Comments on California Department of Water Resources July 26, 2004 News Release and Report on the Potential Impacts of Depositing Polluted Dredged Sediments on the Trapper Slough Levee

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Abstract

In late July 2004 the California Department of Water Resources (DWR) purchased Deep Water Ship Channel sediments that were in a dredged material disposal area owned by the Port of Stockton to enhance the Trapper Slough levee in the Delta. When questions were raised about the potential for these dredged sediments to lead to surface water pollution associated with runoff from the levee where they were placed, DWR conducted some hazardous waste leaching tests to "characterize" the pollution potential of these dredged sediments. DWR, working with the Port of Stockton, issued a report and a press release stating that the dredged sediments were not hazardous waste. The characterization of wastes and the impact of dredged sediments on water quality are areas in which I have been active for over 30 years. Presented herein is a discussion of the inappropriate approach that DWR used to characterize the pollution potential of the dredged sediments that were placed on the Trapper Slough levee. Also, guidance is provided on the type of studies that need to be conducted to properly evaluate the potential for the dredged sediments to lead to water pollution in Trapper Slough by chemical constituents in the dredged sediments.

Introduction

On July 26, 2004, the California Department of Water Resources (DWR), working with the Port of Stockton, developed a "News for Immediate Release" entitled "Tests Indicate Trapper Slough Levee Material Not Hazardous, But Further Study Warranted." This press release states that the concentrations of barium, copper and zinc are well below the hazardous threshold which would constitute hazardous material. This press release is inadequate in reliably informing the public about the issues of concern. The water quality impacts of the dredged sediments that the Port of Stockton sold to DWR as part of levee enhancement along Trapper Slough are much broader than whether the dredged sediments are a hazardous waste, but include whether these contaminated dredged sediments placed on the Trapper Slough levee represent a potential threat to cause water quality problems in the Delta.

Presented below is a discussion of the technical problems associated with DWR's press release and report (DWR, 2004) upon which the press release was based. Also discussed is background information in the literature that is pertinent to properly evaluating the water quality

significance of the pollutants in the Port of Stockton's dredged sediments that were sold to DWR for placement on the Trapper Slough levee.

A critical review of the data in DWR's "Laboratory Analysis of Soil and Water Samples, Trapper Slough Levee, Upper Jones Tract, July 23, 2004," which served as the basis for the DWR/Port of Stockton press release, shows that, under conditions which could occur, several heavy metals are leachable at concentrations that are above US EPA and Central Valley Regional Water Quality Control Board (CVRWQCB) water quality criteria/objectives (standards) and, therefore, could cause violations of the US EPA's Clean Water Act and the state of California's Porter-Cologne Act requirements for protection of water quality. The statement in the press release that the testing shows that the dredged sediments placed on the Trapper Slough levee are not hazardous material reflects a lack of understanding and proper reporting on "hazardous waste" versus "hazardous material." Based on the data generated by DWR and presented in its Laboratory Analysis report, the dredged sediments that were sold to DWR by the Port and placed on the Trapper Slough levee contain constituents that are leachable and that are a threat to aquatic life. However, based on the DWR testing that has been done thus far, these sediments do not violate the US EPA's Resource Conservation Recovery Act (RCRA) concentration limits that govern whether the materials are to be placed in a hazardous waste landfill versus a municipal solid waste landfill for their disposal.

It is important to understand that the hazardous waste classification system that was developed by the US EPA in the late 1970s/early 1980s was not designed to evaluate whether constituents such as heavy metals could be leached from solids, such as dredged sediments, at sufficient concentrations to be a hazard to aquatic life. This is a topic area in which I have been involved for over 30 years. I have published several papers on this issue. One of these, "Application of Site-Specific Hazard Assessment Testing to Solid Wastes" (Lee and Jones, 1981), was presented at an American Society for Testing and Materials (ASTM) conference on waste testing. This paper was judged by the conference committee to tie for first place as the best paper presented at the conference. This paper contains information on the proper interpretation of the water quality significance of chemicals in wastes as they may impact public health and the environment.

I have recently developed a review on inappropriate approaches for interpretation of the hazards of metals in wastes as they may impact public health and the environment. Recently, unreliable information in connection with the disposal of electronic materials, such as televisions, computers, etc., in landfills was developed by the Solid Waste Association of North America (SWANA, 2004). Their report states that the heavy metals in municipal landfill leachate are not a threat to cause pollution of groundwaters. I developed a detailed discussion of SWANA's inappropriate conclusions (Lee, 2004). As discussed in my report, if SWANA had properly analyzed the data on the composition of landfill leachate, the SWANA report would have concluded that there is a significant threat to cause groundwater pollution and, at some locations, surface water pollution, due to the leaching of heavy metals in municipal solid wastes. The SWANA report conclusions relied on the observation that the mean concentrations of metals in landfill leachate were less than the limiting concentrations that the US EPA will allow in the leaching of solid waste which can be placed in a municipal solid waste landfill. However, as I discuss, the US EPA's concentration limits for hazardous waste classification were arbitrarily

developed and do not properly evaluate the potential for a solid waste to leach sufficient constituents to cause ground and/or surface water pollution. This is basically the same problem that DWR had in reporting on the results of their testing of the dredged sediments that the Port of Stockton sold to DWR which were placed on the Trapper Slough levee.

Review of the July 26, 2004, DWR Report

The DWR July 26, 2004, report on the characteristics of the dredged sediments sold to DWR that were placed on the Trapper Slough levee is of limited utility in providing needed information on the potential for these sediments to leach heavy metals or other constituents at a sufficient rate and amount to cause water quality problems in Trapper Slough and other Delta waterbodies potentially impacted by the Port's dredged sediments. A discussion of the limitations of the DWR approach is presented below.

Totals Test. DWR conducted analysis ("Totals Test") for total metals in the Trapper Slough levee sediments that are regulated by the California Department of Toxic Substances Control (DTSC) under California Code of Regulations (CCR) Title 22 for evaluating whether a solid waste is a "hazardous" or "nonhazardous" waste. Title 22 presents the Total Threshold Limit Concentrations (TTLC). An exceedance of a TTLC requires that the waste be deposited in a landfill that has been approved to accept hazardous wastes.

Several years ago, I was involved as part of a DTSC review panel on the approaches used for classifying waste as hazardous versus nonhazardous. As a result I became familiar with the background to the DTSC current approach for waste classification. A critical review of the technical basis for the TTLC limits shows that they were developed several years ago and were based on limited technical information. The TTLC limits have no applicability to evaluating whether a dredged sediment has the potential to leach (release) selected heavy metals in open water or upland disposal, including placing the dredged sediment on a levee for levee enhancement.

Citrate Waste Extraction Test (WET). The DTSC developed a Citrate Waste Extraction Test (WET) for classification of a waste as hazardous or nonhazardous, in which dilute citric acid is used to leach the solid. DTSC has developed Soluble Threshold Limit Concentrations (STLC) under Title 22 to determine if a waste leaches sufficient constituents to require placement in a hazardous waste landfill. The conditions of the WET are such that the concentrations leached during the test would likely overestimate the amount of metals that would be leached in a situation like that which exists for the Port of Stockton dredged sediments that were sold to DWR for placement on the Trapper Slough levee. The WET data can be considered an upper bound for leachable metals.

It is important to understand that the TTLC and STLC tests consider only a limited number of constituents of potential concern in protecting water quality from leaching from dredged sediments, other sediments and solid wastes. These issues have been recently reviewed by Lee in the *Stormwater Runoff Water Quality Science/Engineering Newsletter* NL 7-3 (Jones-Lee, 2004). This and other Newsletters are available at www.gfredlee.com in the Newsletter section. As discussed, there are many thousands/millions of chemical constituents in wastewaters and stormwater runoff from urban and agricultural sources that are not regulated but

have the potential to be adverse to water quality beneficial uses. Passing the TTLC and the STLC limits does not mean that the sediments do not leach unregulated chemicals at concentrations that are adverse to aquatic life. In addition to toxicity to aquatic life, there is also concern that chemicals present in the dredged sediments, either through leaching or through food web uptake, could lead to excessive bioaccumulation of hazardous chemicals in edible fish tissue that are a threat to cause cancer in those who use the fish as food.

As discussed by Lee and Jones-Lee (2002, 2004a), fish in parts of the Delta have been found to contain excessive concentrations of hazardous chemicals that tend to be associated with sediments. For example, sediments dredged from the Port of Stockton and the Deep Water Ship Channel (DWSC) contain PCBs, dioxins, chlorinated hydrocarbon legacy pesticides such as DDT, as well as other potentially hazardous chemicals. In addition, it is likely that these sediments contain pesticides currently used in agricultural and urban areas, such as pyrethroid-based pesticides, that are a threat to cause water quality problems in the waters that are in contact with the dredged sediments. Weston et al. (2004) have recently reported that sediments are being found in Central Valley waterbodies that contain pyrethroid pesticides and are toxic to aquatic life.

Deionized Water Waste Extraction Test (DI-WET). DWR also used a Deionized Water Waste Extraction Test (DI-WET) to examine the Port of Stockton dredged sediments that were sold to DWR for placement on the Trapper Slough levee. The DI-WET uses distilled water to leach the solid, where the amounts of selected metals leached are compared to the DTSC STLC limits. Comparison of the DI-WET results to the DTSC STLC limits has no relevance to estimating the potential water quality impacts of heavy metals or other constituents associated with a dredged sediment. The basic problem is that the STLC limits do not consider the current understanding of critical concentrations of selected chemicals for which there are US EPA water quality criteria or state of California water quality objectives (standards). These concentrations are much less that the concentrations that are allowed in the DTSC STLC limits.

Examination of the DI-WET results can provide some insight into the leachability of heavy metals from the dredged sediments. The leaching of regulated constituents in the DI-WET in excess of the US EPA (2000) California Toxics Rule criteria or US EPA (2002) updated National Recommended Water Quality Criteria is an indication of potential water quality problems for chemicals considered in the leaching test. Exceedance of or failure to exceed these water quality criteria should not be interpreted to mean that the placement of a dredged sediment will or will not cause water quality problems due to leaching of the constituent at a sufficient rate to be adverse to aquatic life. The DI-WET results that exceed the US EPA water quality criteria should lead to further site-specific studies. These studies should also be conducted if the dredged sediments are derived from a channel where there is a potential for contamination of the sediments by discharges/runoff from urban and/or agricultural sources by the vast arena of unregulated chemicals discussed above, such as the sediments that the Port of Stockton sold to DWR.

Examination of the data presented in the DWR (2004) report shows that several heavy metals, such as copper and zinc, are leachable in the DI-WET at concentrations above the US EPA (2002) Recommended Water Quality Criteria and California Toxics Rule (US EPA, 2000)

criteria. As discussed above, this is an indication of a potential water quality problem that needs further investigation through site-specific studies. One of the issues of particular concern is that the DWR Trapper Slough water data show copper concentrations in excess of the water quality criterion. This means that Trapper Slough water, at least in this region, has no assimilative capacity for additional copper that could be leached from the Port sediments located on the Trapper Slough levee.

Evaluation of the Potential Impacts of Sediments on Water Quality

During the 1970s, while I held the position of Professor of Environmental Engineering and Director of the Center for Environmental Studies at the University of Texas at Dallas, my graduate students and I conducted over a million dollars in research on the leaching of chemicals from dredged sediments similar to those that the Port sold to DWR to place on the Trapper Slough levee. In 1978, the Corps of Engineers Waterways Experiment Station Dredged Material Research Program published a 1,500-page report that my associates and I developed, "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Material Disposal" (Jones and Lee, 1978; Lee et al., 1978), covering the studies that we conducted at over 100 sites located throughout the US on the leaching of about 30 chemicals from dredged sediments and the sediments' toxicity to aquatic life. Our work on this topic is recognized as the most comprehensive study of this issue that ever has or ever will likely be conducted. A summary of this work is presented in the Handbook of Dredging Engineering (Lee and Jones-Lee, 2000). This and other work that has been done on this topic shows that placement on the Trapper Slough levee of contaminated dredged sediments of the type that the Port sold to DWR can lead to significant water quality problems.

As part of Dr. Jones-Lee and my efforts to educate the water quality management field on the approach that should be followed to manage contaminated sediments and other solids, we published an invited review, "A Risk Assessment Approach for Evaluating the Environmental Significance of Chemical Contaminants in Solid Wastes" (Lee and Jones, 1982), in which we discussed how contaminated sediments of the type that were placed on the Trapper Slough levee should be investigated to determine whether there are significant potential water quality problems. This involves a site-specific investigation of the amount of leaching, the rate of leaching, and the mixing of the leachate with the receiving waters in order to evaluate the potential adverse impacts on water quality of heavy metals and other constituents in the solid waste materials. While the DWR staff and the Port, in their press release, acknowledge that further work may be needed to determine the water quality problems associated with the placement of contaminated dredged sediments on the Trapper Slough levee, the press release and the report fail to provide reliable information on this issue.

During the past year Dr. Jones-Lee and I conducted a comprehensive review of current water quality problems in the Delta, which has been published in a 150-page report (Lee and Jones-Lee, 2004a). One of the important conclusions from this study is that DWR, as one of the primary agencies responsible for evaluating the impacts of exporting large amounts of Delta water to Central and Southern California and the San Francisco Bay region, has failed to evaluate the impacts of these exports on Delta water quality. In fact, DWR has failed to properly monitor for these impacts.

Based on the approach used to evaluate the leaching data, the authors of the DWR report on the investigation of the Trapper Slough levee sediments' leaching of heavy metals evidently do not understand that, in accordance with the Clean Water Act, there are well-established limits on the amounts of heavy metals (such as copper) that can be present in a water sample without being adverse to aquatic life, such as through causing toxicity to fish, fish larvae or fish food organisms. In their report they discuss the LC50 – i.e., lethal concentration that will kill half of a certain type of fish in a standard toxicity test. It is stated in the report that the LC50 of copper to blue sunfish is 240 µg/L. However, the critical concentration of copper to fish is about 10 µg/L. DWR staff also report the acute oral LC50 concentration of copper sulfate for rats as 900 mg/kg. This has no relevance to the issues of concern with respect to evaluating the water quality significance of the Port of Stockton dredged sediment impacts in Trapper Slough and elsewhere. What should have been reported on is the concentrations of copper, zinc, lead, etc., leachable from the solids, based on the DWR leaching data, relative to the water quality objectives (standards) that have been established by the US EPA, the State Water Resources Control Board and the Central Valley Regional Water Quality Control Board for protection of aquatic life.

An issue of particular concern associated with the sediments that were examined by DWR is that they tend to cause water in contact with them to be somewhat acidic. This will promote the release of heavy metals from the sediments. As discussed by Lee and Jones-Lee (2003), Litton (2003) found that the Deep Water Ship Channel sediments have substantial amounts of rapid oxygen demand related to the oxidation of iron and sulfur compounds. This oxidation (reaction with dissolved oxygen) is an abiotic (non-biochemical) process that leads to acid production and a lower pH. This is one of the reasons why studies of areas where upland (on-land) disposal of dredged sediments is practiced have found that the waters associated with the sediments over time become acidic, and dissolve/release heavy metals.

The same reactions would be expected with the Deep Water Ship Channel sediments that have been deposited on land to the extent that there is still oxygen demand in the sediments in the form of reduced iron and sulfur compounds. These compounds will be oxidized to form additional acid, lowering the pH of the sediments and soils in which they are located. This acid release will be in the direction of leaching heavy metals from the deposited dredged sediments and the nearby soils. These reactions have been studied in detail by the US Army Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi. For further information on the studies that have been done by the Corps of Engineers Waterways Experiment Station on the potential impacts of open water and on-land disposal of contaminated sediments, go to www.wes.army.mil/el/dots/drieb.html.

The reaction between iron and dissolved oxygen represents an area of my studies. Following the completion of my PhD work at Harvard University in the late 1950s, I spent a year in postdoctoral study with Professor Werner Stumm, who is recognized as the father of modern aquatic chemistry, studying the reactions between dissolved oxygen and iron. This resulted in a classic paper published on this topic, "Oxygenation of Ferrous Iron" (Stumm and Lee, 1961). This paper demonstrated the effects of pH on the rates of oxidation, where in more acidic soils the rates are slowed down; however, in the presence of copper the rates are accelerated due to a copper catalysis. Dr. Stumm and I published a review paper on the chemistry of aqueous iron

(Stumm and Lee, 1960). This paper summarized the information available at the time of paper development on the reactions of iron in aquatic systems. Many of these reactions are applicable to the situation that is occurring on the Trapper Slough levee.

The current regulatory approach that is being followed by the Central Valley Regional Water Quality Control Board is based on exceedence of water quality criteria in standard leaching tests. These tests, such as those conducted by DWR, are indicative of potential problems. Since the conditions of the test oversimplify what can happen in the environment, an opportunity exists for the discharger (the Port and DWR) to conduct detailed studies such as those described in our paper to determine whether excessive leaching is occurring under the various conditions that can exist on the Trapper Slough levee.

Because of the apparent lack of familiarity with the proper approach for evaluating water quality associated with the leaching of constituents from contaminated dredged sediments and the campaign that the Port and DWR have carried out to try to gain public support for the lack of a problem, it will be essential that further studies be done to evaluate the real water quality problems associated with the contaminated sediments on the Trapper Slough levee. These studies should be conducted under the supervision of an independent advisory board consisting of interested parties and experts in the field. This would take the studies out of the political arena that DWR and the Port are now attempting to use, and place them in a public technical arena where they can be properly reviewed.

Dr Jones-Lee and I have developed several papers and reports on the issues that should be considered and approaches that should be followed in evaluating the water quality significance of chemicals in aquatic sediments. These are available on our website, www.gfredlee.com in the Contaminated Sediments/Aquafund section. Recently, we have published a discussion of the recommended approach for evaluating the water quality significance of contaminants in sediments (Lee and Jones-Lee, 2004b). This approach is based on a weight of evidence triad best professional judgment (BPJ) evaluation of the information that needs to be developed in evaluating the water quality significance of contaminants in sediments. The studies that need to be done to evaluate the water quality significance of the chemical constituents in the sediments that the Port of Stockton sold to DWR, which were placed on the Trapper Slough levee, should involve a BPJ weight of evidence approach. These studies should be organized, supervised and reviewed by a panel of experts. Failure to follow this approach could readily lead to questions about a perceived bias in conducting the studies and reporting the results.

The proposed studies have implications far beyond the Trapper Slough levee situation. From the information available, the sediments that the Port of Stockton sold to DWR were derived from Roberts-2 Dredged Material Disposal area. This area has been considered by the CVRWQCB to contain Deep Water Ship Channel dredged sediments that have limited contamination. It appears, however, from the DWR report that these so-called “clean” sediments contain sufficient concentrations of several heavy metals to require a much more comprehensive review of the use of these sediments for levee enhancement or other purposes. There may be need for a comprehensive study of all of the areas where Roberts-2 sediments have been used/sold by the Port for levee enhancement.

References

DWR, "Laboratory Analysis of Soil and Water Samples, Trapper Slough Levee, Upper Jones Tract," California Department of Water Resources, Sacramento, CA, July 23 (2004).

Jones, R. A. and Lee, G. F., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Material Disposal, Vol. I: Discussion," Tech Report D-78-45, US Army Engineer Waterways Experiment Station, Vicksburg, MS, August (1978).

Jones-Lee, A. (ed), *Stormwater Runoff Water Quality Science/Engineering Newsletter* (2004). http://www.gfredlee.com/newsindex.html

Lee, G. F., "Comments on 'The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment,'" Report of G. Fred Lee & Associates, El Macero, CA, July (2004).
http://www.members.aol.com/duklee2307/SWANA-heavymetals-comments.pdf

Lee, G. F. and Jones, R. A., "Application of Site-Specific Hazard Assessment Testing to Solid Wastes," In: Hazardous Solid Waste Testing, ASTM STP 760. American Society for Testing and Materials, pp. 331-344, (1981). http://www.members.aol.com/apple27298/hazassesstest.pdf

Lee, G. F. and Jones, R. A., "A Risk Assessment Approach for Evaluating the Environmental Significance of Chemical Contaminants in Solid Wastes," In: Environmental Risk Analysis for Chemicals, Van Nostrand, New York, pp. 529-549 (1982).
http://www.members.aol.com/apple27298/SiteSpecificTCLP.pdf

Lee, G. F. and Jones-Lee, A., "Water Quality Aspects of Dredging and Dredged Sediment Disposal," In: Handbook of Dredging Engineering, Second Edition, McGraw Hill, pp. 14-1 to 14-42 (2000). http://www.gfredlee.com/dredging.html

Lee, G. F. and Jones-Lee, A., "Organochlorine Pesticide, PCB and Dioxin/Furan Excessive Bioaccumulation Management Guidance," California Water Institute Report TP 02-06 to the California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 170 pp, California State University Fresno, Fresno, CA, December (2002). http://www.gfredlee.com/OClTMDLRpt12-11-02.pdf

Lee, G. F. and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel Near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003).
http://www.gfredlee.com/SynthesisRpt3-21-03.pdf

Lee, G. F. and Jones-Lee, A., "Overview of Sacramento-San Joaquin River Delta Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA, June (2004a).

http://www.members.aol.com/apple27298/Delta-WQ-IssuesRpt.pdf

Lee, G. F. and Jones-Lee, A., "Appropriate Incorporation of Chemical Information in a Best Professional Judgment 'Triad' Weight of Evidence Evaluation of Sediment Quality," Presented at the Fifth International Symposium on Sediment Quality Assessment (SQA5), "Aquatic Ecosystems and Public Health: Linking Chemical, Nutrient, Habitat and Pathogen Issues," Published in *Aquatic Ecosystem Health & Management* 7(3):351-356, Taylor & Francis, Philadelphia, PA (2004b). http://www.gfredlee.com/BPJWOEpaper.pdf

Lee, G. F., Jones, R. A., Saleh, F. Y., Mariani, G. M., Homer, D. H., Butler, J. S. and Bandyopadhyay, P., "Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Materials Disposal, Vol. II: Data Report," Technical Report D-78-45, US Army Engineer Waterways Experiment Station, Vicksburg, MS, 1186 pp., August (1978).

Litton, G. M., "Deposition Rates and Oxygen Demands in the Stockton Deep Water Ship Channel of the San Joaquin River, June-November 2001," Report prepared for San Joaquin River Dissolved Oxygen TMDL Steering Committee and TAC (2003). Available from www.sjrtmdl.org.

Stumm, W. and Lee, G. F., "The Chemistry of Aqueous Iron," *Schweizerische Zeitschruft fur Hydrology* XXII:95-139 (1960).

Stumm, W. and Lee, G. F., "Oxygenation of Ferrous Iron," *Ind. Eng. Chem.* 53:143-146 (1961).

SWANA, "The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment," Solid Waste Association of North America, March (2004).

US EPA, "Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule," US Environmental Protection Agency, Region 9, Federal Register 40 CFR Part 131, Vol. 65, No. 97, [FRL-6587-9], RIN 2040-AC44, San Francisco, CA (2000).

US EPA, "National Recommended Water Quality Criteria," EPA 822-R-02-047, US Environmental Protection Agency, Washington, D.C. (2002).

Weston, D. P.; You, J. and Lydy, M. J., "Distribution and Toxicity of Sediment-Associated Pesticides in Agriculture-Dominated Water Bodies of California's Central Valley," *Environmental Science & Technology* 38(10): 2752-2759 (2004).