 μG/L objective. Threats to water bodies from Se are traditionally greatest during low flows and dry years."*[xxviii]

From personal experience as manager of the SJVDP, I can attest that the local initiatives and creativity evinced by the Grassland drainers influenced the substance of the Rainbow Report—in the Grasslands Subarea Plan. Despite the responsible and costly effort that is the Bypass Project, however, assurances that the Bypass project will meet future WQOs for selenium have been questioned based on scientific analysis of the forecasts that Project personnel used in applying for a renewal to continue the "experiment" of bypassing drainage around the wetlands. Representing the USGS scientists, Presser concludes:

> *"Dry-year water-quality standards for the San Joaquin River below the Merced River are not met through the nine-year process of this EIS/EIR* [to justify the extension]. *Loads in 2009 remain over 2-fold above those proposed by the state to meet a 5-μg/L Se objective in 2010. The USEPA's criterion of 5 μg/L cannot be met in Mud Slough and the San Joaquin River above the Merced River…"* (See last preceding footnote.).

In commenting on dilution of selenium loads to meet WQOs, scientists stress the difference between selenium—which tends to increase in concentrations in organisms as it moves up trophic levels from prey to predator—and salt and boron that do not. Dr. Presser, Dr. Sam Luoma and other scientists are concerned about the load of selenium accumulating in the Bay/Delta and the lack of rigorous technical and scientific monitoring of the fate and effects of selenium in the LSJR. While acknowledging the general beneficial effects of augmenting low flows of the SJR, they call for the establishment of a comprehensive, science-based program of monitoring and investigation in the Lower San Joaquin River Basin and affected downriver regions.

D. Ameliorating Other Water Quality Problems with Restoration Flows

The Basin Plan of the Central Valley Board designates an array of beneficial uses to be served by the quality of San Joaquin River water in various sections of the River. The list includes, but is not limited to: fish and wildlife, recreation, agriculture, domestic water supply, municipal water supply, and industrial water supply. The capability of the SJR to serve these uses is defined by the presence or absence of certain parameters of water quality in the water. Other than salinity and selenium, several major problem areas have come under the scrutiny or regulation of the Central Valley Board and have been the focus of scientific study. [xxix]

The Central Valley Board lists several organophosphorous (OP) pesticides for load-control limits (TMDL); and TMDLs are pending for several organochlorine (Ocl) pesticides. OP pesticides from agricultural use cause aquatic life toxicity in the SJR. Increasing the SJR flow by releases from Friant Dam will reduce these problematic concentrations. Similarly, there will be major benefits from diluting the excessive concentrations of Ocl pesticides that continue to be contributed to the SJR as a legacy of past practices. Lowering the concentrations of Ocls in SJR waters is especially important because Ocls bioaccumulate in organisms and biomagnify through the food web of life. This, in turn, will be helpful in meeting the goal of eventually rescinding public health advisories for eating fish caught in the lower SJR and the Delta.

The impacts of SJR flows on water quality extend into the Stockton Deep Water Ship Channel. The Central Valley Board has developed a TMDL to address the dissolved oxygen (DO) impairment in the LSJR which harms fish and other aquatic life. The Regional Board has concluded that this impairment is caused in part by reduced SJR flows, along with two other factors: the deepening of the channel to accommodate shipping in the Stockton area, and discharges of nutrients into the SJR. Load limits on nutrient contributions to the SJR fall heavily on the City of Stockton, which is remedying its discharges of ammonia, one of the oxygen-demanding substances that affect the Ship Channel. Tens of millions of dollars have been spent and more are committed to ameliorating the impacts of the depletion of oxygen in the Ship Channel. Under low-flow conditions in the channel, flushing is slow and the water body stratifies to produce a zone devoid of oxygen. Mechanical aeration – an expensive, but potentially effective strategy -- is being experimented with as one solution. Since monitoring has shown that DO conditions in the Ship Channel generally improve with increased flow, additional flows from restoration will improve the DO problem and reduce the need for costly control measures such as aeration. Indeed, in adopting its TMDL for DO, the Regional Board has identified increased flows as a possible solution to the impairment, but has cited its lack of authority over water rights as the reason for not requiring USBR – the largest diverter on the SJR system -- to increase flows through the ship channel. However, the TMDL does recommend that the State Board consider using its water rights permit authority to impose such requirements.

Other substances causing water quality problems in the LSJR include: PCBs (for which a TMDL is pending), dioxins/furans, mercury, pathogens, nutrients (leading to excessive growth of aquatic plants), pyrethroid-based pesticides, total organic carbon (causing water utilities to develop expensive treatment to control trihalomethane and other disinfection byproducts), and herbicides (e.g., diuron). In each case, Friant Dam releases of high quality to the SJR will provide dilution benefits and reduce the impacts on water quality of an array of substances of concern.

E. Revision of Selenium Criteria; an Activity Relevant to Restoration Flows

I am including this section in my report because, of the constituents that are troublesome for water users, selenium is one of the most critical in terms of the costs of preventing its entry into water bodies and the ecological harm it can cause once in the water bodies.

Some in the agricultural community, in recognition of the high costs of controlling selenium to meet WQOs, have expressed hope that the present numeric standards for selenium will be softened. Presently, the EPA is in the process of revising the water quality criterion for selenium for aquatic life.[xxx] EPA staff scientists and peer experts agree generally that, because selenium tends to bioaccumultate in the environment, regulators need to move toward a criterion that when exceeded is more indicative of potential harm to biota than simply testing for concentrations in water.[xxxi] And EPA has proposed abandoning the present 5-μ/L standard in favor of a tissue-based criterion. (Whether or not California regulators would follow that guideline is another matter.)

Among selenium scientists, there is strong advocacy for a tissue-based criterion that would integrate the biotransformation of selenium that is occurring in the environment, but in the body of selenium scientists there is no general agreement on lowering the present waterborne standard, or replacing it solely with a tissue-based criterion.[xxxii] Instead, several leading governmental and academic scientists assert that, if the funds and technical means ever become available, there should be composite criteria, water-sediment-tissue, implemented on a site-specific basis, watershed by watershed.[xxxiii] Scientists working in industry tend to agree on a site-specific method of establishing criteria, but a national protocol for site-specific has not been established, and going watershed to watershed is expensive and time-consuming.

EPA's criteria setting process for selenium has been extended several times and is still open. Such processes do not go quickly or smoothly.[xxxiv]

Ongoing research in California waterbodies—in pond, river and estuarine environments[xxxv]—indicates that harm to biota can occur with waterborne concentrations of selenium at only a little above a background of 1 µ/L. Recognizing this, the Central Valley Board prohibits discharge of agricultural subsurface drainage to wetlands in the Grasslands watershed and in Salt Slough, in concentrations exceeding 2 µ/L. But, as I have stated previously, this numerical limit has been exceeded numerous times in various places in the wetland supply system.

I believe that based on the direction science is heading, and the practicable measures and financial means available to water quality regulators, there will be no "softening" of selenium water quality criteria. But, there will be opportunities to revise water quality criteria—where justified by sound science—to more effectively and safely use water bodies for multiple uses. That opportunity is represented in the LSJR by the proposal to create salmon restoration flows.

IV. STATEMENT OF QUALIFICATIONS

Overview of Career: Edgar A. Imhoff is a water resources planner, professional geologist and practicing hydrologist who has acquired several decades of experience in natural resources planning and in managing scientific investigations to achieve practicable results. Mr. Imhoff has worked in private and university settings, and at all levels of government—in efforts involving

California’s water resources, Idaho’s water resources, New Mexico’s mineral and water resources, river basin planning in Wisconsin, national water resources research, coordination of state and federal water agencies in the ten-state Missouri River Basin, management of a national mine reclamation program, water information programs of the USGS, and private consulting in hydrology.

Principal Experience in California: Serving as an engineering geologist for Thomas Stetson, Inc., Mr. Imhoff gathered field data and prepared exhibits for the lawsuits of: San Gabriel v. Long Beach et al, Arizona v. California, and Inyo County v. Los Angeles. Then he served as District Hydrologist of the Santa Clara Valley Water Conservation District and contributed to the investigations of importation of South Bay Aqueduct water and San Luis Water into the Santa Clara Valley. After many years of absence from California, Mr. Imhoff returned, as a Senior Executive in Interior Department to manage the San Joaquin Valley Drainage Program, from 1986 to 1991. He is a co-author of the “Rainbow Report.” After retirement from the USGS, Mr. Imhoff remained in California until 1996, working first as an Associate in the firm of Hydrologic Consultants, Inc., and then as a private consultant for Natural Heritage Institute, on studies of the conjunctive use of water. Until recent years he served as an Advisory Consultant to Boyle Engineering Corporation, on a California project.

Listing of Experience in Water Quality Investigations: Established a system for monitoring and testing chloride and TDS concentrations of ground water in the Santa Clara Valley Water Conservation District; supervised studies of DO, temperature, and bacterial contamination of streams in southeast Wisconsin; drafted water quality criteria for the rivers of Idaho (Idaho Department of Health); managed research programs on the quality of water in Maine’s lakes and the BOD/DO relationships in Maine’s Rivers; directed the science-based program (SJVDP) in the San Joaquin Valley that produced unprecedented and major findings on the source, distribution, fate and impact of selenium, boron and salt; applied the findings of science and engineering in the drafting of plans for managing drainage problems to meet water quality objectives, protect human health, sustain agriculture, and protect the environment.

EMPLOYMENT (REVERSE CHRONOLOGY):

- Consulting in hydrology, while based in Davis, CA and Charlottesville, VA
- Manager (SES), San Joaquin Valley Drainage Program, Sacramento, California
- Chief (SES), national Office of Water Data Coordination, Washington, DC
- Senior Hydrologist, U.S. Geological Survey (USGS), Reston, Virginia
- Regional Director (SES), U.S. Office of Surface Mining, Indianapolis, IN
- Senior Environmental Planner, Resources and Land Investigations, USGS
- Director of Planning, Missouri River Basin Commission, Omaha, NB
- Director, Office of Water Resources Research, University of Maine, Orono
- Director of Planning, Idaho Water Resource Board, Boise
- Chief Natural Resources Planner, SE Wisconsin Regional Planning Commission
- Hydrological Consultant, Wisconsin Dept. of Resource Development, Madison
- Resources Planner, State of New Mexico, Santa Fe
- District Hydrologist, Santa Clara Valley Water Conservation District, CA
- Engineering Geologist, Stetson Consulting Engineers, Los Angeles

Education, Licenses and Professional Recognition: Mr. Imhoff holds a B.S. in geology from the University of Utah and an M.S. in Water Resources Management from the University of Wisconsin. He is a graduate of the Westinghouse School of Environmental Management. He is a certified Professional Geologist (by exam) and was accredited as a professional planner (by ACIP exam).

Mr. Imhoff's awards include:

- The William C. Ackermann Medal of the American Water Resources Association for "Excellence in Water Management"
- The Distinguished Service Award of the Department of Interior for contributions to water resources investigations and information programs
- The Presidential Rank of Meritorious Executive for the management of the San Joaquin Valley Drainage Program (a State/federal/Stakeholder task force)
- U.S. House of Representatives Resolution, 102nd Congress, 2nd session, honoring Mr. Imhoff for his career achievements and for his role in the Rainbow Report.

Technical Publications and Presentations (last ten years)**:**

- "Understanding the Past: How we got here. An Overview of the 1990 Rainbow Report." March 27, 2001. Sacramento, California. Proceedings published by the San Francisco Estuary Project, Oakland, California.
- "System Earth," 2002. Series of earth science lectures in the Jefferson Institute of Lifelong Learning, University of Virginia.

- "Water Planning Practices, Propositions, and Problems," Oct. 31, 1996. Lecture to School of Planning, University of Virginia.

V. PRIOR TESTIMONY IN COURT AND DEPOSITIONS

In 1978, in the U.S. District Court in Indianapolis, while Regional Director of the federal Office of Surface Mining (OSM), I testified as an expert on mined area reclamation in the case of Indiana v. the U.S. Department of Interior. On May 6, 1994, in Sacramento, on the Sumner Peck case, I testified as an expert on hydrology and water quality conditions in the Westside San Joaquin drainage problem areas.

VI. COMPENSATION

I am charging NRDC a public interest rate of $50/hr for preparation of this Expert Report. My rate for testifying and deposition is $200/hr.

VII. INFORMATION CONSIDERED

A listing of the materials I considered in preparing this report is attached hereto as Attachment A.

DATE: 9/17/05

Edgar A. Imhoff
Edgar A. Imhoff

FOOTNOTES

[i] / For example, see reports and data of the Central Valley Regional Water Quality Control Board (CVRWQCB), the San Joaquin Valley Drainage Program (SJVDP), and the Bureau of Reclamation. E.G., Appendix 1, CVRWQCB, TMDL Report for Salt and Boron in the LSJR, September 2003, peer review.

[ii] I refer to the considerable salt load that is imported into the Westside SJ via the DMC and San Luis Canal.

[iii] / San Joaquin River Restoration Study Background Report, December 2002.

[iv] / See Staff Report of the CVRWQCB, "Total Maximum Daily Load for Selenium in the Lower San Joaquin River, August 2001."

[v] / Memorandum of 22 November 2004, from U.S. Fish and Wildlife Service to Chief, Resources Management Division, USBR, South-Central California Area Office (correspondence 1-1-04-I-2958).

[vi] / See USBR's report "Upper San Joaquin River Basin Storage Investigation Information Report, 2005.

[vii] / See a report of extensive monitoring in 1999-2000, by Eppinger, staff report for CVRWQCB.

[viii] / See CVRWQCB Draft Final Staff Report of July 2004, "Amendments…for the Control of Salt and Boron Discharges into the Lower San Joaquin River" and CVRWQCB Resolution R5-2004-0108.

[ix] / Christopher White is the General Manager and District Engineer of the Central California Irrigation Dist.

[x] / See CVRWQCB draft final staff report for control of Salt and boron, Economic Analysis, July 2004.

[xi] / "Drainage service is defined broadly to include any measure, structural or non-structural, that will reduce or eliminate the conditions causing growers to drain water from crop root zones. Taking land out of irrigation can be considered "drainage service."

[xii] / USBR, "San Luis Drainage Feature Re-evaluation Draft EIS." See Table 2.12-1.

[xiii] / Pages 17-9 and 17-10 of "San Luis Drainage Feature Re-evaluation Draft EIS"

[xiv] / Page D-35, Appendix D, "San Luis Drainage Feature Re-evaluation Draft EIS"

[xv] / USBR, May 2005, "San Luis Drainage Feature Re-evaluation," Draft EIS.

[xvi]/ USBR, March 2005, "Technical Appendices to the San Luis Drainage Re-evaluation," Draft EIS.

[xvii] / See pages 42-49 of the SJVDP Report of 1990, the "Rainbow Report"; Frankenberger et al , "Advanced Treatment Technology in the Remediation of Seleniferous Drainage Waters and Sediments," Feb. 2004, Irrigation and Drainage System, vol.18, no.1, pp 19-42. Critical inquiries about the pilot systems touted by USBR in the Draft EIS are found in a USFWS review of the Draft EIS, memorandum of Nov. 17, 2004, correspondence item FWS/EC-05-005.

[xviii] / Appendix G of USBR's draft EIS, "Ecological Risk Assessment , In-Valley Disposal Alternative."

[xix] / See USFWS draft Report of February 2005 on the USBR draft EIS Feature Re-evaluation.

[xx] / See Skorupa (1998).

[xxi] / See source material citation of USGS (Presser) memo to USBR.

[xxii] / CVRWQCB staff report of August 2001, "TMDL for Selenium in the LSJR."

[xxiii] / R. Jacobsma, Friant Water Line, August 2005.

[xxiv] See page 7, Lee memo to Imhoff

[xxv] / Table on page 6-20 of Background Report

[xxvi] / See page 139 of SJVDP report of 1990, "A Management Plan for Agricultural Subsurface Drainage…"

[xxvii] / For explanation of this process see Dr. Sam Luoma's paper, "Understanding the Linkages," pp.20-27 of proceedings of a workshop, Beyond the Drain, March 27, 2001, Sacramento. Luoma does not vouchsafe, without site-specific investigation of bioaccumulation, for the beneficial effects of flow augmentation of selenium discharges.

[xxviii] / See Presser memorandum to Delamore (USBR), February 26, 2001

[xxix] / See Jones & Stokes negative declaration of Feb. 2005, the CVRWQCB executive report of October 2002 and Dr. Fred Lee's "Overview of Sacramento-San Joaquin River Delta Water Quality Issues," 22 June 2004.

[xxx] / EPA, "Draft Aquatic Life Criteria Document for Selenium," Federal Register 69 (242), Dec. 17, 2004

[xxxi] / EPA, Peer Consultation Workshop on Selenium Aquatic Toxicity and Bioaccumulation, Report 822R98007

[xxxii] / See: Hamilton, S. J. (2002). "Review of residue-based selenium toxicity threshold for freshwater fish," Ecotox. And Environ. Safety 56, 201-210.

[xxxiii] / E.G., as presented by Dr. A. Dennis Lemly in "A Procedure for Setting Environmentally Safe TMDLs for Selenium in San Diego Creek and Newport Bay, California". (January, 2001)

[xxxiv] / My remarks on selenium criterion-setting are based on an extensive review of the scientific literature, personal communications with leading scientists, and on a meeting with scientists of EPA in Washington DC on June 28, 2005. (All of these activities preceded and were unrelated to NRDC asking me to be an expert in this case.)

[xxxv] / See especially: Luoma, S.N. and T.S. Presser, (2000), USGS Open-File Report 00-416; and Skorupa and Ohlendorf, “Contaminants in Drainage water and Avian Risk Thresholds,” pp.345-368 in: The Economics and Management of Water and Drainage in Agriculture, Kluwer Academic Publishers.

ATTACHMENT A – INFORMATION CONSIDERED

In preparing my Report, I considered the following information. My Report also references various materials in footnotes. To the extent that any of the footnote references are not also listed below, that was merely an oversight and those materials should be deemed part of this list.

Brix, K.V. and others.2000.Critical Review of Tissue-based Selenium Toxicity Thresholds. http://www.kennecott.com/pdf/toxicity.pdf

Central Valley Regional Water Quality Control Board (CVRWQCB). August 2001. Total Maximum Daily Load for Selenium in the Lower San Joaquin River. Staff Report.http://www.waterboards.ca.gov/centralvalley/programs/tmdl/TMDL_selenium.pdf

CVRWQCB. October 17/18, 2002. Executive Officer Report. http://www.waterboards.ca.gov/centralvalley/link/index/html/#FileFormat

CVRWQCB. September 2003. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River. The Control of Salt and Boron Discharges into the San Joaquin River. Appendix 1: Technical TMDL Report.http://www.swrcb.ca.gov/rwqcb5/programs/tmdl/vernalis-salt-boron/index/html#sept2

CVRWQCB. July 2004. Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River. The Control of Salt and Boron Discharges into the San Joaquin River. Draft Final Staff Report. http://www.waterboards.ca.gov/centralvalley/programs/tmdl/vernalis-salt-boron/index.html

CVRWQCB. 10 September 2004. Resolution No. R5-2004-0108. Amending the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River. http://www.waterboards.ca.gov/centralvalley/adopted_orders/Resolutions/R5-2004-0108.pdf

CVRWQCB. Loads of Salt, Boron, and Selenium in the Grassland Watershed and Lower San Joaquin River, October 1985 to September 1995. (http://www. waterboards.ca.gov/central valley/programs/agunit/load/exec_sum.htm

Deverel, S.J. August 2005, Expert Report in *Natural Resources Defense Council v. Rodgers.*

Eppinger, J. and J. Chilcott. 2000. Review of Selenium Concentrations in Wetland Water Supply Channel in the Grassland Watershed (water years 1999 and 2000). Staff Report of the CVRWQCB. Scramento. http://www.waterboards.ca.gov/centralvalley/available_documents/agunit/bypass/SJR9900.pdf

Frankenberger and others. February 2004. Advanced Treatment Technology in the Remediation of Seleniferous Drainage Waters and Sediments. *Irrigation and Drainage Systems*, vol. 18, no. 1, pp 19-42. http://www.ingentaconnect.com/content/klu/irri/2004/00000018/00000001/051476

Friant Water Users Authority and Natural Resources Defense Council. December 2002. San Joaquin River Restoration Study Background Report.

Hamilton, S.J. and A. Dennis Lemly, 1999. Water-Sediment Controversy in Setting Environmental Standards for Selenium. *Ecotox. & Environ. Safety 44, 227-235*.

Hamilton, S.J. 2002. Review of residue-based selenium toxicity threshold for freshwater fish. *Ecotox. & Environ. Safety 56, 201-210*.

Jacobsma, R., August 2005, Friant Water Line. www.friantwater.org/waterline/waterline.htm.

Jones & Stokes, February 2005. Deep Water Ship Channel Demonstration Dissolved Oxygen Aeration Facility Mitigated Negative Declaration. http://baydeltaoffice.ca.gov/announcement/IS-MNDPublicDraft02905Release

Keys, John. July 28, 2005. Statement before the HR Subcommittee on Water and Power

Kondolf, G. Mathias. August 2005. Expert Report in *Natural Resources Defense Council v. Rodgers*.

Lee, G.F. and Jones-Lee, A., 2000. Issues in Developing the San Joaquin River Deep Water Ship Channel DO TMDL, Report tot San Joaquin River Dissolved Oxygen TMDL Steering Committee and the CVRWQCB, Sacramento, CA, August 17. http://www.gfredlee.com/Agwaivermonitoring-dec.pdf

Lee, G.F. and Jones-Lee, A., 2004. Overview of Sacramento-San Joaquin River Delta Water Quality Issues, Report of G. Fred Lee & Associates, El macero, CA, June. http://www.members.aol.com/apple27298/Delta-WQ-IssuesRpt.pdf

Lee, G.F. and Jones-Lee, A., 2002. An Integrated Approach for TMDL Development for Agricultural Stormwater Runoff, Tailwater Releases and Subsurface Drain Water. Proc. 2002, Water Management Conference, "Helping Irrigated Agriculture Adjust to TMDLs," pp 161-172, US Committee on Irrigation and Drainage, Denver, CO, October 2002. http://www.gfredlee.com/tmdl_07.2002.pdf

Lee, G.F. August 28, 2005. San Joaquin River Water Quality Implications of Restoring Flows Below Friant Dam. Memorandum to Ed Imhoff. 20pp.

Lemly, A. Dennis. January 2001. A Procedure for Setting Environmentally Safe TMDLs for Selenium in San Diego Creek and Newport Bay, California. www.trout.forprod.vt.edu/fishpubs/lemly2001_02.pdf.

Lemly, A. Dennis, May 2005, personal communication.

Luoma, S.N. and Theresa S. Presser. Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension. USGS Open File Report 00-416. http://pubs.usgs.gov/of/ofr00-416-19k

Maier, K.J., and Knight, A.W. 1994. Ecotoxicology of Selenium in Freshwater Systems. Rev. Environ. Contam. Toxicol. 134m 31-48. www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_vids=8

McGahan, Joseph C. May 31, 2005. Grassland ByPass Project Storm Event Operation during winter 2004/2005. Report to USBR, Mid-Pacific Region by Grassland Watershed Coordinator. http://www.0531JCM970High_Rainfall-1.pdf

Moyle, Peter B. August 2005. Expert Report in *Natural Resources Defense Council v. Rodgers.*

Presser, S.N. February 26, 2001. Comments on Draft Environmental Impact Statement/Environmental Impact Report for the nine-year renewal of the Grassland Bypass Project. Memorandum from USGS, Water Resources Division, Melo Park to Michael Delamore (USBR, Fresno) and Joseph McGahan, Summers Engineering

San Francisco Estuary Project. May 27, 2001. Beyond the Drain: Proceedings of a conference on Sustaining Agriculture and Improving Water Quality in California's San Joaquin Valley. (See papers by E. Imhoff, Neil Dubrovsky, Les Grober, Earle Cummings, Steve Schwarzbach, Theresa Presser, and Sam Luoma.)

San Joaquin River Water Quality Management Group. June 2005. Summary Recommendations of the SJRWQMG for Meeting the Water Quality Objectives for Salinity Measured at Vernalis and Dissolved Oxygen in the Stockton Deep Water Ship Channel.

San Joaquin Valley Drainage Program (SJVDP). 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. Final Report (a.k.a. "The Rainbow Report"). Prepared for the U.S. Department of the Interior and California Resources Agency. September.

San Joaquin Valley Drainage Implementation Program (SJVDIP). 1998. Drainage Management in the San Joaquin Valley: A status Report. February. www.cdfa.ca.gov/exec/aep/aes/sjvdip/-24k

Skorupa, J.P. 2005. Hazards of Selenium for Aquatic Life. http://www.wvu.edu/~agexten/landrec/2005/TFPPPRS/pptskorupa.pdf

Skorupa, J.P. and Ohlendorf, H. 1990. Contaminants in Drainage Water and Avian Risk Thresholds. Pp. 345-368. In *The Economics and Management of Water and Drainage in Agriculture*. Kluwer Academic Publishers.

U.S. Bureau of Reclamation (USBR). March 2005. San Luis Drainage Feature Re-evaluation. Draft Environmental Impact Statement. Technical Appendices.

USBR. May 2005. San Luis Drainage Feature Re-evaluation Draft Environmental Impact Statement.

USBR. June 29, 2005. Recirculation Pilot Study Final Report. Mid-Pacific Region.

USBR. August 31, 2005. Upper San Joaquin River Basin Storage Investigation Information Report. www.usbr.gov/mp/sccao/storage/-9k

U.S. Environmental Protection Agency (EPA). May 1998. Proceeding of Consultation Workshop on Selenium Aquatic Toxicity and Bioaccumulation of May 27/28, 1998. EPA Publication98007. www.epa.gov/fedrgstr/EPA_TOX/1998/May/Day_12/tl12581.htm-19k

U.S. Environmental Protection Agency (EPA). Draft Aquatic Life Criteria Document for Selenium. *Federal Register* 69 (242), December 17, 2004. http://www.epa.gov/waterscience/criteria/selenium/fs.htm

U.S. Environmental Protection Agency (EPA). June 29, 2005. Technical discussion meeting on Selenium Criteria with Director and staff of EPA Health and Ecological Criteria Division and representatives of stakeholders.

U.S. Fish & Wildlife Service (USFWS). 22 November 2004. Review of USBR Draft Fish & Wildlife Coordination Act Report for the San Luis Drainage Feature Re-Evaluation, Memorandum to Chief , Resources Management Division, USBR, South Central California Area Office, correspondence I-1-04-I-2958.

U.S. Fish & Wildlife Service. 7 February 2005. Draft Fish and Wildlife Coordination Report for the San Luis Drainage Feature Re-evaluation. (published in USBR Technical Appendices to San Luis Re-evaluation Draft EIS)

White, Christopher L. July 28, 2005. Testimony to the HR Subcommittee on Water and Power.