# Stormwater Runoff Water Quality Science/Engineering Newsletter Devoted to Urban/Rural Stormwater Runoff Water Quality Management Issues

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This issue of the Newsletter is devoted to further review of **stormwater runoff aquatic life toxicity** associated with the use of **organophosphorus (OP) pesticides, diazinon and chlorpyrifos,** in urban areas. Newsletters NL 2-1, and 3-5 have previously discussed this issue. These Newsletters are available from www.gfredlee.com. As part of the California Central Valley Regional Water Quality Control Board (CVRWQCB) TMDL program, Lee and Jones-Lee (2002a) have developed a report that provides information pertinent to developing a TMDL to control aquatic life toxicity in city of Stockton, CA, stormwater runoff. The Executive Summary and Recommendations from this report are included in this Newsletter.

Lee (2001) has provided background to the pesticide-caused aquatic life toxicity problem in urban stormwater runoff. Beginning in the 1980s, diazinon and chlorpyrifos have been used by urban residents to control termites, ants, and urban residential and commercial structural and lawn and garden pests. As part of investigating whether the elevated concentrations of heavy metals in urban stormwater runoff were toxic to aquatic life, it was found in the early 1990s that stormwater runoff from urban areas in California were toxic to *Ceriodaphnia* (water flea). *Ceriodaphnia* is one of the US EPA standard aquatic life test organisms. The studies on the toxicity of urban stormwater runoff showed that the heavy metals in the runoff were nontoxic; however, the toxicity was due to the organophosphorus pesticides, diazinon and chlorpyrifos.

In 1994 Dr. Valerie Connor of the CVRWQCB, in cooperation with the University of California Davis Aquatic Toxicity Laboratory, initiated an aquatic life toxicity monitoring program for stormwater runoff in the city of Stockton, CA. In the mid-1990s through 1999, William Jennings of the DeltaKeeper continued this monitoring program. Lee and Jones-Lee (2001) developed a write up of this 1994-99 database. It was found that Stockton stormwater runoff was toxic to *Ceriodaphnia* in every runoff event. Toxicity identification evaluations (TIEs) showed that this toxicity was due to diazinon and chlorpyrifos. Generally there was no toxicity to the other US EPA standard freshwater test organisms, fathead minnow larva and the alga *Selenastrum*. The water in the city of Stockton waterways that receive the City's stormwater runoff was generally nontoxic between stormwater runoff events.

The stormwater-runoff-associated toxicity in Stockton's urban waterways violated the CVRWQCB Basin Plan objective (standard) of "no aquatic life toxicity." This led to the CVRWQCB listing two Stockton waterways, Mosher Slough and Five Mile Slough, as Clean Water Act (CWA) "impaired" resulting in their being placed on the CWA 303(d)

list of impaired waterbodies. Once listed, the CVRWQCB must develop a TMDL to control this toxicity.

The first step in implementing a TMDL is developing a technical report to the regional US EPA. Drs. G. Fred Lee and Anne Jones-Lee (2002a) developed a TMDL guidance report for the CVRWQCB in December 2002. The approach followed is that recommended by Lee and Jones-Lee (2000) and Jones-Lee and Lee (2000a). The Executive Summary and Recommendations for the city of Stockton OP pesticide TMDL report are presented below. The complete report is available from <http://www.gfredlee.com/StockDiaTMDL12-14-02.pdf> or from gfredlee@aol.com.

The aquatic life toxicity problem associated with urban stormwater runoff is not restricted to Stockton, CA. As discussed by Lee and Taylor (1999) and Lee, *et al.* (2001), monitoring of stormwater runoff in all California cities where monitoring has occurred (San Francisco Bay area, Orange County, San Diego, Los Angeles area, Sacramento) and elsewhere such as Fort Worth, TX, has shown aquatic life toxicity to *Ceriodaphnia*. A review of the USGS national pesticide monitoring data has shown that there are sufficient concentrations of diazinon and chlorpyrifos in several urban waterways located across the US to be toxic to *Ceriodaphnia*. The urban stormwater runoff aquatic life toxicity problem due to the OP pesticides is a largely unrecognized national urban stormwater runoff problem. It is also a problem associated with agricultural runoff where the OP pesticides are used to control agricultural pests.

Information on the diazinon TMDL that is being developed for San Diego, CA, is available as "Final Draft of Chollas Creek Diazinon TMDL" from <http://www.swrcb.ca.gov/rwqcb9/tmdls/chollas%20creek%20diazinon.html>.

Information on the TMDL that is being developed for San Francisco Bay area is available as "Diazinon and Pesticide-Related Toxicity in San Francisco Bay Area Urban Creeks TMDL Project" from <http://www.swrcb.ca.gov/rwqcb2/urbancrksdiazinontmdl.htm>.

A Basin Plan amendment to incorporate a Total Maximum Daily Load (TMDL) for diazinon and chlorpyrifos in the Upper Newport Bay watershed is proposed. Further information is available from <http://www.swrcb.ca.gov/~rwqcb8/pdf/tmdlnotice.pdf>.

As discussed by Lee and Jones-Lee (2002a), since chlorpyrifos has been banned from further sales for urban use and diazinon will soon be banned from further sales for urban use by the US EPA Office of Pesticide Programs (US EPA OPP) because of a potential health threat to children, the aquatic life toxicity problem found in urban stormwater runoff due to these compounds is expected to soon disappear. However, since the pests that caused the use will still be a problem, other pesticides will used as alternates.

In the California Central Valley and possibly elsewhere several of the pyrethroid-based pesticides are being sold for residential use. Several of these pesticides are more toxic to aquatic life than the OP pesticides. The pyrethroid pesticides tend to be less mobile because of their higher octanol water partition coefficients than the OP pesticides and

therefore are potentially less subject to runoff than the OPs. As a result they will be transported from the place of application to receiving waters associated with particulate matter, where they will tend to accumulate in the receiving water sediments. D. Weston (2003) of UC Berkeley has recently reported finding that several pyrethroid pesticides that are sorbed to sediments are bioavailable for uptake by some benthic organisms. The impact of the pyrethroid pesticides on urban waterway water quality has not been evaluated. There is a major problem with the permitted use of the pyrethroid pesticides in that there are inadequate analytical methods for measuring the pyrethroid pesticides at concentrations that are potentially toxic to aquatic life.

Jones-Lee and Lee (2000b) and Lee and Jones-Lee (2002b) have discussed the serious deficiencies in the way that the US EPA OPP and state pesticide regulatory agencies register pesticides. Pesticides which are highly toxic to aquatic life are not evaluated as part of the registration process to determine if labeled use could lead to aquatic life toxicity in urban and rural stormwater runoff/discharges. Further the US EPA will register a pesticide for certain uses which are likely to lead to it being present in stormwater runoff, where there are no analytical methods available to determine if the pesticide is present in runoff from areas where it is used at concentrations above about 0.1 times the $LC_{50}$ for aquatic life such as zooplankton and fish larvae.

This leads to problems for stormwater runoff water quality managers and water quality regulatory agencies being unable to determine if the use of a pesticide in accord with the label leads to violations of water quality narrative toxicity standards in stormwater runoff. Lee and Jones-Lee (2002b) provide guidance on developing monitoring programs for aquatic life toxicity due to pesticides. As they discuss, there is need for the US EPA OPP to change its pesticide registration process to properly consider the fate and effects of a pesticide from its place of application to the receiving waters and the impacts of this runoff/discharge to the waterbodies' aquatic-life-related beneficial uses.

**References**

Jones-Lee, A. and Lee, G. F., "Development of TMDLs for Control of Organophosphate Pesticide Caused Aquatic Life Toxicity in Urban Stormwater Runoff," Proceedings WEFTECH 2000 Water Environment Federation annual meeting, Anaheim, CA, October (2000a).

Jones-Lee, A. and Lee, G. F. , "Proactive Approach for Managing Pesticide-Caused Aquatic Life Toxicity," Report of G. Fred Lee & Associates, El Macero , CA, October (2000b).

Lee, G. F., "The Urban Pesticide Problem: How Do We Know the Substitutes Aren't Worse Than the Ones They're Replacing?" *Stormwater* 2 (1):68-71, Forrester Press, January/February (2001).

Lee, G. F. and Jones-Lee, A., "Importance of Integrating Aquatic Chemistry with Toxicology/Biology in Regulating Urban-Area Stormwater Runoff: OP Pesticide

Aquatic Life Toxicity Management," presented at American Chemical Society annual meeting, San Francisco, CA, March (2000).

Lee, G. F. and Jones-Lee, A., "Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the CVRWQCB, DeltaKeeper and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 2000," Report to the Central Valley Regional Water Quality Control Board, G. Fred Lee & Associates, El Macero, CA, October (2001).

Lee, G. F. and Jones-Lee, A., "City of Stockton Mosher Slough and Five Mile Slough Diazinon and Chlorpyrifos Aquatic Life Toxicity Management Report," California Water Institute Report TP 02-08 to the California State Water Resources Control Board/Central Valley Regional Water Quality Control Board, 44 pp, California State University Fresno, Fresno, CA, December (2002a).

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 (2002b).
http://www.gfredlee.com/Agwaivermonitoring-dec.pdf"

Lee, G. F. and Taylor, S., "Results of Aquatic Life Toxicity Studies Conducted During 1997-98 in the Upper Newport Bay Watershed and Review of Existing Water Quality Characteristics of Upper Newport Bay, Orange County, CA and its Watershed," Report to the State Water Resources Control Board, Santa Ana Regional Water Quality Control Board and the Orange County Public Facilities and Resources Department to meet the requirements of a US EPA 205(j) Project, G. Fred Lee & Associates, El Macero, CA and Robert Bein, William Frost Associates, Irvine, CA, October (1999).

Weston, D., "Bioavailability of Sediment-Associated Pyrethroid Pesticides," Presentation to the Sacramento River Watershed Program OP Focus Group, Sacramento, CA, January (2003).

**Updated Lee and Jones-Lee Website**

Drs. G. F. Lee and A. Jones-Lee developed a website (www.gfredlee.com) from which they can make available their recently published papers and reports. The website provides pull-down menus for publications on Publications on Landfills-Groundwater, Surface Water Quality, Hazardous Chemical Sites, Contaminated Sediment, Domestic Water Supply, Excessive Fertilization, Reclaimed Wastewater, and Watershed Studies. Also, past issues of this Newsletter are available from this site. Recently this website has been updated to improve its ease of use. As part of updating the site the papers and reports of greatest importance to a topic area are provided as downloadable files. Others pertinent to the topic area are available by request. Further, a Google "search" feature has been added. New papers and reports are added to the site every month or so.

CALIFORNIA WATER INSTITUTE

Report TP 02-08

# City of Stockton Mosher Slough and Five Mile Slough Diazinon and Chlorpyrifos Aquatic Life Toxicity Management Report


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*This publication is a technical report by staff of the California Water Institute to the California State Water Resources Control Board and the Regional Water Quality Control Board, Central Valley Region. No policy or regulation is either expressed or intended.*

## Disclosure Statement

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## California Water Institute
## California State University, Fresno

The California Water Institute was started with seed money provided by the Proposition 13 Water Bond Measure, approved by voters in 2000. The Institute is housed at the California State University, Fresno.

The goal of the Institute is to provide a place where agricultural, urban, and environmental interests can be brought together in an unbiased, open, collaborative process to develop a shared vision of how to best utilize our water resources. It is the stated purpose of the Institute to work on collaborative solutions to pressing water issues facing the State. The staff of the Institute includes economists, chemists, crop water usage specialists, resource specialists, and environmental engineers. In addition, faculty at the California State University, Fresno, collaborate with the Institute in important research efforts.

# Executive Summary

Mosher Slough and Five Mile Slough are stormwater drainage ways located in the city of Stockton, California. Monitoring studies conducted by the Central Valley Regional Water Quality Control Board (CVRWQCB) and the DeltaKeeper from 1994 through 2000 have found measurable, potentially toxic concentrations of diazinon and, at times, chlorpyrifos, as well as aquatic life toxicity to *Ceriodaphnia dubia* during and for a short time after stormwater runoff events. The concentrations of diazinon and chlorpyrifos are sufficient to cause the aquatic life toxicity found. Mosher Slough and Five Mile Slough have CVRWQCB designated beneficial uses of municipal and domestic supply, agricultural supply, industrial supply, contact and non-contact water recreation, freshwater aquatic habitat, fish migration, fish spawning, and wildlife habitat. The presence of aquatic life toxicity in these sloughs represents a violation of the CVRWQCB Basin Plan water quality objective of "no toxics in toxic amounts."

Mosher Slough receives stormwater runoff and irrigation tailwater discharges upstream of the City. Within the City, it receives stormwater runoff from residential and commercial areas. Five Mile Slough receives runoff from residential and commercial areas. Mosher Slough and Five Mile Slough are freshwater tidal tributaries with about a three-foot tide that discharge to the San Joaquin River Deep Water Ship Channel, via Fourteen Mile Slough or Disappointment Slough. They are part of the San Joaquin River-Sacramento River Delta.

Mosher Slough and Five Mile Slough are listed on the Federal Clean Water Act's 303(d) list as impaired for diazinon and chlorpyrifos. The impairment is expected to extend throughout Mosher Slough and Five Mile Slough within the city of Stockton and for some undefined distance into the San Joaquin River Deep Water Ship Channel and the Delta via Fourteen Mile Slough or Disappointment Slough. The 303(d) listing requires development of a Total Maximum Daily Load (TMDL) for diazinon and chlorpyrifos for Mosher Slough and Five Mile Slough. This report has been developed to present information that is pertinent to managing the aquatic life toxicity that is due to diazinon and chlorpyrifos in Mosher Slough and Five Mile Slough associated with stormwater runoff events.

Since information is not available on the loads of diazinon and chlorpyrifos to Mosher Slough and Five Mile Slough and within these sloughs during a stormwater runoff event, it was necessary to consider an alternative US EPA recommended approach of using the water quality management goal (proposed water quality objective) for protection of aquatic life from diazinon and chlorpyrifos toxicity as the allowable loading capacity (concentration) for Mosher Slough and Five Mile Slough. This translates for diazinon allowed loading capacity concentrations for Mosher Slough and Five Mile Slough to 0.08 µg/L for a 1-hour average (acute exposure), and 0.05 µg/L for a 4-day average (chronic exposure). For chlorpyrifos, the corresponding allowed loading capacities, expressed as concentrations, are 0.020 µg/L for acute exposure and 0.014 µg/L for chronic exposure.

In addition to urban stormwater-runoff-derived diazinon and chlorpyrifos from urban, residential and commercial properties, some unquantified loads of these pesticides to Mosher Slough and Five Mile Slough are believed to be due to atmospheric transport of diazinon and chlorpyrifos used in agricultural areas in San Joaquin County and in the Central Valley. Further, during stormwater runoff events there is a potential for upstream of the City agricultural use of diazinon and chlorpyrifos to be transported to Mosher Slough within the City via Mosher Creek, and thereby contribute to the loads of these pesticides within Mosher Slough. The magnitude of this loading is unknown. It is believed, however, that the primary sources of diazinon and chlorpyrifos for Mosher Slough and Five Mile Slough within the city of Stockton are storm sewers that drain residential and commercial properties within these sloughs' urban watersheds.

## Recommendations

An aquatic life toxicity and chemical concentration monitoring program should be conducted on both Mosher and Five Mile Sloughs. This monitoring program should include evaluation of the toxicity, using the US EPA standard three species testing procedure of the slough waters at several locations in the City and into the Delta just prior to, during, and following stormwater runoff events. Chemical concentration measurements of diazinon and chlorpyrifos should be made of the samples that are tested for toxicity. Stormwater runoff events in the late fall, mid-winter and early spring should be monitored. The toxicity testing should include measurement of the total acute toxicity units through the use of toxicity test dilution series which are conducted with and without PBO. Lee (1999) and Deanovic, *et al.* (1998) have presented guidance on the approach that should be used to monitor urban stormwater runoff for aquatic life toxicity.

If a significant part of the measured toxicity cannot be accounted for by concentrations of diazinon and chlorpyrifos, then toxicity identification evaluation (TIE) studies should be conducted to identify the cause of the non-OP pesticide-caused toxicity. Particular attention should be given to evaluating the potential for the common pesticides sold over the counter for residential use to cause aquatic life toxicity in stormwater runoff from the Mosher Slough and Five Mile Slough watersheds. To the extent possible, chemical monitoring of the commonly sold pesticides within the city of Stockton should be conducted of storm sewer discharges and Mosher and Five Mile Sloughs during stormwater runoff events with analytical methods that can reliably measure their concentrations at less than 0.1 of the $LC_{50}$ for toxicity to zooplankton and/or fish (see US EPA, 2002b for $LC_{50}$ values).

A monitoring station which includes a stream gage should be established on Mosher Creek just upstream of the point where it enters the City. This location should be sampled with each rainfall runoff event that causes Mosher Creek to flow into Mosher Slough. Aquatic life toxicity and the concentrations of diazinon and chlorpyrifos should be measured in these samples.

An atmospheric loading station should be established in the Mosher Slough watershed within the City to measure the dry-fallout- and precipitation-associated concentrations of diazinon, chlorpyrifos and aquatic life toxicity.

**References**

Deanovic, L.; Cortright, K.; Larsen, K.; Bailey, H.; Hinton, D. E. and Connor, V. 1998. Guidelines for Conducting Toxicity Identification Evaluation Procedures in Urban Runoff, a Laboratory Manual. Draft Report Prepared for the Central Valley Regional Water Quality Control Board, Sacramento, CA. (Being updated.)

Lee, G. F. 1999. Recommended Aquatic Life Toxicity Testing Program for Urban Stormwater Runoff. Comments submitted to E. Bromley, US EPA Region IX, San Francisco, CA.

US EPA. 2002b. Ecotoxicity Database. US Environmental Protection Agency, Office of Pesticide Programs, Washington D.C.