Toxic Organic Constituent Literature Assessment

(with Attachments)

Prepared for

San Francisco Bay Area Pollution Prevention Group

Prepared by
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AUGUST 1996

SAN FRANCISCO BAY AREA POLLUTION PREVENTION GROUP

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SFBAPPG

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EXECUTIVE SUMMARY

The San Francisco Bay Area Pollution Prevention Group (SFBAPPG) conducted activities to gain a better understanding of the issues surrounding toxic organic constituents (TOCs) and to identify future SFBAPPG projects that would benefit Bay Area POTWs and would be enhanced by a regional effort. The following activities were conducted by the SFBAPPG over the past year:

- An Ecological Overview of the Estuary Workshop which presented information on pollutants found in the San Francisco Bay.
- A Toxic Organic Pollutant Survey which collected information on TOCs listed in Bay Area POTW NPDES permits.
- A literature and source control program assessment which collected information from around the country regarding three specific TOCs: diazinon, chlorpyrifos and tributyltin.

This report presents the results of the literature review and program assessment. Before beginning the literature assessment, the results of the Ecological Overview of the Estuary Workshop and the Toxic Organic Pollutant Survey were reviewed. The review of the workshop contents and survey results led to the identification of a list of TOCs in the following categories: chlorinated pesticides, monocyclic aromatics, polynuclear aromatic hydrocarbons, organophosphate pesticides, PCBs, dioxin, tributyltin, and cyanide. From this list, diazinon, chlorpyrifos, and tributyltin were selected by the SFBAPPG Research subcommittee as important TOCs of concern to the Bay Area and as topics for a nationwide literature review and program assessment. These constituents were chosen because they exist in wastewater discharges, present water quality problems in the Bay, and would be potentially responsive to region wide source control. The following information was collected on each of the three selected TOCs:

- Environmental impacts
- Sampling results and methodologies
- Source identification, reduction and control strategies
- Economic impacts of the control strategies

Information was gathered through computerized literature searches and Internet searches, and by contacting representatives from state and local pollution prevention and stormwater programs around the country.

CONCLUSIONS

Based on the literature assessment, estuary workshop, and TOC survey, the following conclusions can be drawn about TBT, organophosphate pesticides, and other TOCs in the Bay.

Tributyltin

Anti-fouling paints and cooling water additives have been comprehensively described in the literature as the primary sources of TBT. Both sources have been associated with adverse water quality impacts and bans have been implemented for anti-fouling paints and cooling water additives containing TBT. The Federal ban on antifouling paints applies to its use on recreational boats, but use on larger boats (over 25 m in length) is still permitted. This ban has been in effect since 1988. While antifouling paints are still in use, it is unlikely that this is a source of TBT in POTW effluent in the Bay Area.

California's ban on cooling water additives containing TBT is limited to the San Francisco Bay Area and was implemented in December of 1995 as an emergency regulation. This ban has recently become a permanent regulation for the Bay Area. It is expected that no TBT cooling water additives will be available in the Bay Area for purchase within the year. To ensure the effectiveness of the ban, it may be beneficial to conduct additional outreach programs throughout the Bay Area to inform affected businesses of the conditions of the ban, alternative products, and alternative practices for maintaining cooling water systems.

If the TBT ban is not effective in reducing TBT levels in wastewater treatment plant effluent, additional evaluation of other TBT sources, including toilet bowl cleaners, carpet disinfectants, use on shower curtains, and other fungicidal applications, would be warranted. However, it is recommended that the effectiveness of the ban be assessed after it has been in effect for a maximum of one year before conducting further source evaluation.

Organophosphate Pesticides

Diazinon and chlorpyrifos have been detected in both stormwater and wastewater discharges in the Bay Area and the Central Valley. Sources in wastewater are most likely associated with residential use and some commercial uses of these pesticides. In some parts of the Bay Area, agricultural sources may also contribute to the presence of organophosphate pesticides in stormwater through agricultural runoff and pesticide volatilization (i.e., presence in fog and rainfall).

Public education efforts regarding Integrated Pest Management (IPM) and proper handling and disposal of pesticides have proven effective in other parts of the country. Developing regional public education materials are recommended and may prove to be effective in the Bay Area.

Stormwater agencies in the Bay Area and the Central Valley are also targeting diazinon and chlorpyrifos as pollutants of concern. Therefore, any projects implemented by the SFBAPPG should be coordinated with other regional efforts. This may be accomplished through the Urban Pesticide Toxicity Committee.

Other TOCs

Monitoring by the RMP and information provided in the Toxic Organic Pollutant Survey indicate that other TOCs of concern include PAHs, PCBs, DDT, cyanide and dioxin. As discussed earlier, achievable detection limits are currently greater than permit limits for PAHs and PCBs. However, further evaluation of these pollutants may be warranted as analytical methods improve. Identification of non-industrial sources of cyanide and dioxin may also warrant further investigation.

Recommendations

Based upon an evaluation of the literature reviewed, the following activities are recommended for future consideration by the SFBAPPG:

1. Develop regional outreach materials addressing diazinon and organophosphate pesticides drawing on existing materials on IPM, and proper handling and disposal methods. Specific activities may include:

    - Developing BMPs and educational brochures for sources including pest control operators, pet groomers, and kennels.

    - Developing educational materials concerning IPM methods.

2. Coordinate organophosphate pesticide activities with other regional control and education efforts through the Urban Pesticide Toxicity Committee. Specific activities may include:

    - Identifying pathways that transport the pesticide from the area of use to the environment.

    - Determining the relative contribution of riverine, storm drain, and sanitary sewer input of pesticides to the Bay.

- Work with EPA and other organizations to develop labeling practices that provide more information regarding handling and disposal of pesticides.

3. Monitor the effectiveness of the Bay Area's TBT ban and evaluate the need for further source control efforts in June, 1997.

4. Consider follow-up on initial outreach to affected businesses regarding the TBT ban. Outreach materials could emphasize information on alternative products and cooling water system maintenance practices.

5. Track information concerning improved analytical methods and lower detection limits for PAHs and PCBs.

6. Consider investigating non-industrial sources of dioxin.

INTRODUCTION

Several organic constituents have been identified as harmful to aquatic life at levels found in wastewater, stormwater and surface waters. Many of these organic constituents are persistent in the environment and tend to bioaccumulate in aquatic species. Some may pose health risks to humans, animals and birds as well.

Because of these concerns, the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) has included effluent limits for certain toxic organic constituents (TOCs) in wastewater discharge permits issued to Bay Area Publicly Owned Treatment Works (POTWs) in recent years under the National Pollutant Discharge Elimination System (NPDES) provisions of the Clean Water Act.

The San Francisco Bay Area Pollution Prevention Group (SFBAPPG) conducted activities to gain a better understanding of the issues surrounding TOCs and to identify future SFBAPPG projects that would benefit Bay Area POTWs and would be enhanced by a regional effort. The following activities were conducted by the SFBAPPG over the past year:

- An Ecological Overview of the Estuary Workshop which presented information on pollutants found in the San Francisco Bay.
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- Environmental impacts
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Information was gathered through computerized literature searches and Internet searches, and by contacting representatives from state and local pollution prevention and stormwater programs around the country.

The recommendations for future research needs as derived from the initial workshop, the TOC survey, and the literature review and program assessment are discussed below in the following sections:

- Ecological Overview of the Estuary Workshop
- Priority TOCs Survey
- Tributyltin Assessment
- Organophosphate Pesticide (Diazinon, Chlorpyrifos) Assessment
- Conclusions and Recommendations

ECOLOGICAL OVERVIEW OF THE ESTUARY WORKSHOP

The Ecological Overview of the Estuary Workshop was held in Oakland, CA on August 2, 1995 to discuss historical and current monitoring efforts, and to identify pollutants of concern, environmental impacts, and future goals for the San Francisco Estuary. The purpose of this workshop was to gain some perspective on pollutants in the San Francisco Bay as opposed to pollutants of concern to POTWs. Speakers presented their perspectives regarding pollutants in the San Francisco Bay at the workshop. A list of these speakers are included in Table 1.

The information presented by these speakers at the workshop is summarized below.

Historical and Current Monitoring

Some aspects of historical and current efforts to measure pollutant levels in San Francisco Estuary were discussed by the workshop speakers. The Interagency Ecological Program (IMP) started to study fisheries in the Bay Area in the late 1960's. This program has provided the basis for what is known about endangered species, long-life predators, and commercial species. The IMP is ongoing and is concentrating on the biological effects of water diversion (i.e. number of fish species, spawning locations, etc.). The U.S. Geological Survey (USGS) also established a water quality program in the late 1960s and initiated numerous individual studies since then. In 1977, the Army Corps of Engineers (COE) studied sediment movement and

TABLE 1.

NAME	ORGANIZATION	PRESENTATION TITLE
Dr. Sam Luoma	U.S. Geological Survey	San Francisco Estuary: Ecological Overview
Michael Carlin	SFRWQCB	1. History of Regional Monitoring in the Estuary 2. Where Do We Go From Here?
Karen Taberski	SFRWQCB	Contaminants in Fish Tissue: Results of Pilot Study
Dr. Rainer Hoenicke	San Francisco Estuary Institute	1. Local Effects Monitoring: Overview of What Others Are Doing 2. Regional Monitoring Program for Trace Substances in the San Francisco Estuary: 1993-1994 results

contamination throughout the Bay system. In 1987, the San Francisco Bay became part of USEPA's National Estuary Program. The San Francisco Estuary Project grew out of this program and was developed as an institutional framework for regional planning, monitoring, and management. The Regional Monitoring Program (RMP) was designed to determine regional pollution trends, the impact of pollutants on the estuary as a whole, and the levels of pollutants that are affecting water quality. The RMP's original focus was on trace elements and was later expanded to include organic pollutants. Eventually, studies on water and sediment toxicity, sediment and bio-accumulation, and special studies were added to the program. In the future, the RMP plans to focus on the development of overall indices of habitat health, fish contamination studies, and watershed monitoring. Success of the RMP depends upon cooperative efforts among existing monitoring programs. Currently, 62 different agencies are participants in the RMP. In the future, volunteers may be included in monitoring efforts.

Identification of Pollutants of Concern

The monitoring efforts described above have identified several pollutants of concern in the San Francisco Estuary. Some of the pollutants which have been detected in the Bay water column and sediments are trace metals including mercury, silver, copper, chromium, selenium, nickel, and zinc. All of these metals are of potential concern due to their toxicity to aquatic life. In addition, nickel is a known human carcinogen. Mercury bioaccumulates in fish and is toxic to humans. Selenium has had adverse effects on avian populations at high concentrations.

Three studies regarding pollutant levels in the Bay were presented at the workshop: Studies of sediment cores, fish tissue studies, and the Regional Monitoring Program (RMP). Some of the information presented from these studies is highlighted below.

Sediment Core Analysis

According to Dr. Luoma of the USGS, analysis of sediment cores has helped to identify historical and current levels of some trace metals. Observations based on sediment core analysis in the Bay are listed below:

- Nickel was present in sediments as early as 1840 at levels similar to those found today. This trend indicates that the levels of nickel in Bay sediments are probably naturally occurring and may therefore be difficult to address through source control efforts.

- Mercury concentrations in the Bay peaked between 1900 to 1930 when mercury was heavily used in gold mining activities. Levels have declined since that time; however, mercury levels are still of concern in the Bay Area.

- Silver appeared in sediment at levels of concern in the 1960's, most likely due to industrial and commercial activities. More recent sediment cores as well as measurements in clams at specific locations in the Bay indicate significant decreases in silver levels.

- In one case study, sampling conducted near the Palo Alto wastewater treatment plant outfall indicated that copper concentrations detected in sediments and clams have dropped considerably in the last 20 years at that location.

- Chromium concentrations are highest at the mouth of the estuary, but a substantial decline has been observed towards Suisun Bay. Chromium in the Bay is thought to have industrial sources.

- Selenium concentrations in Bay sediment have increased since the 1960s and have been detected in water and clams. A comment was made during the presentation that the probable source of selenium is discharge from refineries.

Regional Monitoring Program

Some observations on pollutants in the Bay presented by Dr. Hoenicke based on the RMP 1993-94 results are listed below:

With respect to trace metals, concentrations of total copper, mercury, and nickel were frequently above the EPA criteria. Mercury concentrations were higher in the South Bay and near the Petaluma River. Levels throughout the Bay were higher during the wet season, indicating runoff as a possible source. Total copper levels exceeded water quality criteria throughout the Bay with higher levels in the South Bay and parts of the North Bay when compared to the central area of the Bay. Zinc concentrations were greatest in the Central Bay.

RMP study results from 1993/94 indicate that concentrations of total PAH compounds exceeded water quality criteria. Sources of PAHs include industrial operations, street runoff, atmospheric input, and many other activities.

The use of DDT was banned by EPA in the 1970s and levels found in the environment have since declined. However, concentrations are still apparent in some areas of the Bay, (e.g. towards the Delta where rivers may introduce pesticides into the system). Interestingly, despite the 20 plus year ban, undegraded DDT was detected during 1993/94 RMP activities.

Since PCBs were banned in the late 1970s, decreased levels have been detected in Bay sediments. However, PCB concentrations exceeded water quality criteria at all stations sampled during 1993/94 RMP efforts and levels were considerably higher than the water quality criteria in the South Bay. Additionally, PCBs was the only group of organic contaminants that exceeded criteria everywhere throughout the estuary.

Diazinon concentrations and their inputs to the estuary have been studied by the USGS and the Central Valley RWQCB. Diazinon was found to move into the estuary "in pulses" following January/ February rainfall events in the Central Valley. High levels of diazinon have been detected at key freshwater stations at levels above the guideline established by National Academy of Sciences.

Fish Tissue Study

K. Taberski presented results from a 1995 study conducted by the San Francisco Bay RWQCB to determine the concentrations of pollutants in the tissues of various fish species caught in the Bay and consumed by humans. Pollutant levels in the fish tissue were compared to screening values developed by EPA to identify pollutant levels of concern to human health in fish tissue. PCB levels in white croaker were found at high concentrations, exceeding the screening value by several hundred times at all locations but one. Mercury was detected in white croaker and certain shark species. Dioxin was also detected above screening values in some samples. Results from this study showed a noticeable decrease in PCBs and DDT when compared to sixteen years of mussel watch data, lower than expected concentrations of selenium, and lower dioxin levels in the Bay than in most areas of the United States.

As a result of the fish tissue study and an independent analysis, the Office of Environmental Health Hazards and the Department of Health Services established an interim health advisory affecting sport fishing in San Francisco Bay. The advisory states that adults should limit their consumption of San Francisco Bay sport fish to no more than two meals per month and should not eat any striped bass. The advisory also provides special guidelines for women who are pregnant or are nursing. The RWQCB is working with the Department of Health Services, local governments, and several community organizations to publicize the striped bass health advisory.

The Future of San Francisco Estuary Program

Implementation of programs such as the above studies have helped to identify problems in the Bay and provide a perspective on what problem areas need to be focused on. The RMP will hopefully provide a way to measure the effect of source control efforts in the future. It was pointed out at the workshop that there are limitations of the RMP. Specifically, in adequate resources are currently available to determine the relative contributions of contaminants from point sources, urban runoff, agricultural runoff, atmospheric deposition and sediment resuspension. Understanding these complexities in the system is necessary to determine which actions will improve or not improve the state of the estuary in the future.

PRIORITY TOXIC ORGANIC CONSTITUENTS (TOCs) SURVEY

To gather more information about TOC effluent limits and monitoring requirements in the Bay Area, the SFBAPPG developed and distributed the Priority Toxic Organic Pollutant Survey to 42 Bay Area POTWs in the Fall of 1995 (Montgomery-Watson, 1996). Thirty-two POTWs (75% of those surveyed) responded. The flow from these 32 POTWs accounts for more than 90% of the total POTW flow in the Bay

Area. Organic pollutants most commonly included in Bay Area NPDES permits can be divided into the following categories: chlorinated pesticides, monocyclic aromatics, polynuclear aromatic hydrocarbons (PAHs), and others (i.e., PCBs, dioxin/ furans, tributyltin, and cyanide). Sampling data provided by survey respondents indicated that the following TOCs exceeded permit limits for at least one POTW: chlorinated pesticides, hexachlorobenzene, cyanide, and tributyltin. In addition, although permit limits have not been established for organophosphate pesticides, diazinon and chlorpyrifos were identified as causing toxicity failures in the effluent of two Bay Area POTWs. The survey also indicated that POTWs are conducting special studies concerning the following TOCs: diazinon, tributyltin, PCBs, PAHs, cyanide, and dioxin.

For this study, organophosphate pesticides, tributyltin, PCBs, PAHs, cyanide and dioxin were evaluated with respect to the need for further research. Currently achievable detection limits are not low enough to evaluate compliance with water quality criteria for PAHs, PCBs, hexachlorobenzene, and several chlorinated pesticides. This makes a determination of the extent of the problem for these TOCs difficult. In addition, chlorinated pesticides and PCBs have been banned or withdrawn from use limiting the pollution prevention options for these chemicals. Dioxin is expected to have industrial sources. Residential and commercial monitoring in San Jose has not detected cyanide. In addition, recent work shows that cyanide may be produced in some WWTPs as a result of chlorination. Therefore, regional pollution prevention efforts would not be effective for cyanide and dioxin.

Organophosphate pesticides and tributyltin are TOCs of concern to several POTWs. Since both residential and commercial sources exist for these TOCs, pollution prevention efforts may be effective, and further research is warranted. Organophosphate pesticides have also been identified as a concern through other local studies, including work presented at the Ecological Overview of the Estuary Workshop. While certain uses of tributyltin have recently been banned in the Bay Area, there may still be additional source identification and education opportunities that could enhance the ban's effectiveness. For these reasons, chlorpyrifos, diazinon, and tributyltin were chosen for further evaluation through a national literature review and assessment of pollution prevention programs. The results of this assessment are discussed below.

TRIBUTYLTIN ASSESSMENT

Tributyltin (TBT) is an organometallic compound that acts as a pesticide in several applications. TBT compounds are used as antifouling agents in paints applied to boats, ships, and marine structures; as a biocide in commercial cooling water systems; as a disinfectant and preservative for textiles, molluscicide, fungicide; and as a wood preservative or stain (DPR, 1996a). Historically, TBT has been widely used in marine paints to prevent growth of nuisance organisms on the hulls of boats because it provides excellent antifouling action, has a long half-life, and does not corrode (Hall, 1987; Bushong, et al, 1989). In the early 1980s, however, antifouling paints containing TBT were determined to contribute to aquatic toxicity in harbors and other coastal waters (Hall, 1984). Numerous studies demonstrated that TBT was released from antifouling paints into the marine environment at levels toxic to non-target organisms. Due to this observed toxicity, Federal legislation was enacted to limit the use of TBT based antifouling paints.[1]

Evidence also exists that cooling water additives discharged to sanitary systems and storm drains represent a source of TBT. In response to this concern, the State of California has prohibited the possession, use, and sale of cooling water additives containing TBT in the San Francisco Bay Area in an effort to reduce TBT levels in the Bay (DPR, 1996b).

The following sections discuss the information available in the literature regarding TBT's environmental impacts, TBT monitoring studies, source identification and control strategies, and economic impacts of control strategies.

Environmental Impacts of TBT

Numerous studies have been conducted to evaluate the environmental impacts of TBT in marine environments. Most of these studies focus on areas with commercial shipping and recreational boating activities. These investigations revealed that TBT is highly toxic to aquatic plants, invertebrates, and fish at levels as low as fractions of a µg/L. (Richard, 1988). One researcher described TBT as "the most toxic substance ever deliberately introduced into the aquatic environment" (Goldberg, 1986).

One of the first observations of TBT toxicity was to the commercially cultivated Pacific oyster (*Crassostrea gigas)* in Arcachon Bay, France in the late 1970s. By 1980, decreasing oyster numbers and oyster shell malformation was attributed to recreational boats in the vicinity of the oyster beds (Alzieu and Heral, 1984). Concurrent with the findings in France and other European countries, the U.S. Navy began to investigate its use and environmental impacts of TBT antifouling coatings. In 1985, the U.S. Navy completed an Environmental Assessment (EA) called the Fleetwide Use of Organotin Antifouling Paint, which concluded that "no significant impacts" would occur if all Navy vessels were painted with TBT containing paints (Huggett, 1992). The EA's findings presented in the Navy's report were not readily accepted by the scientific community and others who felt the conclusions were not

[1]See Organotin Antifouling Paint Control Act of 1988, 33 U.S.C. § 2401 et seq.

supported by the available data. Ultimately, this lack of acceptance led to a rising concern throughout the United States about the potential environmental impacts to sensitive coastal habitats (Huggett, 1992).

In response to this growing concern, several impact studies were conducted during the mid to late 1980s in an attempt to determine the toxicity of TBT in marine environments. A report published by the U.S. Fish and Wildlife Service provides a comprehensive summary of lethal and sublethal effects of organotin compounds to aquatic organisms (Eisler, 1989). Eisler reports that TBT compounds were the most toxic of the triorganotin compounds tested. Adverse effects were noted in molluscs at water concentrations of 0.001 to 0.06 $\mu g/L$, and in algae, fish, and other species of invertebrates at 0.1 to 1.0 $\mu g/L$. In addition, the California State Water Resources Control Board (SWRCB) produced a report entitled "Tributyltin: A California Water Quality Assessment Report" which presents detailed information on the toxicity of TBT to both marine and freshwater organisms in California and other locations in the United States (Richard, 1988). Toxicity information presented in the SWRCB's report confirms that some TBT concentrations detected in California waters and other waters in the U.S. are well above those found to be lethal or to cause other adverse effects to aquatic organisms in laboratory studies.

Due to the high concentrations of TBT detected in Chesapeake Bay waters, several studies have been conducted on Chesapeake Bay biota. Hall (1988) presents and discusses available data on TBT toxicity studies conducted in Chesapeake Bay from 1982-1987. During this time period, toxicity tests were performed on several species and a wide range of sensitivity to TBT was observed. Zooplankton were the most sensitive organisms tested. The copepod (*Eurytemora affinis*) was the most acutely sensitive (72 hour LC_{50} of 500 ng/L) and chronically sensitive (Lowest Observed Adverse Effect Level (LOAEL) of 85 ng/L after 6 days) of the species. Tested acute toxicity (96 hour LC_{50}) to fish ranged from 3000 ng/L for inland silversides (*Menidia beryllina*) to 25,900 ng/L for sheepshead minnows (*Cyprinodon variegatus)* (Hall 1988). According to Hall, these toxicity studies conclude that maximum TBT concentrations reported in the water column of Virginia and Maryland marinas are likely to be toxic to some Chesapeake Bay copepods, bivalve embryos, and bivalve larvae. TBT measured in rivers tributary to the Chesapeake Bay (24 - 67 ng/L), however, would not be toxic to the studied biota (Id.). In 1992, a reevaluation of the Chesapeake Bay Basinwide Toxics Reduction Strategy (which was established in 1987) was conducted and the results were published in 1994 by the Chesapeake Bay Program. TBT was not found to be a significant concern during the reevaluation (i.e. there is no mention of recent TBT detections in environmental media or significant impacts to biota).

Other relevant environmental impact reports have been compiled which demonstrate reduced growth of marine micro-algae at low levels of TBT (Beaumont 1986). Smith et al. (1987) utilized juvenile oysters to monitor the toxic effects of TBT in California waters. Stephenson et al. (1986) observed growth abnormalities in mussels and oysters from areas with high levels of TBT in San Diego Bay. Thain (1986) studied the impact of TBT antifouling paints on molluscan fisheries. Wolnickowski et al. (1987) reported TBT concentrations and evidence of Pacific oyster deformations in Coos Bay, Oregon, and Lenhan et al. (1990) examined the changes in hard bottom species in boat mooring areas of San Diego Bay. Huggett et al. (1992) identified some of the toxicity studies in which TBT was shown to be toxic at low (e.g., approximately 8-150 ng/L for chronic exposure) concentrations, and stressed the need for better methods of field verification and improved toxicity testing procedures, as well as a standardized methodology for conducting risk assessments. More recently, St-Hilaire and Pellerin (1995) focused on the chronic toxicity of TBT and its transfer through the food chain by evaluating the variations of scope for growth in two bivalve species after a chronic exposure to TBT. It is evident from theses studies and others that TBT can significantly impact biota when it is introduced into aquatic environments.

Federal TBT Restrictions

Due to the high concentrations of TBT detected and the resulting impacts to aquatic organisms, State and Federal legislation has restricted the use of TBT-containing antifouling paints to control further degradation of coastal habitats.

In mid-1987, several states including California, Florida, Maryland, Maine, New Jersey, New York, Oregon, Virginia, and Washington recognized TBT as a problem and implemented restrictions on the use of TBT-containing paints. Most state legislation was modeled after provisions established by the State of Virginia which included a ban of TBT paints from non-aluminum-hulled boats shorter than 25 m long, and a prescribed release rate of TBT no greater than 5 $\mu g/cm^2$/day (Weis, 1989). State action eventually led to restrictions of TBT antifouling paints at the national level. In 1988, the "Organotin Antifouling Paint Control Act" established restrictions on painting vessels shorter that 25 m (excluding aluminum hulls) and a release rate of TBT no greater that 4 $\mu g/cm^2$/day (Huggett, 1992). In addition, the Act prohibits the sale, delivery, or purchase of certain organotin antifouling paints and additives and requires continued monitoring and environmental impact assessment in representative coastal areas. 33 U.S.C. § 2404 and 2406.

Continued TBT impact studies are being conducted as part of monitoring studies required by the Organotin Antifouling Paint Control Act of 1988 discussed in the following section.

Ambient Monitoring and Sampling Studies

The majority of information available for TBT focuses on monitoring and sampling studies conducted in areas of commercial shipping and recreational boating activities. Fewer studies have been conducted where urban effluent is the suspected source of TBT contamination.

Studies related to antifouling paints

High concentrations of TBT have been observed in coastal waters at several locations throughout the United States. Significant monitoring efforts for TBT in the U.S. began in the early 1980s. These monitoring efforts focused on marinas, harbors, and other coastal waters used for commercial and recreational boating activities. A report prepared by Eisler (1989) presented environmental concentrations of TBT found in various waters of the U.S. Reported maximum levels ranged from 0.93 μg/L in the water column in San Diego Bay, CA, to 4.57 μg/L in the surface microlayer of Baltimore Harbor in Maryland.

Many of the initial sampling studies regarding the impact of antifouling paints were conducted in Chesapeake Bay, where surveys revealed that 50 - 75 % of recreational boats in Maryland waters were painted with TBT-containing paints. Virginia waters were also threatened by the use of TBT-containing paints, at local ship building operations, and at a large Naval facility (Hall, 1988). Hall (1988) summarized monitoring activities in Chesapeake Bay from 1982 -1987, and included results from surface microlayer, water column, sediment, and tissue samples. Espourteille et al. (1993) presented results from sediment and pacific oyster samples collected in the southern Chesapeake Bay in 1986 and 1987. TBT detections were directly correlated with commercial shipping and recreational boating activity. Sediment concentrations of TBT in these areas were found to be as high as 4,000 μg/kg dry weight. The maximum concentration in oysters *(Crassostrea virginica)* was detected in the Elizabeth River, VA, at 5,600 μg/kg.

Monitoring objectives in Chesapeake Bay changed after 1987 when State and Federal legislation limited the use of TBT-containing paints on the hulls of boats (discussed in the following section). Monitoring was conducted to evaluate the effectiveness of legislative action by comparing newly collected data with results reported prior to the ban enacted in 1987 (Hall, 1992). Hall et al. (1992) conducted monitoring in a northern Chesapeake Bay marina and river system in 1989 and compared this data to data collected in previous years. TBT concentrations were not significantly reduced between 1986 and 1989 when mean concentrations were averaged across stations and dates for each year. A statistically significant reduction, however, was observed at

Port Annapolis Marina when each station was examined for differences between years. Approximate TBT concentrations at this station in 1986, 1988, and 1989 were 440, 165, and 155 ng/L, respectively. It is important to note, however, that the sampling design of this study, which consisted of limited sampling frequency, did not allow for detection of gradual decreases in TBT. According to data presented in the Chesapeake Bay Basinwide Toxics Reduction Strategy Reevaluation, TBT was detected in the surface microlayer from 1986 - 1988, but was not detected in 1991 (Chesapeake Bay Program 1994).

Notable ambient monitoring efforts have also been conducted in San Diego Bay. The Naval Oceans Systems Center in San Diego began analyzing San Diego Bay waters for TBT in 1983 (Richard, 1988). The Navy's monitoring results from 1983 to 1986 reported TBT concentrations in San Diego Bay ranging from 10 to 930 ng/L. From 1984 to 1986, the U.S. Navy analyzed surface water samples from other locations in California as part of an extensive study of 15 harbors in the United States. In addition to San Diego Bay, samples were collected from Los Angeles/Long Beach Harbor, San Francisco Bay, and Mare Island. Maximum TBT concentrations at each location were reported as follows: 930 ng/L in San Diego Bay, 158 ng/L in San Francisco Bay, 119 ng/L in Los Angeles/Long Beach Harbor, and 46 ng/L in Mare Island (Grovhoug et al., 1987 in Richard, 1988). Similar to the Chesapeake Bay efforts, monitoring of California waters conducted after 1987 assessed the effectiveness of State and Federal legislation. Effectiveness studies were performed by Valkirs et al. (1991) in San Diego Bay and by the California Department of Fish and Game (DFG) in San Diego Bay and Lake Tahoe (Davidson, 1995). Valkirs reported that TBT surface water concentrations decreased significantly in San Diego Bay following enactment of the legislative ban on use of TBT in marine paints. Three of the four locations sampled demonstrated TBT levels below the 6 ng/L water quality criteria adopted by the State of California SWRCB for the protection of marine species. DFG found that TBT residues in the sediments and organisms in San Diego Bay and Lake Tahoe declined sharply after 1987, demonstrating the effectiveness of TBT restrictions (Menconi,1994 in Davidson, 1995).

Since 1991, a full-scale EPA Environmental Monitoring and Assessment Program (EMAP) has been under way in the Louisianian Province, encompassing the Gulf Coast from northern Florida through Texas (USEPA, 1993). Results of the EMAP study found TBT in nearly all samples collected in Galveston Bay, with several reported concentrations above 5 ppb. In contrast, concentrations were low (<1 ppb) in the majority of samples collected in other locations throughout the Louisianian Province. Continuing EMAP efforts have been outlined which will attempt to further document the extent of contamination and determine the severity of effects on aquatic life resulting from TBT concentrations (USEPA, 1993).

Washington State, as part of the USEPA's National Estuary Program, conducted sediment monitoring for TBT in marinas and waterways of Puget Sound (Krone et al., 1989). Krone et al. (1989) reported that the sediments with the highest levels of butyltins (including TBT) were collected either adjacent to ship repair facilities or within marinas. More recently, TBT has been detected at Harbor Island at sumps and catchments in dry docks. Data suggest that TBT maybe migrating up river (Shuman, 1996). Ship building operations in the area, including sand blasting, are the suspected source. Extensive sediment monitoring and toxicity testing is being conducted of Harbor Island in an effort to establish a sediment clean-up level for TBT (Keeley, 1996).

Currently, TBT is being monitored in other regions of the country as required by provisions outlined in the Organotin Antifouling Paint Control Act of 1988. This law provides that representative estuaries and near-coastal waters shall monitor the concentrations of organotin in water column, sediments, and aquatic organisms until 1998[2]. Results of monitoring under this program will be utilized to assess the effectiveness of current laws in controlling TBT and to develop recommendations for additional measures to protect human health and the environment. U.S.C. § 2406(e).

Recent monitoring and impact studies evaluated the effectiveness of these laws regarding TBT antifouling paints and many have reported decreased concentrations of TBT in the aquatic environment. Evans et al. (1995) presented a qualitative review of several effectiveness studies and concluded that ambient levels of TBT have decreased in the water column, sediments and tissues of molluscs, and a recovery from adverse effects has occurred in dogwhelks and oysters. In addition, pollution was found to be confined primarily to "hot spots" of heavy boating activity and TBT was not expected to constitute a major problem in open seas and oceanic waters (Evans et al., 1995). Mollusk monitoring conducted by the National Oceanic and Atmospheric Administration (NOAA) concluded that contamination of U.S. coastal areas may be decreasing as a result of the environmental laws and regulations banning the use of TBT-containing antifouling paint (NOAA, 1995).

To further reduce TBT levels, the State of Virginia has adopted strict TBT water quality objectives for commercial ship yards. Such objectives are necessary because State and Federal legislation do not restrict the use of TBT paints on large commercial vessels (e.g., over 25 m in length). Newport News Ship Building Co., for example, was issued an industrial stormwater permit which requires concentrations of TBT in their ship yards to be less than 50 ng/L (Grace, 1996). Newport News was given four years to reach compliance with this standard. It is hoped that this strict water quality standard will force Newport News to discontinue use of TBT-containing antifouling

[2]See Organotin Antifouling Paint Control Act of 1988,33 U.S.C. § 2401 et seq

paints.

Urban Wastewater Effluent

Published literature regarding contributions of TBT to marine environments from urban effluent is extremely limited. As discussed previously in this report, the SFBAPPG conducted a survey of San Francisco Bay Area POTWs. Results of the survey indicated that 3 POTWs: City of Livermore, Palo Alto RWQCP, and the Union Sanitary District exceeded effluent limits for TBT (Montgomery-Watson, 1996). The Regional Water Quality Control Plant (RWQCP), operated by the City of Palo Alto, identified cooling water discharge as a potential source of TBT detected in their effluent (RWQCP, 1995) The City and County of San Francisco evaluated cooling tower discharges (Montgomery-Watson, 1995). Samples collected from industrial cooling towers exhibited concentrations of TBT ranging from 0.14 µg/L to 1.5 ug/L.

The Toxic Organic Pollutant Management Study conducted by San Francisco also detected TBT at several locations in the City (CCSF, 1996). In response to NPDES permit requirements, CCSF is evaluating the ability of its Southeast Water Pollution Control Plant (SEWPCP) to meet "levels of concern" for certain TOCs and developing source reduction programs as necessary. During the initial phase of the program conducted between July 1995 and June 1996, TOCs were identified and focused sampling effort was performed at the following locations: the SEWPCP and Oceanside WPCP influent and effluent, major trunk lines, and targeted areas in the City. The TOCs included in the study were 7 chlorinated pesticides, 8 organophosphate pesticides (including diazinon and chlorpyrifos), PAHs, PCBs, dioxins, and tributyltin. The results of the sampling program were as follows:

- Tributyltin (TBT) was detected in all 16 of the Southeast and Oceanside WPCP influent and effluent samples analyzed. The median effluent levels were 0.027 µg/L at the SEWPCP and 0.008 µg/L at the OCWPCP. None of the other TOCs included in the study were detected in the effluent of either plant. In addition, TBT was detected in 17 of 19 collection system source samples and were associated with a variety of commercial and industrial sources.

- PAHs were detected in 26% of the more than 300 samples analyzed from collection system sources and were primarily associated with runoff from industrial areas, vehicle service businesses, and catch basin sediments.

- Chlorinated pesticides were present in less than 5% of the collection system source samples taken.

- The other TOCs included in the study (i.e., PCBs, organophosphate pesticides, and dioxin) were not detected in any of the samples analyzed.

Future work in this study will include wet weather sampling for PAHs, TBT, dioxins, and organophosphate pesticides; additional sampling for TBT from individual dischargers; and additional analysis of samples for individual PAH compounds and other dioxin/furan isomers.

Other cities have recently begun to look at urban effluent as a potential source of TBT contamination. Due to permit non-compliance, the City of Arcata, CA, is required to monitor for TBT and investigate potential sources. Preliminary monitoring results indicate that TBT is most likely not an industrial problem, but instead is attributable to residential sources. Continued monitoring, however, is needed to verify these initial findings (Geist, 1996). The City of Woodland, CA has detected TBT in effluent samples. TBT was detected in 6 of 8 effluent samples collected from the City of Woodland's Water Pollution Control Facility; a maximum concentration of 0.017 μg/L was reported (LWA, 1995). Woodland is currently preparing a source identification and control strategy program to control TBT concentrations in wastewater influent and effluent. The City of West Sacramento has detected TBT in influent, effluent, and residential sewer samples at average concentrations of 57 ng/L, 11 ng/L, and 9.5 ng/L, respectively. The City has recently established a maximum allowable industrial headworks loading (MAIHL) for TBT of 0.00048 lbs/day (LWA, 1995).

In addition to studies in California, the State of North Carolina conducted monitoring in the early 1980s which detected high levels of TBT in industrial effluents and receiving waters. In response to these high detections, North Carolina established strict water quality standards (described in the following section).

Source Identification and Control Strategies

As previously stated, potential sources of TBT entering aquatic environments include antifouling paints and stains, biocidal cooling water additives, wood preservatives, disinfectant carpet and upholstery cleaners, fiber and textile preservatives, and disinfectant toilet bowl cleaners (Davidson, 1995).

Over 20 different chemical forms of TBT are used as active ingredients in products. To identify TBT-containing products, therefore, it is necessary to know the salt, oxide, etc. of TBT that is the active ingredient in the product. Following is a list of the active ingredients that contain TBT:

- Bis (tributyltin) adipate
- Bis (tributyltin) oxide
- Bis (tributyltin) sulfone
- Bis (tributyltin) sulphide
- Ethylene oxide comples of abietylamine, tributyltin
- Ethylene oxide condensate of abietylamine, tributyltin chloride
- Oxybis (tributyltin)
- Tributyltin Acetate
- Tributyltin Benzoate
- Tributyltin Chloride
- Tributyltin Chloride, Myristylamine salt
- Tributyltin Fluoride
- Tributyltin isopropyl succinate
- Tributyltin Linoleate
- Tributyltin Maleate
- Tributyltin Methacrylate
- Tributyltin Monopropylene glycol maleate
- Tributyltin Neodecanoate
- Tributyltin oxide
- Tributyltin resinate
- Tributyltin sulfide

Table 2 provides a list of actively registered TBT-containing products in California and their registered site of use (DPR, 1996a). Source control strategies for anti-fouling paints were discussed in the previous section. Strategies for other TBT-containing products are discussed below.

According to the available literature and personal communications with staff from USEPA, State, County, and City governments, and various environmental organizations, most municipal studies have only focused on commercial cooling water systems as a significant source of TBT in urban effluent. California has been a leader in implementing measures to control TBT entering aquatic environments via cooling water discharge. TBT was identified as a toxic pollutant of concern in the San Francisco Bay Area when local POTWs were unable to meet water quality standards established by the San Francisco Bay Regional Water Quality Control Board (RWQCB) (i.e. 0.005 µg/L for the protection of aquatic life in the Bay). The City of Palo Alto's Regional Water Quality Control Plant (RWQCP), for example, reported several exceedances in 1992 and 1993. In response, RWQCP staff investigated possible sources of TBT, and concluded that discharge from cooling water systems was the apparent source. To assist POTWs in eliminating TBT in their effluents, and

TABLE 2
Tributyltin-Containing Products and Their Registered Sites of Use*

Product Name	Site of Use
Devran 218 Red Antifouling Paint	Antifouling treatment site (all or unspecified)
Devran 222 Red Antifouling Paint	Antifouling treatment site (all or unspecified)
Devran 222 Blue Antifouling Paint	Antifouling treatment site (all or unspecified)
Devchlor Red Antifouling Paint	Antifouling treatment site (all or unspecified)
Super Tropical 280 Antifouling Paint	Antifouling treatment site (all or unspecified)
ABC #2 Red ablative antifouling coating	Antifouling treatment site (all or unspecified)
ABC #2 Black ablative antifouling coating	Antifouling treatment site (all or unspecified)
ABC #2 Blue ablative antifouling coating	Antifouling treatment site (all or unspecified)
ABC #8 Red ablative antifouling coating	Antifouling treatment site (all or unspecified)
Add-X- Mildewcide Paint Additive	commercial, institutional or industrial areas
Amercoat 3224 White Aerosol Antifoulant	Antifouling treatment site (all or not-specified)
Amercoat 635 Antifouling, White	Antifouling treatment site (all or unspecified)
Amercoat 635 Antifouling, Black	Antifouling treatment site (all or unspecified)
Amercoat 635 Antifouling, Blue	Antifouling treatment site (all or unspecified)
Amercoat 635 Antifouling, Green	Antifouling treatment site (all or unspecified)
Amercoat 635 Antifouling, Red Oxide	Antifouling treatment site (all or unspecified)
Amercoat 698HS Antifouling, Black	Antifouling treatment site (all or unspecified)
Amercoat 698HS Antifouling, Green	Antifouling treatment site (all or unspecified)
Amercoat 698HS Antifouling, Medium Gray	Antifouling treatment site (all or unspecified)
Amercoat 698HS Antifouling, Red	Antifouling treatment site (all or unspecified)
Amercoat 698HS Antifouling, Blue	Antifouling treatment site (all or unspecified)
Biosentry 904	commercial transport facilities (all or unspecified), hatching eggs/hatcheries (combined site), and human facegear and footwear (combined site)
Cuprinol Siding Stain & Preservative (semi-transparent)	wood protective treatments (all or unspecified)

TABLE 2 (cont.)
Tributyltin-Containing Products and Their Registered Sites of Use

Product Name	Site of Use
Cuprinol Siding Stain & Preservative (solid color)	wood protective treatments (all or unspecified)
Cuprinol Stain & Wood Preservative (semi-transparent)	lumber (seasoned/unseasoned),wood structures (above ground & finished structures)
Cuprinol Stain & Wood Preservative (solid color)	lumber (seasoned/unseasoned),wood structures (above ground & finished structures)
Dearcide 717	cooling tower influent conduits (antifouling), pulp and paper mill systems, sheet pulp, etc.
Fiberfresh MBI	carpets (hospital, commercial, household), upholstery (hospital, commercial, household)
Formulation HS-138D	water washer/cooler/condenser systems
Formulation HS-69D	water washer/cooler/condenser systems
Fungitrol 158 Fungicide	pesticides for manufac., reform., repack. use, and pesticides used in non-pesticide product manuf.
Garratt-Callahan Formula 34-A	water washer/cooler/condenser system
Intersmooth Hisol BFA254 Plum SPC	Antifouling treatment site (all or unspecified)
Intersmooth Hisol BFA256 Pink SPC	Antifouling treatment site (all or unspecified)
Micron 33 an organo-metallic polymer antifouling paint for brush or roller application 460 Blue	Antifouling treatment site (all or unspecified)
Micron 33 an organo-metallic polymer antifouling paint for brush or roller application 461 Green	Antifouling treatment site (all or unspecified)
Micron 33 an organo-metallic polymer antifouling paint for brush or roller application 462 Red	Antifouling treatment site (all or unspecified)
Micron 33 an organo-metallic polymer antifouling paint for brush or roller application 463 Black	Antifouling treatment site (all or unspecified)
Micron 33 an organo-metallic polymer antifouling paint for brush or roller application 464 White	Antifouling treatment site (all or unspecified)

TABLE 2 (cont.)
Tributyltin-Containing Products and Their Registered Sites of Use

Product Name	Site of Use
Mira-Fresh MI-50	carpets (hospital, commercial, household)
Nalco 2532 Microorganism Control Chemical	water washer/cooler/condenser systems
Nalco 7328 Microorganism Control Chemical	water washer/cooler/condenser systems
Natural Wood Semi-Transparent Oil Wood Stain & Preservative	lumber (seasoned/unseasoned), wood protection treatments (all or unspecified)
Olympic Clear Wood Preservative	wood protection treatments (all or unspecified), wood structures (above ground & finished struct.)
Olympic Performer Wood Preservative Clear	wood protection treatments (all or unspecified), wood structures (above ground & finished struct.)
Pacific Natural Look Clear Wood Preservative	wood or wood structure protection treatments
Skasol Microbiocide No. 8	aquatic site - industrial use (combined site)
Super Di-All Liquid Mildewcide	paint & coatings preservatives (combined site)
Troysan 364	adhesives (preservative incorporation), pesticides for manufac., reform., repack. use
Ultra Fresh DM-50 CC	textiles, fibers, cordage (preserv./add. incorp.)
Ultra Fresh DM-50	material preservatives/protectants
Visco 3951	secondary oil recovery injection & ore processing water
Watkins Toilet Bowl Cleanser	toilets, toilet bowls, urinals (all or unspecified)
West C-106	aquatic site - industrial use (combined site)

SOURCE: Department of Pesticide Regulation (DPR), 1996a.

more importantly to protect San Francisco Bay, the California Department of Pesticide Regulation (DPR) enacted emergency regulations prohibiting the possession, sale, and use of TBT-containing cooling water additives (neodecanoate and oxide) in the nine Bay Area counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma (DPR, 1996b). The Control Strategies Committee of the SFBAPPG developed an action plan for the TBT ban which provides recommendations to POTWs and outlines notification efforts (i.e. notify County Agricultural Commissioners, cooling tower owners/operators, vendors, and the public) to control TBT discharges (SFBAPPG, 1995).

The RWQCP implemented a cooling water systems source control program (RWQCP, 1996). The program collected information about cooling water systems, developed Best Management Practices (BMPs), and distributed the BMPs to cooling tower users within the RWQCP's service area. Benefits from source control efforts have already been identified by the RWQCP. The level of TBT in the 1995 effluent sample (0.002 μg/L) was significantly lower than values reported in 1993 and 1994 and below the effluent limitation of 0.005 µg/L. Low levels are expected to continue in response to RWQCP's outreach efforts and the Bay Area sales ban enacted by DPR (RWQCP, 1996).

Alternatives to the use of TBT in cooling water systems have been outlined in detail in the literature (Davidson,1995). Synthetic chemical alternatives are classified into two categories, oxidizers and non-oxidizers. Oxidizers include chlorine, calcium and sodium hypochlorite, solid organo-chlorinated hydantoins, bromine-generating compounds, chlorine dioxide, and ozone. Non-oxidizers include organo-bromine, triazines, isothiazoline compounds, quaternary ammonium salts, organo-sulfur compounds, glutaraldehyde, and organic thiocyano-azole compound. Some of these substitutes (e.g. glutaraldehyde) for TBT may also require treatment before discharge to the sanitary sewer.

Operational alternatives have also been shown to be effective in reducing the amounts of TBT in cooling water systems. The North Carolina Pollution Prevention Program (NCPPP) reported that automatic bleed/feed systems can reduce discharges of excess biocides that are causing toxicity problems (NCPPP, 1987). Industries in the southeastern United States have implemented this technology to control the rate of chemical addition (biocides) for treating cooling water in large air conditioner units (Schecter & Hunt, 1989). Automatic controllers minimize the consumption of both chemicals and water by monitoring the dissolved solids in the cooling tower and avoiding excess bleed/feed (e.g., bleed-off containing biocide compounds can reach the aquatic environment) during periods of lower air conditioning load. These controllers are cost-effective as discussed in the next section, Economic Impacts of Control Strategies. In addition, many industries have substituted a biodegradable compound for the organotin compound previously used as the biocidal agent. However, the NCPPP did not discuss the effectiveness of these control measures in reducing toxicity in the aquatic environment.

Ozone treatment system technology offers another effective alternative to the use of TBT in cooling water. The Triox ozone treatment system replaces chemical biocides, such as TBT, with a computer controlled continuous ozonation system for control of biological growth in cooling towers. The Department of Toxic Substances Control (DTSC) recently certified this new environmental technology (DTSC, 1996). The DTSC certification involves a critical evaluation of the efficiency and safety of new environmental technologies, and ensures that these technologies do not pose risk to human health or the environment.

Other potential sources of TBT in urban effluents include the use of TBT compounds in wood preservatives and stains, disinfectant carpet and upholstery cleaners, disinfectant toilet bowl cleaners, textile and fiber preservatives, and facegear and footwear disinfectant (DPR, 1996a). Most TBT-containing products used in California are either antifouling paints or cooling water additives. Published literature was not found regarding the introduction of TBT into the environment via any sources other than these two. However, personal communications revealed that the state of North Carolina has addressed some of these sources. The State of North Carolina identified textile plants as a major source of TBT in state waters (Ausley, 1996). North Carolina also identified widespread biocidal use (in cooling towers) and fungicidal use (on mattresses and shower curtains) as supplemental sources of TBT. In response, the state developed stringent water quality standards for freshwater (0.008 μg/L) and salt water (0.002 μg/L).

Economic Impacts of Control Strategies

Antifouling paints

TBT has proven to be one of the most cost effective antifouling agents used in paints applied to the hulls of ships and other watercraft. The benefits of TBT, namely its long lifetime and lack of corrosion problems, have significant economic implications. TBT antifouling paints remain effective for five to seven years, whereas copper-based antifouling paints (one of the few alternatives) only last 14 months or less (Bushong et al., 1989) and can also cause water quality problems. In 1987, the possible economic impacts of the then proposed Federal legislation regarding TBT-containing antifouling paints was examined (Ludgate, 1987). This study predicted that the end-user or consumer would be the most negatively affected by legislation and that annual operating costs could increase as much as 50%. Additionally, it was estimated that fuel savings for a large vessel using TBT-containing coatings was between $200,000 and $400,000 per year. Champ and Lowenstein (1987) reported that the cost for dry-docking and applying antifouling paints to a large vessel is about $1 million. The USEPA also performed economic impact studies before the Federal TBT legislation was enacted and reported that "if all users substituted conventional copper paints for all TBT paint use, the loss would be an estimated $460.8 million annually" (USEPA, 1987 in Weis, 1989). However, if "new" copper copolymers paints were used, the loss would be reduced to $179 million. USEPA ultimately concluded that banning TBT would not significantly impact recreational boaters economically, but would impact commercial vessels. These conclusions were key in outlining the provisions to be contained in the final TBT legislation (i.e. banning use on small watercraft and allowing large vessels to continue using TBT-containing coatings). Actual cost increases following the enforcement of legislation were not found in the available literature.

Urban Effluent

Most source control strategies for TBT in urban effluent have focused on cooling water systems. Information is available on the cost implications of alternative cooling water additives and cooling system operational changes. Davidson (1995) presents a comprehensive cost comparison between synthetic cooling water chemical alternatives. Several steps were involved in this cost analysis, including a determination of the recommended range of treatment dosages and frequencies from the product label, identification of the type of product, standardized costs to per month and per 1,000 gallons of system capacity, obtained range of costs per pound of the product from dealers, monthly maintenance cost using the product dosage and frequency, and cost per pound of the product. Results showed a wide variance in costs between products. The isothiazoline compound alternative, Nalco 2810, was the most expensive with estimated monthly costs (including maintenance costs) ranging from $72.40 - $464.00/month while the gluteraldehyde-containing compound, Nalco 8396, was the least expensive with estimated costs ranging from $2.62 - $8.41/month. The majority of the estimated costs of the alternative products ranged between $5 and $40/month. This compares to an estimated monthly cost of approximately $25/month for TBT-containing additives (Forbes, 1996).

Prior to the enforcement of regulations prohibiting the sale and use of TBT-containing cooling water additives in the San Francisco Bay Area, DPR examined possible economic impacts. DPR considered alternatives that would reduce any possible adverse economic impacts, including small businesses, and concluded that the proposed regulatory action would result in the least impact on businesses of all sizes. However, DPR realizes that other alternatives may exist that have not yet been evaluated.

Cost effective operational alternatives, which reduce the amount of chemical additive needed, are available for cooling water systems. Automated bleed/feed systems utilize automatic controllers to keep the optimum concentration of active biocidal chemical (e.g. TBT) at all times and eliminate unintentional discharge of the chemical (NCPPP, 1987). The continuous control results in reduced labor costs for cleaning and manual adjustments and provides lowered energy consumption as well. Industries in the southeastern United States using automated bleed/feed systems have reported savings as great as $130,000 per year (Schecter & Hunt, 1989).

ORGANOPHOSPHATE PESTICIDE ASSESSMENT

Diazinon and chlorpyrifos are organophosphate insecticides used for structural pest control, landscape maintenance and agricultural applications. Organophosphates kill insects through their effect on the target pest's nervous system through the inhibition of the enzyme, acetyl cholinesterase (AChE). These two pesticides have been shown to have toxic effects on non-target species, including fish, birds and mammals, in addition to the targeted insects (Cox, 1992; Cox, 1994; USFWS, 1986).

Approximately 8 to 10 million pounds of diazinon are sold annually throughout the United States (Cooper, 1996). Approximately 1 to 4 million pounds of diazinon are sold in California annually. The primary U.S. manufacturer of diazinon is Ciba Geigy Corporation (Cox, 1992).

Approximately 9 to 12 million pounds of chlorpyrifos are used nationally for non-agricultural applications and approximately 10 to 15 million pounds are used for agriculture annually (Cox, 1994). In 1992, close to 1 million pounds of chlorpyrifos were used for structural pest control in California. In that same year, approximately 1.6 million pounds were used for agricultural purposes in California. Chlorpyrifos is manufactured by DowElanco under the brand names of Dursban and Lorsban.

The literature reviewed contained information about diazinon and chlorpyrifos with respect to environmental impacts, monitoring studies, source identification, and source control and reduction. Limited information was available concerning economic impacts of source control. Economic impacts are included in the discussion of source control strategies and are not discussed separately.

Environmental Impacts

The environmental fate, aquatic toxicity, and effects in humans and animals of diazinon and chlorpyrifos are discussed below.

Environmental Fate

Diazinon is commonly used as a dormant spray on crops during the winter months in the Central Valley. A 1994 hazard assessment conducted by the California Department of Fish and Game (CDFG) described diazinon's environmental fate (CDFG, 1994). Diazinon does not appear to bioconcentrate and is rapidly excreted after exposure. Diazinon's half-life on soil, ranges from 7 to 80 days (Cooper, 1996). Its half-life in water is 4 to 12 days at a pH of 5; 78 to 138 days at a pH of 7; and 40 to 77 days at a pH of 9. Diazinon is soluble in water up to 60 mg/L at a pH of 7.

Diazinon's soil absorption rate is moderate as compared with other organophosphate pesticides (Cooper, 1996). Its half-life and moderate absorption in soil indicate a potential for diazinon to be carried by stormwater runoff to nearby surface water. Its long half-life in water at near neutral pH levels typical of Central Valley and Bay Area surface water and POTW effluent indicates a potential for exposure of aquatic life to diazinon. In addition, diazinon is also carried in air. The effects of this are discussed further in the section entitled Monitoring Studies.

Once released into the environment, chlorpyrifos absorbs readily into soil and is relatively immobile (Cox, 1995). Therefore, this insecticide is considered to have a low potential for contaminating ground and surface water. Results from studies conducted by the University of Georgia, University of Nebraska and Iowa State University support this contention. In these studies, almost no leaching was seen, even under conditions of heavy irrigation or rainfall (USGA, 1996). Typical soil persistence for chlorpyrifos is between 60 and 120 days, while its persistence in water is between 17 and 24 days.

Aquatic Toxicity and Water Quality Criteria

Using EPA guidelines, a water quality criterion for the protection of freshwater aquatic life for diazinon was developed (CDFG, 1994). Based on tests of acute and chronic effects to aquatic animals, it was determined that freshwater aquatic organisms should not be unacceptably affected by chronic diazinon levels of 0.04 μg/L (4-day average) or acute diazinon levels of 0.08 µg/L (one-hour average). The National Academy of Science has recommended a criterion of 0.009 μg/L for the protection of aquatic life. EPA has not established water quality criteria for diazinon.

Diazinon was linked to toxicity to *ceriodaphnia* following stormwater events in Sacramento (RWQCB, 1995a) and in Alameda County creeks (Hanson, 1995). After storm events, toxicity to fathead minnows (*Pimephales*), *Ceriodaphnia*, and *Selenastrum* increased in the Sacramento River downstream of Sacramento. The toxicity to *Ceriodaphnia* was linked to diazinon in residential areas, industrial areas and in urban stormwater runoff.

Water quality criteria were developed by EPA for chlorpyrifos in 1986 (US EPA, 1986). The freshwater criteria are 0.041 $\mu g/L$ as a four-day average concentration, and 0.083 $\mu g/L$ as a one-hour average concentration. Acute toxicity values for 18 freshwater species ranged from 0.11 $\mu g/L$ to 806 $\mu g/L$.

Chlorpyrifos has been found in urban stormwater in Sacramento, and in POTW effluent and urban stormwater in the Bay area as discussed in more detail under Monitoring Studies. According to an analysis conducted by the Los Angeles RWQCB, chlorpyrifos has contributed to the impairment of at least 3 inland watersheds: Revelon Slough, Beardsley Channel and the Los Angeles River Reach 5 (LARWQCB, 1996).

Human and Animal Exposure

Humans may be exposed to diazinon through several sources (Cox, 1992). Food surveys have found diazinon in fruits, vegetables, grains, fish, shellfish, and milk. The U.S. Food and Drug Administration included diazinon among 200 pesticides analyzed in its Total Diet Study in 1990. Diazinon was the eighth most commonly detected pesticide in the study.

As a result of diazinon's common use in homes, yards and gardens, this pesticide has been involved in many accidental poisonings. Two EPA surveys (Cox, 1992) found diazinon to be the sixth most frequent cause of accidental death due to pesticides and the sixth most frequent cause of pesticide-related hospitalizations.

Diazinon has adverse effects on birds, fish, beneficial arthropods, and microbes at certain levels (Cox, 1992). Birds are particularly sensitive to diazinon toxicity. Over 50 incidents involving close to 1000 birds have been documented in the United States (Id). In 1990, due to the record of bird mortalities related to diazinon use, EPA canceled diazinon's registration for use on golf courses and sod farms.

Humans may be exposed to chlorpyrifos through food and through their indoor environment (Cox, 1995). Chlorpyrifos residues have been found on a variety of foods including tomatoes, oranges, broccoli, grapes and tea. A 1993 FDA food testing study found that chlorpyrifos was the fifth most commonly detected pesticide and was found in 10% of the food samples tested. Another source of human exposure is applications made to homes and other buildings for pest control. Between 1985 and 1992, 10,000 adults and 11,000 children reported chlorpyrifos exposures to poison control centers.

Chlorpyrifos has had adverse and lethal effects on birds, cats, monkeys and other animals at certain concentrations (Cox, 1995). After chlorpyrifos treatment of a brassica field in the United Kingdom, 200 birds were killed (Id). Adverse effects on birds include reduced weight gain, anorexia, and birth deformities. Toxic effects have been observed in cats following treatments of their owners' homes. The treatment of a monkey rearing facility with chlorpyrifos was linked to the death of 20% of the monkeys (Id). Young animals are typically more susceptible to chlorpyrifos poisoning than adult animals.

Monitoring Studies

Both diazinon and chlorpyrifos have been detected in surface water, stormwater, and wastewater as reported in monitoring studies conducted around the country. For example, in 1989-90, a Pesticide Reconnaissance Survey was conducted in the Puget Sound Estuary to assess the extent and toxicological significance of pesticide residues present in sediment and in the water column (PTI Environmental Services, 1991). Diazinon, one of 34 pesticides monitored during the survey, was detected at three of the four sites included in the study at concentrations ranging from 0.054 to 0.14 $\mu g/L$. Diazinon was also detected in the sediment at one site within one order of magnitude of its LC_{50}-derived sediment toxicity index.

In 1993, the USGS studied the movement of diazinon through the Sacramento-San Joaquin delta. Diazinon was applied as a dormant spray pesticide in orchards in the Central Valley in the last two weeks of January in 1993. After a series of rainstorms in early February, diazinon concentrations were measured at different points along the Sacramento and San Joaquin Rivers. Concentrations of diazinon were measured at Freeport (a site near Sacramento) in the Sacramento River a few days after each rainfall. Diazinon concentrations in the Sacramento River peaked at 0.39 $\mu g/L$ after the first rainfall, and 0.19 $\mu g/L$ after a subsequent rainfall. Similarly, concentrations in the San Joaquin River peaked a few days after each rainfall when measured at Vernalis (a site near Modesto). Diazinon concentrations reached a maximum of 1.1 $\mu g/L$ in the San Joaquin River approximately 2 days after the first rainfall. The movement of a diazinon "pulse" down each river was documented at several points. Where the Sacramento and San Joaquin rivers converge in the delta, diazinon concentrations increased steadily throughout February 1993, from 0.035 to 0.15 $\mu g/L$.

The USGS also monitored pesticide levels from January, 1991 to April, 1994 on the Sacramento River at Freeport and on the San Joaquin River at Vernalis (MacCoy, et. al., 1995). Diazinon was detected primarily in the winter months each year in both rivers. Concentrations ranged from 0.02 to 0.7 $\mu g/L$ during the winter months.

As part of a Toxicity Identification Evaluation (TIE) on Sacramento and Stockton receiving waters, the Central Valley Regional Water Quality Control Board (CVRWQCB) collected samples after storm events during the 1994-1995 winter season and analyzed these samples for chlorpyrifos and diazinon (CVRWQCB, 1996). Toxic levels of chlorpyrifos and diazinon were detected in receiving water samples. The TIE confirmed that both chemicals were contributing to the toxicity observed in the receiving waters.

A 1995 memorandum summarized diazinon sampling efforts in the Bay (Moran, 1995). Alameda County conducted toxicity testing that linked diazinon levels of 0.1 to 3 μg/L in local creeks to toxicity to *ceriodaphnia*. Diazinon levels in Palo Alto creeks were found to range up to 0.39 μg/L, with typical values ranging from 0.5 to 2 μg/L. A compilation of data from approximately 200 samples collected by several Bay Area cities found diazinon in most Bay Area creeks. Concentrations ranged up to about 3.3 μg/L, with typical values in the 0.1 to 0.3 μg/L range.

Recent studies in Atlanta, Baltimore and Milwaukee also detected diazinon and chlorpyrifos in urban stormwater (Schueler, 1995). Average levels of chlorpyrifos and diazinon detected in these studies are shown in Table 3.

Table 3. Average Diazinon and Chlorpyrifos levels in Stormwater Runoff (1992-1994)

City	Diazinon (μg/L)	Chlorpyrifos (μg/L)
Baltimore	ND	0.01 - 0.021
Atlanta	0.02	0.008
Milwaukee	0.5	NA

ND = Not detected; NA = Not available

Diazinon and chlorpyrifos have also been detected in rainwater. During TIE sampling in Sacramento and Stockton receiving waters, rainfall samples were also collected and analyzed for diazinon and chlorpyrifos (CVRWQCB, 1996). Samples were also taken in the San Francisco Bay. Eighty percent, or 72 of the 90 Sacramento/Stockton samples exceeded the CDFG's water quality criterion for chlorpyrifos of 0.015 μg/L. Seventy-five percent of the 46 samples taken in the San Francisco Bay and ninety percent, or 28 of the 31 rain samples collected in Sacramento and Stockton exceededsamples exceeded the CDFG's water quality criterion for chlorpyrifos of 0.015 μg/L. Seventy-five percent of the 46 samples taken in the San Francisco Bay and ninety this water quality criterion for chlorpyrifos. Diazinon levels, which were also monitored in the study, declined in March following the end of the dormant spray season, while chlorpyrifos levels remained high. Other data concerning the presence of these constituents in rainwater are discussed in the section on Source Identification.

Atmospheric transport of diazinon and chlorpyrifos from the Central Valley to the Sierra Nevada foothills was assessed by collecting air- and wet-deposition samples during the winter months (Zabik, 1993). The findings of this study indicate that transport of these pesticides is occurring, but that deposition levels decrease as distance from the valley and elevation increase. Levels of diazinon in rain and snow in the foothills ranged from 0.02 $\mu g/L$ to 6 $\mu g/L$, while levels of chlorpyrifos ranged from 0.02 $\mu g/L$ to 0.18 $\mu g/L$.

Source Identification

Sources of diazinon and chlorpyrifos have been identified through monitoring, surveys, and reported use data for the Department of Pesticide Regulation (DPR). DPR requires that use of pesticides for agricultural uses be reported annually. In addition to application to crops, "agricultural uses" include pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, and along roadsides. Pesticide applications by commercial pest control operators must also be reported. Reporting is not required for the private use of pesticides for homes and gardens, or for industrial or institutional use.

According to information provided by the Department of Pesticide Regulation (DPR), approximately 1 to 4 million pounds of diazinon is sold annually in California. One to 1.5 million pounds is used annually for reported uses. The City of Palo Alto has evaluated diazinon use in California and Santa Clara County (Cooper, 1996). In 1994, 22,000 pounds were used for reportable uses in Santa Clara County including 9700 pounds (44%) used for structural pest control, and 6200 pounds (28%) used for landscape maintenance (Cooper, 1996). The remainder (6100 pounds) was used in agricultural applications. The distribution of use in Santa Clara appears much different than that in the Central Valley, where as indicated above, approximately 84% of the diazinon used for reportable uses is for agriculture.

As part of the CVRWQCB's TIE, sources of diazinon in Central Valley urban stormwater were determined, based on reported use data, to be both urban and agricultural (CVRWQCB, 1995a). Reported use of diazinon in the Central Valley in 1990 included professional landscape maintenance (33,000 lbs.), structural pest control (74,000 lbs.), and agricultural uses (560,000 lbs).

The CVRWQCB also identified rainfall as a source of diazinon. Diazinon levels in rainfall taken throughout the Central Valley are shown in Table 4.

Table 4. Diazinon in Central Valley Rainfall (February, 1995)

Location	Concentration ($\mu g/L$)
Colusa	0.42
Sacramento	0.70
North Stockton	0.84
Davis	0.89
South Sacramento	1.2
Central Stockton	1.8
Hamilton	2.0
South Stockton	3.7
Yuba City	4.0
Red Bluff	4.1
Tracy	4.2
Nicolaus	4.5
Patterson	5.5

In another source identification effort, the City of Palo Alto investigated the types and uses of diazinon products registered in California (Cooper, 1996). Palo Alto found that there are 267 products containing diazinon registered for use with the DPR. These products are divided by formulation type into the following categories: solution/liquid, emulsifiable concentrate, aqueous concentrate, pressurized liquids, sprays, flowable concentrate, dust/powder, wettable powder, granular/flake, impregnated material, and microencapsulated. Sixty of the products are impregnated materials (e.g., flea collars) and were not included in further evaluation because they were unlikely to be a source of diazinon in wastewater or stormwater.

Information on sites of use is provided for each registered product. The uses indicated for each registered product were divided into indoor and outdoor uses and into commercial and residential uses. Most of the products (202 of the 217) have outdoor uses, while the other 15 have only indoor uses. Of the products with outdoor uses, all but one have at least one residential use. In addition, 103 products have commercial outdoor uses. Approximately 50 of the outdoor use products can be used indoors as well.

The City of Palo Alto evaluated where each type of formulation is likely to be used.

Ninety-six percent or 69 of the 72 granular/flake products registered are for outdoor use. Solution/liquid and pressurized spray products are generally used both indoors and outdoors. Over half of the products in the other categories are designated solely for outdoor uses. This breakdown of product types may be used to focus source control efforts.

To gain more information about how the product is used, Palo Alto also surveyed retail stores in its service area that sell diazinon (Cooper, 1996d). The survey results indicated the following:

- The target pests in the Palo Alto service area are ants, fleas, and grubs.
- Only 29 of the 246 registered diazinon products are available in stores in the Palo Alto service area.
- Formulations in significant use in the Palo Alto service area include granules, dusts, concentrates, and one ready-to-use liquid.
- Diazinon sales occur primarily in the spring and summer.

The Central Contra Costa Sanitary District (CCCSD) also investigated sources of chlorpyrifos and diazinon (Brandenburg, 1996). Wastewater samples were collected from a residential community and from a number of commercial sources including self-service pet washes, kennels, and certified pesticide applicators. The results of CCCSD's investigation are shown in Table 5.

Table 5. Sources of Diazinon and Chlorpyrifos (CCCSD, 1995)

Source	Chlorpyrifos (μg/L)	Diazinon (μg/L)
Residential	1.8 - 3.0	0.71 - 2.0
Self-service pet washers	0.38 - 7.0	0.045 - 0.099
Certified applicators	0.056 - 1.8	0.035 - 1.1
Kennels	3.1 - 4.8	0.068 - 16

CCCSD identified flea shampoos as a significant potential source of chlorpyrifos in wastewater effluent. Estimates were made concerning the number of pet washings that would result in enough insecticide to cause toxicity in the CCCSD effluent (35 MGD plant). For flea shampoos containing D-limonene or pyrethrins (i.e., non-chlorpyrifos containing products), between 4300 and 18,000 pets would have to be washed to put enough insecticide in the sewer system to cause toxicity in the effluent. In contrast, toxicity in the CCCSD effluent would result from between 2 and 7 pets being washed per day with a chlorpyrifos-containing product.

Source Control and Source Reduction

Available diazinon and chlorpyrifos control strategies, surveys regarding pesticide use, and public education programs targeting pesticides are discussed below.

Control Strategies

Strategies for controlling sources of diazinon and chlorpyrifos are typically the same strategies employed for other pesticides, and include:

- Employing integrated pest management (IPM) methods
- Switching to less toxic pesticides, such as pyrethrins or insecticidal soaps, where appropriate and available
- Employing proper disposal and handling techniques to minimize the amount of pesticide entering the sewer or storm drain.

Integrated Pest Management (IPM) is a program that is typically applied to agriculture although its principles can also be applied to urban pest control (Robinson, 1995). IPM encourages the use of non-chemical controls, but allows for pesticide use under certain circumstances. The message of IPM is that alternatives to pesticides exist which can result in significant reductions in pesticide use.

IPM is based on the implementation of four basic principles.

1. The pest causing the problem must be identified so that a pest control approach best suited to the particular pest can be chosen.

2. The applicator must decide what level of pest control is necessary. For example, a residential yard may not need to be completely bug or weed free

3. Long-term strategies should be used to keep pests under control. Long-term strategies include introduction of disease-resistant plants, use of beneficial insects such as ladybugs, and removal of accessible food supplies for ants and cockroaches.

4. Short-term strategies are used when pests cannot be controlled due to unusual circumstances. Short-term strategies may include the use of pesticides, but the least toxic pesticide that will be effective is recommended.

Applying IPM to lawn care includes several practices (Schultz, 1990). Grass can be fertilized using organic fertilizers. IPM recommends fertilizing lightly and less frequently. Grass can be mowed higher leading to a healthier lawn that is more weed resistant, thus decreasing the need for pesticides. If pest problems occur, some damage may be tolerated and the least toxic controls available should be used. For example, biological controls, such as certain fungi or bacteria, can be effective pest controls. Also, the grass type chosen should be pest resistant and compatible with the local climate. Employing these practices can reduce the use of pesticides.

Less toxic alternatives to diazinon and chlorpyrifos have been identified based on the individual targeted pests (RWQCP, 1996d). For example, ant stakes are recommended as a good way to control small ant problems. Insecticidal soaps and pyrethrins are available as alternatives to diazinon although these alternative products must be applied more often and are typically used for spot applications. Beneficial insects are available and can work well to control grubs or fleas. However, in some cases beneficial insects may be more expensive than diazinon.

Another control strategy, the use of constructed wetlands, was tested as a method of treating diazinon in Denton, Texas (Guinn, 1995). A pilot wetlands facility was constructed at Denton's 15 MGD wastewater treatment plant in 1993. In 1994, the wetlands received 5000 gallons per day of wastewater with a typical retention time of 30 days. Diazinon concentrations of 0.5 μg/L entering the wetlands were reduced to less than 0.05 μg/L after 48 hours. Toxicity to *ceriodaphnia* was observed at the site where wastewater first entered the wetlands, but little toxicity was observed elsewhere.

Another source control approach is the development of a cooperative effort. For example, interested parties from the Central Valley and the San Francisco Bay area have formed a work group called the Urban Pesticide Toxicity Control Strategy Bay Area/Central Valley Coordinating Committee (Urban Pesticide Toxicity Committee) to examine issues of common interest concerning pesticides (Mumley, 1996). The purpose of this workgroup is to provide a forum for information exchange, coordination, and collaboration on the development and implementation of an urban pesticide toxicity control strategy which recognizes that the best solutions will be based on partnership among federal, state, and local agencies, industries, businesses, and the public. Currently, the group is developing a control strategy to reduce toxicity in urban creeks, wastewater and stormwater runoff due to diazinon. Participants in the workgroup include representatives from the Central Valley and San Francisco RWQCBs, stormwater programs including Alameda County, Santa Clara County, City and County of Sacramento; wastewater programs including CCCSD, Palo Alto; DPR; CIBA Crop Protection; and county agriculture commissioners.

Surveys on Pesticide Handling

Surveys have been conducted around the country to obtain more information on pesticide handling. In Ohio, pesticide applicators were surveyed regarding pesticide application and disposal practices (Ozkan, 1992). Survey results were based on 1380 responses received from applicators in 18 counties. Over two-thirds of the respondents reported that they calibrate their equipment at least once per year. Over 90% always rinse pesticide containers after emptying them. However, only 71% follow safe rinsing procedures (i.e., triple rinsing, pressure rinsing). Survey respondents indicated the use of several improper disposal methods (e.g. pouring down drain or storm drain).

The City of Madison, Wisconsin conducted a lawn care survey for one neighborhood in 1995 (Kroupa, 1995). One of the objectives of this survey was to identify the usage of weed killers and insecticides. Eighty-three percent of the 204 respondents indicated that they do not use insecticides. Twenty-seven of the 34 respondents who use insecticides indicated that they use diazinon. Other insecticides that were commonly used include Raid, malathion, Insect Control and Sevin.

Other surveys conducted in Virginia, Maryland, and Minnesota indicate that about two-thirds of homeowners perform their own lawn care (Schueler, 1995). Approximately 20 - 40% of homeowners use insecticides, with the most common products used including diazinon and chlorpyrifos. The Maryland survey indicated that two-thirds of the homeowners who apply their own pesticides rinse their equipment over grass, pavement, or directly into gutters or storm sewers.

One conclusion that may be drawn from these surveys is that a need exists for more public education regarding pesticide handling and disposal.

Public Education Programs

Sources of pesticides are likely to include unregulated commercial businesses or residential home and lawn maintenance. Public education programs have been implemented by several communities to encourage residents to implement the strategies discussed earlier. Public education programs targeting diazinon or chlorpyrifos, as well as programs targeting pesticides in general, are described below.

Diazinon was identified as the primary cause of wastewater whole effluent toxicity failures in several POTWs in EPA Region 6 (i.e., Texas, Oklahoma, New Mexico) (Water, Environment & Technology, 1995). At the request of EPA, CIBA Crop Production (diazinon manufacturer) conducted a study of 350 wastewater treatment plants in Texas, Oklahoma, and New Mexico which are required to perform biomonitoring. The study results indicated that diazinon levels in effluent can be reduced through increased solids retention time and aeration capacity. However, public education efforts to discourage residents from pouring pesticides down the drain are more economical than treatment and have proven to be effective. Public education programs developed in response to toxicity failures in Greenville, Texas, and Oklahoma City, Oklahoma, are described below.

Greenville, Texas

The City of Greenville, Texas, has a population of 23,000 and an average dry weather flow at its treatment plant of 3 MGD (Erwin, 1996). In 1991 and 1992, the plant effluent failed 6 out of 7, and 11 out of 12 toxicity tests, respectively. Diazinon was identified as the cause of the toxicity and monitoring indicated the diazinon was probably coming from residential sources. Diazinon levels ranged from 0.1 to 0.2 $\mu g/L$.

In late 1992, Greenville implemented a public education program. The program discouraged residents from using diazinon, encouraged the use of IPM practices, and recommended alternatives to pouring diazinon or even rinsewater down the drain. Outreach methods included highway billboards, radio public service announcements, newspaper articles, school programs, and speakers for community groups.

Since 1993, Greenville has conducted toxicity testing monthly in the summer and quarterly in the winter. Toxicity failure has occurred no more than once per year from 1993 - 1995, with no toxicity failures through the middle of 1996. Since the public education program was implemented, diazinon levels in the City's effluent are primarily below the detection limit of 0.1 $\mu g/L$.

Oklahoma City, Oklahoma

Oklahoma City has a population of 480,000 and is served by 4 wastewater treatment plants with a total capacity of 81 MGD (APA, 1995). Biomonitoring at all four plants identified toxicity which was linked to diazinon through Toxicity Reduction Evaluations (TREs) conducted in 1992. Sources appeared to be residential; therefore, the City determined that a public education program represented the most economical and effective control strategy.

The initial task of the educational program was to conduct a series of user surveys. Separate surveys were conducted for the following groups: residential users; professional exterminators; lawn service and nursery professionals; veterinary clinics and groomers; animal shelters and kennels; janitorial services and carpet cleaners; apartments, motels, and hotels; food service establishments; and retail stores. The results of the surveys indicated that the Public Education Program would be most effective by targeting residential users of pesticides. The City created its Public Education Program to inform the general public about the correct selection, handling and disposal of pesticides. Program elements include brochures, bill inserts, public television program, radio announcements, radio talk shows, information on buses and billboards, home and garden show exhibits, a home and garden club newsletter, and newspaper articles.

There are several sources of information on alternatives to the use of organophosphate pesticides. Reference information for four excellent sources describing alternatives are listed below:

1. Common Sense Pest Control: Least-toxic solutions for your home, garden, pets and community by William Olkowski, Sheila Daar and Helga Olkowski, copywright 1991 by Taunton Books and Videos.

2. Rebugging your home and garden: A step by step guide to modern pest control by Ruth Troetschler, Alison Woodworth, Sonja Wilcomer, Janet Hoffman and Mary Allen, copywright 1996, PTF Press, Los Altos, CA.

3. The IPM Practioner, Volume 17, No. 11/12, November/December 1995.

4. National Park Service Integrated Pest Management Manual (on-line manual); http://www.colostate.edu/depts/ipm/natparks.htm.

Several Federal and State agencies have developed educational materials for the general public that provide information on IPM and other pesticide issues. Examples of brochures describing methods of home and garden care without pesticides and pesticide handling and disposal which are available from different agencies are listed below:

Agency	Brochures available
US EPA, Office of Pesticide Programs	- Pest Control in the School Environment - Healthy Lawn, Healthy Environment - Citizen's Guide to Pest Control and Pesticide Safety
Wisconsin Department of Natural Resources	- Lawn and Garden Pesticides
North Carolina Agricultural Extension Service	- Disposal of Pesticides and Pesticide Containers

City and County of San Francisco, CA	-	Grow It ! The Less Toxic Garden
City of Sunnyvale, CA	-	Companion Planting
City of Greenville, Texas	-	A Pennywise Guide to Practical Pest Control
King County Water Pollution Control Division (Washington)	-	Six steps to a healthy pesticide free garden
	-	Ten most wanted pests
	-	Trouble free plants
City of Oklahoma City, Oklahoma	-	Know When, Know How, A Gardener's Guide to Pesticides
Central Contra Costa Sanitary District	-	Unwanter Pesticides: Out of Sight, Out of Mind...Right?

CONCLUSIONS AND RECOMMENDATIONS

Based on the literature assessment, estuary workshop, and TOC survey, the following conclusions can be drawn about TBT, organophosphate pesticides, and other TOCs in the Bay.

Tributyltin

Anti-fouling paints and cooling water additives have been comprehensively described in the literature as the primary sources of TBT. Both sources have been associated with adverse water quality impacts and bans have been implemented for anti-fouling paints and cooling water additives containing TBT. The Federal ban on antifouling paints applies to its use on recreational boats, but use on larger boats (over 25 m in length) is still permitted. This ban has been in effect since 1988. While antifouling paints are still in use, it is unlikely that this is a source of TBT in POTW effluent in the Bay Area.

California's ban on cooling water additives containing TBT is limited to the San Francisco Bay Area and was implemented in December of 1995 as an emergency regulation. This ban has recently become a permanent regulation for the Bay Area. It is expected that no TBT cooling water additives will be available in the Bay Area for purchase within the year.

Removal of TBT from cooling water may be effective in reducing TBT levels in POTW effluent in the Bay Area. The City of Palo Alto has conducted effective outreach efforts to discourage the use of TBT in cooling towers in their service area, resulting in reduced levels of TBT in their effluent. To ensure the effectiveness of the ban, it may be beneficial to conduct additional outreach programs throughout the Bay Area to inform affected businesses of the conditions of the ban, alternative products, and alternative practices for maintaining cooling water systems.

If the TBT ban is not effective in reducing TBT levels in wastewater treatment plant effluent, additional evaluation of other TBT sources, including toilet bowl cleaners, carpet disinfectants, use on shower curtains, and other fungicidal applications, would be warranted. However, it is recommended that the effectiveness of the ban be assessed after it has been in effect for a maximum of one year before conducting further source evaluation.

Organophosphate Pesticides

Diazinon and chlorpyrifos have been detected in both stormwater and wastewater discharges in the Bay Area. Sources in wastewater are most likely associated with residential use and some commercial uses of these pesticides. In some parts of the Bay Area, agricultural sources may also contribute to the presence of organophosphate pesticides in stormwater through agricultural runoff and pesticide volatilization (i.e., presence in fog and rainfall).

Public education efforts regarding Integrated Pest Management (IPM) and proper handling and disposal of pesticides have proven effective in other parts of the country. Developing regional public education materials are recommended and may prove to be effective in the Bay Area.

Stormwater agencies in the Bay Area and the Central Valley are also targeting diazinon and chlorpyrifos as pollutants of concern. Therefore, any projects implemented by the SFBAPPG should be coordinated with other regional efforts. This may be accomplished through the Urban Pesticide Toxicity Committee.

Other TOCs

Monitoring by the RMP and information provided in the Toxic Organic Pollutant Survey indicate that other TOCs of concern include PAHs, PCBs, DDT, cyanide and dioxin. As discussed earlier, achievable detection limits are currently greater than permit limits for PAHs and PCBs. However, further evaluation of these pollutants may be warranted as analytical methods improve. Identification of non-industrial sources of cyanide and dioxin may also warrant further investigation.

Recommendations

Based upon an evaluation of the literature reviewed, the following activities are recommended for future consideration by the SFBAPPG:

1. Develop regional outreach materials addressing diazinon and organophosphate pesticides drawing on existing materials on IPM, and proper handling and disposal methods. Specific activities may include:

   - Developing BMPs and educational brochures for sources including pest control operators, pet groomers, and kennels.

   - Developing educational materials concerning IPM methods.

2. Coordinate organophosphate pesticide activities with other regional control and education efforts through the Urban Pesticide Toxicity Committee. Specific activities may include:

   - Identifying pathways that transport the pesticide from the area of use to the environment.

   - Determining the relative contribution of riverine, storm drain, and sanitary sewer input of pesticides to the Bay.

   - Work with EPA and other organizations to develop labeling practices that provide more information regarding handling and disposal of pesticides.

3. Monitor the effectiveness of the Bay Area's TBT ban and evaluate the need for further source control efforts in June, 1997.

4. Consider follow-up on initial outreach to affected businesses regarding the TBT ban. Outreach materials could emphasize information on alternative products and cooling water system maintenance practices.

5. Track information concerning improved analytical methods and lower detection limits for PAHs and PCBs.

6. Consider investigating non-industrial sources of dioxin.

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Attachment 1

Priority Toxic Organic Pollutant Survey, 1995

Prepared by Montgomery Watson

San Francisco Bay Area Pollution Prevention Group

Priority Toxic Organic Pollutant Survey, 1995

August 1996

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INTRODUCTION

Organic pollutants such as PCBs, PAHs, pesticides, and dioxins are a concern in the environment, including in San Francisco Bay and estuarine areas. They have been found in water, sediment, and biota in the San Francisco Bay. Many of these pollutants are highly persistent in the environment and tend to bioaccumulate in aquatic organisms. Most are probable carcinogens and could pose serious health risks to humans.

In the past several years, the San Francisco Bay Regional Water Quality Control Board (Regional Board) has included new limits for toxic organic pollutants (TOPs) in NPDES permit renewals for many Bay Area POTWs. The permit renewals contain effluent limits based on water quality objectives for TOPs that were either not listed in previous NPDES permits or are now listed at lower limits. In addition, the Board has required some POTWs to submit technical reports including analysis of monitoring results for these newly listed pollutants.

PURPOSE OF TOP SURVEY

In order to gather more information on TOP limits and monitoring requirements, the San Francisco Bay Area Pollution Prevention Group (SFBAPPG) developed and distributed the Priority Toxic Organic Pollutant Survey to Bay Area POTWs. The purpose of the survey was to coordinate and plan pollution prevention efforts by taking advantage of existing knowledge regarding TOPs in the Bay Area. Specifically, SFBAPPG sought to collect, and make available to POTWs, information on TOP limits, laboratory methodologies, and monitoring requirements in NPDES permits. The survey also inquired about voluntary source identification studies being undertaken by POTWs to characterize organic pollutants in their influent. SFBAPPG will use the results from this survey to coordinate Bay Area wide pollution prevention strategies for the identified TOPs.

SURVEY METHODOLOGY

The TOP survey form consisted of seven "Yes" or "No" questions and requested copies of TOP limits, monitoring data, and studies. A copy of the survey form is included as Appendix A. Table 1 presents the list of Bay Area POTWs that were mailed a copy of the survey. These POTWs were known to hold NPDES discharge permits. In order to maximize the response rate, POTWs that had not returned a survey by the one month deadline received follow up phone calls.

TABLE 1
LIST OF POTWs SENT SURVEYS

No.	POTW	No.	POTW
1	Central Costa Costa Sanitary District	22	Fairfield-Suisun Sewer District
2	Central Marin Sanitation Agency	23	Las Gallinas Valley Sanitary District
3	City and County of San Francisco	24	Mt. View Sanitary District
4	City of Benicia	25	Napa Sanitation District
5	City of Burlingame	26	North San Mateo County SD
6	City of Calistoga	27	Novato Sanitary District
7	City of Hayward	28	Oro Loma Sanitary District
8	City of Hercules	29	Palo Alto RWQCP
9	City of Livermore	30	Rodeo Sanitary District
10	City of Millbrae	31	San Jose/Santa Clara WPCP
11	City of Pacifica	32	Sanitary District #5 of Marin City
12	City of Petaluma	33	Sausalito-Marin City Sanitary District
13	City of Pinole	34	Sewer Authority Mid-Coastside
14	City of Richmond	35	Sewerage Agency of Southern Marin
15	City of San Leandro	36	Sonoma Valley County S.D.
16	City of San Mateo	37	South Bayside Systems Authority
17	City of St. Helena	38	South San Francisco
18	City of Sunnyvale	39	Town of Yountville
19	Delta Diablo Sanitation District	40	Union Sanitary District
20	Dublin/San Ramon Services District	41	Vallejo Sanitation & Flood Control District
21	EBMUD	42	West County Wastewater District

SURVEY RESULTS

As shown in Figure 1, 76% of the POTWs responded to the survey. 32 POTWs returned completed surveys or gave their responses on the telephone. Appendix B lists responding POTWs and summarizes NPDES permit TOP requirements.

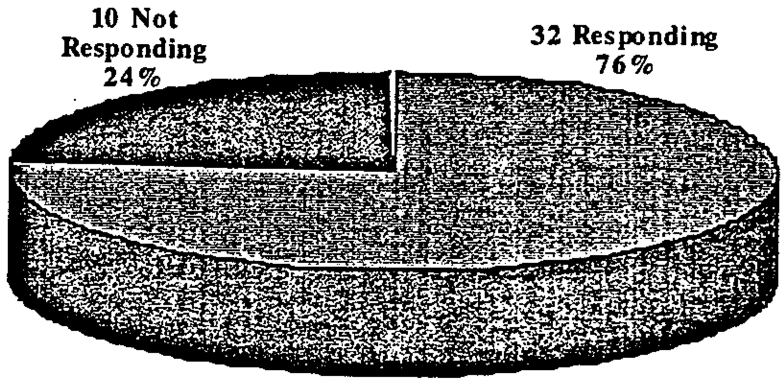

Figure 1

The results of the survey are described in the following section.

Question 1: Number of POTWs with TOP Limits

Figure 2 shows that 19 of the responding POTWs (59% of respondents) have TOP limits in their NPDES permits. The organic pollutants included in most permits with TOP limits are of the following categories:

- Chlorinated Pesticides
- Monocyclic Aromatics
- Polynuclear Aromatic Hydrocarbons (PAHs)
- Others including PCBs, TCDD Equivalents (Dioxins/Furans), Tributyltin, and Cyanide

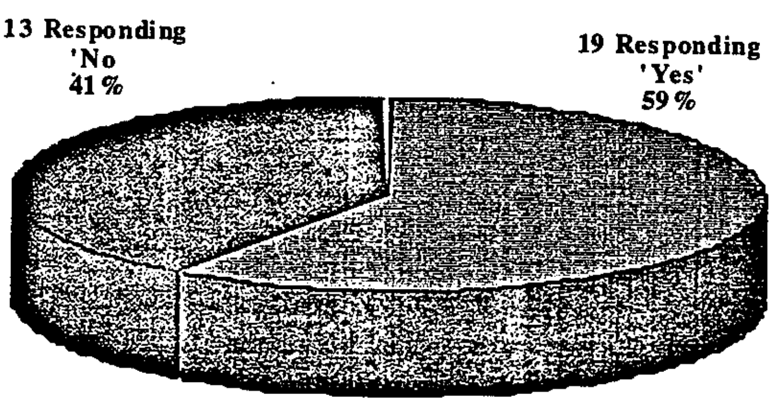

Figure 2

A smaller subset of responding POTWs also have permits with limits for the following TOP groups: halogenated aliphatic hydrocarbons, halogenated ethers, phtalate esters, and nitrogen compounds. Table 2 presents the organics categories and the number of responding POTWs with TOP limits for each pollutant.

TABLE 2
NUMBER OF POTWs WITH TOP EFFLUENT LIMITS BY POLLUTANT

Group	Toxic Organic Pollutant	Number of POTWs
Chlorinated Pesticides	Acrolein	2
	Aldrin	18
	Alpha-BHC	15
	Beta-BHC	14
	Chlordane	16
	DDT	17
	Dieldrin	18
	Endosulfan	15
	Endrin	18
	Gamma-BHC (Lindane)	16
	Heptachlor	18
	Heptachlor Epoxide	16
	Isophorone	2
	Toxaphene	16
Halogenated Aliphatic Hydrocarbons	Carbon Tetrachloride	2
	Halomethanes	18
	Dichloromethane	14
	1,1,2,2-Tetrachloroethane	2
	1,1,1-Trichloroethane	2
	1,1,2-Trichloroethane	2
	Hexachlorocyclopentadiene	2
	1,2-Dichloroethane	2
	1,3-Dichloropropene	2
	1,1-Dichloroethylene	2
	TCE	2
	Vinyl chloride	2
	Hexachlorobutadiene	2
	Hexachloroethane	2
Monocyclic Aromatics	Benzene	11
	Chlorobenzene	2
	Dichlorobenzenes	2
	1,2 Dichlorobenzene	13
	1,3 Dichlorobenzene	14

TABLE 2
NUMBER OF POTWs WITH TOP EFFLUENT LIMITS BY POLLUTANT (continued)

Group	Toxic Organic Pollutant	Number of POTWs
	1,4 Diclorobenzene	13
	Ethylbenzene	2
	Hexachlorobenzene	17
	Nitrobenzene	2
	Toluene	11
	2,4-Dinitrotoluene	2
	Pentachlorophenol	12
	Phenol	25
	2,4 Dichlorophenol	5
	2,4,6 Trichlorophenol	12
	2,4-Dinitrophenol	2
	4,6-Dinitro-2-methylphenol	2
	4-Chloro-3-methylphenol	3
Polynuclear Aromatic Hydrocarbons	PAHs	27
	Fluoranthene	14
Others	PCBs	19
	TCDD Equivalents	18
	Tributyltin	18
	Cyanide	20
Halogenated Ethers	Bis(2-chloroisopropyl)ether	2
	Bis(2-chloroethyl)ether	2
	Bis(2-chloroethoxy)methane	2
Phthalate Esters	Di-n-butyl Phthalate	2
	Diethyl phthalate	2
	Dimethyl phthalate	2
	Bis(2-ethylhexyl)phthalate	2
Miscellaneous Nitrogen Compounds	Acrylonitrile	2
	Benzidine	2
	3,3'-Dichlorobenzidine	2
	1,2-Diphenylhydrazine	2
	N-nitrosodimethylamine	2
	N-nitrosodiphenylamine	2

In Table 2, POTWs with phenol, PAHs, and cyanide limits exceeded the number of POTWs with new TOP limits. The reason is that these pollutants have already been regulated for a number of years by the Regional Board.

The groups of organic pollutants have different sources in the environment. Some of the TOP categories more commonly included in new NPDES permits are introduced below.

Chlorinated Pesticides. Chlorinated pesticides have been widely used in the past in agricultural and residential applications. Most TOPs in this category have been banned or voluntarily canceled by manufacturers. They may continue to be detected in environment because they tend to sorb onto particulate matter (i.e. sediment) and are highly persistent.

Halogenated Aliphatic Hydrocarbons and Monocyclic Aromatics. The halogenated aliphated hydrocarbons and the monocyclic aromatics are a general group of synthetic organic pollutants. They are often used as chemical solvents or chemical intermediaries and include benzenes, toluene, and phenols.

Halogenated Ethers, Phthalate Esters, and Miscellaneous Nitrogen Compounds. These groups of compounds are primarily chemical intermediaries. Many of the ethers and esters are used as plasticizers.

PAHs. PAHs are a byproduct of petroleum or combustion. Automobiles are a major source of PAHs in urban areas, as are some industrial operations.

PCBs. PCBs were banned for most uses in the 1970s. They are still allowed in limited and contained uses in some electrical applications. PCBs detected in the environment may come from accidental spills or may persist from historical uses.

Dioxins/Furans. Dioxins/furans are primarily byproducts of combustion and can be generated by automobiles and incinerators. This pollutant group is extremely toxic and is highly sorbed to particulates. Their primary pathway in the environment is through aerial deposition of particulates.

Tributyltin. Tributyltin is used as a biocide in various residential, commercial and industrial applications. Recently, the use of tributyltin in cooling towers was recently banned by the Department of Pesticides Regulation. Some tributyltin may still be present in residential applications.

Cyanide. The majority of cyanide found in wastewater is from industrial applications. The cyanides are typically present in stable metal-cyanide bonds and are fairly non-toxic.

TOP limits vary between shallow water bay, deep water bay, and ocean dischargers. However, limits can vary by up to one or two orders of magnitude within each discharger category. Table 3 presents the range of TOP limits reported by Bay Area POTWs for the three classes of dischargers. In instances where permits include both daily and average limits, the most stringent limit is included in the table. Some NPDES permits include both interim and final limits. As best as can be determined, only final limits have been summarized in Table 3.

TABLE 3
RANGE OF TOP LIMITS

Group	Toxic Organic Pollutant	Range of NPDES Permit Limits (µg/L)[a] Shallow Water Discharge	Deep Water Discharge	Ocean Discharge
Chlorinated Pesticides	Acrolein	NA	15,620	20,460
	Aldrin	.0.0001 - 0.00014	0.0013 - 0.01562	0.02046
	Alpha-BHC	0.0039 - 0.013	0.0039 - 0.13	NA
	Beta-BHC	0.01 - 0.05	0.14 - 0.46	NA
	Chlordane	0.00008 - 0.0001	0.0008 - 0.1	0.002139
	DDT	0.00059 - 0.0006	0.00059 - 0.01207	0.01581
	Dieldrin	0.0001 - 0.00014	0.0014 - 0.1	NA
	Endosulfan	0.0087 - 0.056	0.056 - 0.87	1.674
	Endrin	0.002 - 0.0023	0.002 - 0.023	0.372
	Gamma-BHC (Lindane)	0.08 - 0.16	0.019 - 0.62	NA
	Heptachlor	0.00016 - 0.0036	0.0016 - 0.05112	0.06696
	Heptachlor Epoxide	0.00007 - 0.0001	0.0007	NA
	Isophorone	NA	NA	13,950,000
	Toxaphene	0.00002 - 0.0007	0.0069 - 0.0141	0.01953
Halogenated Aliphatic Hydrocarbons	Carbon Tetrachloride	NA	63.9	83.7
	Halomethanes	100 - 480	100 - 9,230	12,090
	Dichloromethane	4.6 - 1600	4.6 - 31,950	41,850
	1,1,2,2-Tetrachloroethane	NA	85,200	111,600
	1,1,1-Trichloroethane	NA	NA	50,220,000
	1,1,2-Trichloroethane	NA	NA	3,999,000
	Hexachlorocyclopentadiene	NA	4,120	5,394
	1,2-Dichloroethane	NA	9,230	12,090
	1,3-Dichloropropene	NA	631.9	827.7
	1,1-Dichloroethylene	NA	504,100	660,300
	Trichloroethene	NA	1,920	2,511
	Vinyl chloride	NA	2,560	3,348
	Hexachlorobutadiene	NA	994	1,302
	Hexachloroethane	NA	177.5	232.5
Monocyclic Aromatics	Benzene	0.34 - 21	3.4 - 418.9	548
	Chlorobenzene	NA	40470 - 53010	53,010
	Dichlorobenzenes	NA	362100 - 474300	474,300
	1,2 Dichlorobenzene	2700 - 18000	27,000 - 180,000	NA
	1,3 Dichlorobenzene	400 - 2600	4,000 - 26,000	NA
	1,4 Diclorobenzene	9.9 - 64	99 - 640	1,674
	Ethylbenzene	NA	291,100	381,300
	Hexachlorobenzene	0.00066 - 0.0007	0.0066 - 0.2	0.01953
	Nitrobenzene	NA	347.9	455.7
	Toluene	10,000 - 300,000	100,000 - 3,000,000	7,905,000
	2,4-Dinitrotoluene	NA	184.6	241.8
	Pentachlorophenol	0.28 - 82	79 - 95	NA
	Phenol	5 - 3,000	300 - 3,000	11160

TABLE 3
RANGE OF TOP LIMITS

Group	Toxic Organic Pollutant	Range of NPDES Permit Limits (μg/L)[a] Shallow Water Discharge	Deep Water Discharge	Ocean Discharge
	2,4 Dichlorophenol	0.3	0.3 - 3	NA
	2,4,6 Trichlorophenol	0.34	3.4 - 20.59	26.97
	2,4-Dinitrophenol	NA	284	372
	4,6-Dinitro-2-methylphenol	NA	15,620	20,460
	4-Chloro-3-methylphenol	3,000	30,000	NA
Polynuclear Aromatic Hydrocarbons	PAHs	0.0028 - 15	0.028 - 150	1,395
	Fluoranthene	42	42 - 1070	0.8184
Others	PCBs	0.00007 - 0.0001	0.0007 - 1.05	0.001767
	TCDD Equivalents	1E-08 - 1.4E-08	1.3E-07 - 0.005	3.63E-07
	Tributyltin	0.005 - 0.02	0.05 - 0.2	0.1302
	Cyanide	5.0 - 20	10 - 284	372
Halogenated Ethers	Bis(2-chloroisopropyl)ether	NA	85,200	111,600
	Bis(2-chloroethyl)ether	NA	3.2	4.185
	Bis(2-chloroethoxy)methane	NA	312.4	409.2
Phthalate Esters	Di-n-butyl Phthalate	NA	248,500	325,500
	Diethyl phthalate	NA	2,434,000	3,069,000
	Dimethyl phthalate	NA	5,822,000	7,626,000
	Bis(2-ethylhexyl)phthalate	NA	248.5	325.5
Miscellaneous Nitrogen Compounds	Acrylonitrile	NA	7.1	9.3
	Benzidine	NA	0.0049	0.006417
	3,3'-Dichlorobenzidine	NA	0.5751	0.7533
	1,2-Diphenylhydrazine	NA	11.36	14.88
	N-nitrosodimethylamine	NA	518.3	678.9
	N-nitrosodiphenylamine	NA	177.5	232.5

[a]Values represent facilities' most stringent limits.

Question 2: POTWs with Special Analytical Reporting Requirements?

Nine POTWs responded that their NPDES permit includes special reporting requirements such as technical reports summarizing TOP sampling results, limits of method detection, and limits of quantification for each constituent. Most technical reports are required to contain recommendations for further effluent sampling and analysis in order to provide background for subsequent NPDES permit modifications. Table 4 lists the POTWs with special analytical reporting requirements and the status of their report submissions.

TABLE 4
POTWs WITH SPECIAL ANALYTICAL REPORTING REQUIREMENTS

POTW	Reporting Status
San Francisco City and County	Effluent monitoring report required by Jan 30, 1998.
City of Burlingame	No submittal date given for organics monitoring report.
City of Livermore	Submitted effluent monitoring report in May 1995.
City of San Mateo	No submittal date given for organics monitoring report.
Dublin San Ramon	Required submittal of effluent monitoring report Apr 30, 1995.
EBMUD	Effluent monitoring report required by Jan 30, 1998.
Mt. View Sanitary District	Required submittal of effluent monitioring report Nov 1, 1993.
Novato Sanitary District	Required submittal of effluent monitioring report May 15, 1993.
Union Sanitary District	Submitted effluent monitoring report in May 1995.

Question 3: Sampling for TOPs

Twenty of the responding POTWs sampled for TOPs and provided sample data results, laboratory methodologies, and method detection limits. The detection limits for each constituent vary between plants and often between each sample, occasionally by several orders of magnitude. Detection limits can vary with high pollutant concentrations, analytical methods, and potential matrix interference on the samples. Table 5 presents the range of TOP effluent sampling results analyzed by responding POTWs. As shown on the tables, most of the sampling results were not detected.

TABLE 5
TOP EFFLUENT SAMPLING RESULTS

Group	Toxic Organic Pollutant	Range of Sample Data (µg/L)	Comments
Chlorinated Pesticides	Aldrin	<0.0005 - <1	All NDs
	Alpha-BHC	<0.005 - <1	All NDs
	Beta-BHC	<0.01 - <1.3	All NDs
	Chlordane	<0.01 - <10	All NDs
	DDT	<0.0005 - 0.072	Mostly NDs
	Dieldrin	<0.007 - 0.03	Mostly NDs
	Endosulfan	<0.005 - <1.5	All NDs
	Endrin	<0.0021 - 0.046	Mostly NDs
	Gamma-BHC (Lindane)	<0.002 - 0.05	Mostly NDs
	Heptachlor	<0.0005 - 0.078	Mostly NDs
	Heptachlor Epoxide	<0.0005 - 0.12	Mostly NDs
	Toxaphene	<0.02 - <20	All NDs
Halogenated Aliphatic Hydrocarbons	Halomethanes	<10 - 99	Half NDs
	Dichloromethane	<2 - 31	Mostly NDs
Monocyclic Aromatics	Benzene	<0.5 - 30	All NDs
	1,2 Dichlorobenzene	<0.1 - <50	All NDs
	1,3 Dichlorobenzene	<0.1 - <50	All NDs
	1,4 Diclorobenzene	<0.1 - 4.0	Mostly NDs
	2,4 Dichlorophenol	<0.2 - <5	All NDs
	2,4,6 Trichlorophenol	<0.1 - 0.5	Mostly NDs
	4-Chloro-3-methylphenol	<2	All NDs
	Hexachlorobenzene	<0.1 - 2.3	Mostly NDs
	Pentachlorophenol	<0.2 - <100	All NDs
	Phenol	<0.05 - 29	Mostly NDs
	Toluene	<1 - 4.6	Mostly NDs
Polynuclear Aromatic Hydrocarbons	PAHs	<0.2 - 11	Mostly NDs
	Flouranthene	<0.09 - <50	All NDs
Organophosphate Pesticides	Chlorpyrifos (Dursban)	0.033 - 0.11	Limited Data
	Diazinon	0.087 - 2.3	Limited Data
Others	PCBs	<0.015 - <40	All NDs
	TCDD Equivalents	4.2E-08 - 1.1E-05	Mostly NDs
	Tributyltin	<2E-06 - 0.051	Half NDs
	Cyanide	<3 - 22	Mostly NDs

Several organic pollutants have permit limits that are lower than the lowest possible detection limits achievable by standard laboratory practices. In other words, due to the limitations of the current analytical methods, POTWs are uncertain whether they can comply with these limits. Table 6 shows the comparison between the lowest effluent permit limits and lowest detection limits achieved by Bay Area POTWs. The Table also presents the POTW that analyzed the sample at the lowest detection limit.

The shaded compounds cannot be analyzed to detection limits low enough to determine compliance with permit limits. As shown in the table, over half of the TOPs in the chlorinated pesticide group fall into the category where compliance with permit limits is uncertain. PCBs, PAHs, and hexachlorobenzene also fall into this category.

Question 4: Sample Data Exceeding Permit Limits?

Several POTWs reported that the results of individual samples exceeded their permit limits. Table 7 summarizes the TOPs that were analyzed at levels higher than their permit limits and the POTW that analyzed that sample. The range of sample data for all POTWs and detection rates are also tabulated for each pollutant. In most cases the exceedence represented one "hit" in the POTWs effluent, the rest of the samples were not detected. SBSA received one "hit" of TCDD Equivalents; however, reanalysis of the sample yielded a result below the permit limit. The TOP exceeded most frequently was tributytin; three POTWs reported individual sample values higher than their permit limits.

TABLE 6
COMPARISON OF EFFLUENT LIMITS AND SAMPLING DATA

Group	Toxic Organic Pollutant	Lowest Limit (µg/L)	Lowest Sample Data (µg/L)	EPA Method No.	POTW that Analyzed Lowest Sample/Detection Limt
Chlorinated Pesticides	Acrolein	15,620	NA	608	
	Aldrin	0.0001	<0.0005	608	Millbrae
	Alpha-BHC	0.0039	<0.005	608	SBSA
	Beta-BHC	0.01	<0.01	608	Novato
	Chlordane	0.0008	<0.01	608	many
	DDT	0.0006	<0.0005	608	Millbrae
	Dieldrin	0.0001	<0.007	608	Dublin/San Ramon and Livermore
	Endosulfan	0.0087	<0.005	608	SBSA
	Endrin	0.002	<0.0021	608	CCSF
	Gamma-BHC (Lindane)	0.0190	<0.002	608	Millbrae
	Heptachlor	0.0002	<0.0005	608	Millbrae
	Heptachlor Epoxide	0.00007	<0.0005	608	Millbrae
	Isophorone	13,950,000	NA	608	
	Toxaphene	0.0007	<0.02	608	Millbrae
Halogenated Aliphatic Hydrocarbons	Carbon Tetrachloride	63.9	NA	601/624	Burlingame
	Halomethanes	100	<10	601/624	Millbrae and USD
	Dichloromethane	4.6	<2	601/624	
	1,1,2,2-Tetrachloroethane	85,200 - 111,600	NA	601	
	1,1,1-Trichloroethane	50,220,000	NA	601	
	1,1,2-Trichloroethane	3,999,000	NA	601	
	Hexachlorocyclopentadiene	4,120 - 5,394	NA	612	
	1,2-Dichloroethane	9,230 - 12,090	NA	624	
	1,3-Dichloropropene	631.9 - 827.7	NA	624	
	1,1-Dichloroethylene	504,100 - 660,300	NA	601	
	TCE	1,920 - 2,511	NA	601	
	Vinyl chloride	2,560 - 3,348	NA	601/624	
	Hexachlorobutadiene	994 - 1,302	NA	625	
	Hexachloroethane	177.5 - 232.5	NA	625	
Monocyclic Aromatics	Benzene	2,700	<0.5	624	many
	Chlorobenzene	40,470	NA	624	
	Dichlorobenzenes	362,100	NA	624	
	1,2 Dichlorobenzene	9.9	<0.1	624	SBSA
	1,3 Dichlorobenzene	0.34	<0.1	624	SBSA
	1,4 Diclorobenzene	10,000	<0.1	624	SBSA
	Ethylbenzene	291,100	NA	624	
	Hexachlorobenzene	0.00066	<0.1	625	SBSA
	Nitrobenzene	347.9	NA	625	
	Toluene	400	<1	624	Dublin/San Ramon
	2,4-Dinitrotoluene	184.6	NA	625	
	Pentachlorophenol	0.28	<0.2	604/625	SBSA

TABLE 6
COMPARISON OF EFFLUENT LIMITS AND SAMPLING DATA

Group	Toxic Organic Pollutant	Lowest Limit (µg/L)	Lowest Sample Data (µg/L)	EPA Method No.	POTW that Analyzed Lowest Sample/Detection Limt
	Phenol	30	<0.05	604/625	SBSA
	2,4 Dichlorophenol	0.3	<0.2	604/625	Dublin/San Ramon
	2,4,6 Trichlorophenol	0.34	<0.1	604/625	SBSA
	2,4-Dinitrophenol	284	NA	604/625	
	4,6-Dinitro-2-methylphenol	15,620	NA	604/625	
	4-Chloro-3-methylphenol	3,000	<2	604/625	Delta Diablo
Polynuclear Aromatic Hydrocarbons	PAHs	0.0028	<0.2	610	many
	Fluoranthene	42	<0.09	610	SBSA
Others	PCBs	0.00007	<0.015	617	CCSF
	TCDD Equivalents	1.00E-08	4.20E-08	613	SBSA
	Tributyltin	0.005	<2E-06	GC/FPD	Dublin/San Ramon
	Cyanide	5	<3		many
Organophosphate Pesticides	Chlorpyrifos (Dursban)	NA	0.033		CCCSD
	Diazinon	NA	0.087		CCCSD
Halogenated Ethers	Bis(2-chloroisopropyl)ether	85,200	NA	625	
	Bis(2-chloroethyl)ether	3.2	NA	625	
	Bis(2-chloroethoxy)methane	312.4 - 409.2	NA	611	
Phthalate Esters	Di-n-butyl Phthalate	248,500	NA	625	
	Diethyl phthalate	2,434,000	NA	625	
	Dimethyl phthalate	5,822,000	NA	625	
	Bis(2-ethylhexyl)phthalate	248.5	NA	625	
Miscellaneous Nitrogen Compounds	Acrylonitrile	7.1	NA		
	Benzidine	0.0049	NA	605	
	3,3'-Dichlorobenzidine	0.5751	NA	605/625	
	1,2-Diphenylhydrazine	11.36	NA		
	N-nitrosodimethylamine	518.3	NA		
	N-nitrosodiphenylamine	177.5	NA		

* Shading denotes compounds with Permit limits lower than lowest possible detection limits.

TABLE 7
NUMBER OF POTWs REPORTING EFFLUENT SAMPLE VALUES HIGHER THAN TOP LIMITS

Group	Toxic Organic Pollutant	Range of Sample Data (µg/L)	Detection	No. of POTWs with Exceeding Values	POTW
Chlorinated Pesticides	DDT	<0.0005 - 0.072	Mostly NDs	1	Livermore
	Dieldrin	<0.007 - 0.03	Mostly NDs	1	Novato
	Endrin	<0.0021 - 0.046	Mostly NDs	2	Livermore, USD
	Heptachlor	<0.0005 - 0.078	Mostly NDs	2	Livermore, Dublin San Ramon
	Heptachlor Epoxide	<0.0005 - 0.12	Mostly NDs	1	Dublin San Ramon
Others	Hexachlorobenzene	<0.1 - 2.3	Mostly NDs	1	SBSA
	TCDD Equivalents	4.2E-08 - 1.1E-05	Mostly NDs	1	SBSA (a)
	Cyanide	<3 - 22	Mostly NDs	1	Palo Alto
	Tributyltin	<2E-06 - 0.051	Half NDs	3	Livermore, Palo Alto, USD

(a) Reanalysis of the exceeding sample yielded a result below the Permit limit for TCDD Equivalents.

Question 5 and 6: Has TIE Been Required and Any Toxicity Associated with TOPs?

Bay Area POTWs are required to conduct toxicity identification evaluation (TIE) and toxicity reduction evaluation (TRE) studies if their effluent exhibits acute or chronic toxicity as part of their NPDES permit monitoring. Over the last several years, several POTWs have conducted TIE/TRE studies. The causes of toxicity included organics, metals, as well as other constituents. Questions 5 and 6 of the TOP Survey identified three POTWs with effluent toxicity caused by TOPs (as shown in Table 8).

TABLE 8
TIE STUDY RESULTS

POTW	TIE Study Pollutants	Year
Central Contra Costa Sanitary District	Diazinon and Chlorpyrifos	1995
Delta Diablo Sanitation District	Surfactants	1994-95
East Bay Dischargers Authority	Diazinon	1992-95

Both CCCSD and EBDA (consisting of six POTWs) TIE studies used *Ceriodaphnia dubia* bioassays to determine effluent toxicity. The studies identified organothiophosphate pesticides (diazinon and chlorpyrifos) as the cause of toxicity. Organothiophosphate pesticides are commonly used in residential applications throughout the Bay Area. CCCSD performed acute and chronic toxicity testing to ten pet flea control products using *C. dubia*. The results of their study indicate that only flea control products containing chlorpyrifos would add measurable toxicity to CCCSD influent. Organothiophosphate pesticides have not been identified to cause toxicity at other Bay Area POTWs.

Question 7: Source Identification or Influent/Effluent Studies?

Seven of the responding POTWs have performed or are performing voluntary source identification or influent/effluent monitoring studies. These voluntary studies have focused on chlorinated pesticides, PCBs, PAHs, tributyltin, dioxin, and organothiophosphate pesticides. Some POTWs have issued a report on their findings and others are performing routine monitoring not as part of a study. Table 9 presents the POTWs that have performed voluntary TOP monitoring efforts and lists the pollutants studied.

TABLE 9
POTWs PERFORMING VOLUNTARY TOP STUDIES

POTW	Type of Study	Pollutant(s)	Status
CCCSD	Source identification and influent/effluent analysis	Diazinon, Chlorpyrifos, Cyanide	Draft report issued 9/27/95.
CCSF	Source identification, influent/effluent analysis, and analytical methodology	Chlorinated pesticides, PCBs, PAHs, Dioxins, Tributyltin, Cyanide	Report will be available in 1997.
City of Livermore	Source identification	Tributyltin	Source identification memorandum issued 7/10/95.
City of Richmond	Source identification	Cyanide, Benzene, Toluene,Chloroform, Dichloromethane, Phenols, Fluoranthene	Routine monitoring, no report available
EBMUD	Voluntary influent TOP characterization		Results of additional monitoring are not yet available (10/95).
Palo Alto RWQCP	Source identification/literature review	Dioxin, PCBs	
Union Sanitary District	Voluntary influent/effluent analysis	Tributyltin, PAHs, Dioxin, Diazinon	Results of additional monitoring are not yet available (10/95).

Question 8: Interim Limits?

The Regional Board has issued interim limits to twelve of the responding POTWs for several TOPs on their NPDES permits. Table 10 shows the POTWs with interim limits and the duration of these limits. These interim limits are valid on a temporary basis and when they expire the more stringent permit limits will apply. Table 11 includes the range of the interim limits on Bay Area POTWs permits.

At this time, if a TOP is not detected in the discharge of a POTW, that POTW will be required to monitor only. If a TOP is measured in the discharge above a level of concern, a permit limit will be required. Additionally, the POTW will be required to conduct source identification and reduction under a compliance schedule if the levels measured are above the effluent limit. An interim limit may be specified in this case to hold facilities at their current level of performance until the TOP can be controlled and reduced.

TABLE 10
POTWs WITH INTERIM LIMITS

POTW	Pollutants	Duration
CCSF*	Aldrin, Chlordane, Dieldrin, Endrin Heptachlor, Hexachlorobenzene, PAHs, PCBs, TCDDs, Toxaphene	8/94 to 9/98
City of Benicia	PAHs	?
City of Livermore	PCBs, TCDDs	6/94 to 6/99
City of Pinole	PAHs	6/94 to 9/99
Dublin/San Ramon Services District	PCBs, TCDDs	6/94 to 6/97
EBMUD	PCBs, TCDDs	6/94 to 6/97
Mt. View Sanitary District	Cyanide	1/94 to 4/96
Union Sanitary District (EBDA)	PAHs, PCBs, TCDDs	6/94 to 6/99
Union Sanitary District (Hayward Marsh)	Cyanide, PAHs	12/93 to 12/98
Palo Alto RWQCP	Cyanide	?
San Jose/Santa Clara WPCP	Cyanide	?
City of Sunnyvale	Cyanide	?

*Permit is under approval.

TABLE 11
RANGE OF INTERIM LIMITS

Group	Toxic Organic Pollutant	Interim Limit Range (μg/L)
Chlorinated Pesticides	Aldrin	0.005
	Chlordane	0.1
	Dieldrin	0.1
	Endrin	0.2
	Heptachlor	0.005
	Toxaphene	0.2
Monocyclic Aromatics	Hexachlorobenzene	0.2
Polynuclear Aromatic Hydrocarbons	PAHs	1.0 - 16
PCBs and Dioxins/Furans	PCBs	0.2
	TCDD Equivalents	1.5E-05 - 5E-03
Cyanide	Cyanide	17.5 - 20

CONCLUSIONS AND RECOMMENDATIONS

SFBAPPG used the TOP Survey to gather information on the Bay Area POTWs' TOP limits, sampling and reporting requirements, and source identification studies. The following conclusions can be drawn from the information collected:

1. The majority of responding POTWs have new NPDES effluent limits for TOPs. Limits for TOPs vary between shallow water bay, deep water bay, and ocean dischargers. Limits can also vary between POTWs in the same discharger category, often by one or two orders of magnitude.

2. The currently achievable detection limits are not low enough to determine compliance with permit limits for many TOPs, including PAHs, PCBs, hexachlorobenzene, and over half of the chlorinated pesticides. Bay Area POTWs should continue to share information on analytical method development. The SFBAPPG may be a good forum for the information exchange.

3. Many NPDES permits currently emphasize organic pollutants such as chlorinated pesticides and PCBs that have been previously banned or withdrawn from the commercial market. The potential for these constituents to be present in wastewater should be considered in future permit activities.

4. Two of the three POTWs that have performed TIE studies for organics identified organothiophospate pesticides diazinon and chlorpyrifos as the cause of toxicity in their effluent. These commonly available household pesticides have not been included in NPDES permits at this time. POTWs should also focus on these organic compounds as their use and disposal practices can be influenced by pollution prevention and public education activities.

Appendix A

TOP Survey Form

SAN FRANCISCO BAY AREA POLLUTION PREVENTION GROUP

Priority Toxic Organic Pollutant Survey

August 28, 1995

Dear POTW Representative:

The Regional Water Quality Control Board recently reissued NPDES permit renewals to Region 2's POTWs. These permit renewals contain water quality based effluent limits for Toxic Organic Pollutants (TOPs) that were either not listed before in previous NPDES permits or are now listed at lower limits. Technical progress reports on monitoring results and evaluation of sampling and monitoring results and evaluation of sampling and monitoring methodologies for these pollutants are now also required.

These new parameters might include, but are not limited to the following:

1,2 Dichlorobenzene
1,3 Dichlorobenzene
1,4 Dichlorobenzene
Aldrin
α-BHC (Alpha - Lindane)
β-BHC (Beta - Lindane)
δ-BHC (Delta - Lindane)
γ-BHC (Lindane)
Benzene
Chlordane
Chloroform
Cyanide
Dieldrin
Dichloromethane
DDT
Endrin
2,4,6, Trichlorophenol
Fluoranthene
Halomethanes
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene
Mercury
PAHs
PCBs (Total)
Pentachlorophenol
Phenol
TCDD Equivalents
Toluene
Toxaphene
Tributyltin

The purpose of this survey is to coordinate and plan our pollution prevention efforts by taking advantage of existing knowledge regarding toxics in the Bay. We will distribute the survey results (e.g. sampling results, lab methodologies, source identification studies and pollution prevention strategies, etc.) by the end of November 1995.

The San Francisco Bay Area Pollution Prevention Group (SFBAPPG) will concurrently conduct a national literature search to collect information on pollutants identified in a recent workshop sponsored by the SFBAPPG. This information will be distributed with the survey results. After the survey and literature search is completed, the SFBAPPG will develop an action plan to implement pollution prevention strategies for the identified TOPs. Please fill out the survey and submit by September 29, 1995 to Tony Hui, Montgomery Watson, 355 Lennon Lane, Walnut Creek, CA 94598. Thank you in advance for your time and effort.

Sincerely,

Daniel StandFree

Daniel StandFree
Chair, Source Identification Committee

The San Francisco Bay Area Pollution Prevention Group is committed to coordinating all dischargers' pollution prevention activities in order to reduce the amount of toxic pollutants discharged into the Bay

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY

Contact Name

POTW

NPDES Permit Issue Date

Address

City

State

Zip

Phone

Fax

Survey Questions

1. Does your POTW's NPDES permit currently contain additional TOP effluent limits that have not been listed in previous NPDES permits?

☐ Yes ☐ No ☐ Not applicable

If no, please stop and go to question #8.

2. Does your POTW's NPDES permit contain any special reporting requirements, e.g., technical reports summarizing TOP sampling results, limits of method detection, limits of quantification, and/or any other special conditions?

☐ Yes ☐ No ☐ Not applicable

If yes, please include a copy of that section from your NPDES permit.

3. Have you sampled for any TOPs?

☐ Yes ☐ No ☐ Not applicable

If yes, please include a copy of any effluent and/or influent TOP sampling results (including chemical methodology and method detection limits used) for the past two calendar years (January 1993 to the present).

4. If you have sampled for TOPs, have any NPDES permit limits been exceeded over the past two calendar years (January 1993 to the present)? Also include any heavy metals that exceeded your NPDES permit limits.

☐ Yes ☐ No ☐ Not applicable

If yes, please list the constituent exceeded and the associated value, frequency of noncompliance events, and any corrective actions taken.

5. Has any effluent acute or chronic toxicity testing been adversely affected by "hits" from TOPs (including false negatives)?

☐ Yes ☐ No ☐ Not applicable

If yes, please include a brief description of the events.

6. If your POTW's acute or chronic toxicity testing has revealed toxicity, has your POTW been required to conduct a Toxic Identification Evaluation (TIE)?

☐ Yes ☐ No ☐ Not applicable

If yes, please include a copy of the TIE.

7. Are you currently conducting or do you intend to conduct any source identification studies or voluntary influent and/or effluent characterizations for your NPDES listed TOPs?

☐ Yes ☐ No ☐ Not applicable

If yes, please identify targeted TOP and include a copy of the scope of work, completed studies, and/or other observations regarding sources of TOPs.

8. Please include with this survey a copy of the limits from your NPDES permit or draft NPDES permit. If the permit contains interim limits, please indicate the duration of those limits.

Please return your survey by September 29, 1995, to:

Tony Hui
Montgomery Watson
355 Lennon Lane
Walnut Creek, CA 94598

If you have any questions, call Tony Hui at (510) 274-2255 or Daniel StandFree at (415) 695-7363.

Appendix B

Survey Respondents

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY RESPONDENTS

No.	POTW	Returned Survey	New NPDES Reporting for TOPs Limits	Monitoning	None
1	Central Contra Costa Sanitary District	Yes	X		
2	Central Marin Sanitation Agency	Yes			X
3	City and County of San Francisco	Yes	X		
4	City of Benicia (a)	Yes			X
5	City of Burlingame	Yes		X	
6	City of Calistoga	Yes			X
7	City of Livermore	Yes	X		
8	City of Millbrae	Yes	X		
9	City of Pacifica	Yes	X		
10	City of Petaluma	Yes			X
11	City of Pinole	Yes			X
12	City of Richmond	Yes	X		
13	City of San Mateo	Yes		X	
14	City of St. Helena	Yes			X
15	City of Sunnyvale	Yes	X		
16	Delta Diablo Sanitation District	Yes	X		
17	Dublin/San Ramon Services District	Yes	X		
18	EBMUD	Yes	X		
19	Las Gallinas Valley Sanitary District	Yes	X		
20	Mt. View Sanitary District	Yes	X		
21	North San Mateo County SD	Yes	X		
22	Novato Sanitary District (Ignacio Plant)	Yes	X		
23	Novato Sanitary District (Novato Plant)	Yes	X		
24	Palo Alto RWQCP	Yes	X		
25	Rodeo Sanitary District	Yes			X
26	San Jose/Santa Clara WPCP	Yes	X		
27	Sausalito-Marin City Sanitary District	Yes			X
28	Sewerage Agency of Southern Marin	Yes			X
29	South Bayside Systems Authority	Yes	X		
30	South San Francisco	Yes	X		
31	Town of Yountville	Yes			X
32	Union Sanitary District (EBDA)	Yes	X		
33	Union Sanitary District (Hayward Marsh)	Yes	X		
34	Vallejo Sanitation & Flood Control District	Yes			X
35	City of Hayward	No			
36	City of Hercules	No			

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY RESPONDENTS

No.	POTW	Returned Survey	New NPDES Reporting for TOPs		
			Limits	Monitoning	None
37	City of San Leandro	No			
38	Fairfield-Suisun Sewer District	No			
39	Napa Sanitation District	No			
40	Oro Loma Sanitary District	No			
41	Sanitary District #5 of Marin City	No			
42	Sewer Authority Mid-Coastside	No			
43	Sonoma Valley County S.D.	No			
44	West County Wastewater District	No			

Appendix C

TOP Effluent Limits and Sampling Data

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Permit Date	Aldrin Monthly	Aldrin Monitor	Aldrin n	Aldrin EPA Method	Aldrin Sample Range	Alpha-BHC Monthly	Alpha-BHC Monitor	Alpha-BHC n	Alpha-BHC Sample Range	Benzene Monthly	Benzene Monitor	Benzene n	Benzene EPA Method	Benzene Sample Range
1	City of Calistoga	S	Jun-92														
2	City of Petaluma	S	Dec. 1990														
3	City of St. Helena	S															
4	City of Sunnyvale	S	Jul-94	0.00014		6	608	<0.025-<0.05	0.013		6	<0.025-0.05	21		15	624	<2
5	Mt. View Sanitary District	S	Jan-93	0.00013		5	608	<.025-<0.13	0.0039		5	<.025-<0.13	0.34		2		<0.5
6	Novato Sanitary District (Novato Plant)	S	Aug-92	0.0001		2	608	<0.01-0.03	0.01		2	<0.1	21		2	624	<0.5
7	Novato Sanitary District (Ignacio Plant)	S	Aug-92	0.0001			608	<0.01			2	<0.1			2	624	<0.5
8	Palo Alto RWQCP	S	Jul-93	0.00014		2	608	<0.025	0.013		2	<0.025					
9	San Jose/Santa Clara WPCP	S	Oct-93	0.00014													
10	Town of Yountville	S	1993														
11	Union Sanitary District (Hayward Marsh)	S	Dec-93	0.0001					0.01								
12	Las Gallinas Valley Sanitary District	S	Aug-92	0.0001					0.004				0.34				
13	City of Pacifica	O	Oct-94	0.02046		4		<0.025-<1.0			4	<0.025	548		1		<2.0
14	Delta Diablo Sanitation District	D		0.0013		2	608	<0.025-<0.13	0.039		4	<0.006-<0.01	3.4		2	624	<2
15	Central Contra Costa Sanitary District	D	May-95														
16	Central Marin Sanitation Agency	D	Jan-91														
17	City and County of San Francisco	D	Sep-94	0.005 (Int)				<0.0022									
18	City of Benicia (a)	D	Aug-94			8	625	<.05-<1			7	<1			8	624	<0.5-4.1
19	City of Burlingame	D	Oct-95		M		608	<0.01-<0.25		M		<0.01-<0.25		M	5		<2.0
20	City of Livermore	D	Jun-94	0.0014		8	608	<0.006	0.13		8	<0.006	210				<0.5
21	City of Millbrae	D	Aug-93	0.005		6	608	<0.0005	0.13		6	<0.01	210		6	624	<2-30
22	City of Richmond	D	Jan-94	0.0014		1		<0.01	0.13		1	<0.02	210				
23	City of San Mateo	D	Mar-95		M					M				M			
24	Dublin/San Ramon Services District	D	Jun-94	0.0014		4	608	<0.006-<0.01	0.13		4	<0.006-<0.01	210		6		<1-<5
25	EBMUD	D	Sep-94	0.0014					0.13								
26	Sausalito-Marin City Sanitary District	D	May-94														
27	Sewerage Agency of Southern Marin	D	Jun-95														
28	South Bayside Systems Authority	D	Jul-93	0.0014		6		<.005-<.028	0.13		5	<.005-<.22	210		6		<2.0
29	South San Francisco	D	Apr-92														
30	Union Sanitary District (EBDA)	D	Jun-94						0.13		6	<0.05-0.05	210		6		<1.0-1.2
31	Vallejo Sanitation & Flood Control District	D	Oct-88														
32	North San Mateo County SD	D	Oct-94	0.01562									418.9				
33	City of Pinole	?	Sep. 1994														
34	Rodeo Sanitary District	?															

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Beta-BHC Monthly	Beta-BHC Monitor	Beta-BHC n	Beta-BHC EPA Method	Beta-BHC Sample Range	Chlordane 1-day	Chlordane Monthly	Chlordane Monitor	Chlordane n	Chlordane EPA Method	Chlordane Sample Range	Chlorpyrifos (Dursban) n	Chlorpyrifos (Dursban) EPA Method	Chlorpyrifos (Dursban) Sample Range
1	City of Calistoga	S														
2	City of Petaluma	S														
3	City of St. Helena	S														
4	City of Sunnyvale	S	0.046		6	608	<0.025-<0.05	0.004	0.000081		6	608	<0.5-<1			
5	Mt. View Sanitary District	S	0.014		5	608	<.025-<.13	0.0043	0.00008		5	608	<0.5-<2.0			
6	Novato Sanitary District (Novato Plant)	S	0.05		2	608	<0.01	0.004	0.0001		2	608	<0.02			
7	Novato Sanitary District (Ignacio Plant)	S	0.05		2	608	<0.01	0.004	0.0001		2	608	<0.02			
8	Palo Alto RWQCP	S	0.046		2	608	<0.025	0.004	0.000081		2	608	<0.5			
9	San Jose/Santa Clara WPCP	S						0.004	0.000081							
10	Town of Yountville	S														
11	Union Sanitary District (Hayward Marsh)	S	0.05					0.004	0.0001							
12	Las Gallinas Valley Sanitary District	S	0.01					0.004	0.0001							
13	City of Pacifica	O			4		<0.025		0.002139		3		<0.5			
14	Delta Diablo Sanitation District	D	0.14		2	608	<0.025-<0.13	0.043	0.00081		2	608	<0.13-<0.025			
15	Central Contra Costa Sanitary District	D														
16	Central Marin Sanitation Agency	D												10		0.033-0.11
17	City and County of San Francisco	D						0.1 (int)	0.1 (int)				<0.0034			
18	City of Benicia (a)	D			7	625	<1				8	625	<0.5-<10			
19	City of Burlingame	D		M	5		<0.025			M	5		<0.01-<0.5			
20	City of Livermore	D	0.46		8	608	<0.011	0.04	0.0008		8		<0.05			
21	City of Millbrae	D	0.46		6	608	<0.025	0.043	0.1		6	608	<0.01			
22	City of Richmond	D	0.46		1		<0.02	0.04	0.00081		1		<0.1			
23	City of San Mateo	D		M						M						
24	Dublin/San Ramon Services District	D	0.46		4	608	<0.011	0.04	0.0008		4		<0.01-<0.05			
25	EBMUD	D	0.46					0.04	0.08							
26	Sausalito-Marin City Sanitary District	D														
27	Sewerage Agency of Southern Marin	D														
28	South Bayside Systems Authority	D	0.46		6		<.025-<.18	0.04	0.00081		6		<0.025-<0.5			
29	South San Francisco	D														
30	Union Sanitary District (EBDA)	D	0.46		6		<0.025	0.04	0.0008		6		<0.05			
31	Vallejo Sanitation & Flood Control District	D														
32	North San Mateo County SD	D						0.00163								
33	City of Pinole	?														
34	Rodeo Sanitary District	?														

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Cyanide 1-day	Cyanide Monitor	Cyanide n	Cyanide EPA Method	Cyanide Sample Range	Diazinon n	Diazinon EPA Method	Diazinon Sample Range
1	City of Calistoga	S								
2	City of Petaluma	S								
3	City of St. Helena	S								
4	City of Sunnyvale	S	5							
5	Mt. View Sanitary District	S	5.2(17.5 Int)							
6	Novato Sanitary District (Novato Plant)	S	5(20 Interim)		14	335.2	<3-<10			
7	Novato Sanitary District (Ignacio Plant)	S			14	335.2	<3-23			
8	Palo Alto RWQCP	S	5		>50		3-8.5			
9	San Jose/Santa Clara WPCP	S	5							
10	Town of Yountville	S								
11	Union Sanitary District (Hayward Marsh)	S	20							
12	Las Gallinas Valley Sanitary District	S	5							
13	City of Pacifica	O	372		1		<10			
14	Delta Diablo Sanitation District	D	25		1		<4			
15	Central Contra Costa Sanitary District	D	25					10		0.087-0.32
16	Central Marin Sanitation Agency	D								
17	City and County of San Francisco	D	10				<10			
18	City of Benicia (a)	D	25		10	9010	<10-22	7	614	<1-2.3
19	City of Burlingame	D	10		5		<10-11			
20	City of Livermore	D	10							
21	City of Millbrae	D	10		6	335.2	<10			
22	City of Richmond	D	25		>50		<3-36			
23	City of San Mateo	D	10							
24	Dublin/San Ramon Services District	D	10							
25	EBMUD	D	10							
26	Sausalito-Marin City Sanitary District	D								
27	Sewerage Agency of Southern Marin	D								
28	South Bayside Systems Authority	D	25		6		<10			
29	South San Francisco	D								
30	Union Sanitary District (EBDA)	D	10		12		<3			
31	Vallejo Sanitation & Flood Control District	D								
32	North San Mateo County SD	D	284							
33	City of Pinole	?								
34	Rodeo Sanitary District	?								

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	DDT 1-day	DDT Monthly	DDT Monitor	DDT n	DDT EPA Method	DDT Sample Range	Dichloromethane Monthly	Dichloromethane Monitor	Dichloromethane n	Dichloromethane EPA Method	Dichloromethane Sample Range
1	City of Calistoga	S											
2	City of Petaluma	S											
3	City of St. Helena	S											
4	City of Sunnyvale	S	0.001	0.0006		6	608	<0.15-<0.3	1600				
5	Mt. View Sanitary District	S	0.001	0.00059		5	608	<0.15-<0.6	4.6				
6	Novato Sanitary District (Novato Plant)	S	0.001	0.0006		2	608	<0.01	1600				
7	Novato Sanitary District (Ignacio Plant)	S	0.001	0.0006		2	608	<0.01	1600				
8	Palo Alto RWQCP	S	0.001	0.0006		2	608	<0.05-<0.15					
9	San Jose/Santa Clara WPCP	S	0.001	0.0006									
10	Town of Yountville	S											
11	Union Sanitary District (Hayward Marsh)	S	0.001	0.0006									
12	Las Gallinas Valley Sanitary District	S	0.001	0.0006					4.6				
13	City of Pacifica	O		0.01581		4		<0.035-<0.15	41850				
14	Delta Diablo Sanitation District	D	0.01	0.0059		2	608	<0.15-<0.25	46				
15	Central Contra Costa Sanitary District	D											
16	Central Marin Sanitation Agency	D											
17	City and County of San Francisco	D											
18	City of Benicia (a)	D				8	625	<0.5-<1					
19	City of Burlingame	D			M	5	608	<0.15-<0.50		M			
20	City of Livermore	D	0.01	0.006		8	608	<0.023-0.072	16000				
21	City of Millbrae	D	0.01	0.006		6	608	<0.0005	4.6		6	624	<2
22	City of Richmond	D	0.01	0.006		1		<0.02	16000				<5
23	City of San Mateo	D			M					M			
24	Dublin/San Ramon Services District	D	0.01	0.006		4		<0.02-0.045	16000				
25	EBMUD	D	0.01	0.006									
26	Sausalito-Marin City Sanitary District	D											
27	Sewerage Agency of Southern Marin	D											
28	South Bayside Systems Authority	D	0.01	0.006		6		<0.005-<0.24	16000		6		<10-31
29	South San Francisco	D											
30	Union Sanitary District (EBDA)	D	0.01	0.006		6		<0.10	16000		6		<2.0-12
31	Vallejo Sanitation & Flood Control District	D											
32	North San Mateo County SD	D		0.01207					31950				
33	City of Pinole	?											
34	Rodeo Sanitary District	?											

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Dieldrin						Endosulfan					
			1-day	Monthly	Monitor	n	EPA Method	Sample Range	1-day	Monthly	Monitor	n	EPA Method	Sample Range
1	City of Calistoga	S												
2	City of Petaluma	S												
3	City of St. Helena	S												
4	City of Sunnyvale	S	0.0019	0.00014		6	608	<0.05-<0.1	0.0087	2		6	608	<0.05-<0.1
5	Mt. View Sanitary District	S	0.0019	0.00014		5		<0.05-<0.2	0.056			5	608	<0.15-<0.75
6	Novato Sanitary District (Novato Plant)	S	0.002	0.0001		2	608	<0.01	0.009			2	608	<0.01
7	Novato Sanitary District (Ignacio Plant)	S	0.002	0.0001		2	608	<0.01-0.03				2	608	<0.01
8	Palo Alto RWQCP	S	0.0019	0.00014		2	608	<0.05	0.0087	2		2	608	<0.05-<0.015
9	San Jose/Santa Clara WPCP	S	0.0019	0.00014										
10	Town of Yountville	S												
11	Union Sanitary District (Hayward Marsh)	S	0.002	0.0001					0.009					
12	Las Gallinas Valley Sanitary District	S	0.002	0.0001					0.009					
13	City of Pacifica	O	·	0.00372		3		<0.075-<0.15	1.674			1		<0.05
14	Delta Diablo Sanitation District	D	0.019	0.0014		2	608	<0.15-<0.25	0.056			2	608	<0.05-<0.25
15	Central Contra Costa Sanitary District	D												
16	Central Marin Sanitation Agency	D												
17	City and County of San Francisco	D	0.1 (int)	0.1 (int)										
18	City of Benicia (a)	D				8	625	<1				7	625	<0.5-<1
19	City of Burlingame	D			M	5		<0.01-<0.5			M	5		<0.02-<1.5
20	City of Livermore	D	0.019	0.0014			608	<0.007	0.87					<0.01-0.013
21	City of Millbrae	D	0.0019	0.1		6	608	<0.05	0.087	20		6	608	<0.05
22	City of Richmond	D	0.019	0.0014		1		<0.01	0.087			1		<0.02
23	City of San Mateo	D			M						M			
24	Dublin/San Ramon Services District	D	0.019	0.0014		4		<0.007-<0.02	0.87			4		<0.007-<0.01
25	EBMUD	D	0.019	0.0014					0.087					
26	Sausalito-Marin City Sanitary District	D												
27	Sewerage Agency of Southern Marin	D												
28	South Bayside Systems Authority	D	0.019	0.0014		6		<0.025-<0.14	0.087	20		6		<0.005-<0.16
29	South San Francisco	D												
30	Union Sanitary District (EBDA)	D	0.019	0.0014		6		<0.25	0.87			6		0.013-<0.25
31	Vallejo Sanitation & Flood Control District	D												
32	North San Mateo County SD	D		0.00284										
33	City of Pinole	?												
34	Rodeo Sanitary District	?												

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Endrin 1-day	Endrin Monthly	Endrin Monitor	Endrin n	Endrin EPA Method	Endrin Sample Range	Flouranthene 1-day	Flouranthene Monthly	Flouranthene Monitor	Flouranthene n	Flouranthene EPA Method	Flouranthene Sample Range
1	City of Calistoga	S												
2	City of Petaluma	S												
3	City of St. Helena	S												
4	City of Sunnyvale	S	0.0023	0.8		6	608	<0.05-<0.1		42		8	610	<2
5	Mt. View Sanitary District	S	0.0023			5	608	<0.05-<0.25		42		2	625	<2.0
6	Novato Sanitary District (Novato Plant)	S	0.002			2	608	<0.01		42		2	625	<1
7	Novato Sanitary District (Ignacio Plant)	S	0.002			2	608	<0.01		42		2	625	<1
8	Palo Alto RWQCP	S	0.0023	0.8		2	608	<0.05-<0.15						
9	San Jose/Santa Clara WPCP	S	0.0023	0.8										
10	Town of Yountville	S												
11	Union Sanitary District (Hayward Marsh)	S	0.002											
12	Las Gallinas Valley Sanitary District	S	0.002							42				
13	City of Pacifica	O	0.372			4		<0.05-<1.0		1395		1		<5.0
14	Delta Diablo Sanitation District	D	0.023			2	608	<0.05-<0.25		420		2	625	<2
15	Central Contra Costa Sanitary District	D												
16	Central Marin Sanitation Agency	D												
17	City and County of San Francisco	D	0.2 (Int)	0.2 (Int)				<0.0021						
18	City of Benicia (a)	D				8	625	<0.5-<1				8	610	<1
19	City of Burlingame	D			M	5		<0.01-<0.5			M	5	625 & 8270	<2-<50
20	City of Livermore	D	0.023			8	608	<0.009-0.046		42				<5.0
21	City of Millbrae	D	0.0023	0.2		6	608	<0.02		42		6	625	<4
22	City of Richmond	D	0.023			1		<0.01		420		2		<2-<5
23	City of San Mateo	D			M						M			
24	Dublin/San Ramon Services District	D	0.023			4		<0.009-<0.02		42		6		<5
25	EBMUD	D	0.023											
26	Sausalito-Marin City Sanitary District	D												
27	Sewerage Agency of Southern Marin	D												
28	South Bayside Systems Authority	D	0.023	8		6		<0.005-<0.12		420		6		<0.09-<2
29	South San Francisco	D												
30	Union Sanitary District (EBDA)	D	0.023			6		<0.011-0.03		42				<0.25-1.6
31	Vallejo Sanitation & Flood Control District	D												
32	North San Mateo County SD	D								1070				
33	City of Pinole	?												
34	Rodeo Sanitary District	?												

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Gamma-BHC (Lindane)						Halomethanes					
			1-day	Monthly	Monitor	n	EPA Method	Sample Range	1-day	Monthly	Monitor	n	EPA Method	Sample Range
1	City of Calistoga	S												
2	City of Petaluma	S												
3	City of St. Helena	S												
4	City of Sunnyvale	S	0.08	0.062		2	608	<0.05-<0.25		480				
5	Mt. View Sanitary District	S	0.08	0.019		6		<0.025-<0.13		100				
6	Novato Sanitary District (Novato Plant)	S	0.16	0.062		2	608	0.02		480				
7	Novato Sanitary District (Ignacio Plant)	S	0.16	0.062		2	608	<0.01		480				
8	Palo Alto RWQCP	S	0.16	0.062		2	608	<0.025		480		2	624	96-99
9	San Jose/Santa Clara WPCP	S								480				
10	Town of Yountville	S												
11	Union Sanitary District (Hayward Marsh)	S												
12	Las Gallinas Valley Sanitary District	S	0.08	0.02						100				
13	City of Pacifica	O				4		<0.025		12090				
14	Delta Diablo Sanitation District	D	0.8	0.19		2	608	.057-<0.13		1000				
15	Central Contra Costa Sanitary District	D	1.6	0.62						4800				
16	Central Marin Sanitation Agency	D												
17	City and County of San Francisco	D												
18	City of Benicia (a)	D				7	625	<0.5-<1						
19	City of Burlingame	D			M	5	608 (8080)	<0.01-<0.25			M	5	624	<10
20	City of Livermore	D	1.6	0.62				<0.007-0.019		4800				
21	City of Millbrae	D	0.08	0.019		6	608	<0.002		100		6	601	7.12-21.3
22	City of Richmond	D	1.6	0.62		1		0.05		4800				
23	City of San Mateo	D			M						M			
24	Dublin/San Ramon Services District	D	1.6	0.62		4		<0.007-0.11		4800				
25	EBMUD	D	1.6	0.62						4800				
26	Sausalito-Marin City Sanitary District	D												
27	Sewerage Agency of Southern Marin	D												
28	South Bayside Systems Authority	D	1.6	0.62		6		<0.005-<0.2		4800		6		<10.9-<45.5
29	South San Francisco	D												
30	Union Sanitary District (EBDA)	D	1.6	0.62		6		<0.007-0.05		4800		6		2.5-52.5
31	Vallejo Sanitation & Flood Control District	D												
32	North San Mateo County SD	D								9230				
33	City of Pinole	?												
34	Rodeo Sanitary District	?												

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Heptachlor 1-day	Heptachlor Monthly	Heptachlor Monitor	Heptachlor n	Heptachlor EPA Method	Heptachlor Sample Range	Heptachlor Epoxide Monthly	Heptachlor Epoxide Monitor	Heptachlor Epoxide n	Heptachlor Epoxide EPA Method	Heptachlor Epoxide Sample Range
1	City of Calistoga	S											
2	City of Petaluma	S											
3	City of St. Helena	S											
4	City of Sunnyvale	S	0.0036	0.00017		6	608	<0.025-<0.05	0.00007		6	608	<0.025-<0.05
5	Mt. View Sanitary District	S	0.0038	0.00016		5	608	<0.025-<0.13	0.00007		5	608	<0.025-<0.13
6	Novato Sanitary District (Novato Plant)	S	0.004	0.0002		2	608	<0.01	0.0001		2	608	<0.01
7	Novato Sanitary District (Ignacio Plant)	S	0.004	0.0002		2	608	<0.01	0.0001		2	608	<0.01
8	Palo Alto RWQCP	S	0.0036	0.00017		2	608	<0.025	0.00007		2	608	<.025
9	San Jose/Santa Clara WPCP	S	0.00017	0.0036					0.00007				
10	Town of Yountville	S											
11	Union Sanitary District (Hayward Marsh)	S	0.004	0.0002					0.0001				
12	Las Gallinas Valley Sanitary District	S	0.0004	0.0002					0.0001				
13	City of Pacifica	O		0.06696		1		<0.025					
14	Delta Diablo Sanitation District	D	0.038	0.0016		2	608	<0.025-<0.13	0.0007		2	608	<0.025-<0.13
15	Central Contra Costa Sanitary District	D											
16	Central Marin Sanitation Agency	D											
17	City and County of San Francisco	D	.005 (int)	.005 (int)				<0.0012					
18	City of Benicia (a)	D				8	625	<0.5-<1			7	<0.5-<1	
19	City of Burlingame	D			M	5		<0.01-<0.25		M			<0.01-<2.0
20	City of Livermore	D	0.036	0.0017				<0.007-0.046	0.0007				<0.007
21	City of Millbrae	D	0.0036	0.005		6	608	<0.0005	0.0007		6	608	<0.0005
22	City of Richmond	D	0.036	0.0017		1		<0.01	0.0007		1		<0.01
23	City of San Mateo	D			M					M			
24	Dublin/San Ramon Services District	D	0.036	0.0017		6		<0.007-0.078	0.0007		4		<0.007-0.012
25	EBMUD	D	0.036	0.0017					0.0007				
26	Sausalito-Marin City Sanitary District	D											
27	Sewerage Agency of Southern Marin	D											
28	South Bayside Systems Authority	D	0.036	0.0017		6		<0.01-<0.28	0.0007		6		<0.025-<0.18
29	South San Francisco	D											
30	Union Sanitary District (EBDA)	D	0.036	0.0017		6		<0.007-0.018	0.0007		6		<0.007-<0.5
31	Vallejo Sanitation & Flood Control District	D											
32	North San Mateo County SD	D		0.05112									
33	City of Pinole	?											
34	Rodeo Sanitary District	?											

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Hexachlorobenzene Monthly	Hexachlorobenzene Monitor	Hexachlorobenzene n	Hexachlorobenzene EPA Method	Hexachlorobenzene Sample Range	PAHs 1-day	PAHs Monthly	PAHs Monitor	PAHs n	PAHs EPA Method	PAHs Sample Range
1	City of Calistoga	S							0.03				
2	City of Petaluma	S						15					
3	City of St. Helena	S							0.03				
4	City of Sunnyvale	S	0.00069		8	625	<2	15	0.031		8	610	<5
5	Mt. View Sanitary District	S	0.00066		2	625	<2.0		0.0028		3		<1-<2
6	Novato Sanitary District (Novato Plant)	S	0.0007		2	625	<5	15	0.03		5		ND
7	Novato Sanitary District (Ignacio Plant)	S	0.0007		2	625	<5	15	0.03		5		ND
8	Palo Alto RWQCP	S	0.00069		2	625	<1-<5	15	0.031				
9	San Jose/Santa Clara WPCP	S	0.00069					15	0.031		2	608	ND - 0.11
10	Town of Yountville	S							0.0028				
11	Union Sanitary District (Hayward Marsh)	S	0.0007						15 (Int)				
12	Las Gallinas Valley Sanitary District	S	0.0007						0.003				
13	City of Pacifica	O	0.01953		1		<5.0		0.8184		1		<5
14	Delta Diablo Sanitation District	D	0.0066		2	625	<2-<4		0.028		3	625	<2-<10
15	Central Contra Costa Sanitary District	D						47			8	625	<0.2-<7.0
16	Central Marin Sanitation Agency	D						150					
17	City and County of San Francisco	D	0.2 (Int)				<0.2-<10	10 (Int)	10 (Int)				
18	City of Benicia (a)	D			8	625	<1-<5		0.31 (1 int.)		8	610	<1
19	City of Burlingame	D			5		<5-<50	150	0.31		5		<2.0-<50
20	City of Livermore	D	0.0069				<5.0	150	0.31				<10
21	City of Millbrae	D	0.2		6	625	<0.02	150	10		6	8310	<1-1.1
22	City of Richmond	D	0.0069		1		<5		0.31		20		<0.31-11
23	City of San Mateo	D		M									
24	Dublin/San Ramon Services District	D	0.0069		6		<5	150	0.31		6		<0.2-<5
25	EBMUD	D	0.0069		>50	625	<0.2-<2	150	0.31		>50	625	<0.2-2
26	Sausalito-Marin City Sanitary District	D							0.31				
27	Sewerage Agency of Southern Marin	D							0.31				
28	South Bayside Systems Authority	D	0.0069		6		<0.1-2.3	150	0.31		6		<0.39-<4.8
29	South San Francisco	D											
30	Union Sanitary District (EBDA)	D	0.0069		6		<2.0-<5.0		10 (int.)		12		<0.25
31	Vallejo Sanitation & Flood Control District	D											
32	North San Mateo County SD	D	0.01491						0.6248				
33	City of Pinole	?							0.31 (16 int.)				
34	Rodeo Sanitary District	?											

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

			PCBs						Pentachlorophenol						
No.	POTW	Deep/Shallow	1-day	Monthly	Monitor	n	EPA Method	Sample Range	1-day	4-day	Monthly	Monitor	n	EPA Method	Sample Range
1	City of Calistoga	S													
2	City of Petaluma	S													
3	City of St. Helena	S													
4	City of Sunnyvale	S	0.014	0.00007		6	608	<0.5-<4		7.9	8.2		10	625	<10
5	Mt. View Sanitary District	S	0.014	0.00007		5	608	<2-<10	9.5		0.28		2	625	<10
6	Novato Sanitary District (Novato Plant)	S	0.03	0.0001		2	608	<0.1-<0.2	7.9				2	625	<1
7	Novato Sanitary District (Ignacio Plant)	S	0.03	0.0001		2	608	<0.1-<0.2	7.9				2	625	<1
8	Palo Alto RWQCP	S	0.03	0.00007		2	608	<0.5-<2							
9	San Jose/Santa Clara WPCP	S	0.014	0.00007											
10	Town of Yountville	S													
11	Union Sanitary District (Hayward Marsh)	S	0.03	0.0001											
12	Las Gallinas Valley Sanitary District	S	0.01	0.0001					7.9		0.28				
13	City of Pacifica	O		0.001767		5	608 & 8080	<1.0-<40							
14	Delta Diablo Sanitation District	D	0.14	0.0007		3	608	<0.5-<10	95		2.8		3	625	<10
15	Central Contra Costa Sanitary District	D		1.05											
16	Central Marin Sanitation Agency	D													
17	City and County of San Francisco	D	0.2 (int)	0.2 (int)				<0.015							
18	City of Benicia (a)	D				8	625	<0.5-<1					8	625	<1
19	City of Burlingame	D			M			<2.0-<5.0				M	5		<50-<100
20	City of Livermore	D	0.2 (int)			8	608	<0.20	79		28		8		<5
21	City of Millbrae	D	0.3	0.2		6	608	<0.02	79		28		6	625	<10
22	City of Richmond	D	0.3	0.0007		1		<0.1	79				1		<50
23	City of San Mateo	D			M							M			
24	Dublin/San Ramon Services District	D		0.2 (int)		4		<0.2-<10	79		28		6		0.2-<13
25	EBMUD	D		0.2 (int)											
26	Sausalito-Marin City Sanitary District	D													
27	Sewerage Agency of Southern Marin	D													
28	South Bayside Systems Authority	D	0.3	0.0007		6		<0.5-<1.5	79		82		6		<0.2-<50
29	South San Francisco	D													
30	Union Sanitary District (EBDA)	D		0.2 (int)		6		<0.2-<0.8							
31	Vallejo Sanitation & Flood Control District	D													
32	North San Mateo County SD	D		0.00134											
33	City of Pinole	?													
34	Rodeo Sanitary District	?													

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Phenol					TCDD Equivalents				
			1-day	Monthly	Monitor	n	Sample Range	1-day	Monthly	Monitor	n	Sample Range
1	City of Calistoga	S		1000								
2	City of Petaluma	S	500									
3	City of St. Helena	S	1000	3000								
4	City of Sunnyvale	S	120			10	<5		1.40E-08			
5	Mt. View Sanitary District	S		300		2	<2.0		1.30E-08			
6	Novato Sanitary District (Novato Plant)	S		30		2	<1		1E-08			
7	Novato Sanitary District (Ignacio Plant)	S		30		2	<1		1E-08			
8	Palo Alto RWQCP	S	100			2	<1-<5		1.40E-08			
9	San Jose/Santa Clara WPCP	S	5						1.40E-08			
10	Town of Yountville	S		300								
11	Union Sanitary District (Hayward Marsh)	S		30					1E-08			
12	Las Gallinas Valley Sanitary District	S		30					1E-08			
13	City of Pacifica	O	11160				<0.10		3.63E-07		1	<5.5E-6
14	Delta Diablo Sanitation District	D		3000		3	<2-<5		1.30E-07		1	<1.7E-06
15	Central Contra Costa Sanitary District	D	500			8	<1.0-<5.0		1.20E-04		7	<1.4E-6 - <7E-6
16	Central Marin Sanitation Agency	D	500									
17	City and County of San Francisco	D							0.005 (int)			
18	City of Benicia (a)	D		500		8	<1-1					
19	City of Burlingame	D	500			5	<10-<50			M		
20	City of Livermore	D		300		8	<10		0.000015 (int)			<1.8E-6 - 8.5E-6
21	City of Millbrae	D	1000	300		6	<5		0.005		6	2E-6 - 1.1E-5
22	City of Richmond	D		500		1	<10		1.40E-07			
23	City of San Mateo	D	500							M		
24	Dublin/San Ramon Services District	D		300		6	<2.5-<5		0.000015 (int)		4	<2.3E-6 - <4E-6
25	EBMUD	D		500		29	<0.2-29		0.000015 (int)			
26	Sausalito-Marin City Sanitary District	D										
27	Sewerage Agency of Southern Marin	D										
28	South Bayside Systems Authority	D		500		6	<0.05-<2		1.40E-07		3	4.2E-8 - 2.5E-7
29	South San Francisco	D										
30	Union Sanitary District (EBDA)	D		300		6	<2-<10		0.000015 (int)		6	<1E-6 - 1.2E-7
31	Vallejo Sanitation & Flood Control District	D										
32	North San Mateo County SD	D							2.70E-05			
33	City of Pinole	?		500								
34	Rodeo Sanitary District	?										

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Toluene 1-day	Toluene Monthly	Toluene Monitor	Toluene n	Toluene Sample Range	Toxaphene 1-day	Toxaphene 4-day	Toxaphene Monthly	Toxaphene Monitor	Toxaphene Sample Range
1	City of Calistoga	S										
2	City of Petaluma	S										
3	City of St. Helena	S										
4	City of Sunnyvale	S		300000					0.00002	0.00069		<2-<4
5	Mt. View Sanitary District	S		10000		2	1.6-3.5	0.0002				<2.0-<10.0
6	Novato Sanitary District (Novato Plant)	S		300000		2	<0.5 - 0.8	0.0002				<0.1
7	Novato Sanitary District (Ignacio Plant)	S		300000		2	0.5	0.0002				<0.1
8	Palo Alto RWQCP	S							0.00002	0.00069		<2.0
9	San Jose/Santa Clara WPCP	S							0.00002	0.00069		
10	Town of Yountville	S										
11	Union Sanitary District (Hayward Marsh)	S						0.0002		0.0007		
12	Las Gallinas Valley Sanitary District	S		10000				0.0002				
13	City of Pacifica	O		7905000		1	<2.0			0.01953		<2.0
14	Delta Diablo Sanitation District	D		100000		3	<2	0.002				<2-<10
15	Central Contra Costa Sanitary District	D										
16	Central Marin Sanitation Agency	D										
17	City and County of San Francisco	D						0.2 (int)		0.2 (int)		<0.035
18	City of Benicia (a)	D				4	<0.5-2.4					<0.5-<1
19	City of Burlingame	D			M	5	<2.0-2.4			M		<0.8-<20
20	City of Livermore	D		3000000				0.002				<0.5
21	City of Millbrae	D		3000000		6	<2-2.8	0.002		0.2		<0.02
22	City of Richmond	D		3000000		1	1.5	0.002				
23	City of San Mateo	D			M						M	
24	Dublin/San Ramon Services District	D		3000000		69	<1-4.6	0.002				<0.2-<1
25	EBMUD	D						0.002				
26	Sausalito-Marin City Sanitary District	D										
27	Sewerage Agency of Southern Marin	D										
28	South Bayside Systems Authority	D		3000000		6	<2.0	0.002		0.0069		<0.25-<1.0
29	South San Francisco	D										
30	Union Sanitary District (EBDA)	D						0.002				<0.025-<2.0
31	Vallejo Sanitation & Flood Control District	D										
32	North San Mateo County SD	D		6035000						0.01491		
33	City of Pinole	?										
34	Rodeo Sanitary District	?										

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY TOP EFFLUENT LIMITS AND SAMPLING DATA			Tributyltin				1,2 Dichlorobenzene				1,3 Dichlorobenzene			
No.	POTW	Deep/Shallow	1-day	Monthly	Monitor	Sample Range	Monthly	Monitor	n	Sample Range	Monthly	Monitor	n	Sample Range
1	City of Calistoga	S												
2	City of Petaluma	S												
3	City of St. Helena	S												
4	City of Sunnyvale	S	0.04	0.005			18000		10	<2-<5	2600		10	<2-<5
5	Mt. View Sanitary District	S	0.04	0.02			2700		5	<0.5-<2.0	400		5	<0.5-<2.0
6	Novato Sanitary District (Novato Plant)	S	0.01	0.005										
7	Novato Sanitary District (Ignacio Plant)	S	0.01	0.005										
8	Palo Alto RWQCP	S		0.005		0.006-0.051								
9	San Jose/Santa Clara WPCP	S	0.04	0.005										
10	Town of Yountville	S												
11	Union Sanitary District (Hayward Marsh)	S	0.01	0.005		0.007-0.043								
12	Las Gallinas Valley Sanitary District	S	0.01	0.005			2700				400		5	<0.5-<2.0
13	City of Pacifica	O		0.1302		0.007								
14	Delta Diablo Sanitation District	D	0.4	0.2		<0.02	27000		3	<2	4000		3	<2
15	Central Contra Costa Sanitary District	D	0.12	0.06										
16	Central Marin Sanitation Agency	D												
17	City and County of San Francisco	D		0.05										
18	City of Benicia (a)	D												
19	City of Burlingame	D						M	6	<10-<50		M	6	<10-<50
20	City of Livermore	D	0.12	0.05		0.003-0.13	180000				26000			
21	City of Millbrae	D		0.05		<0.005-0.007	180000		6	<5	26000		6	<5
22	City of Richmond	D		0.05		<0.05	180000		1	<0.5	26000		1	<0.5
23	City of San Mateo	D		M				M				M		
24	Dublin/San Ramon Services District	D	0.12	0.05		<2E-6-<1	180000		10	<1-<10	26000		10	<5
25	EBMUD	D		0.05		<0.02								
26	Sausalito-Marin City Sanitary District	D												
27	Sewerage Agency of Southern Marin	D												
28	South Bayside Systems Authority	D		0.05		<0.02-0.017	180000		6	<0.1-1.1	26000		6	<0.1-<2
29	South San Francisco	D												
30	Union Sanitary District (EBDA)	D	0.12	0.05		0.001-0.009								
31	Vallejo Sanitation & Flood Control District	D												
32	North San Mateo County SD	D												
33	City of Pinole	?												
34	Rodeo Sanitary District	?												

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	1,4 Diclorobenzene Monthly	Monitor	n	Sample Range	2,4 Dichlorophenol Monthly	4-day	n	Sample Range	2,4,6 Trichlorophenol Monthly	Monitor	n	Sample Range
1	City of Calistoga	S												
2	City of Petaluma	S												
3	City of St. Helena	S												
4	City of Sunnyvale	S	64		10	<2-<5					0.34		3	<2
5	Mt. View Sanitary District	S	9.9		5	<0.5-<2.0	0.3				0.34		2	<2.0
6	Novato Sanitary District (Novato Plant)	S												
7	Novato Sanitary District (Ignacio Plant)	S												
8	Palo Alto RWQCP	S												
9	San Jose/Santa Clara WPCP	S												
10	Town of Yountville	S												
11	Union Sanitary District (Hayward Marsh)	S												
12	Las Gallinas Valley Sanitary District	S	9.9					0.3			0.34			
13	City of Pacifica	O	1674		1	<5.0					26.97		1	<5.0
14	Delta Diablo Sanitation District	D	99		3	<2	3		3	<2	3.4		3	<2
15	Central Contra Costa Sanitary District	D												
16	Central Marin Sanitation Agency	D												
17	City and County of San Francisco	D												
18	City of Benicia (a)	D												
19	City of Burlingame	D		M	6	<10-<50						M		<10-<50
20	City of Livermore	D	640				0.3				10			
21	City of Millbrae	D	640		6	<5					10		6	<1
22	City of Richmond	D	640		1	1.2					10		1	<10
23	City of San Mateo	D		M								M		
24	Dublin/San Ramon Services District	D	640		10	<1-<5	0.3		6	<0.2-<5	10		6	<0.2-<5
25	EBMUD	D												
26	Sausalito-Marin City Sanitary District	D												
27	Sewerage Agency of Southern Marin	D												
28	South Bayside Systems Authority	D	640		6	<0.1-<13					10		6	<0.10-0.5
29	South San Francisco	D												
30	Union Sanitary District (EBDA)	D	640		6	1.1-4.0								
31	Vallejo Sanitation & Flood Control District	D												
32	North San Mateo County SD	D	1280								20.59			
33	City of Pinole	?												
34	Rodeo Sanitary District	?												

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	4-Chloro-3-Methylphenol Monthly	4-day	n	Sample Range
1	City of Calistoga	S				
2	City of Petaluma	S				
3	City of St. Helena	S				
4	City of Sunnyvale	S				
5	Mt. View Sanitary District	S	3000			
6	Novato Sanitary District (Novato Plant)	S				
7	Novato Sanitary District (Ignacio Plant)	S				
8	Palo Alto RWQCP	S				
9	San Jose/Santa Clara WPCP	S				
10	Town of Yountville	S				
11	Union Sanitary District (Hayward Marsh)	S				
12	Las Gallinas Valley Sanitary District	S		3000		
13	City of Pacifica	O				
14	Delta Diablo Sanitation District	D	30000		3	<2
15	Central Contra Costa Sanitary District	D				
16	Central Marin Sanitation Agency	D				
17	City and County of San Francisco	D				
18	City of Benicia (a)	D				
19	City of Burlingame	D				
20	City of Livermore	D				
21	City of Millbrae	D				
22	City of Richmond	D				
23	City of San Mateo	D				
24	Dublin/San Ramon Services District	D				
25	EBMUD	D				
26	Sausalito-Marin City Sanitary District	D				
27	Sewerage Agency of Southern Marin	D				
28	South Bayside Systems Authority	D				
29	South San Francisco	D				
30	Union Sanitary District (EBDA)	D				
31	Vallejo Sanitation & Flood Control District	D				
32	North San Mateo County SD	D				
33	City of Pinole	?				
34	Rodeo Sanitary District	?				

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Acrolein	Antimony	Bis(2-chloroethoxy)methane	Bis(2-chloroisopropyl)ether	Chlorobenzene	Di-n-butyl Phthalate	Dichlorobenzenes
			Limits for other new TOP constituents (Limited sampling data indicates that these are all non-detects).						
			Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
1	City of Calistoga	S							
2	City of Petaluma	S							
3	City of St. Helena	S							
4	City of Sunnyvale	S							
5	Mt. View Sanitary District	S							
6	Novato Sanitary District (Novato Plant)	S							
7	Novato Sanitary District (Ignacio Plant)	S							
8	Palo Alto RWQCP	S							
9	San Jose/Santa Clara WPCP	S							
10	Town of Yountville	S							
11	Union Sanitary District (Hayward Marsh)	S							
12	Las Gallinas Valley Sanitary District	S							
13	City of Pacifica	O	20460	111600	409.2	111600	53010	325500	474300
14	Delta Diablo Sanitation District	D							
15	Central Contra Costa Sanitary District	D							
16	Central Marin Sanitation Agency	D							
17	City and County of San Francisco	D							
18	City of Benicia (a)	D							
19	City of Burlingame	D							
20	City of Livermore	D							
21	City of Millbrae	D							
22	City of Richmond	D							
23	City of San Mateo	D							
24	Dublin/San Ramon Services District	D							
25	EBMUD	D							
26	Sausalito-Marin City Sanitary District	D							
27	Sewerage Agency of Southern Marin	D							
28	South Bayside Systems Authority	D							
29	South San Francisco	D							
30	Union Sanitary District (EBDA)	D							
31	Vallejo Sanitation & Flood Control District	D							
32	North San Mateo County SD	D	15620	85200	312.4	85200	40470	248500	362100
33	City of Pinole	?							
34	Rodeo Sanitary District	?							

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	1,1-Dichloroethylene	Diethyl phthalate	Dimethyl phthalate	4,6-Dinitro-2-methylphenol	2,4-Dinitrophenol	Ethylbenzene
			Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
1	City of Calistoga	S						
2	City of Petaluma	S						
3	City of St. Helena	S						
4	City of Sunnyvale	S						
5	Mt. View Sanitary District	S						
6	Novato Sanitary District (Novato Plant)	S						
7	Novato Sanitary District (Ignacio Plant)	S						
8	Palo Alto RWQCP	S						
9	San Jose/Santa Clara WPCP	S						
10	Town of Yountville	S						
11	Union Sanitary District (Hayward Marsh)	S						
12	Las Gallinas Valley Sanitary District	S						
13	City of Pacifica	O	660300	3069000	7626000	20460	372	381300
14	Delta Diablo Sanitation District	D						
15	Central Contra Costa Sanitary District	D						
16	Central Marin Sanitation Agency	D						
17	City and County of San Francisco	D						
18	City of Benicia (a)	D						
19	City of Burlingame	D						
20	City of Livermore	D						
21	City of Millbrae	D						
22	City of Richmond	D						
23	City of San Mateo	D						
24	Dublin/San Ramon Services District	D						
25	EBMUD	D						
26	Sausalito-Marin City Sanitary District	D						
27	Sewerage Agency of Southern Marin	D						
28	South Bayside Systems Authority	D						
29	South San Francisco	D						
30	Union Sanitary District (EBDA)	D						
31	Vallejo Sanitation & Flood Control District	D						
32	North San Mateo County SD	D	504100	2434000	58220000	15620	284	291100
33	City of Pinole	?						
34	Rodeo Sanitary District	?						

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Hexachlorocyclopentadiene Monthly	Isophorone Monthly	Nitrobenzene Monthly	Thallium Monthly	1,1,2,2-Tetrachloroethane Monthly	1,1,1-Trichloroethane Monthly	1,1,2-Trichloroethane Monthly
1	City of Calistoga	S							
2	City of Petaluma	S							
3	City of St. Helena	S							
4	City of Sunnyvale	S							
5	Mt. View Sanitary District	S							
6	Novato Sanitary District (Novato Plant)	S							
7	Novato Sanitary District (Ignacio Plant)	S							
8	Palo Alto RWQCP	S							
9	San Jose/Santa Clara WPCP	S							
10	Town of Yountville	S							
11	Union Sanitary District (Hayward Marsh)	S							
12	Las Gallinas Valley Sanitary District	S							
13	City of Pacifica	O	5394	13950000	455.7	1302	111600	50220000	3999000
14	Delta Diablo Sanitation District	D							
15	Central Contra Costa Sanitary District	D							
16	Central Marin Sanitation Agency	D							
17	City and County of San Francisco	D							
18	City of Benicia (a)	D							
19	City of Burlingame	D							
20	City of Livermore	D							
21	City of Millbrae	D							
22	City of Richmond	D							
23	City of San Mateo	D							
24	Dublin/San Ramon Services District	D							
25	EBMUD	D							
26	Sausalito-Marin City Sanitary District	D							
27	Sewerage Agency of Southern Marin	D							
28	South Bayside Systems Authority	D							
29	South San Francisco	D							
30	Union Sanitary District (EBDA)	D							
31	Vallejo Sanitation & Flood Control District	D							
32	North San Mateo County SD	D	4120		347.9	994	85200		
33	City of Pinole	?							
34	Rodeo Sanitary District	?							

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	Acrylonitrile	Benzidine	Beryllium	Bis(2-chloroethyl)ether	Bis(2-ethylhexyl)phthalate	Carbon Tetrachloride	3,3'-Dichlorobenzidine
			Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
1	City of Calistoga	S							
2	City of Petaluma	S							
3	City of St. Helena	S							
4	City of Sunnyvale	S							
5	Mt. View Sanitary District	S							
6	Novato Sanitary District (Novato Plant)	S							
7	Novato Sanitary District (Ignacio Plant)	S							
8	Palo Alto RWQCP	S							
9	San Jose/Santa Clara WPCP	S							
10	Town of Yountville	S							
11	Union Sanitary District (Hayward Marsh)	S							
12	Las Gallinas Valley Sanitary District	S							
13	City of Pacifica	O	9.3	0.006417	3.069	4.185	325.5	83.7	0.7533
14	Delta Diablo Sanitation District	D							
15	Central Contra Costa Sanitary District	D							
16	Central Marin Sanitation Agency	D							
17	City and County of San Francisco	D							
18	City of Benicia (a)	D							
19	City of Burlingame	D							
20	City of Livermore	D							
21	City of Millbrae	D							
22	City of Richmond	D							
23	City of San Mateo	D							
24	Dublin/San Ramon Services District	D							
25	EBMUD	D							
26	Sausalito-Marin City Sanitary District	D							
27	Sewerage Agency of Southern Marin	D							
28	South Bayside Systems Authority	D							
29	South San Francisco	D							
30	Union Sanitary District (EBDA)	D							
31	Vallejo Sanitation & Flood Control District	D							
32	North San Mateo County SD	D	7.1	0.0049	2.343	3.2	248.5	63.9	0.5751
33	City of Pinole	?							
34	Rodeo Sanitary District	?							

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	1,2-Dichloroethane	1,3-Dichloropropene	2,4-Dinitrotoluene	1,2-Diphenylhydrazine	Hexachlorobutadiene	Hexachloroethane	N-nitrosodimethylamine
			Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
1	City of Calistoga	S							
2	City of Petaluma	S							
3	City of St. Helena	S							
4	City of Sunnyvale	S							
5	Mt. View Sanitary District	S							
6	Novato Sanitary District (Novato Plant)	S							
7	Novato Sanitary District (Ignacio Plant)	S							
8	Palo Alto RWQCP	S							
9	San Jose/Santa Clara WPCP	S							
10	Town of Yountville	S							
11	Union Sanitary District (Hayward Marsh)	S							
12	Las Gallinas Valley Sanitary District	S							
13	City of Pacifica	O	12090	827.7	241.8	14.88	1302	232.5	678.9
14	Delta Diablo Sanitation District	D							
15	Central Contra Costa Sanitary District	D							
16	Central Marin Sanitation Agency	D							
17	City and County of San Francisco	D							
18	City of Benicia (a)	D							
19	City of Burlingame	D							
20	City of Livermore	D							
21	City of Millbrae	D							
22	City of Richmond	D							
23	City of San Mateo	D							
24	Dublin/San Ramon Services District	D							
25	EBMUD	D							
26	Sausalito-Marin City Sanitary District	D							
27	Sewerage Agency of Southern Marin	D							
28	South Bayside Systems Authority	D							
29	South San Francisco	D							
30	Union Sanitary District (EBDA)	D							
31	Vallejo Sanitation & Flood Control District	D							
32	North San Mateo County SD	D	9230	631.9	184.6	11.36	994	177.5	518.3
33	City of Pinole	?							
34	Rodeo Sanitary District	?							

Units of concentration are µg/L.

PRIORITY TOXIC ORGANIC POLLUTANT SURVEY
TOP EFFLUENT LIMITS AND SAMPLING DATA

No.	POTW	Deep/Shallow	N-nitrosodiphenylamine	TCE	Vinyl chloride
			Monthly	Monthly	Monthly
1	City of Calistoga	S			
2	City of Petaluma	S			
3	City of St. Helena	S			
4	City of Sunnyvale	S			
5	Mt. View Sanitary District	S			
6	Novato Sanitary District (Novato Plant)	S			
7	Novato Sanitary District (Ignacio Plant)	S			
8	Palo Alto RWQCP	S			
9	San Jose/Santa Clara WPCP	S			
10	Town of Yountville	S			
11	Union Sanitary District (Hayward Marsh)	S			
12	Las Gallinas Valley Sanitary District	S			
13	City of Pacifica	O	232.5	2511	3348
14	Delta Diablo Sanitation District	D			
15	Central Contra Costa Sanitary District	D			
16	Central Marin Sanitation Agency	D			
17	City and County of San Francisco	D			
18	City of Benicia (a)	D			
19	City of Burlingame	D			
20	City of Livermore	D			
21	City of Millbrae	D			
22	City of Richmond	D			
23	City of San Mateo	D			
24	Dublin/San Ramon Services District	D			
25	EBMUD	D			
26	Sausalito-Marin City Sanitary District	D			
27	Sewerage Agency of Southern Marin	D			
28	South Bayside Systems Authority	D			
29	South San Francisco	D			
30	Union Sanitary District (EBDA)	D			
31	Vallejo Sanitation & Flood Control District	D			
32	North San Mateo County SD	D	177.5	1920	2560
33	City of Pinole	?			
34	Rodeo Sanitary District	?			
Units of concentration are µg/L.					

Attachment 2

Ecological Overview of the Estuary Transcript Summary

Prepared by Larry Walkers Associates

SAN FRANCISCO BAY AREA
POLLUTION PREVENTION GROUP
ECOLOGICAL OVERVIEW OF THE ESTUARY
TRANSCRIPT SUMMARY
August 2, 1995

Welcome and Introduction by Dr. Teng-chung Wu

First Speaker - Dr. Sam Luoma, U.S. Geological Survey
San Francisco Estuary: Ecological Overview

1. History of Monitoring Programs in the Bay Area

   a. Late 1960's the Interagency Ecological Program began monitoring fisheries. Basis for the things that we know about endangered species, long-life predators, and commercial species come from that monitoring.

   b. U.S.G.S. program began in the late 1960's more with the focus on understanding the Bay. By the 1980s, a series of individual studies were initiated.

   c. The SFB Regional Water Quality Control Board had a very important role in stimulating development of scientific information.

   d. More recently the San Francisco Estuary Institute and our most recent monitoring program, the Regional Monitoring Program have made major contributions to region.

2. History of the Bay

   a. The Bay is a very different ecosystem now than it was before the huge growth in population occurred in about 1850. It's unlikely we can go back to what the Bay, the kind of bay that existed in 1850 but there are some important things that we can do, some important goals that we can set.

   b. Pollution prevention and waste treatment has made a big difference in what's happened in the last 20 years in the Bay in terms of the trends in both the ecological and chemical characteristics that effect the ecology of San Francisco Bay.

   c. Various disturbances (ex. hydraulic mining) have affected the various characteristics of the Bay. Ninety to ninety-five percent of the marshes that historically surrounded this system and made it such a complicated structure in the past, have been destroyed or paved over.

d. About 60 percent of the water that originates in the watershed of the Bay is diverted before it hits the San Francisco Bay so that the amount of water coming into the Bay is probably substantially less then it was historically.

e. And of course one of the basic impacts, is the eight million people that live in the Bay Area. The wastes of all eight million of those people is in this system, and how we treat those wastes before they get into the system is very important.

f. At one time, there were three salmon runs with millions of salmon, as salmon usually run in the spring, winter, and the fall. The spring and the winter salmon runs are essentially gone, essentially extinct. The fall salmon run which happens in the lower rivers still exists but they contain a very narrow genetic pool of salmon.

g. The trends in other fisheries are also fairly disturbing, especially the trends in the hardier species that have been monitored for a long period of time. For example, striped bass is a species that was introduced to San Francisco Bay, but was historically very successful in the Bay. Since the early 1960s, the trend in this commercially valuable fish has been steadily downward. Striped bass numbers decreased through increases in water diversion until about 1976/77, and then the striped bass suddenly collapsed. Currently, there's extremely low populations of striped bass.

h. A number of other organisms (e.g., sturgeon, smaller marsh fish) that have been monitored through time appear to be collapsing in populations compared to what occurred in earlier years.

i. So these largely indicative organisms suggest to us that again not only have there been big changes in the estuary. It's the only estuary that we know of where we have no commercial fishery left, no existing commercial fishery that people eat. There is no shell fish fishery, there is no clam or oyster fishery, there is no big fish fishery that people consume. There's only a small herring fishery and there's a small bait and shrimp fishery.

j. Fortunately, all the trends are not down, there are some trends reversing one another. There are complexities that we don't understand completely, but we are starting to understand the response as a whole. This understanding may help us in the future to determine whether an action or activity improves or does not improve the state of the estuary.

k.. So while we cannot take the Bay back to where it was in 1840, a reasonable goal would be to try to establish a system whereby at least we have a commercial fishery where people can support such a fishery.

3. Determining the Role Pollutants Play in the Trends Seen

a. By taking sediment and using isotopes or other various methods, we can determine trends in pollutant concentration over a long period of history. What we see in these cores gives us again a pretty interesting perspective historically of events in San Francisco Bay, both from a point of view of the individual pollutants, and from the point of view of fisheries.

b. First of all, some pollutant concentrations were much in earlier times than they now are in terms of concentration in sediments.

 1) Since the use of DDT was banned in the 1970s, and DDT peaked and since has declined over that period of time, although there are still concentrations of DDT in some places in the Bay.

 2) Similarly, PCBs were banned in the late 1970's, and PCB concentrations in the sediments have declined.

c. Mercury and silver are the two elements that occur in the highest concentration factor in sediments today relative to what they were historically.

 1) The peak in mercury concentrations in this Richardson Bay core actually occurred very early, in the 1900 to the 1930's period. Mercury concentrations since then have been declining. This is fairly consistent with what we know about the usage of mercury in the area. One of the big uses of mercury in the area, of course, was gold mining. The sediments that came from the gold mining area didn't clear out of the rivers until the 1930's to the 1950's.

 2) Silver on the other hand is undoubtedly, at least in more recent times, related to certain kinds of industrial and commercial activities. There was a very large silver peak in the sediments of the Bay about the 1960s. Silver concentrations have begun to decline since the 1960s.

d. The more persistent pollutants have more new sources. For example, polyaromatic hydrocarbons (PAHs), come from industrial activities, such as refineries, from street runoff , atmospheric input, and many other kinds of activities. The decline in PAH concentrations are less noticeable.

e. For all sulphur elements, and other trace element contaminants like copper and zinc, we see a mixture of results, declines in some places in north San Francisco Bay, and little declines in other areas, like the sediments of Richardson Bay near the mouth of the estuary.

f. Individual pollutants each seem to follow their own trends. Where an attempt has been made to limit the inputs of pollutants, we see resultant effects. But pollutants don't act one at a time, pollutants act as mixtures. So it's interesting to look at the mixtures of pollutants that have existed in the sediments and to think about how our society was behaving at the time those mixtures occurred.

4. Pollutant Time Line.

a. View segments of data from periods of time: the period that ended in 1900, the period that ended in 1950, the period that ended in 1970 and the period that ended in 1900.

b. 1900 to 1950 was a time of steady growth in population and commercial and industrial activity in the Bay Area. For example, around 1900 most of the refineries were started. The lead smelter was started in 1879 and continued to operate until 1970.

c. 1950 to 1970 was a period of very dramatic changes in the Bay Area. The most rapid industrial growth occurred after World War II and a very rapid growth in population occurred during this time too.

d. 1950 and 1970 was a period with very little waste treatment, and very little concern about the effects of pollutants in the system as well as a period of continuing economic growth, and continuing population growth. Of course, in the late 1960's and from 1970 on our society began to invest in waste treatment, trying to eliminate nutrients.

e. We can see the dominant pollutants that occur through each of these periods. One thing we learned from the sediment core studies is that natural pollutants exist in San Francisco Bay, one of which is nickel, which is very high in our watersheds mainly because of the serpentine rocks that are so abundant in many places in the watershed. So throughout the periods and probably forever, we will have high, potentially toxic concentrations of nickel in the sediments of San Francisco Bay. We don't know the availability of the geological source of nickel, but it's one of the natural pollutants.

f. By 1950, as a result of what happened between 1900 and 1950, the most important pollutants in the San Francisco Bay sediments were mercury and PAHs. Again, mercury was a result of the gold mining activity and PAH was a result of refinery activities, the burning of coal and eventually oil and petroleum.

g. A big jump in pollutants that were in relatively low concentrations happened in 1970. We have some ecological indicators for this period of time. 1970 was about the time when brown pelican populations were collapsing. This was a period when we were reaching a threshold of pretty dramatic ecological effects both on a global scale and in our local San Francisco Bay estuary. This kind of situation in the world would create a mixture which would presumably result in some fairly traumatic and fairly observable effects.

h. By 1990, as a result of waste treatment, the concentration of some of these pollutants were starting to decline. Right now we're in a situation that's somewhere between where we were in 1950 and where we were in 1970. It's not unreasonable to think that there are recovering populations in the Bay or that there are pollutant-affected populations in the Bay. We're still in the phase where both of those are possible.

i. The ERL number is the sediment concentration of each of these pollutants that causes toxicity in something like 15 to 30 percent, depending upon the pollutant. When numbers are reviewed from 1900 to 1950 to 1970, we start to see that by 1970 almost all the pollutants exceeded these criteria. As we go into 1990, this is starting to subside.

5. Case Study of Palo Alto Sewage Treatment Plant

a. In the late 1970's we conducted a transect looking at metal concentrations in sediments and in a small plant that lives along this area, two times a year. It consistently showed copper concentrations in the plant were very high just south of the outfall and declined as we went further south. Interestingly enough, they were not high north but we now know that the currents here, because the winds consistently move south, carry that waste to the south.

b. The animals right next to the outfall were .1 percent by weight copper in their tissues. Copper and silver were the two pollutants of most concern here, they were in extreme concentration in the tissues of plants.

c. Of course, the Palo Alto Sewage Treatment Plant has changed since the time that study was done. In 1980, the Treatment Plant added a number of different treatments and doubled the amount of secondary treatment. In 1988, clarifiers were added, and some changes were made in the way wastes were processed in order to try to get rid of some of the pollutants. In 1989, solids were reduced and source control began, especially for silver and copper. Some trends occurred through 1991 in the effluent concentrations of copper, effluent concentrations have declined.

d. We now have 20 years of data around this sewage outfall to determine if these changes in the way the treatment plant works have made any difference in terms of the metals concentrations. You can see the very distinct trends in silver concentrations in the plants at Palo Alto. 1980 was when again the biggest change occurred in how the wastes were treated and you can see a couple of years after that a little dip. 1990 concentrations have been reduced further,down to the lowest that we've ever observed in 1991..

e. The same is true for copper, another very strong toxic pollutant. The general trend is one of declining copper concentrations, dramatically declining. You can see the late '70's was a peak. Declining copper concentrations was the trend as of 1990. Just the correlation between the clams and the effluent, as effluent concentrations in copper decline, copper concentrations will decline. Waste treatment certainly made a difference here. If we quit regulating waste, if we allow our regulations to change in ways that will allow more copper to be discharged, we can be sure that this will go up.

6. Case Studies Relevance to the Rest of the Estuary.

a. Can argue that even when you clean up things going into the south Bay, the south Bay won't change because there is so much pollutant in the sediment that's going to stay around because it's constantly being mixed in.

b. We know from looking at sediment cores that a silver peak occurred in Richardson Bay in the 1960's and 70's. Now we can see from that period from those extremely high silver concentrations in the sediments, and even though one part per million doesn't sound right for silver that's a lot, those are very high concentrations. We can see, looking at a more recent sediment core from south Bay, a declining concentration of silver from this peak.

7. Pollutants in the North Bay.

a. The big problem in terms of pollutants today is the north Bay. We have some sampling sites from the last five years, and we also sampled here in the early 1980s, looking at contaminant conditions in this part of the estuary. We used again two clams as indicators. One is the Chinese clam which invaded the Bay in 1986, and the other is the freshwater clam.

b. Many kinds of exposure to a pollutant occur in a complicated estuary like this where you have a combination of natural changes in flow, human influences on the rate of flow, and industrial inputs into the system, inputs that may be better than they once were, but still present at least some contamination problems.

c. Looking at chromium concentrations, there's a large source of chromium, industrial chromium, right here in the estuary. We can see, towards the head of the estuary, substantial chromium contamination has declined as we go through Suisun Bay.

d. As we move toward the mouth of the estuary, we can see cadmium contamination in the sediment. We don't know the source of this but we know that there is consistently a fairly high cadmium contamination in this part of the estuary, when compared to levels upstream and downstream. San Pablo Bay is higher than what we see in the rivers because there is more cadmium in our ocean waters than there is in our river waters as a result of natural cadmium enrichment. So any cadmium we add industrially is probably going to be an add-on to a fairly high natural level of cadmium.

e. As we go down the estuary, we can see another source of contamination is selenium. This concentration of this contaminant hasn't changed much and may have gotten worse since the 60s. There are concentrations of selenium in clams, and in water.

f. So as a fish swims through this estuary, it goes through areas of chromium, cadmium and selenium contamination, as well as one more element, at least during high flow, petroleum related wastes. So whatever is swimming up or down the estuary goes through this progression of exposure to different pollutants.

g. Silver is relatively low in concentration in the north Bay. but is high in concentration in the south Bay. There was one clot of silver in the north Bay, but this appeared to have gotten better in the last five years.

h. The signature of pollutants is different in the north Bay than in the south Bay. The exposures are different, and we would expect that the effects on organisms are different. The south Bay as a whole in fact may be, in terms of settling, one of the less contaminated in general places in the Bay Area.

i. The Sacramento office of USGS looked at diazinon concentrations and their inputs to the estuary. We can see as rainfall events occur and river flow goes up, diazinon moves into the estuary presumably off the fields, and occurring in pulses in the estuary.

j. So we have this chronic metal exposure occurring from industry and these pulses of pesticides coming in and effecting the estuary. You can see then why it becomes to understand exactly what organisms are being affected where. On a long-time scale, we might be going through a recovery of some species. On the short-time scale, species are vulnerable to either these chronic effects or these pulse effects in some parts of the estuary.

8. Other Influences on the Bay/Estuary

a. We know from a couple of decades of studying the south Bay that there's a fairly predictable biological influence that occurs, a bloom of microscopic plants in the water column that occurs in early March and late April. If this continued at this level, we would have a Lake Erie type south Bay. There's enough nutrients to stimulate this, but because of the lack of light and because we have such a good population of clams down there to eat the plants.

b. Interestingly enough, this bloom has a tremendous effect on where the metals occur and on the metal concentrations in the water column. So, for monitoring metals in the Bay we can't understand the dynamics of the Bay without knowing something about the blooms. In the water column of the south Bay during the plant bloom, you can see the concentrations of cadmium are reduced in half as a result of being incorporated into the plant cells. At the same time, particular cadmium increases as the plant cells increase, having a dramatic effect on cadmium concentrations in the water. And here are just some predictions of what would happen to the cadmium in clams as a result of these changes: we'd get quite a bit of cadmium in our clams. So we don't see a decline in clams, in fact we see a small increase and then a larger increase.

c. So again, the important point here is that there are number of complexities we have left to learn about and understand in terms of understanding the dynamics of these metals, but we can see the big trends from the things that we've learned scientifically. And as we understand more of the details we're going to be more sophisticated in our ability to decide what the effects of some of our decisions in terms of cutting back or in terms of releasing the regulations.

9. Answers to Questions

Q: Of the metals of concern in the North Bay is there one that is of particular concern?

DR. LUOMA: There maybe are two. One is selenium which is extremely a dangerous to migratory birds and to fish. Cadmium, which is another one of concern, seems to affect the condition of the invertebrates that live there. Where there are high cadmium concentrations we see skinny invertebrates, skinny clams that aren't doing very well, and that might be an indication that other invertebrates can't live in that area. But I would say selenium is the one that in this estuary we should be very concerned about.

Q: If you had to say what the most important pollutants to the south Bay were what would you say?

DR. LUOMA: Well, I think the most important pollutant in the south Bay is probably silver. I think that the debate about copper is a pretty interesting debate because copper is very hard to understand. Copper is an element that occurs in high concentrations and solution in the south Bay. There's no doubt that the selenities in the south Bay and the copper concentration in the water that we see are much higher than we would normally see in a system like this. However, copper concentrations as we've seen in the sediments and in the clams have come down considerably from what they were 20 years ago
We worry about copper because of its influence on the plant community that exists in the south Bay, and the survival of some kinds of shell fish species.

Q: In your diazinon data, what kind of implications are there?

DR. LUOMA: In the Sacramento River there is very strong toxicity of diazinon in the river itself at the time when these pulses of pesticides are coming through.

Q: Regarding the elevated nickel levels, is this throughout the whole Bay and can you whether part of that comes from point source discharges?

DR. LUOMA: In the sediments, we can't see the influence of any point sources. We know there are point source inputs of nickel. We think there are increases in nickel availability from our clam tissues, although we still have to be sure that we cancel out any possible sediment contamination, and in fact we're working on that right now. But in the sediments there are a hundred to two hundred parts per million of nickel, way above what people think might be the toxicity of nickel. And the concentrations are higher nearest the rivers. One of the highest places is Tomales Bay where there's probably no point source input. As you go down these cores, and you get back into sediments from the 1840s, nickel concentrations were the same as they are now.

So in sediments we can see no influence of point sources, partly because we have this huge noisy natural signal. Is that biologically available? Really good question. We do know that when we take these sediments in put them in a jar to see if something dies, we often see deaths in the most sensitive organisms.

But from the cores we can be sure that that's natural. We can be sure because there was as much there in 1840 as there is now, so that sedimentary nickel is naturally occurring. And probably the serpentine has thousands of parts per million of nickel.

Q: Is water diversion a significant factor in the fish populations?

DR. LUOMA: Water diversion is the first order variable effecting many of the fisheries. Alan Jansen has done statistical work that shows some correlations between water flows into the estuary and the success of a number of either the food species that the fish feed on, the lower level species, or fisheries themselves. And I think that water diversion is extremely important. Building dams and diverting the water has made it much more difficult to clean up pollutants in the north Bay. At the time that the dams were completed and water diversion started to kick in, pollutant concentrations and sediments of north Bay jumped.
We might also expect that in south Bay because, first of all, the dams cut off some of the sediment coming in, and if you've got a local source of input of pollutants the concentration of that pollutant on the sediment is determined by how much suspended sediment is there for it to absorb to. When there's less suspended sediment you get higher concentration.

Second speaker - Michael Carlin, Regional Water Quality Control Board
History of Regional Monitoring in the Estuary

1. Regional Monitoring Program.

   a. Developed a regional monitoring program to have cataloged information on point sources.

   b. Desired to start a regional monitoring program so there is a systematic collection of information from the entire estuary across different medias of what's in the water, what's in the sediment, and what's in the organisms, and then work over time to integrate that with other information, not just from point sources, but also from storm water, from air deposition, etc..

   c. Regional monitoring is not a new idea. There have been efforts to start monitoring going back to 1827, when the British first came into the estuary and started doing mapping exercises of the Bay. This provided us with information on the historical shoreline and with information on what kind of extensive marshes existed. These marshes were very important at one point in time in providing habitat for a number of different species which have subsequently been reduced.

   d. The United States did a survey in the 1800s as well. So we have information available to us from a historical perspective and we can tell changes over time. We also have the USGS again in the 1900s coming back in and doing more extensive surveys.

2. Historical Surveys

   a. In the 50s, the first extensive surveys done of bay population lookied at community effects around outfalls. These are still useful information today because again it demonstrates to us that basically we have these measurable effects, and then once a treatment strategy was put in place, these effects usually would reverse themselves.

   b. In the 60s, UC Berkeley did a very extensive sanitary survey of the entire bay, looking at water column bacteria levels, and toxicity in the water column. This was a Bay-wide surveydone as a first step in doing a planning effort to decide what kind of treatment strategies to implement, how should we actually group treatment plants together, and where should treatment plants be discharging in order to protect the Bay.

   c. In the 70s, the Interagency Ecological Studies Program started a multi-agency federal/state agency effort to monitor inthe Delta, Suisun Bay, and some in San Pablo Bay for biological effects of water diversion. The program has been in existence for twenty-five years. So this is a very extensive data set that exists and they're still out there collecting information. They're mostly concentrating on biological effects of water diversion; i.e., how many fish are there in the Bay, where are the fish spawning, where is the critical habitat of the fish.

d. In 1977, the Army Corps of Engineers studied how dredged material moved in San Francisco Bay, and how sediment actually moved within the Bay. The Corps actually radio tagged some sediment in San Pablo Bay and traced it to get an idea of how sediment would move. They weren't looking at pollution and the way it affects it. But now we're very interested in this study about how sediment moves in the system because a lot these contaminants attach to sediment particles and are being transported around.

e. In 1982, there was an effort by the State Water Resources Control Board to develop a long-term regional monitoring program looking at the long-term effects within the estuary. It was going to look at far field effects and near field effects, to try and tie near field effects nears discharges to the far field effects of what's just happening in the system in general. A plan was developed, there were some pilot studies that were done, but there was no long-term funding that was identified to carry the plan out at that time.

3. Reasons for the Regional Monitoring Program

a. Part of it is rooted into our water quality control plan for the San Francisco Bay Basin since a necessary part of the Basin plan is surveillance and monitoring. It looks at how we are doing on protecting the beneficial uses, how we set the water quality objectives for protection of those beneficial uses, and how to plan implementation to meet those water quality objectives.

b. The Clean Water Act amendments in 1987 basically requires states to adopt toxic contaminant standards or USEPA will adopt them for them. This mandate drove the regional monitoring because one of the things we wanted to know was what were the levels of these contaminants in receiving waters.

c. This estuary was nominated as part of the National Estuary Program back in 1987. It became one of the first five estuaries, called a tier one, around the country that was in the National Estuary Program. Through that program, we actually spent about two years developing a regional monitoring strategy, not just for the water column in San Francisco Bay, but also looking at wetlands monitoring and land use monitoring.

d. Developed an institutional framework for looking at regional monitoring on a grand scale through the San Francisco Estuary Project.

Third speaker - Karen Taberski, Regional Water Quality Control Board
Contaminants in Fish Tissue: Results of Pilot Study

1. Is it Safe to Eat the Fish? San Francisco Bay Fish Tissue Study

   a. Study done on contaminants in the San Francisco Bay, which was funded by the Bay Protection and Toxic Cleanup Program.

   b. Subsistence fishing. Many people who fish in San Francisco Bay are ethnic minorities, have a low income, and use the fish the Bay as a primary source of food. So they have valid concern about the safety of the fish.

   c. Began by putting together a study design committee made up of many state representatives and environmental groups including the Regional Board (study managers), the California Department of Fish and Game (contractors), San Jose State University (sampling), the University of California Santa Cruz marine labs (chemistry analysis), California State Hazardous Materials Laboratory (dioxin analysis), and the California Department of Health Services.

   d. Took 13 samples from a very good geographic distribution of sampling locations throughout the Bay. These locations were chosen based on the fact that people fished in these locations and there was some evidence of contamination, or it was a place where many people fished and we thought may be relatively clean to be used as a control.

   e. We also collected striped bass from the Sacramento River, sturgeon from Grizzly Bay and shark from the north and the south Bay.We had a priority as far as the fish, and the highest priority of fish is white croaker. We sampled three size classes of the highest priority fish, so we not only have three composites from each particular location, but also small, medium and large of each type so we could look at the size effect from different chemicals.

   f. To analyze we filet the fish, small fish with the skin on and the large fish with the skin removed, and we did this because we felt that this was the way most people ate the fish. We analyzed tissue for the pesticides, PAHs, and metals. A total of 494 fish were collected, 56 were analyzed.

2. Prime Study Screening Values.

   a. The prime study screening value was to identify potential chemicals and contaminants. We based those screening values on USEPA guidance document that was designed for this purpose, which came out in August 1993, the same month that we started the study, so this was just hot off the press. The only difference we had in our calculation of screening values was the USEPA guidance document uses consumption data of 6.5 grams per day. We decided to use 30 grams per day because our target population were recreational anglers, and in the document the EPA recommended to use 30 grams per day.

b. Now, everybody's aware there are all the different types of values to look at tissue concentrations. But we decided EPA's screening values because they were the only available values that were designed to screen fish data, the exact purpose of our study.

c. These values received extensive national review. They were reviewed twice by the different states and all federal agencies that have something to do with fish contaminant data, industry and environmental groups.

d. We used these screening values on the data. We identified six chemicals including PCBs, mercury, and dioxin.

3. Study Results

a. We graphed the individual concentrates of each toxic in various fish, white croaker, perch, striped bass, sturgeon, and shark. White croaker accumulated the highest level of PCBs, and that the level of PCBs was directly related to mercury content, so there was a very small correlation between mercury and PCB concentration.

b. In every location where we caught white croaker, except for one, the PCB concentration in the composite exceeded the screening value by several hundred times. This is not true of any of the other chemicals. The only other chemical that exceeded a screening value was dioxin, which exceeded the screening value by fifteen times. This points out that PCBs were clearly the chemical that contributed to the most health risk.

c. Sharks accumulated the highest levels of mercury, and the concentrations of mercury in leopard shark did not vary throughout the Bay.

d. The results of the study found that north Bay fish had the highest content of nonorganic contaminant levels. White croaker exhibits the highest of the concentration and the highest contaminant levels. Mercury levels were high in the two shark species, and white croaker exhibited increasing mercury concentrations.

e. As a result of this study, the Office of Environmental Health Hazards in Sacramento, in coordination with the Department of Health Services, did an independent analysis, and came out with an interim health advisory effecting the sport fishing in San Francisco Bay. This advisory says that adults should limit their consumption of San Francisco Bay sport fish to no more than two meals per month, adults should not eat any striped bass, and women who are pregnant or may become pregnant or who are breast feeding with children under six should not eat more than one meal per month, and in addition should not eat any meal of large shark or large striped bass. This advisory does not apply to salmon, anchovies, smelt, or other ocean type species.

f. We've been working with the Department of Health Services and many community organizations and local governments to publicize the striped bass health advisory.

g. This study was designed as a pilot study to get information on different contaminant levels in different fish species in the Bay. But what it did also was point a lot of deficiencies in the data and raise a lot of the questions. In future studies, we'd like to answer some of these questions.

1) We would like to sample other species of fish. We would like to see where the PCB's are coming from and how they're circulating through the food chain.We would like to collect additional samples of fish. For instance sturgeon, we only really had one sample of sturgeon and that's really not sufficient .

2) We would sample additional sites for all types of different fish. We'd like to look at seasonality, As you probably know, when fish go into reproductive cycle their liquid content decreases in all those tissues, and whether that decreases those contaminants might be something we'd like to know.

3) We'd like to sample where there are different ethnic populations than in San Francisco Bay eating different parts of the fish. For instance, in the sharks we found very low concentrations of organic contaminants in shark populations. Now, shark has a very fatty liver, it's very high in liquid content and it's possible that they could be accumulating those organic contaminants in the liver.

4) We'd like to institute an ongoing monitoring program so that we can keep track of what concentrations are in the fish throughout the Bay on an ongoing basis.

4. Good News from the Study?

a. Some things that are good news are that PCB's and DDT have all been banned in the 1970s and early 80s, a positive step.

b. Looking at sixteen years of mussel watch data, we've found steady and significant decreases of PCBs and DDT throughout those sixteen years. So this is a photo in time showing the concentrations of PCBs and the pesticides are declining.

c. We also measured selenium in the fish in the Bay, and we have lower concentrations than we expected. This is not to say that selenium is not a problem in the Bay, but in this study we did not find levels that would affect human health.

We would like to keep measuring selenium levels in fish and the birds that we catch in order to understand better the selenium cycle in the food chain.

d. And the last thing that's good news is that the dioxin levels were lower than in most areas in the United States. They were around background levels and did exceed EPA screening values but they were not that high. They were actually at background levels compared to other levels in the United States. This is not saying that they're not a problem or that we don't need to control sources of dioxin but they were relatively low compared to other areas.

e. The Regional Board intends to set up committees to study how additional amounts of these chemical contaminants get into the Bay. As we mentioned before with PCBs, there might be a runoff from urban sources or river systems that could contribute to the accumulation of or the input of these chemicals into the system, or storage of some of these chemicals. We're going to set up committees for many of these chemicals in order to determine if there's any way we can control the sources.

f. We want to develop funding for a comprehensive study and then we want to institute an ongoing monitoring program so that someday hopefully we can tell people that consuming fish from San Francisco Bay is healthy and there won't be a risk to you or your children.

5. Answers to Questions

Q: Are you aware of any resource studies being done on commercial fisheries?

MS. TABERSKI: Well, there are no commercial fisheries in San Francisco Bay, but there have been some studies done on commercial fisheries, actually for sharks. There's a national health advisory by FDA on eating shark because of mercury concentrations. We know that they sell shark in the grocery store, and a lot of the ocean grown sharks have higher levels of than what we've measured in San Francisco Bay. Many sharks exceed FDA action levels so there's an advisory of some sharks out there. We've looked at this a little but actually there isn't very much analysis of chemical level in commercial fisheries.

Q: Did you do a fish consumption survey?

MS. TABERSKI: No, we didn't, but Save the Bay has done one and they're coming out with their report shortly. Theirs was kind of a pilot study in a way too because they had 67 people I believe that they interviewed, but it does give us a good feel for the levels of consumption in the Bay. It would be a good idea to do a larger study like that so we can get a better idea of what people are eating from different locations and different communities and people who fish from the shoreline or the pier and people fishing from boats also.

Q: Did you look for a large number of pesticides that are still in use?

MS. TABERSKI: We looked at chlorinated pesticides. The other pesticides that accumulate in fish muscle tissue, we did not look at them. I think we should probably look at them in the comprehensive study, but at the time we didn't. Diazinon, for instance, seems to be a major problem as far as toxicity is concerned. I think that the particular chemicals that are out today could really cause high levels of toxicity but they don't cause as much of the bio-accumulation problem.

Q: Comparing these values to other places in the country like Chesapeake Bay or similar bays do we know if these are higher or lower?

MS. TABERSKI: Well, the levels for PCB's are pretty much similar to those in Santa Monica Bay, they're higher than those in Monterey Bay, they're lower than those in the Great Bay. The mercury levels are a little bit higher than in Monterey Bay and in Santa Monica Bay.

Q: Given you had such different screening values than the FDA action levels, will they make changes to those levels?

MS. TABERSKI: I don't know. I've worked a lot with FDA and it's really difficult to get them to change. I think there's a lot of pressure, particularly with PCB's, to change levels downward. The studies that EPA is doing on PCB's and dioxin might impact that.

Fourth Speaker - Dr. Rainer Hoenicke, San Francisco Estuary Institute
Local Effects Monitoring: Overview of What Others are Doing

1. Local Monitoring Programs; Purposes

   a. There are a number of programs that are spending an enormous of resources on different components in the estuary.

   b. The Interagency Ecological Program focuses on the fish components and some of the indicators that are used to measure the effects that the pumping and the flow regulations or the plumbing system have on the ecosystem. They have an annual budget of approximately ten million dollars.

   c. In addition to flows and pollutants, there are a number of other potential impacts influencing the estuary. That's why we conduct monitoring programs, to find out whether the dollars that we're putting into all of these programs, pollution prevention, are working.

   d. We tied resource goals with pollution prevention goals. We all have measurable goals, particularly for those contaminants that we know don't meet water quality criteria. We make management decisions with them, implement them and then we monitor. Special studies generate information that can be useful in telling you whether your programs' effects are successful or not.

e. One thing that generally is of importance of public awareness, and getting the public involved would be contributing to the solutions.

f. The San Francisco Estuary Program issued the *Comprehensive Information and Management Plan* two years ago now. There are several themes in that plan, pollutants are just one of them. If you don't know the other factors that might influence estuary health you may not be able to tell whether the money you're spending on pollutants is really directed in the right way. If you don't know what else contributes to the decline of biological resources such as fresh water diversion, intensified land use, habitat disruption, exotic species, you can throw money into pollutants until you're broke and you still don't get a healthy estuary. So, keep in mind, that pollutants may not be the only thing that's affecting the health of the estuary

g. The San Francisco Estuary Program is conducting the Regional Monitoring Program to figure out what's happening further away from the outfalls and how the estuary as a whole is impacted by pollutants and what are the levels of pollutants affecting water quality.

h. There's the Sacramento Coordinated Monitoring Program that can form some of the decisions that we make down here because they have some information that is relevant to us. For example, dredging introduces some or may introduce some contaminants too depending on where it's done.

i. Long-term monitoring strategy of the Army Corps together with EPA and fish monitors and a bunch of other entities. The Geological Survey is involved in that monitoring. There's a whole bunch of other programs that try to identify the natural and human impacts and what effects they might have on the health of the estuary.

j. Cooperative Efforts. We can see that there's a lot of potential for overlap, but there is also a lot of potential for cooperation. One of the goals in the next few years would be to take an inventory of these programs, see if we can find out their objectives, are they complimentary to each other, are they overlapping, can use IEP's sample from the north Bay or the Delta rather than activating our own resources. There is potential here for just an incredibly increased level of cooperation and saving money in the long run.

k. Volunteer Monitoring. There is a special effort under way to involve volunteers in monitoring efforts, to collect watershed resource data as well as water quality data. So what this does is that it may provide additional data for very, for relatively little money and help agencies to answer some of the questions that they're interested in, but there also it creates community awareness which you can use to support some of your lobbying activities. There is also a huge potential there for volunteers to take samples that storm water programs just don't have the resources to do.

Fifth Speaker - Michael Carlin, Regional Water Quality Control Board
Where Do We Go From Here?

1. Types of Monitoring Efforts

   a. Must review and prioritize and see how they fit in. It also takes a lot of effort to see how they fit into the ecological health of the estuary as well as the protection of human health.

   b. Regarding the relevant importance of sources, I think this is self-explanatory. The magnitude of sources varies over time, frequency and duration and sources. That's why we're collecting long-term data sets throughout the estuary.

   c. Trend monitoring gives a long-term perspective of how things are changing in response to how we are implementing regulatory measures.

2. Regional Board Monitoring Efforts

   a. The first phase of regional monitoring actually started back in 1988. We decided that we had some funds available, and we were going to go out and look at trace elements, trace metals in the estuary. We came up with a design for about 28 stations throughout the estuary looking at total and dissolved metals that we thought were of particular concern at that time. We also were looking at some toxicity associated with some of those sites with some additional money that we had. But this was just a preliminary effort, we just wanted to go out and see if we could do it.

   b. I must say that in 1988, '89 and '90, we had the most extensive data set of trace elements in an estuary in the country. And that data set has continued since 1989 and now we have a very nice data set of water column concentrations of certain trace elements.

   c. We selected trace elements not because they were of particular concern but we also had some historical data from the estuary that we wanted to compare to. There were some limited surveys that were done previously in the estuary by various researchers and we wanted to see historically how our data would actually compare. And we looked at a number of different data sets and these were the only ones that we considered to be actually viable data sets that the information was accurate.

d. To give you some results from the 1989 data, just to show you this perspective of difference in the concentrations, this is dissolved copper in the water column. Looking at these three different stations located up in San Pablo Bay, Suisun Bay, and one near the Golden Gate and one down in south Bay and you get an idea just visually that the concentrations are different, they're not substantially different, but they are different. The estuary actually functions as two different estuaries, one being the more official estuary that we see in the north, and then we have the southern arm of the estuary which is very much sort of a lagoon type of estuary so things happen differently. We have to approach our sort of interpretation of the data will be differently based on those differences and physical characteristics.

e. Looking at it from another perspective Station 11 happens to be the Golden Gate, Station 1 the extreme south Bay and Stations 26 and 27 being the Sacramento/San Joaquin River. You get an idea this is three different seasons: April, August and December. So you get a difference in seasonality . We do see some fluctuation but there is some trends that have started to develop. These trends have basically held firm but we need to have multiple water years to actually confirm how those are going to fluctuate with different water years.

3. Evolution of the RMP.

a. The Regional Monitoring Program started with just trace elements, then we started to expand it by looking at organics in the water column. That's very expensive to do but we thought it was important to get a perspective of what the concentrations were of certain organics in the water column. We started doing concentrations of organics and trace elements in sediment trying to get a relationship between the sediments in the water column.

b. We also did some bio-accumulation monitoring, and we did it from a little different perspective - seasonally. For certain organics, there are major differences by orders of magnitude whether the organisms will accumulate during the rainy season versus during the dry season.

c. We also started looking at some of the "fringe areas". It was important for us to understand not just what was happening in the channel but also what's happening in the fringes along the estuary. In essence, when we started looking at trace elements and trace organics in marshes we wanted to understand the concentration variations between sort of the channel areas where there's a lot of sediment and those areas which basically trapping sediment.

d. Now where is the future going to go? One of the things that we're interesting in doing is developing overall indices of habitat health. We would like to be able to come out every year and basically say that is the health of the estuary in a perspective way. We also would like to do that so that we can say that we have certain measures of success. If we are implementing a program, a regulatory program and we are doing certain things it's important that we can measure success.

e. Fish consumption is something we're very interested in 1997 pushing forward and we would like to do a comprehensive fish contamination study in the estuary.

f. The last thing is watershed monitoring. We were very interested not just in looking at what's happening in the estuary, but understanding how input from other sort of drainages, watersheds are affecting what's going on in the estuary. We have a very dominant system with the Sacramento and San Joaquin Rivers. We can actually come up with a very accurate number of trace elements coming out of the Sacramento River. But, I think there's little that we understand about how important the Napa River is or Sonoma or Petaluma. We need to understand how interactions take place and how can we improve the health and habitat of the Bay.

g. So that's an overview of where regional monitoring came from and where we're going with it. It is a base line program, a cooperative effort among 62 different participants. It's an effort that basically has gone from about a million dollars a year to about half a million dollars a year and that is going to be very long-term. It's not going to provide instant answers, but it will provide a perspective for now on what we should be looking at and it will hopefully provide us with measures of success in the future.

Sixth speaker -Dr. Rainer Hoenicke, San Francisco Estuary Institute
Regional Monitoring Program for Trace Substances in the San Francisco Estuary: 1993-1994 Results

1. Objectives

a. Collecting of data to tell us how polluted is the estuary, how has the estuary changed from a historical perspective. There's a number of data and studies around that show how estuary contamination has changed over the past hundred and fifty years or so.

b. The program focuses on contaminants, is the contamination getting better or worse, and if so, you know, is it getting better for which contaminant, is it staying the same, are contaminant levels above or below what it used to be. That's the very specific goal and purpose for the Regional Monitoring Program.

c. Lastly, a key objective for the program is to generate data compatible with other studies. We need to agree on performance standards of local effects monitoring programs so we can compare data with what USGS or the Sacramento program is doing, and integrate this information in a way that we can follow up on all the remaining questions.

d. We need to develop partnerships with other programs, to integrate data bases so that these individual pixels that agencies and organizations are developing and individual tiny little monitoring programs, that we can put these pixels into a picture that actually has some information content. So rather than just having snow on your TV screen we'd like to integrate individual pixels into a TV picture that makes sense.

2. What questions is the Regional Monitoring Program unable to answer at this stage?

a. There are definitely things we're not able to answer with the amount of certainty that is required for the pollution prevention managers to really focus on specific management actions quite yet. We're getting there though.

b. We're not able to point to or determine what the relevant contributions of contaminants are from municipal and industrial point sources, from urban runoff, from agricultural runoff, from atmospheric fallout, and sediment resuspension. We have a couple of hints where we can direct more specific studies to figure this question out, but, at this point, we just don't have the resources to determine the relative contributions of each one of these potential sources.

c. We're not able at this point to answer what the potential impact of the contaminants are on the estuary, and that's why the fourth objective of the monitoring program is so important so we can combine our data with other special studies from universities or other entities that are looking into that question. So when we put these things together I think we'll be able to get a better range of contaminant impact.

d. And we're not really, well, we're starting to address but not completely what the appropriate measurements are for evaluating whether certain reductions in pollutants are actually having their desired effect, and show the correlation between management actions and what we see in the environment. So we're looking into that, we're not there yet.

3. Changes in the 1993/94 RMP

a. Here are the sampling, the various sampling locations for 1994. We added eight stations to last year's program. At the request by the Regional Board, and with the consensus of all the participants, we added these two stations that are right by or around the outfall for the treatment plant. And another up into the rivers where the Sacramento and San Joaquin come together.

b. In 1994, we also looked for the second year in a row at two stations up river from there at Manteca and at Rio Vista. That program was discontinued in 1995 to make sure that we evaluate first what the Sacramento Regional Board is doing with USGS and to design that river component a little bit better. In 1995 our program commission just felt that we weren't getting enough information from the component to really continue that and we could spend the resources better in other areas. But, keep in mind for 1994, we also have two river stations further upstream.

4. Are certain contaminants that are above water quality criteria?

a. In 1993, PCB's were above water quality criteria at all stations sampled. In 1994, which was again a dry year, PCB levels were considerably higher than in 1993, and one of the patterns was that the south Bay in particular was much higher than the other stations. The National Toxics Rule says that the PCB criterion for water is .4 grams per liter, and you can see it's exceeded by a large magnitude, especially in the southern region of the estuary.

b. There were a couple of other organic contaminants too that were exceeding criteria at some stations monitoring all the DDT compounds. It's not surprising that there are higher concentrations towards the river end in the north Bay than in the south Bay, because we do have indications that the rivers are definitely a source of a number of pesticides. Ultimately there's a large reservoir either in the soil or storage. Who knows, maybe it still is being applied. We know that from our Manteca and Rio Vista stations that the river definitely contributes pesticides to the estuary.

c. Interestingly enough we found fresh DDT indicating that there's some fresh source of the stuff coming into the estuary. Usually DDT breaks down pretty quickly into the DDEs and DDDs, and by looking at the ratio of the break-down product you can just kind of age the stuff and find out how recently this source was introduced into the estuary. So that was kind of a surprising find at the north end of the Golden Gate Bridge. But DDT was found only at some stations, like four or five at the most. PCB's was the only group of organic contaminants that was exceeded everywhere throughout the estuary, which is kind of puzzling.

d. As far as the trace metals are concerned, concentrations of total copper, mercury and nickel were frequently above the EPA criteria.

e. As Michael and Sam indicated, the insecticide diazinon was above the guideline of the National Academy of Sciences for our fresh water station in the estuary. So we found pretty high diazinon levels in the south Bay also. So diazinon was above that guideline at key fresh water stations in the south Bay. I think the only time that we measured that was during the wet season, at the end of the wet season in April we found high levels in the south Bay.

f. There were three PAH compounds that were above water quality criteria. Total PAH, the sum of all the individual compounds, did not meet water quality criteria anywhere, but interestingly enough some of the compounds did. It was pretty obvious that they were derived from automobile combustion products. So urban runoff apparently contributes quite a bit of this contaminant group.

g. What we're planning to do next year is to look at the fingerprints that the PAH group provides for us out there in sediment and in the water and figure out what specific sources might contribute to the pattern that we find in testing the water so that we might be able to pinpoint down exactly what the different contributors to the whole profile are.

h. The same with PCB content. We'll dig deeper into the PCB story next year and we have some funding allocated for that. We'll be able to determine what the relevant contributors are, the point sources, the urban runoff, sediment resuspension. So we'll be able to assign some relative importance to different kinds of sources for PCBs.

i As far as trace elements go, copper had widespread elevation. A pattern is pretty apparent where copper is in high concentrations in the south Bay. The central Bay, which is primarily influenced by the ocean, had lower concentrations. And the Petaluma River station had some elevated concentrations as well. We don't use the hydrochloric extractions, we use a weak acid extraction for determining near total copper, and it's slightly different, it underestimates the copper concentrations in water, so these are conservative but they're still above water quality criteria.

j. Mercury and nickel were also found above various criteria. And the nickel story you have to take with a grain of salt because it may be natural. At the Petaluma River station, mercury stuck out like a sore thumb. Almost every year that during the April sampling period, we get a whole bunch of suspended sediment samples and it's reflected by the high concentrations. Generally mercury concentrations were highest in the south Bay. You still could make an argument that from the seasonal picture that we get more mercury, higher mercury concentrations in the wet season than in the dry season, so runoff might be a source.

k. Another example involves zinc. We see the similar patterns with the south Bay, it's most elevated than the central Bay. This whole zinc again we see that the shallow stations generally are much higher so there is a definite difference between dissolved and just whole concentrations. And the ratios aren't constant either, they're highly variable.

l. In addition to looking at water concentrations, we also looked at concentrations of sediment to show what the sediment concentrations looked like, and how they corresponded to the water concentrations.

m. We did find some aquatic toxicity at some stations, just south of the Richmond Bridge near the original harbor, and at the Napa River, so we did get some toxicity there during the wet season, but we have no idea what it means. They don't necessarily correlate with particularly elevated concentrations of one thing or another. We have no ability to do toxicity evaluations at this point so take those numbers with a grain of salt, we don't know what they're caused by.

n. In the sediments, we also found some toxicity mix. We found that nine of the twelve stations where we took sediments and where we tested for toxicity we found indications that sediments were toxic. Again, we don't know what that is caused by.

o. Most trace metals and all of the trace organic compounds were available for bio-accumulation. The PCB concentrations interestingly enough showed the same spatial patterns in biological tissue as in water. We happened to have oysters, the same species deployed in the south and some in the northern estuary stations so we could eliminate species variability there for that variable. And they showed distinct patterns.

p. We normalized these rates because different biospecies have different, I should say most organic contaminants are lipophilic, in other words, they accumulate primarily in the fatty tissue of organisms. And there are large differences between oysters, clams and muscles. Oysters are of the highest liquid content. We normalized it to make sure that we somehow accounted for the differences in liquid weight. Even if you liquid normalize it you generally see slightly higher concentrations in the oysters in the south Bay and in the north Bay than you'd see for example in the central Bay.

q. We also tried to figure out whether there were seasonal differences. In sediments, we had a hard time finding seasonal differences in trace organics in particular. And when we tried to compare patterns among the three different media, water, sediment and tissue, we really weren't able to identify any particular station that had extremely elevated concentrations, elevated dissolved concentrations in water, elevated total concentrations in sediment.

r. So there isn't any particular location in the Bay that is elevated in all three media, in any obvious way anyway, and that indicates, especially for sediments, that things are extremely variable and that we need quite a large data base to determine and kind of piece things out, especially with sediments.

s. Of course sediment contamination is also highly influenced by sediment type, the coarser the sediment is the lower the concentrations are in general. And the finer the sediment, the more surface we have for contaminants to cling onto. Therefore, the fine grain sediment locations have generally concentrations of contaminants and that may outweigh other variables.

t. Next year we're trying to integrate this a little bit more. Every year we're making additional steps to find out where or what the possible sources might be of different types of contaminants. As the data base grows we'll be able to determine with pretty quite a bit of certainty which contaminants are consistently elevated and should be focused on.

Attachment 3

TOC Literature Assessment Bibliography

Prepared by Larry Walker Associates

Toxic Organic Constituents Literature Assessment
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** Bolded references have or will be reviewed.*

Toxic Organic Constituents Literature Assessment
Section II Summary of Literature Reviewed

Author, Date, Title	TOC(s) Addressed				Topic(s) Covered					Summary
	Chlorpyrifos	Diazinon	Pesticides in General	Tributyltin	Source Ident.	Source Reduction & Control	Economic Impacts of Control Strats.	Sampling Results	Env. Impacts	
Chesapeake Bay Program, Basinwide Toxics Reduction Strategy, June 1994				x (toxics in general)	x			x		very broad description of toxics reduciton strategy.
Davidson, Nita A. Evaluation of Copper- and Tributyltin- containing Compounds, 1995				x	x	x			x	discusses fate of TBT in the env., alternatives to the use of TBT in cooling water systems, and options for controlling TBT.
Dept. of Pesticide Regulation, Public Report Pertaining to Copper and TBT-containing Pesticides, 1995				x	x	x				description of DPR ban on TBT cooling water additives.
Ernst, W., P. Hennigar, G. Julien, and J. Hanson. Changes in Organotin Concentrations of Water, Sediments, and Mussels in the Atlantic Region from 1988 to 1994.				x		x		x	x	monitoring of TBT in water, sediment, and mussels in high vessel (shipping) traffic, ship repair areas, and fishing and pleasure craft in an attempt to assess the effectiveness of the 1989 TBT ban. Was inconclusive.
Tributyltin Contam. of Sediments and Crassostrea Virinica in the Southern Chesepeake Bay, 1993				x	x			x		TBT in sediments and oysters correlated w/ commercial shipping & rec. boating
Evans et al, Tributyltin Pollution: A Diminishing Problem Following Legislation Limiting the Use...1995				x	x	x		provides refs.	x	evidence of effectiveness of tributyltin ban
Hall, Jr.,Lenwood,W.,Tributyltin Environmental Studies in Chesapeake Bay, 1988				x				x		Presents & discusses all available data on TBT monitor. and tox. studies in Ches.Bay
Hall,Jr. et al, Butyltin & Copper Monitoring in a N. Chesapeake Bay Marina and River System...1992				x	x			x		Measured TBT in water column during peak boating season & surveyed boat owners
Harrington, J.M., Tributyltin Residues in Lake Tahoe & San Diego Bay, CA, 1988				x		x		x		monitoring of DBT & TBT levels after 1987 ban
Huggett, R.J. et al. The Marine Biocide TBT, Assessing and Managing the Environmental Risks, 1992				x	x			x	x	Primary focus is on legislation restricting use of TBT on boats, some sampling results, and some recommendation for further risk assessment.
Hurwitz, E., NOAA Mollusk Monitoring Program Reveals Decreasing Contamination Along U.S. Coast, 9/27/95				x				x		brief news release re:mussel watch project which sampled for TBT.
ICI Paints, Paint and the Environment, 1996.				x		x				states that TBT (a fungicide) in paints has been replaced.
Kees, J., M. Kramer (ed.), Biomonitoring of coastal water and estuaries, July 1994				x				x		identifies contents which includes article on biomonitoring of TBT pollution using the imposex response of neogastropod mollusks.
Lenhan, H.S., et al, Changes in hard bottom communities related to boat mooring and TBT...1990				x				x		comparing TBT results of bays with many boats and few boats

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Matthiessen, P, et al, A method for studying the impact of polluted marine sediments on intertidal...1989				x				x		study of pollution of marine sediments on intertidal colonizing organism; test w/TBT
Minsky, Gary R. et al, Environmental Considerations for Cooling Towers, 1992				x	x	x	x			discusses altern. to wood treated materials used in construction of cooling towers
Press release, Toxics banned to help bay, 12/22/95				x	x	x				describes S.F. Bay area ban on tributyltin biocides.
Richard, NJ, HP Lillebo, Tributyltin: A California Water Quality Assessment, 1988				x						summarizes concerns over env. impacts from TBT, provides data & impacts in CA and elsewhere & outlines restrictions.
St. Hilaire, N. and J. Pellerin. Variations in the Scope for Growth of M. Edulis and M. Arenaria after a chronic exposure to TBT.				x	x				x	abstracts from workshop re: species specific tests with TBT, canadian restrictions on TBT, monitoring results, and USEPA cancellation of registration of products containing TBT flouride.
Trlox, Ozone Treatment for Cooling Tower Water, 1994				x		x				fact sheet re: alternative ozone system.
U.S. Coast Guard, Sea Partners Campaign, 1996				x	x					notice to boaters of dangers of and ban on TBT in anti-fouling paints.
USEPA Region VI, Regional Environmental Monitoring and Assessment Program (EMAP), 1993				x				x		Results of 1991 EMAP and plans for future sampling of sediments for TBT.
USF&WS, Tin Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, Jan 1989				x	x				x	toxicological aspects of tin compounds w/ emphasis on fish and wildlife resources. Discusses sources and recommends criteria.
Water Resources Research Center, Publications List			x	x						Reference list
Weis, Judith S., Tributyltin and Public Policy, 1989				x	x	x	x			discusses history of use, development of legislation (opponents & supporters)
S.F. Estuary Institute, S.F. Estuary Regional Monitoring Program for Trace Substances 1994 Annual Report	x	x		x	x			x	x	results of water sampling for diazinon and methylchlorpyrifos and bivalve tissue sampling for TBT (pg. 61,78,131,256-7
MacCoy, D, K.L. Crepeau and K.M. Kuivila, Dissolved pesticide data for the San Joaquin River at Vernalis and the Sacto River at Sacto, CA, 1991-94, 1995	x	x	x					x		data results and explanation of monitoring program.
Pressley, T.A. and J.E. Longbottom, The Determination of Organophosphorus Pesticides in Industrial & Municipal Wastewater, Jan 1982	x	x	x					x		Technical report - method 622 (gas chromatograph) sampling methos, QA/QC, results

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USEPA. Best Management Practices for Agricultural Nonpoint Source Control. IV, Pesticides: for the project rural nonpoint source control water quality...1992	x	x	x		x	x				discusses pesticide pollution prevention controls to reduce pesticide loses to aquatic systems, some chemical specific info., but mostly crop specific. Also discusses integrated pest management (IPM) systems.
USEPA Region 10, 1990 Puget Sound Pesticide Reconnaissance Survey, Aug 1991	x	x	x		x			x		Description of 1989-90 pesticide reconnaisance survey monitoring for 33 pesticides in water and sediment,
USGS, Water Fact Sheet; Diazinon concentrations in the Sacto and San Joaquin Rivers and S.F. Bay, CA, Feb 1993	x	x	x		x			x	x	Describes dissolved concentrations and movement of diazinon through the Sac/San Joaquin Delta and S.F. Bay.
RWQCB (Central Valley) Memo from Val Connor to Jerry Bruns re: status of urban storm runoff projects, Jan 30, 1995	x	x			x			x		Summarizes status of urban storm runoff program to identify constituents in Sacto urban runoff.
RWQCB (Central Valley), Assessment of Needs for Pesticide Control, April 18, 1995	x	x			x					Draft of a proposed program to control pesticide contamination in the Delta watershed.
RWQCB Memo from Val Connor to Jerry Bruns & Chris Foe re: Chlorpyrifos in Urban Storm Runoff, Jan 28, 1996	x	x						x		Results of 1994-95 storm season study in Sacto, Stockton and Bay area.
S.R. Hansen Associates to Elissa Callman (letter), City of Sacramento, Jan 8, 1996	x	x						x		Letter discussing finding of diazinon as cause of toxicity.
Sacramento Ambient Program, Discussion Paper re: options for pesticide analysis by the ambient monitoring program, Nov 1995	x	x						x		options and cost projections for diazinon and chlorpyrifos sampling.
Kroll, R.B. and D.L. Murphy, Pilot Monitoring Project for 14 Pesticides in Maryland Surface Waters, EPA/Chesepeake Bay Program, Mar 1994	x		x		x			x		Description of 1992 monitoring of surface waters and sediments for pesticides
Snow, J.T., Loss of Nitrogen and Pesticides from Turf via leaching and runoff, date?	x		x		x	x				Results of pesticide runoff studies from golf courses and brief evaluation of runoff control BMPs.
Jarvinen, A.W., D.K. Tanner, & E.R. Kline, Toxicity of Chlorpyrifos, Endrin, or Fenvalerate to Fathead Minnows following episodic or continuous...1988	x								x	Review of toxicological hazard to Fathead Minnows, toxicity test methods and results.
USF&WS, Chlorpyrifos Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, Mar 1988	x				x	x			x	Chemical and toxicological evaluation including proposed criteria and research needs to protect fish and wildlife.

Toxic Organic Constituents Literature Assessment

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USGA, Research Results (no date)	x				x			x		Results of research to determine impact of pesticides in groundwater and surface water/leaching potential from golf course
APAI, Diazinon Occurence, 1993		x					x	x		Results from studies around the country in very brief fromat. Gives costs of diazinon treatment methods.
Burkhard, L.P. and J.J. Jensen, Identification of ammonia, chlorine and diazinon as toxicants in municipal effluent, Nov 1993		x						x		Describes TIE performed on municipal effluent.
Cal. Dept. of Fish & Game, Hazard Assessment of the Insecticide Diazinon to Aquatic Organisms in the Sacto / San Joaquin River System, 1994		x			x				x	Review of studies to assess hazard of diazinon to aquatic life.
Guinn, R., J. Coulter and K. Dickson, Use of Constructed Wetlands to Reduce Diazinon, 1995		x				x				Inconclusive results of study using constructed wetlands to treat diazinon.
Mayer, J.R. and N.R. Elkins, Potential for agricultural pesticide runoff to a Puget Sound Estuary, Aug 1990		x						x		Runoff monitoring for 14 pesticides into estuary. No samples found diazinon.
Regional Urban Stormwater Management Strategy for the Dallas/Fortworth Metroplex, 1995 (?)		x						x		Diazinon judged to be of high priority as a constituent of local concern.
RWQCB (Central Valley) - overheads from a presentation on pesticide toxicity on urban strom runoff		x						x		overhead slides detailing RWQCB studies on pesticides in urban runoff
RWQCB-Central Valley Region, EPA 104(B)(3) Proposal to Study Aerial Distribution and Transport of Diazinon, 1994		x			x			x		Proposed to determine the temporal and spatial distribution of diazinon in the air
Short, Don E. and Jim Castner, Beneficial Insects (no date)		x				x	x		x	1 page fact sheet about environmental costs of using diazinon and other pesticides.
Texas Water Commission, Analysis of Fish Kills & Assoc. Water Quality Conditions in the Trinity River, 1990		x						x		Brief description of available pollutant monitoring study report (Internet site)
USF&WS, Diazinon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, Aug 1986		x			x				x	Ecological and toxicological review of diazinon including chemistry, toxicity, sublethal effects and criteria recommendations.
Anderson, Changes in pest control practices reduces toll on wildlife, 1995			x		x	x			x	focus on ecotox. & loss of biodiversity due to use of biocides

Toxic Organic Constituents Literature Assessment
Section II Summary of Literature Reviewed

Author, Date, Title	TOC(s) Addressed				Topic(s) Covered					Summary
	Chlorpyrifos	Diazinon	Pesticides in General	Tributyltin	Source Ident.	Source Reduction & Control	Economic Impacts of Control Strats.	Sampling Results	Env. Impacts	
Robinson, James C., et al, Pesticides in the Home & Community: Health Risks & Policy Alternatives, 1994			x			x	x			source control, reduction, economic issues of pesticide use are discussed
USGS, California Water Issues and Program Development, Apr. 1995			x							Non pollutant specific account of USGS programs which mention pesticides as one type of pollutant being sampled.
Valkirs, Aldis O., et al, Long-Term Monitoring of TBT in San Diego Bay, CA, 1991			x		x	x		x		Water, Sediment, & Tissue Monitor. results before & after ban of TBT anti-fouling use
Bane, G., Raspberry Growers and a Cleaner Puget Sound, Journal of Pesticide Reform 20, 1994						x				Non-specific article about clubs sharing experiences with alternative pesticide use practices.
Chesapeake Bay Program, Chesapeake Bay Attitudes Survey, April 28, 1994.										Results of residential survey re: pollution in Chesapeake Bay - very general & not particularly applicable.

Toxic Organic Constituents Literature Assessment
Bibliography
Section III Personal Communications*

EPA Region 1

Cromwell, Nicole. Save the Bay. Rhode Island.

Linker, Lewis. Chesapeake Bay Program.

EPA Region 2

EPA Region 3

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EPA Region 7

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Christensen, Lyle. Lincoln-Lancaster POTW. Nebraska.

Davis, Jeri. USGS Water Resources Division.

Elfving, Julie. USEPA.

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Jensen, Dave. Nebraska.

Keehart, Betty. Missouri. Non-point source contact.

Smethen, Don. Kansas. Non-point source contact.

Timmons, Terry. DNR-drinking water. Missouri.

Twilman, Ron. City of St. Louis, public water supply.

Witt, Emmitt. USGS Water Resources Division.

EPA Region 8

EPA Region 9

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Gorke, Roger. Heal the Bay. CA.

Jurkevics, Lauma. Los Angelos Regional Water Quality Control Board, CA.

Pesticide Action Network (Adam).

Wybenga, Jim. Orange County.

Yu Wang, Guang.

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