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Screening Evaluation of Dioxins Pollution Prevention Options

Prepared for the San Francisco Bay Area Dioxins Project

September 5, 2001

PREFACE

This is a report of research performed by TDC Environmental LLC for the San Francisco Bay Area Dioxins Project. The Bay Area Dioxins Project was started in the fall of 1999 by San Francisco Bay Area local government agencies wishing to work together to study the problems of dioxins and recommend possible solutions or actions for local governments around the San Francisco Bay.

The San Francisco Bay Area Dioxins Project is managed by the Association of Bay Area Governments (ABAG). Project activities, including this work, are funded by the United States Environmental Protection Agency and contributions from several of participating municipalities: the City and Port of Oakland, Alameda County, the Cities of Berkeley and Palo Alto, and ABAG.

Because of the uncertainties inherent in research work and the finite resources available for this work, TDC Environmental does not make any warranty, expressed or implied, nor assume any legal liability or responsibility for any third party's use of the results of or the results of such use of any information, product, or process described in this report. Mention of trade names or commercial products, organizations, or suppliers does not constitute endorsement or recommendation for use.

Although the work described in this report has been funded in part by the United States Environmental Protection Agency through Grant Number X989636-01 to the Association of Bay Area Governments, it has not been subjected to the Agency's required peer and policy review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

ACKNOWLEDGEMENTS

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ABAG and many of the municipalities participating in the San Francisco Bay Area Dioxins Project provided valuable information to support this work.

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INTRODUCTION

On behalf of the San Francisco Bay Area Dioxins Project, TDC Environmental conducted a screening evaluation of various dioxins pollution prevention options for San Francisco Bay Area municipalities. This report summarizes the findings of the review. Appendix A provides the detailed results. The report includes a small amount of background information to answer questions commonly raised during discussion of pollution prevention alternatives for dioxins sources.

This report explores potentially feasible actions that can be taken by San Francisco Bay Area local governments that would prevent dioxins formation. In order to make the most effective use of available resources, the review focused on a relatively small set of likely pollution prevention project options, seeking to identify critical factors that could affect municipalities' interest in pursuing each option. This type of analysis is called a "screening evaluation" because it involves a systematic investigation of a set of possible actions to identify benefits, detriments, and implementation issues associated with each possible action. Given the nature of this review, it is possible that municipalities seeking to implement one of the identified pollution prevention options may encounter significant issues not identified in this screening exercise. This report does not imply that implementing the types of actions reviewed here will achieve a particular outcome, as outcomes depend on the context and details of a project's implementation.

The report does not recommend a specific path of action for dioxins project participants. Such decisions rest with the municipalities participating in the Bay Area Dioxins Project.

To prepare this report, TDC Environmental reviewed information on the identified dioxins pollution prevention alternatives obtained from participating municipalities, the United States Environmental Protection Agency (U.S. EPA) and other state and Federal agencies, TDC Environmental's library, technical journals, high-quality Internet sites, the Dioxins 2000 and People's Dioxins Conferences, and other professionals in the pollution prevention field. TDC Environmental received significant data gathering assistance from the retired engineers program of the Western Regional Pollution Prevention Network.

A draft of this report was circulated for public review and comment. Almost 40 people and organizations commented on the draft report. Appendix C describes the public input process and contains answers to questions regarding the purpose and format of this report. The public comments included a good deal of useful information that was incorporated into this final report.

BACKGROUND

The term "dioxins" commonly refers to a family of complex, but related molecules with similar chemical structures. Within the dioxin family of substances (which includes dioxins, furans, and dioxin-like polychlorinated biphenyls), each unique structure is

called a "congener." Among dioxins and furans there are 210 distinct congeners; polychlorinated bipyenyls (PCBs) have 209 congeners.[1]

The many members of the family of dioxins molecules exhibit similar toxicity; however, not all dioxins, furans, and dioxin-like PCB congeners are equally toxic. The number and location of the chlorine atoms attached to these molecules and the molecule shape (for PCBs) determine their toxicity. The most toxic congener in the dioxins family is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, often called TCDD. The "Toxicity Equivalency Factors" (TEFs) were developed to provide a convenient method for evaluating the complex mixtures of these substances that exist in the environment.

Using TEFs, it is possible to convert chemical concentrations of dozens of individual congeners into a single number, which is an estimate of an equivalent quantity of TCDD. The U.S. EPA has proposed to adopt the World Health Organization's (WHO's) 1998 TEF scheme to weight each dioxin, furan, and dioxin-like PCB congener according to its relative toxicity (U.S. EPA, September 2000). The WHO 1998 scheme has TEFs for 7 dioxins, 10 furans, and 12 dioxin-like PCBs (the remaining congeners are assumed to have TEFs of zero). When the quantities of various congeners are multiplied by their TEFs and added together, the result is a "Toxic Equivalent" (TEQ).

Because the TEQ system greatly simplifies presentation of dioxins data, this report (like most other work on dioxins) utilizes this convenient shorthand. In reviewing this report, readers should assume that all dioxins values presented are TEQs. Unfortunately, since most historic dioxins source investigations have not analyzed for dioxin-like PCBs, none of the quantitative data presented in this report includes dioxin-like PCBs. This unavoidable problem is likely to result in understating dioxins levels in many instances. Since most available U.S. dioxins data uses the previously preferred scheme adopted by U.S. EPA in 1989 (the I-TEQ scheme, which considers only 17 dioxins and furans), the data in this report use that scheme unless otherwise noted.

Dioxins Health Issues

The National Toxicology Program, part of the U.S. Department of Health and Human Services, and the International Agency for Research on Cancer have classified TCDD as a known human carcinogen (NTP, 2001; McGregor, 1998). U.S. EPA has similarly proposed to classify TCDD as a human carcinogen and other dioxin-like compounds as "likely human carcinogens" (U.S. EPA, September 2000).

Non-cancer health effects from dioxins may be of even greater concern than cancer. In humans, dioxins have the potential to produce a broad spectrum of adverse effects, because they can alter the fundamental growth and development of cells in ways that have the potential to lead to many kinds of impacts (U.S. EPA, September 2000). For example, dioxins can weaken the immune system and interfere with the endocrine system, which is responsible for making hormones needed to regulate bodily functions including sexual development and fertility.

[1] Additional dioxin-like molecules may be formed where some or all of the chlorine atoms are substituted with fluorine or bromine, elements with many properties similar to chlorine. Alternatively, sulfur atoms could replace oxygen atoms. This report does not address these substitutions because limited data exist on these molecules, their toxicities, and their presence in various environmental media.

At current human population body burdens, U.S. EPA research shows the following (U.S. EPA, September 2000; Birnbaum, 2000):

- Biochemical effects from dioxins exposures may be occurring in the general population. We do not know whether these changes are adverse for people.
- Many clearly adverse effects (such as impacts on immune system function and diabetes) may occur at concentrations that are less than 10 times the average exposure of the U.S. population.
- Cancer risks could exceed 1 in 1000 for the general population.

However, it must be recognized that these findings are based on risk assessment methods that include extrapolation of test data from animals to people. For this reason, U.S. EPA scientists caution that actual risks to most U.S. residents are likely to be lower than the risks presented above and may be as low as zero for some members of the population (Birnbaum, 2000; U.S. EPA, September 2000).

U.S. EPA estimates that the typical U.S. resident receives more than 95% of his or her dioxins exposure from consumption of animal fats. Meat, fish, poultry, and dairy products provide most of the dioxins in a typical U.S. resident's diet (U.S. EPA, September 2000). A 1995 nationwide survey of the food supply using FDA estimates of food consumption in typical U.S. diets found that U.S. population dioxins exposures[2] exceed current World Health Organization dioxins consumption guidelines[3] (Schecter, 2001). Currently, there is no routine monitoring of the U.S. food supply for dioxins levels; however, the Food and Drug Administration is planning to add dioxins monitoring to its national food monitoring program (Osvath, 2001).

In California, only one systematic study of dioxins levels in humans has been conducted (Petreas, 2001). That study, which evaluated dioxins levels in breast tissue from women in the San Francisco Bay Area and dioxins in breast milk from low-income women in Stockton (generally downwind of the Bay Area), found dioxin levels to be similar to those measured elsewhere in the world. Comparison with similar data from the late 1980s showed a small but statistically significant decrease in dioxins levels, consistent with worldwide observed decreases in human dioxins body burdens.[4]

Certain communities are exposed to higher than average dioxins levels. U.S. EPA has documented elevated community dioxins exposures from food contamination incidents, workplace exposures, industrial accidents, and consumption of unusually high amounts of fish, meat, and dairy products containing elevated levels of dioxins (U.S. EPA, September 2000). Locally, concerns have been raised regarding people who rely heavily on San Francisco Bay fish as a food source and people residing near air emissions sources like incinerators or truck terminals. Because such special exposures

[2] 2 to 6 picograms (WHO TEQ) per kilogram body weight per day. Nursing infants were found to have a higher exposure of 42 picograms (WHO TEQ) per kilogram body weight per day. These values were calculated using WHO's TEQ scheme that includes PCBs.

[3] The World Health Organization (WHO) recently revised its intake guidance ("tolerable daily intake") for dioxins, changing it from 1 to 4 picograms per kilogram body weight per day (WHO TEQ, WHO Consultation, 1998) to a provisional tolerable monthly intake of 70 picograms per kilogram body weight per month (WHO TEQ; an average of about 2.3 picograms per day). According to WHO, a considerable fraction of the world population has a food consumption–related dioxin intake above this level (FAO/WHO, 2001). These values are all based on WHO's TEQ scheme that includes PCBs.

[4] These reductions may be related to reduced dioxins releases from known dioxins sources (see Appendix B).

have received little scrutiny, it is not clear how significant they are to overall human health risk (Birnbaum, August 14, 2000).

The U.S. EPA Science Advisory Board completed a peer review of the draft U.S. EPA dioxins risk assessment that is the source of much of the above health information (U.S. EPA, May 2001). In its peer review report, the Science Advisory Board Review Panel concluded that the draft risk assessment provided a careful, thorough review of the voluminous literature on dioxins health effects. While there was some disagreement about certain risk assessment elements due to gaps in the available data (for example, almost half of the Review Panel did not support classification of TCDD as a known human carcinogen), the review panel agreed that additional research is unlikely to bridge many of the important data gaps in the foreseeable future. After recommending that U.S. EPA proceed expeditiously to complete the dioxins risk assessment, the Review Panel stated:

> "Consistent with sound environmental and public health policy, the [SAB Review] Panel believes that it is important that EPA continue to limit emissions and human exposure to this class of chemicals in view of the very long biological and environmental persistence of these chemicals."

Dioxins Environmental Properties

Dioxins are highly toxic substances that persist for long[5] periods in the environment, where they bioaccumulate in living tissues—hence, their classification as "persistent, bioaccumulative, toxic pollutants." Due to their chemical properties (slow decomposition rate and low but environmentally important volatility), dioxins released to the environment can travel far from their sources. In the environment, dioxins move from one environmental medium to another relatively readily.

BAY AREA DIOXINS PROJECT

In 1999 and 2000, several San Francisco Bay Area municipalities and the Executive Board of the Association of Bay Area Governments (ABAG) adopted resolutions calling for dioxins pollution prevention and dioxins elimination.[6] The resolutions were motivated by concerns about the health and environmental effects of typical dioxins exposures as well as by the additional risks experienced by highly exposed communities (*e.g.*, members of communities who routinely consume fish from San Francisco Bay and neighbors of a regional medical waste incinerator). To meet the challenge of the resolutions—the elimination of dioxins formation—the municipalities initiated the San Francisco Bay Area Dioxins Project under the auspices of ABAG.

The primary goals of the Bay Area Dioxins Project are:

- To pool local governments' knowledge and resources to study dioxins and to provide information about possible solutions or actions for local governments in the San Francisco Bay Area;
- To coordinate efforts with state, federal, and regional agencies working on dioxins issues; and

[5] Some evidence has shown that dioxins can degrade in the environment, but in general they are considered very persistent—among the most persistent organic compounds (U.S. EPA, September 2000).

[6] To date, the City and County of San Francisco, County of Marin, the Cities of Oakland, Palo Alto and Berkeley, and the Port of Oakland have passed dioxins resolutions.

- To work with community groups, trade and industry groups, and the general public on issues of concern related to dioxins.

Municipalities' concern about environmental justice is a fundamental reason for forming the Bay Area Dioxins Project. Environmental justice is the fair treatment of people of all races, cultures, and income with respect to the development, implementation, and enforcement of environmental laws, regulations, programs, and policies. Fair treatment means that no racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from the operation of industrial, municipal, and commercial enterprises and from the execution of federal, state and local programs and policies. To address environmental justice, the Bay Area Dioxins Project is identifying the geographic area (and where possible, specific communities) affected by possible dioxins-related actions and is soliciting public participation in its activities.

This report is part of the Dioxins Project's effort to identify ways that local government agencies can prevent further dioxins releases locally and within the global context. Partially funded by a Persistent, Bioaccumulative and Toxic (PBT) Substances Program grant from U.S. EPA and partially funded by Bay Area local governments, this screening evaluation report is intended to provide participating municipalities with information needed to assess the viability of possible dioxins pollution prevention projects. The Center for Environmental Health, under additional grant funding from U.S. EPA, helped to ensure a broad public review process for this report so that interested parties were able to offer input to local government agencies selecting projects.

This report is intended to provide information to project participants that—along with public input—will inform the project selection process. Using information from this report and the input from the public review process, local governments will select projects for implementation. Then a consultant will work with agencies to develop, implement, and evaluate the selected projects. Project participants plan to implement the selected dioxins pollution prevention projects working cooperatively with the San Francisco Bay Area community and state and federal agencies (involving all environmental media).

DIOXINS SOURCES

Dioxins are not created intentionally. They are waste byproducts of combustion, chemical manufacturing, and chlorine bleaching. While dioxins generally appear to be formed by human action, some dioxins have been linked to apparently natural sources, such as those in ball clays (Ferrario, 2000).

Dioxins are so prevalent in today's environment that every person, animal, plant, and product probably contains dioxins. This means that even if chlorinated chemical manufacture, chlorine bleaching or combustion are not involved in a manufacturing process, a product probably contains dioxins. For example, virgin pulp sources (trees) and paper processing solutions contain dioxins from air deposition. Even if such materials are used in "chlorine free" paper manufacturing, the paper product is not completely "dioxin-free" (Commoner, 1996).

Unfortunately, even natural products that are burned today contain above-background levels of chlorine from biochemical uptake of chlorinated compounds dispersed by humans into the environment. For this reason, complete prevention of human-caused

dioxins formation would necessitate either the termination of all fires or the prevention of all releases of human-made chlorinated substances into the earth's ecosystem.

The U.S. EPA, several other nations, and many groups of scientists have attempted to inventory national or world dioxins emissions (U.S. EPA, September 2000; U.S. EPA, March 2001; New Hampshire Department of Environmental Services, 2001; Battelle, August 2000; Environment Canada, 2000; Eisenberg, 1998; Thomas, 1996; Baker, 2000; Duarte-Davidson, 1997; Brzuzy, 1996; Holoubek, 2000; Dyke, 2000). Appendix B contains a summary of the U.S. EPA's National Dioxins Inventory (all of the other inventories rely heavily on the U.S. inventory information). Unfortunately, current dioxins source inventories do not account for most of the world's annual dioxins deposition. A recent analysis of global dioxins inventories concluded that inventoried emissions account for only a small fraction[7] of all of the dioxins deposited annually on the earth's surface (Eisenberg, 1998). Remaining sources of the deposited dioxins are unknown (but are likely to be related to human activities to some extent)—they may include additional sources of dioxins formation, dioxins cycling to and from soils and sediments, and atmospheric formation of dioxins from airborne precursors.

Currently, available information regarding local dioxins sources is limited.[8] The Bay Area Air Quality Management District and the San Francisco Bay Regional Water Quality Control Board have attempted to estimate current dioxins releases to air and water, respectively. Appendix B contains summaries of these limited available data regarding San Francisco Bay Area dioxins sources. The data in Appendix B are highly uncertain because they are based on limited source testing and extensive extrapolation of that limited data. For example, the BAAQMD's diesel vehicle emissions estimates relied on a 1998 U.S. EPA emissions estimate that was based on tests of two U.S. trucks and several contradictory sets of European diesel vehicle test data (results differed by more than 1,000 times) (Bateman, 1998; U.S. EPA, April 1998).[9] Wood burning estimates are also based on extrapolation of extremely limited data—two measurements of dioxins emissions from wood stoves (not fireplaces) in Europe.

The most important limitation of available dioxins source inventories is that many dioxins sources have not been adequately characterized. In a 1998 report, Communities for a Better Environment (CBE) provided a lengthy critique of San Francisco Bay Area dioxins source inventories. In addition to calling for more complete and more frequent monitoring of dioxins sources using lower detection limits, the report provided a list of sources that CBE believes are priorities for characterization, which included refineries, chemical companies, hazardous waste management companies, metal reclaimers, drum reclaimers, sewage sludge incinerators, cement kilns, foundries, power plants, and medical waste incinerators (CBE, 1998). A recent paper by the same author (Karras, 2001) follows up on the 1998 CBE report by offering a "Dioxin Pollution Prevention

[7] Depending on the world dioxins inventory used (several have been prepared), the fraction accounted for ranged from a low of one twentieth (about 5%) to a high of one sixth (about 17%) of all dioxins deposited on the earth's surface each year (Eisenberg, 1998).

[8] Most available environmental data provides information on dioxins levels in humans or the environment or about dioxins conveyances, not actual sources or prevention measures.

[9] The data set included no data whatsoever for off-road vehicle sources (almost half of the BAAQMD diesel emissions estimate) . Additional studies conducted since 1998 continue to show significant scientific disagreement about the magnitude of diesel dioxins emissions (Geuke, 1999; Gertler, 1998). Detection limit problems and methodology problems probably account for the tremendous differences in diesel vehicle emissions estimates (Truex, 1998).

Action Inventory" of San Francisco Bay Area dioxins sources; it suggests that many of the sources named as priorities for investigation in the previous report are also priorities for dioxins pollution prevention actions.

At the Dioxins 2000 and People's Dioxin conferences, various speakers noted that the following sources were missing from the March 2000 version of U.S. EPA's national dioxins emissions inventory: residential and commercial coal combustion, magnesium manufacturing, small commercial incinerators, open-burning of PVC-coated wires, asphalt production, landfill fires, landfill gas combustion, coke production, leaded gasoline combustion, iron sintering, all landfilled wastes, most dioxin-contaminated ball clay uses, and petroleum refining (other than catalyst regeneration) (notes from various conference speakers, compiled in Moran, 2000). Some of these sources were addressed in the September 2000 update to the U.S. EPA national dioxins inventory, but lack of dioxins emissions data keeps many potential sources out of current dioxins inventories (U.S. EPA, September 2000).[10] U.S. EPA has stated that it is unlikely that emissions of dioxins from known sources (those identified in the national dioxins inventory) correlate with general population exposures to dioxins (U.S. EPA, September 2000).

Because dioxins testing is expensive and technically challenging, emissions from many potential dioxins sources have not been measured.[11] Special sample collection and laboratory methods must be used to measure environmentally meaningful dioxins levels. Available dioxins emissions test results are typically difficult to interpret for one or more of the following reasons:

- Many of the important congeners were not detected.[12]
- Dioxin-like PCBs were not included in the testing.
- Blanks or controls contained dioxins (which could mean that the samples or sampling equipment were contaminated).
- Results understated dioxins releases because environmentally meaningful quantities of dioxins were left in sampling apparatus.
- Unusual or upset conditions (such as fires, accidents, and high or low production rates) were not monitored.
- The monitoring involved only a tiny fraction (less than 1%) of annual releases from a given source.

DIOXINS POLLUTION PREVENTION OPTIONS

"Pollution prevention" means stopping pollution at the source. For this project, it has a very simple meaning—preventing the formation of dioxins.[13] For highly toxic, difficult to measure pollutants like dioxins, pollution prevention is a logical approach, because it does not require costly monitoring, it eliminates expensive disposal of contaminated materials, it prevents transfer of the pollutant from one environmental medium to

[10] U.S. EPA has compiled a list of dioxins sources that are "not quantifiable" and therefore not included in source inventories, including ball clay products; uncontrolled combustion of PCBs; primary aluminum and nickel smelting; manufacturing and use of chlorophenols, chlorobenzenes, chlorobiphenyls, dioxazine dyes and pigments, 2,4-D; and tall oil-based liquid soaps, and releases from most reservoir sources, including aquatic sediments and pentachlorophenol treated wood (U.S. EPA, March 2001).

[11] Such sources are, of course, omitted from the Appendix B inventories.

[12] Treatment of the "non-detect" results is the subject of significant scientific and policy debate.

[13] While dioxins controls, treatment, cleanup, and exposure-reduction measures may be of interest, such actions do not prevent formation of dioxins, so they have not been included in this analysis.

another, and it ends the controversy over “how low is low enough” inherent in pollution control measures.

In their quest to select dioxins pollution prevention projects to implement, Bay Area Dioxins Project participants sought to spend their resources reviewing a set of "most likely" dioxins pollution prevention options rather than conducting a comprehensive options screening exercise. Dioxins Project participants and TDC Environmental sought to develop a list of dioxins pollution prevention options that includes a reasonable range of dioxins pollution prevention activities that would be feasible for municipalities to implement. Table 1 presents the list of dioxins pollution prevention options screened in this report, which are listed in alphabetical order by dioxins source.

Table 1. Dioxins Pollution Prevention Options Selected for Screening

Dioxins Source	Pollution Prevention Options
2,4-D (broadleaf weed pesticide)	• Mechanical weed control • Other weed control pesticides
Agricultural Burning	• Non-burning alternatives
Diesel Engines	• Natural Gas • Biodiesel • Oxydiesel • Diesel engine retrofits • Reduce trips/change modes
Drum Reclamation	• Non-burning methods
Medical Waste	• Non-incineration medical waste management methods • Reduce medical waste volumes • Eliminate medical PVC use
Paper Bleaching	• Process or totally chlorine free paper • Elemental chlorine free paper
Pentachlorophenol	• Non-wood alternative utility poles • Different wood preservatives
Petroleum Refining	• Refining process modifications
Polychlorinated Biphenyls (PCBs)	• Remove from service
Polyvinyl Chloride (PVC, “vinyl”)	• Non-PVC alternatives
Wood Burning	• Natural gas fireplaces • EPA-certified wood stoves • BAAQMD model ordinance • “Better wood burning practices” • No burning

No true pollution prevention activity is available for pure polychlorinated biphenyls (PCBs), since PCBs are no longer being manufactured. The option included in Table 1 involves removing PCB-containing items from municipalities. While PCB removal prevents releases of dioxins to the environment, it does not prevent dioxins formation, so it is not technically pollution prevention. While removing PCBs is a valuable activity, it may not be consistent with the project goal of using the pollution prevention approach.

Because the list of options was not created through a complete and formal analysis of dioxins sources, several major categories of dioxins sources included in Bay Area and national dioxins inventories are not included in the list of pollution prevention options. These categories and the initial reasons for their omission are listed below:

- Activities that are not directly or indirectly affected by San Francisco Bay Area municipalities (like municipal waste incineration, which does not occur in the San Francisco Bay Area), because project participants have limited influence over such activities.
- Gasoline vehicles, because a plethora of other programs (being conducted by local, state, and federal agencies) seek to reduce use of gasoline and operation of gasoline vehicles.
- Incineration of hazardous chemical (non-medical) waste generated by municipalities, because the amount of hazardous waste incinerated by participating municipalities is believed to be relatively small.
- Sources for which neither TDC Environmental nor project participants were aware of readily available, likely successful pollution prevention options that would be feasible for local governments (*e.g.*, cement kilns, metal processing and smelting, landfill fires, forest fires, coal fired power plants).
- Certain "complete prevention" options (*e.g.*, ending all purchase and use of chlorinated chemicals or refinery products), because it appeared unlikely that these would be successfully accomplished by local governments at this time.[14]

Additional options are available for some dioxins sources (*e.g.*, electric and diesel/electric hybrids are alternatives for certain diesel uses). Since all possible options could not be screened, the analysis includes a range of the most common options.

SCREENING AND EVALUATION INFORMATION

San Francisco Bay Area Dioxins Project participants developed the list of pollution prevention options screening and evaluation information needs presented in Table 2 (on the next page). The purpose of the list in Table 2 was to focus efforts on collecting data that would provide the basis for a well-informed project selection process. The information needs fall into several general categories:

- Past experience with the activity,
- Relationship to dioxins formation,
- Environmental and other benefits,
- Environmental and other detriments,
- Implementation issues, and
- Cost.

POLLUTION PREVENTION OPTION SCREENING

Table 3 (on pages 13 through 26) summarizes and Appendix A contains the details of the screening of the list of dioxins pollution prevention options. Data collection focused on the screening and evaluation information needs in Table 2. Data sources (listed in the References section of this report) included U.S. EPA and California EPA reports and regulatory documents; articles in the published scientific literature; presentations at the

[14] Related, but more focused options (*e.g.*, purchasing alternatives to PVC, buying non-chlorine bleached paper, and fueling vehicles with natural gas or biodiesel) were included in the analysis.

Table 2. Information Collected for Dioxins Pollution Prevention Option Screening and Evaluation Process

A. Describe Project
1. General description of how a project could be designed
2. Departments potentially involved within interested jurisdiction or agency
3. Other possible participants or affected entities
4. Prior related activities—experience with project (local, regional, national) and results, if available

B. List Possible Project Impacts and Evaluation Methods
1. Potential reduction in dioxins releases
2. Where reduction would occur (which environmental media, geographic location)
3. Other environmental or educational benefits
4. Possible adverse impacts of project
5. Method(s) of measuring effectiveness

C. List Possible Implementation Issues
1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
2. Barriers to implementation
3. Possible methods to bypass barriers
4. Schedule/timing concerns

D. Compile Information about Costs
1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

20th International Symposium on Halogenated Environmental Organic Pollutants & POPS (Dioxins 2000 Conference) and the People's Dioxins Conference; local government publications and regulations; reports and memoranda prepared by non-profit organizations; vendor information provided on Internet sites; personal communications with Federal, state, local government and non-profit organization staff; and information provided by the public in comments on the draft report.

The focus of the review was to identify critical factors that could affect municipalities' interest in pursuing each option. Due to resource limitations, the information provided is a representative sample of available information on each topic, assembled with the goal of identifying the strengths and weaknesses of each pollution prevention option. It should be noted that given the nature of the review process, it is possible that critical factors (*e.g.*, environmental and human health and safety considerations) were not identified during the review. In addition, while data sources that TDC Environmental considers reliable were selected, information was not validated or verified other than by comparison with information collected on the same topic from other sources.

The major findings of the review are as follows:

- Past experience—Most of the dioxins pollution prevention options have been successfully demonstrated or implemented in the U.S. by more than one organization. Only one example of the following types of projects was identified: refinery dioxins pollution prevention, drum reclamation facility dioxins pollution prevention, and use of a utility pole wood preservative other than pentachlorophenol. A few of the options reviewed (*e.g.*, conversion to elemental chlorine free paper, installation of diesel engine retrofits) seem likely to be implemented widely due to regulatory requirements or other expected beneficial public and environmental health outcomes.

- Relationship to dioxins formation—Data regarding dioxins sources are so limited that it is impossible to provide quantitative comparisons among the various pollution prevention options. Some distinctions among options are possible, for example, certain options (*e.g.,* reducing the volume of medical waste that is incinerated) reduce dioxins formation, while other available options for the same source (*e.g.*, use of non-incineration medical waste treatment methods) completely eliminate dioxins formation.

- Environmental and other benefits—Most of the screened dioxins pollution prevention options are environmentally beneficial. Two options (use of alternative wood treatments for utility poles and alternative broadleaf weed control pesticides) are notable in that they involve release of a different and potentially toxic substance to the environment.

- Environmental and other detriments—Almost every option has environmental, human health, or worker safety consequences that should be considered in project selection and addressed during project implementation.

- Implementation issues—All options have implementation issues. The most important technical implementation issue is lack of specific, identified actions to implement the project (a major issue for refinery dioxins pollution prevention, drum reclamation facility dioxins pollution prevention, and removing PCBs from service). All projects require changes in behavior on the part of a group of municipality staff or community members. (Appendix A lists municipality and other organizations and individuals that would be involved in each project). Behavior change will be critical to successful implementation of any project. The level of influence the municipality has over the group that needs to change behavior is a key consideration (*i.e.*, a municipality has more influence over its own employees than it does over the employees of a private business not located within the municipality's borders.)

- Cost—Capital costs for the listed pollution prevention options range widely. Some of the more expensive options (*e.g.*, conversion of diesel vehicles to natural gas) create operational cost savings that in a few years will effectively pay back the initial investment. A few options (*e.g.,* not installing fireplaces, not burning wood in existing fireplaces) provide immediate cost savings.

It should be clear from the above summary that project selection will be somewhat complex—a simple cost/benefit analysis will not suffice. Other factors, such as

community interest and ancillary environmental benefits will necessarily play an important role in the project selection process.

RECOMMENDATIONS

It is outside the scope of this report to recommend specific dioxins pollution prevention actions to Bay Area Dioxins Project participants. Decisions regarding possible dioxins pollution prevention actions rest with individual municipalities, which will consider local priorities and other factors applicable to their own specific situations.

In order to further the goals of the Bay Area Dioxins Project, TDC Environmental recommends that Bay Area Dioxins Project participants consider the following actions in the next phases of the project:

(1) During the workplan development phase for selected projects, obtain additional information to assist with project design and to ensure identification of significant project-related problems (if any exist) prior to project implementation. Recommended additional project-specific investigation includes detailed interviews with the specific staff members responsible for demonstration or implementation of similar projects; obtaining cost information and implementation case studies from equipment, service or material suppliers (if applicable); and contacts with potentially affected municipality staff and representatives of other affected organizations to determine level of interest in and support for project implementation.

(2) Seek support for dioxins pollution prevention project implementation from within the organizations of participating municipalities (from elected and appointed officials and from senior staff members) and from community members and organizations that will be involved in or affected by dioxins pollution prevention activities.

(3) Work with other government agencies to promote the long-term interests of the municipalities with regard to dioxins pollution prevention. Two types of activities are recommended:
   - Seek information to better inform local and community dioxins pollution prevention efforts. For example, municipalities could ask the California Air Resources Board to include dioxins testing in its evaluation of diesel vehicle emissions control options.
   - Ask other agencies to integrate dioxins pollution prevention into their regulatory activities, particularly regulations and initiatives. For example, municipalities could ask U.S. EPA to consider dioxins impacts in the re-registration review of pentachlorophenol that is currently in progress.

(4) Monitor dioxins pollution prevention efforts elsewhere in the U.S. Information from other dioxins pollution prevention efforts can be used to improve ongoing projects and to assist with selection of future dioxins-related actions. U.S. EPA and the State of New Hampshire are both initiating dioxins projects that will include dioxins pollution prevention elements (U.S. EPA, June 12, 2000; Battelle, September 2000; New Hampshire Department of Environmental Services, 2001).

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
I. 2,4-D	**Trace dioxins in 2,4-D are released during manufacture and use. San Francisco Bay area dioxins releases associated with 2,4-D use are probably small.**	**2,4-D controls most broadleaf weeds in turf.**	**2,4-D is itself an environmental concern.**	**2,4-D is typically applied as a component of common weed-and-feed products.**	
Mechanical weed control—could implement an integrated pest management program for weed control. (See page A-1)	To the extent that 2,4-D use is eliminated, associated dioxins releases from manufacturing and use would be eliminated.	Reduced use of 2,4-D.	Certain alternatives involve worker safety issues and fire hazards.	Setting a high tolerance for weeds (and thereby reducing the need for broadleaf weed control) requires staff to understand community goals. Alternative broadleaf weed control practices are generally more labor-intensive.	*Capital & Operating*—Costs depend on the alternative selected, which may be either less or more expensive.
Other weed control pesticides—could switch to another pesticide. (See page A-3)	Same as above.	Reduced use of 2,4-D.	Many alternative broadleaf weed control products are also toxic to humans and/or the environment.	Some alternative pesticides are not particularly effective at controlling broadleaf weeds.	*Capital & Operating*—Costs depend on the alternative selected, but are likely to be similar.
II. Agricultural Burning	**Dioxins are formed during burning of agricultural fields (due to the presence of trace chlorine in crop matter).**	**Burning is a low-cost method for clearing fields and orchards; in some cases it is used as a method of pest control.**	**Agricultural burning is the source of many air pollutants, which is why it is regulated by the Bay Area Air Quality Management District (BAAQMD).**	**Burning methods for field clearing provide pest control and do not require heavy manual labor. Air quality concerns have severely limited the use of such methods.**	

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Non-burning alternatives—could use non-burning methods to manage fields and orchards. (See page A-4)	To the extent that burning is eliminated, associated dioxins emissions would be eliminated.	Reduce agricultural air pollutant emissions.	Alternative methods could create physically difficult jobs for some farm workers.	Non-burning options have not been specifically identified. Participating municipalities have little or no authority over agriculture. Alternative practices may be not as effective in controlling pests. Actions that put pressure on farming can further encourage farmers to sell their lands to developers, which can create sprawl.	*Capital & Operating*—Unknown, but likely to be more expensive than burning, which is relatively inexpensive.
III. Diesel Engines	**Dioxins are present in diesel fuel as well as in diesel exhaust. Although the conclusion is disputed, BAAQMD says that diesel emissions are a major regional dioxins source.**	**Diesel engines power heavy-duty equipment like trucks, railroad engines, and generators. Such engines have long lifetimes and relatively low maintenance needs.**	**Diesel engines emit a variety of air pollutants. Noise and odor from engine operations can be a community concern.**	**Most heavy-duty vehicles in agency fleets are diesel fueled, including construction and maintenance equipment, street sweepers, buses, garbage trucks, and fire engines.**	

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Natural Gas—could replace diesel engines with natural-gas engines. Replacements can burn 100% natural gas or a majority of natural gas and a small amount of diesel. Most vehicles use compressed natural gas (CNG). (See page A-12)	Because natural gas combustion is inherently cleaner than diesel combustion, it is expected to create negligible amounts of dioxins; however, no data regarding dioxins emissions from natural gas use was identified.	Reduces air pollutant emissions, noise, and odors (greatest reduction among the alternatives to diesel).	Neutral to slight increase in greenhouse gas emissions—important to prevent leaks at fueling. Concerns exist about safety of pressurized CNG tanks, but review did not find evidence of any specific safety problems.	Vehicles generally have a shorter driving range than their diesel counterparts. The current high level of activity due to increased regulation of diesel vehicle emissions creates a good climate for projects that implement diesel alternatives. Grant funding may be available.	*Capital*—conversions $3 to $8,000 per vehicle; new vehicles $25 to $50,000 more. *Operating*—cost savings of about $0.25 per gal. A capital investment in CNG buses pays off in about 3 years of typical operation.
Biodiesel—could use biodiesel as a substitute for diesel fuel in existing engines. Biodiesel can be used without modifying engines or fueling infrastructure. Biodiesel is a fuel made from vegetable oils or animal fats. (See page A-5)	No data regarding dioxins emissions from biodiesel use was identified. Use of biodiesel appears to reduce other emissions of concern that are often linked to dioxins formation.	Reduces air pollutant emissions (tests generally show an increase in nitrogen oxide and hydrocarbon emissions). Renewable fuel reduces contribution to global warming. Relatively pleasant exhaust odor. Lower flash point makes handling safer.	Possible adverse impacts should large-scale farming of crops be used to generate biodiesel fuel base (*e.g.*, soy, canola).	Not widely available on open market—must contract with a supplier. Need to check and possibly replace certain rubber engine parts prior to use. If used in vehicles and equipment that previously contained ordinary diesel, need to check and replace fuel filters to prevent clogging during initial few weeks of use.	*Capital*—none *Operating*—$1 to $2 more per gallon than regular diesel fuel.

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Oxydiesel—could use oxydiesel to fuel existing diesel engines. Oxydiesel can be used without modifying engines or fueling infrastructure. Oxydiesel is ordinary diesel fuel, modified with the addition of fuel oxygenates like ethanol. (See page A-9)	No data regarding dioxins emissions from oxydiesel use was identified.	No data was identified although some benefits are likely since oxydiesel is apparently being developed with the purpose of reducing diesel vehicle air pollutant emissions and promoting ethanol use.	Possible adverse impacts of large-scale farming of crops used to generate ethanol (*e.g.*, corn).	Not commercially available.	*Capital*—none. *Operating*—when commercially available expected to cost $0.02 to $0.15 more per gallon.
Diesel engine retrofits—could retrofit existing diesel engines to reduce particulate formation during engine operation. Various types of retrofits are available; from add-on devices to engine "repower" retrofits. (See page A-10)	Retrofits typically create cleaner burning conditions that reduce emissions of particulate matter and would be expected to reduce formation of dioxins; however, no data on dioxins releases was identified.	Most engine retrofits are designed to reduce particulate emissions.	Some diesel engine modifications increase emissions of pollutants other than particulate matter.	Most commercially available retrofits are still not thoroughly demonstrated and have not been broadly deployed.	*Capital*—$200 to $4,000 for add-on retrofits; repowers cost $4,000 to $190,000 depending on engine size. *Operating*—little or no change in fuel and maintenance cost is anticipated.
Reduce trips/change modes—could switch to other methods of transferring goods and people and reduce idling times and avoid heavy acceleration. (See page A-15)	Dioxins releases would be reduced approximately in proportion to diesel fuel use reduction.	Some reduction in air pollutant emissions, noise and odor (approximately proportional to fuel use reduction).	None identified.	Changing modes may be difficult without purchase of alternative fuel vehicles. Driver training is easy, but use of new practices is hard to enforce.	*Capital & Operating*—depends on mode change choices. Cost savings would result from changes that increase operational efficiencies (a likely outcome of examining materials flow).

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
IV. Drum Reclamation	**Drum reclamation furnaces are known dioxins sources that are not well characterized in the San Francisco Bay area.**	**Drum reclamation furnaces remove potentially toxic contents from used drums. The drums can then be recycled.**	**Drum reclamation furnaces probably emit many other air pollutants and may raise worker safety issues.**	**Drum reclamation furnaces have become less common in recent years.**	
Non-burning methods—could change drum reclamation practices from those involving furnaces to use of caustics and solvents ("drum washing") and physical cleaning methods. (See page A-16)	To the extent that facilities convert to other methods, formation of dioxins would be eliminated.	Air emissions associated with drum reclamation furnaces (*e.g.*, solvents, products of incomplete combustion) would be eliminated.	Alternative methods may also pose worker hazards and release pollutants to the environment; for example, drum-cleaning solutions may be toxic, flammable, and/or corrosive.	Changing to drum washing processes requires significant technical expertise (*e.g.*, to identify appropriate cleaning methods and to manage solvents).	*Capital & Operating*—Unknown, but meaningful capital cost to transition technologies is likely.
V. Medical Waste	**Nationally, medical waste incinerators are major dioxins air emissions sources. California's largest medical waste incinerator is in Oakland.**	**Incineration is used to destroy pathogens and other environmental hazards in medical waste.**	**Medical waste incinerators are also major emissions sources of mercury and other air pollutants.**	**Several medical waste management methods are available. Certain wastes (a few percent of medical waste) must be incinerated under current California law.**	

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Non-incineration medical waste management methods—could switch to an alternative disposal method such as autoclaving, chemical disinfection, sterilization, or microwaving. (See page A-19)	To the extent that incineration is replaced by a non-incineration alternative, associated dioxins emissions would be eliminated.	Reduction in air pollutant releases (like carbon monoxide, nitrogen oxides, sulfur oxides, hydrogen chloride, fine particulate matter, polycyclic aromatic hydrocarbons, mercury, cadmium, lead).	Air pollutant and odor emissions from the use of some non-incineration technologies (no quantitative data identified). Worker safety issues at some facilities where waste is shredded prior to treatment. Concern about efficacy of treatment for some methods. Additional waste would be landfilled.	Treated waste still can look like medical waste, which makes its acceptance at landfills problematic.	*Capital & Operating*—Cost depends on selected option. For example, autoclaving on-site is generally less expensive than incineration (requires capital expenditure for autoclaves, but reduces operating cost).
Reduce medical waste volumes—could implement source reduction and waste diversion from the medical waste stream to the solid waste stream. (See page A-17)	If the medical waste is incinerated, dioxins releases would be reduced approximately in proportion to medical waste reduction.	Reduced materials use and increased recycling.	Diverted waste would add to landfill volumes.	Behavior change required (not always easy to obtain). Other issues, like mergers, labor problems, and funding are distracting hospitals. Concern about severe consequences for allowing medical waste to enter the ordinary solid waste or recycling streams.	*Capital & Operating*—Reducing medical waste volumes usually reduces operating costs, as medical waste usually costs more to manage than solid waste. Examples identified during review had relatively low capital costs ($0 to $thousands).

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Eliminate medical PVC use—could substitute non-PVC alternatives like glass IV bottles, Tyvek patient ID bracelets, and chlorine-free plastic gloves and sheeting. (See page A-22)	To the extent that PVC use is reduced, dioxins releases associated with PVC manufacture and disposal (if waste is incinerated) would be reduced. Benefits would be greatest in situations where medical waste is incinerated.	Reduction in other pollutant releases from PVC manufacturing. Reduced patient and worker exposures to PVC additives of concern like phthalates.	Concerns about safety and efficacy of alternative products.	PVC is the most common plastic used in health care. Convenient substitutes do not exist for all medical PVC uses.	*Capital & Operating*— No cost information identified. Costs are expected to primarily be operating costs associated with the purchase of patient care supplies.
VI. Paper Bleaching	**Although the conclusion is controversial, U.S. EPA estimates that paper mill effluents are among the smaller national dioxins sources.**	**Chlorine gas has been used to whiten and brighten pulp in the paper manufacturing process.**	**Paper bleaching creates a variety of chlorinated organic compounds that make paper mill effluents toxic to certain aquatic species.**	**U.S. paper manufacturers plan to shift away from use of chlorine gas in paper production in the next few years in response to U.S. EPA regulatory requirements (most of which took effect in April 2001).**	

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Process or totally chlorine free paper—could purchase process chlorine free (PCF) recycled paper or totally chlorine free (TCF) non-recycled paper products. This analysis focuses on PCF paper since most participating municipalities prefer recycled paper. (See page A-25)	Chlorine-free bleaching eliminates formation of chlorinated organics including dioxins. (Note: Since it starts with recycled fibers that may contain dioxins from previous bleaching or the paper's prior use, PCF paper production may not be dioxin-free).	Eliminates formation of chlorinated organic compounds. Wastewater effluents from mills using TCF/PCF bleaching were found to be the least toxic of effluents from mills using the three typical paper bleaching methods. Effluent can be recycled into process, providing opportunity for significant water savings and reduction in energy use. Commercially available PCF papers often have high recycled content.	Paper may have to be transported relatively long distances to customers, since there are few North American PCF paper mills.	Paper may have darker appearance, different texture, or different surface, affecting user perception of quality. Manufacturers have actively opposed purchasing preferences for PCF over ECF papers.	*Capital*—Relatively low costs ($ thousands) for development of purchasing specifications and testing of PCF papers. *Operating*—paper costs 30 to 50% more than similar ECF or chlorine-bleached recycled paper.
Elemental chlorine free (ECF)—could purchase ECF paper products (products bleached with chlorine dioxide). (See page A-23)	Use of ECF instead of elemental chlorine paper bleaching dramatically reduces (but does not eliminate) formation of and releases of dioxins from paper mills.	Reduces formation of other chlorinated organic compounds (effluent levels decreased by about 90%). Reduced energy use.	Effluents from mills using ECF bleaching processes retain some aquatic toxicity. Use of TCF/PCF paper bleaching methods provides greater reduction in environmental impacts.	Products are often not labeled as ECF. Sales operations and distributors do not always know how paper products are bleached. In response to U.S. EPA regulations, manufacturers generally plan to switch to ECF processes, making purchasing preferences for ECF paper essentially meaningless.	*Capital*—Relatively low costs ($ thousands) for development of purchasing specifications and testing of ECF papers. *Operating*—No specific cost information obtained; informal information suggests costs are competitive to slightly higher than those for chlorine-bleached paper.

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
VII. Pentachlorophenol	**Trace dioxins in pentachlorophenol released during wood treatment and subsequent wood use. The amount of dioxins incorporated into wood treated each year may be significant.**	**Pentachlorophenol is an effective and long-lasting wood preservative.**	**Pentachlorophenol itself is a significant environmental concern. Workers involved in treating and installing treated wood and Children playing near treated wood may be subject to significant health risks.**	**Almost all pentachlorophenol use in the U.S. is for utility poles and cross arms.**	
Non-wood alternative utility poles—could purchase utility poles made of steel, fiberglass, concrete, or another non-wood material or move utilities underground. (See page A-28)	To the extent that pentachlorophenol wood treatment is reduced, associated dioxins releases into treated wood and from treatment sites and utility poles would be eliminated. Reduction could be meaningful, as there are probably tens of thousands of pentachlorophenol-treated utility poles in the San Francisco Bay Area.	Reduce use of pentachlorophenol and other pesticides used to maintain wood poles.	Worker safety may be an issue for metal poles (conductivity) and heavy concrete poles (accidents during installation) and installation of an underground utility conduit (use of heavy equipment). Raptor safety needs to be considered in pole design.	Wood poles are convenient to work on, so behavior and some equipment changes may be needed to facilitate conversion. Workers have safety concerns with metal poles. It is difficult to modify steel and concrete poles. Strength and longevity are issues for fiberglass poles	*Capital*—costs for poles similar for some alternative materials and more expensive for others. Undergrounding involves significant costs. *Operating*—costs are lower, since alternatives last longer and require less maintenance. Underground utilities require significantly less maintenance.

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
Different wood preservatives—could purchase utility poles treated with other wood preservatives (*e.g.*, creosote, chromated copper arsenate [CCA], and "ammoniacal copper quat" [ACQ]). (See page A-31)	Same as above.	Reduced use of pentachlorophenol.	The most common alternatives—creosote, CCA, and ACQ—all have potentially significant environmental impacts. ACQ is considered the least problematic of the 3.	Alternatives are generally toxic or have relatively short lifetimes, requiring frequent maintenance.	*Capital*—costs unknown, but likely to be similar. *Operating*—costs unknown, but likely to be higher since alternatives do not preserve utility poles for as long.
VIII. Petroleum Refining	**Dioxins sources have not been well characterized to date; however, dioxins have been detected in catalyst regeneration emissions, storm water runoff, wastewater, sludges, and diesel fuel.**	**Refineries convert crude oil into numerous petroleum products like asphalt, gasoline, diesel fuel, and coke.**	**Refining processes have many environmental and worker safety impacts. Crude oil transport and refinery product transport, storage, and use have significant impacts in all environmental media.**	**Refinery products are integrated into all facets of our lives. They fuel most transportation of people and goods in the U.S. and many power plants. Asphalt paves our roads. Petroleum-based chemicals are used to synthesize many goods.**	
Refining process modifications—specific pollution prevention actions would need to be determined. (See page A-33)	Opportunities for reductions are likely; however, specifics are unknown.	Since pollution prevention typically reduces the hazard level of manufacturing processes, benefits are likely.	Depending on actions selected, it is possible that new, environmentally adverse releases could occur or that worker safety could be an issue.	Possible pollution prevention actions have not been specifically identified. Participating municipalities have little influence over refineries.	Unknown costs (primarily for refineries).

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
IX. Polychlorinated Biphenyls (PCBs) (Note: This option involves prevention-like PCB removal activities [these do not prevent dioxins formation] so it may not be consistent with the project goal to use a pollution prevention approach).	**PCBs are unique in that they are a group of compounds that include several dioxin-like congeners; mixtures may also be contaminated with dioxins.**	**In the past, widely used as dielectric fluids in capacitor and transformer, heat transfer fluids, hydraulic fluids, lubricating and cutting oils, and as additives in pesticides, paints, carbonless copy paper, adhesives, sealants, and plastics.**	**PCBs pose environmental concerns for many reasons not limited to the dioxins-like activity of some PCB congeners.**	**PCBs are widely dispersed in the urban environment due to their many historic uses,**	
Remove from service—could identify and replace PCB-containing materials. (See page A-35)	Depends on source identification (current use level and potential for release into the San Francisco Bay area environment is unknown).	Removing PCBs can preclude releases of PCBs, which are themselves toxic. Some replacements involve modernizing electrical equipment, creating significant energy savings.	Removing PCB-containing materials could create short-term PCB releases and could cause exposures for workers and neighbors at a removal site.	No surveys have been performed to identify where PCBs exist. PCBs are expensive to dispose of. For certain PCB uses or users, there are no phaseouts, many unrestricted uses, and no management requirements.	*Capital*—costs unknown, but likely to be significant due to the high cost of PCB waste disposal. *Operating*—Savings are likely, as modern replacements are more energy efficient.

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
X. Polyvinyl Chloride (PVC, "vinyl") **Note: medical PVC use is considered in Section I, above.**	**Dioxins are formed and released during PVC manufacture and during fires in locations where PVC is used. (For non-medical items, disposal by incineration is not an issue in the San Francisco Bay area).**	**PVC is the second largest volume plastic produced in the world. It is very inexpensive, can be modified to be appropriate for a wide variety of uses, and has a long history of use.**	**Releases from PVC manufacturing (*e.g.*, vinyl chloride) have detrimental environmental and human health effects. To give PVC desirable properties, PVC often contains additives that are environmentally problematic (*e.g.*, heavy metals and phthalates).**	**PVC products are practically ubiquitous in homes and offices, appearing as building siding, flooring, windows, gutters, electrical cable coating, window coverings, furniture, packaging, automobile parts, computers, non-potable water piping and credit cards.**	
Non-PVC alternatives—could specify and purchase PVC-free materials and products for building construction, interior furnishing, packaging, office supplies, and vehicle parts. (See page A-37)	To the extent that PVC materials and products are replaced, PVC-related dioxins releases from manufacturing sites and accidental fires would be eliminated.	Reduction in other pollutant releases from PVC manufacturing. Reduced population and environmental exposures to PVC additives of concern.	Alternative materials may create environmental impacts during manufacturing, use, and disposal. The impacts depend on the alternative selected. Certain PVC products may have properties that provide environmental advantages over certain alternatives during the useful life of the product (*e.g.*, vinyl windows generally offer better insulating properties than aluminum).	Often difficult to determine which materials and products contain PVC. For certain materials and products, alternatives may be difficult to find in the marketplace.	*Capital & Operating*—Costs depend on the alternative selected, which may be either less or more expensive.

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
XI. Wood Burning	**Wood burning emits dioxins due to the presence of trace chlorine in firewood. Although the conclusion is disputed, BAAQMD believes that wood burning is a major regional dioxins source.**	**Most wood burning in the San Francisco Bay area is for aesthetic purposes.**	**Wood burning emits many air pollutants such as polyaromatic hydrocarbons (PAHs), including benzo(a)pyrene, a persistent, bioaccumulative toxic chemical.**	**Most San Francisco Bay Area homes have fireplaces; however, few are used for heating. Getting residents to discontinue use of existing fireplaces is difficult.**	
Natural gas fireplaces—could install natural gas fireplaces instead of traditional fireplaces. (See page A-46)	No dioxins data identified; however, BAAQMD believes that installing natural gas instead of wood-burning fireplaces reduces particulate emissions (likely related to dioxins emissions) by 99 percent.	Potentially significant reductions in emissions of PAHs (including benzo(a) pyrene), carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter. Among the fireplace alternatives, natural gas has the least pollutant emissions.	Natural gas is a finite resource that contributes somewhat to global warming. It is not renewable like wood.	The 2000-2001 energy crisis has significantly increased the price of natural gas. Most older California fireplaces do not have gas lines installed. For some people, natural gas fires are not as aesthetically pleasing. Many natural gas fireplace retrofits do not generate much heat.	*Capital*—$300 to 500 (or more if gas line needed) to retrofit a fireplace. *Operating*—gas is generally less expensive than wood.
EPA-certified wood stoves—could install certified stoves instead of fireplaces or non-certified wood stoves. (See page A-41)	No dioxins data identified, however, EPA-approved stove technology has been shown to reduce particulate matter emissions (likely related to dioxins) by 75 to 90%.	Reductions in emissions of PAHs (including benzo(a) pyrene), carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter.	None identified.	Most pellet stoves require electricity to operate their fans, so they do not work during a power outage; they also need relatively regular service.	*Capital*—about $1,500 to $2,000 to install a certified stove. *Operating*—fuel cost is marginally lower (primarily because stove heats more efficiently).

Table 3. Summary of the Screening Evaluation of Dioxins Pollution Prevention Options (Continued)

Prevention Option	Dioxins	Benefits	Detriments	Implementation Issues	Cost
BAAQMD model ordinance—could adopt prohibitions on new open fireplaces, burning of problem fuels, and burning on "Spare the Air" nights. (See page A-44)	No dioxins data identified, however, BAAQMD believes that implementing its ordinance will reduce particulate emissions (likely related to dioxins emissions) by 75 to 99 percent.	Reductions in emissions of PAHs (including benzo(a) pyrene), carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter.	None identified.	Public concern about freedom of choice and cost of alternatives. Real estate industry has opposed ordinance adoption in some cases.	*Capital*—up to $1,000 more for installation of a compliant unit in a new residence. *Operating*—alternatives are cheaper to operate (Note: no fireplace at all is cheapest and involves no additional capital cost).
"Better wood burning practices"—could educate the community regarding burning habits. (See page A-49)	Actions that prevent burning of garbage and wood waste could have significant benefits to the extent that such burning occurs today (unknown). In one study, dioxins air emissions from garbage burning were found to be approximately 1000 times greater than burning ordinary wood. Benefits of other burning practice changes are unknown.	Possible reductions in emissions of PAHs (including benzo(a) pyrene), carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter (but probably not as great as from the fuel changes above).	Other pollutants of concern may be emitted from firelogs (unknown).	Trash burning is prohibited, but likely occurs on a small scale. Regulations regarding residential burning practices are nearly impossible to enforce, and education levels needed to implement most changes (with the notable exception of the switch to firelogs) are high.	*Capital*—none. *Operating*—government educational program costs are relatively small ($ thousands), but effectiveness is uncertain.
No burning—could implement burn bans. (See page A-48)	To the extent that burning activities were eliminated, associated dioxins emissions would be eliminated.	Possible reductions in emissions of PAHs (including benzo(a) pyrene), carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter.	None identified.	Mandatory burn bans often meet resistance from the public.	*Capital*—none. *Operating*—government educational program costs are relatively small ($ thousands), but effectiveness is uncertain.

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APPENDIX A. DIOXINS POLLUTION PREVENTION OPTIONS SCREENING DETAILED EVALUATION

I. 2,4-D

Use mechanical weed control

A. Describe Project

1. General description of how a project could be designed
   The basic approach would be to use non-chemical mechanisms for control of broadleaf weeds (to the extent that controls are required). Broadleaf weeds are most commonly considered a problem in turf areas. A typical alternative to use of 2,4-D (often found in a "weed & feed mixture) is an "integrated pest management" (IPM) approach to broadleaf weed control, which would involve setting thresholds for acceptable levels of broadleaf weeds in each area, then developing methods for broadleaf weed control appropriate for each area when the threshold is exceeded. Certain municipal-owned high profile turf areas (such as golf courses, bowling greens, polo fields, and highly visible ornamental turf-containing landscaping) would be areas with relatively low thresholds, where alternatives would be implemented (other areas, like parks and recreational fields would often have high enough thresholds that broadleaf weed control methods would rarely be employed). IPM programs are usually implemented in combination with turf management programs that alter turf management conditions to prevent broadleaf weed germination. Alternative controls include weed cutting, hand removal, flaming, and steam units.
2. Departments potentially involved within interested jurisdiction or agency
   Landscaping, Facility Management, Parks/Recreation, Public Works
3. Other possible participants or affected entities
   Residents, recreational users of turf areas, Fire Departments
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Numerous local government IPM programs exist; particularly effective ones are in San Francisco and Santa Monica. Contact: Debbie Raphael, San Francisco Department of the Environment, 415-554-6399.
- Many pesticide and lawn/garden public education programs provide information about turf management. For example, the regional "IPM Partnership" program sponsored by wastewater and stormwater agencies includes a lawn care fact sheet that promotes IPM for broadleaf weed control (available on the internet at http://www.centralsan.org/education/ipm/hgonlineguide.html). Contact: Bart Brandenburg, Central Contra Costa Sanitary District, 925-229-7361.
- Natural Lawn Care Project—a joint project of King County, the cities of Seattle and Bellevue, and Thurston County. The public education campaign seeks to reduce lawn use of pesticides like 2,4-D and diazinon by promoting better lawn management practices (that prevent weed growth), increasing awareness of pesticide toxicity, and increasing use of IPM techniques. One of the campaign's major messages involves discouraging use of weed-and-feed type products, in order to reduce 2,4-D use. The first year results showed that the public education project was successful in changing awareness and in reducing concerns about the presence of weeds, but it had little effect on use of weed-and-feed products (King County, 1998). Contact: Annette Frahm, Seattle/King County, 206-689-3064.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- Dioxins releases from broadleaf weed control would be eliminated unless fire-based control methods were used. Fire-based methods would create some dioxins; it is unknown whether such methods would release more dioxins in to the environment than would be released by use of 2,4-D.
- 2,4-D is typically applied as a component of weed-and-feed products, which are most commonly applied to turf. On the basis of U.S. EPA data, 2,4-D is estimated to have a typical concentration of 0.1 to 0.15 micrograms per kilogram (μg/kg) of dioxins (TEQ, Johnson, April 1999). For a typical weed-and-feed product, which contains about 0.5% 2,4-D by weight (DPR pesticide registration database), the dioxins concentration is about 0.0005 to 0.00075 μg of dioxins per kilogram of product. Statewide, about 1900 pounds of 2,4-D (active ingredient) was applied for "reportable" urban uses (landscape maintenance, ornamental turf, regulatory pest control, rights of way, and structural pest control) in 1999 (DPR, 2000); this total contains about 0.0001 grams of dioxins (TEQ). Use by California municipalities should be included in this total; however, much of the urban use of 2,4-D, particularly use by private residents, is not "reportable" and therefore not included in this total. Even considering the omission of residential uses, the use of 2,4-D is likely to be a relatively small source of dioxins releases in the San Francisco Bay area. Thus, eliminating 2,4-D use, while possible, provides a relatively small reduction in dioxins releases. This analysis does not consider dioxins releases at 2,4-D manufacturing locations (such data was not readily available).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area and locations (outside the San Francisco Bay Area) where 2,4-D is manufactured.

3. Other environmental or educational benefits
   Reduced use of 2,4-D, a toxic pesticide that itself is an environmental concern (Walters, 1999). 2,4-D is listed by the state Department of Pesticide Regulation as a toxic air contaminant (DPR, 2000).

4. Possible adverse impacts of project

- Certain mechanical weed control methods (*e.g.*, using mechanical "weed whackers") involve tiring physical labor. San Francisco's Public Utilities Department found that making such controls a full-time job raised worker safety concerns that were alleviated when employees were provided with a mixed set of tasks (Raphael, 2000).
- Flaming involves a fire hazard; San Francisco is working with its Fire Department to address this issue (Raphael, 2000).

5. Method(s) of measuring effectiveness
   Municipality use of 2,4-D can be tracked (*e.g.*, via use reports that are required to be submitted to the County Agricultural Commissioner).

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Recently, several San Francisco Bay Area communities have passed resolutions or otherwise called for establishment of least-toxic pest control programs.
- The California Department of Pesticide Regulation is expanding its IPM program; grant opportunities have increased significantly. The Pest Management Grants program may be able to provide funding to support a municipality IPM demonstration project.

2. Barriers to implementation

- Alternatives are generally more labor-intensive. Certain alternatives (*e.g.*, flaming) have safety issues. Some alternatives (*e.g.*, steam control systems) remain unproven. Sometimes chemical weed control is expedient for non-environmental reasons.

- Municipality staff need to understand the community's tolerance for the presence of broadleaf weeds in various locations (a key to setting thresholds for weed management).

3. Possible methods to bypass barriers

- Public information about the benefits of an IPM program, especially the reduced pesticide exposures for children and other community residents.
- IPM programs typically allow use of certain weed control chemicals as a "last resort."
- Sometimes 2,4-D itself doesn't work, so changing methods makes sense. For example, 2,4-D is proving relatively ineffective on one particularly problematic broadleaf weed (English Daisy) in San Francisco (Raphael, 2000).

4. Schedule/timing concerns

- California Department of Regulations' grant programs have application periods in the fall of each year.

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

Use other weed control pesticides

A. Describe Project

1. General description of how a project could be designed
   An alternative chemical control could be used to eliminate broadleaf weeds from municipal-owned turf areas.
2. Departments potentially involved within interested jurisdiction or agency
   Landscaping, Facility Management, Parks/Recreation, Public Works
3. Other possible participants or affected entities
   Residents, recreational users of turf areas
4. Prior related activities—experience with project (local, regional, national) and results, if available
   See above. Most IPM programs allow use of chemical weed control pesticides as a last resort.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   If an alternative that did not contain dioxins and did not cause release of dioxins during its manufacture was selected as a substitute for 2,4-D, dioxins releases from broadleaf weed control would be eliminated. As noted in the previous section, dioxins releases from 2,4-D use in the San Francisco Bay area are probably small; unknown releases also occur at the site of 2,4-D manufacture.
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area and locations (outside the San Francisco Bay Area) where 2,4-D is manufactured.
3. Other environmental or educational benefits
   Reduced use of 2,4-D, a toxic pesticide that itself is an environmental concern (Walters, 1999). 2,4-D is listed by the state Department of Pesticide Regulation as a toxic air contaminant (DPR, 2000).
4. Possible adverse impacts of project
   Some alternative broadleaf weed control products (*e.g.*, dicamba) are also toxic to humans and/or the environment.
5. Method(s) of measuring effectiveness

Municipality use of 2,4-D and broadleaf weed control products can be tracked (*e.g.*, via use reports that are required to be submitted to the County Agricultural Commissioner).

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

Same as previous section (although more opportunities probably exist for IPM-type programs than for pesticide substitution programs).

2. Barriers to implementation

- Alternative pesticides may also be environmentally toxic.
- Some alternative pesticides may not be effective for controlling the particular broadleaf weeds that are common in the San Francisco Bay Area. Application rates and management may be an issue. For example, San Francisco found that corn gluten meal was only effective at high application rates, which were very expensive. At low application rates, the fertilizer-like effect of the material (a nitrogen source) was problematic.

3. Possible methods to bypass barriers

- Chemical weed controls can best be used as part of an IPM program that emphasizes non-chemical weed controls (see above).
- Use of chemical pesticides for spot control (*e.g.*, Roundup, Turflawn) minimizes risks associated with their use.

4. Schedule/timing concerns

None identified.

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

II. Agricultural burning

Non-burning alternatives

A. Describe Project

1. General description of how a project could be designed

Non-burning alternatives could be used to manage fields and orchards.

2. Departments potentially involved within interested jurisdiction or agency

Environmental, possibly Planning

3. Other possible participants or affected entities

BAAQMD, Farmers, Agricultural organizations

4. Prior related activities—experience with project (local, regional, national) and results, if available

- Sacramento area/Central Valley rice straw burning programs—In response to intense public pressure, the California State Legislature passed a series of bills supporting research and demonstration of alternatives to field burning for rice straw management, providing incentives and regulatory changes to support the program (including field burning restrictions).
- Currently, the BAAQMD regulates burning of agricultural fields within the San Francisco Bay Area.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No information identified
2. Where reduction would occur (which environmental media, geographic location)
   Where agricultural burning currently occurs in the San Francisco Bay area
3. Other environmental or educational benefits
   Agricultural burning is the source of many air pollutants, which is why it is regulated already by the BAAQMD.
4. Possible adverse impacts of project
   Burning methods provide pest control and do not require heavy manual labor. Alternative practices may be not as effective and could create physically difficult jobs for farm workers.
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Non-burning options have not been specifically identified.
- Participating municipalities have little or no authority over agriculture.
- Actions that put pressure on farming can further encourage farmers to sell their lands to developers, which can create sprawl.
- Agricultural burning is not a major air quality issue in the San Francisco Bay Area but is considered a major problem in other air basins that have been a focus for recent legislative and political activity.

2. Barriers to implementation
   BAAQMD has regulatory authority; uncertain of the authority or influence of participating agencies.
3. Possible methods to bypass barriers

- Identify specific feasible alternative management methods, demonstrate those methods, and provide incentives or support to farmers who switch methods.
- Ask BAAQMD to prohibit agricultural burning.

4. Schedule/timing concerns
   None identified.

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

III. Diesel Engines

Biodiesel

A. Describe Project

1. General description of how a project could be designed
   Biodiesel (100% biodiesel or a mix of regular diesel [petrodiesel] and biodiesel) could be used in existing, diesel-fueled engines (on-road, off-road and stationary engines). Biodiesel is a fuel made from vegetable oils or animal fats.
2. Departments potentially involved within interested jurisdiction or agency
   Vehicle Fleet, Transit Fleet, Street Maintenance Fleet, Fire Department, Solid Waste Collection Fleet, Purchasing

3. Other possible participants or affected entities

BAAQMD, ARB, drivers, school bus fleet manager, maintenance staff, and drivers, transit agency managers, maintenance staff, and bus drivers, private truck, bus, rail, and shipping operators.

4. Prior related activities—experience with project (local, regional, national) and results, if available

Many biodiesel demonstration projects appear to have occurred in the U.S. Here are summaries of three examples:

- Cincinnati—The Queen City Metro (bus line) conducted a biodiesel demonstration project, using an 80% diesel/20% biodiesel fuel. City staff report that the buses ran well with the alternative fuel, with good mileage and performance (including power, which was important on Cincinnati's hills). One small snag was that biodiesel fuel evidently cleans engines so well that Metro has had a few instances of clogged fuel filters. Once the filters are changed the engines are fine. They suggest a filter change after the first two tanks of the fuel to avoid clogging (this would not be necessary for new vehicles that have not run with ordinary diesel fuel). Test results for efficiency improvements and emissions reductions will be available in fall or winter 2000/01 (Suits, 2000). Contact: J. Bruce Suits, Pollution Prevention Manager, City of Cincinnati, 513-352-6270
- Homestake Mine, South Dakota—biodiesel was used to fuel underground mining equipment. "One of the major advantages of biodiesel is the fact that it can be used in existing engines and fuel injection equipment without negative impacts to operating performance. Biodiesel has a higher cetane[15] number than conventional diesel fuel and its demonstrated use at the Homestake mine in South Dakota resulted in similar fuel consumption, horsepower, torque, and haulage rates compared to conventional diesel fuel." (Howell, 1997).
- Yellowstone National Park—In February 1995, Dodge Truck Inc. donated a new 1995 3/4 ton 4x4 pickup ($30,000 value) to Yellowstone National Park. Since that time, the truck, driven by Yellowstone employees, has gone over 100,000 miles on 100% biodiesel. It averages about 17 miles per gallon, the same as when it was tested with regular diesel fuel during baseline data development. No modifications were made to the truck's engine or fuel system. The emissions test conducted on the truck showed that smoke, hydrocarbons, nitrogen oxides and carbon monoxide emissions were reduced by using the biodiesel. Tests also showed that the food-like odor of biodiesel exhaust does not attract bears, which was a concern to park managers. The park developed an extensive education program for the public. Lectures and information exchanges have occurred at visitor centers, trailheads, greening conferences, and numerous educational institutions (Evanoff, 2000). Contact: Jim Evanoff, 307-344-2311.
- A recent article in Environmental Science & Technology cited approximately 36 studies of biodiesel use and concluded that biodiesel is a promising alternative fuel for diesel engines (Wang, 2000).
- The National Biodiesel Board offers to answer questions regarding past experience with biodiesel (800-841-5849).
- In San Francisco, there is a biodiesel retail outlet that sells biodiesel to both regular retail and commercial customers.
- Several San Francisco Bay Area government agencies and businesses have tested or are using biodiesel, including the Ecology Center (a Berkeley recycling company), San Francisco International Airport, and the City of Palo Alto.

<u>B. List Possible Project Impacts and Evaluation Methods</u>

1. Potential reduction in dioxins releases

[15] The equivalent of octane number for diesel fuels.

- No data regarding dioxins emissions reductions from biodiesel use was identified. Use of biodiesel appears to reduce other emissions of concern that are often linked to dioxins formation. A recent review of 36 studies concluded that biodiesel use provides a considerable benefit for particulate matter emissions (often linked to dioxins) (Wang, 2000). A study using soy-based fuel in an engine typical of those used in underground mines found considerable reduction in particulate matter, polyaromatic hydrocarbon, and vapor-phase-associated mutagenic activity (Bagley, 1998).
- Petrodiesel contains small quantities of dioxins (Truex, 1998). It is uncertain whether these dioxins contribute to tailpipe emissions. A U.C. Riverside study found that its estimates of dioxins emissions from diesel engines were understated due to deposition of dioxins-containing particulate in the test system; this could explain the apparent disagreement among various other studies and was said by report authors to mean that the results of the U.C. Riverside study were low (Truex, 1998). To the extent that petrodiesel is replaced by another fuel, dioxins would be displaced both in the fuel and in tailpipe emissions. The amount of dioxins reduction would depend on the amount of dioxins created by combustion of the alternative fuel source (which is unknown).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area
3. Other environmental or educational benefits

- Biodiesel can be made from waste food oils from restaurants and food processors (Bloom, 2000). Such supplies are apparently limited, which is why commercial and government demonstration projects have typically used fuels based on virgin vegetable oils.
- A recent review of 36 studies concluded that biodiesel use provides a considerable benefit for particulate matter, carbon monoxide, and hydrocarbon emissions, with some small increase in nitrogen oxide emissions (found only in some studies) (Wang, 2000). Occasional studies are not consistent with this general finding—for example, a study of medium trucks operating on biodiesel found inconsistent results in one truck (which had run more than 100,000 miles on ordinary diesel fuel prior to the test, and which the article does not mention fuel system filter change and/or rubber engine part inspection for fuel compatibility), which generated higher particulate emissions on 100% biodiesel than when operated on blends or petrodiesel (Durbin, 2000).
- The flash point of biodiesel blends increases as the percentage of biodiesel increases. The higher flash point makes biodiesel safer to store and use (Howell, 1997).
- Reduction in use of diesel fuel would reduce adverse odors associated with diesel engine operations.
- A National Renewable Energy Laboratory life cycle analysis comparing the use of biodiesel to the use of petrodiesel vehicle fuel found use of 100% biodiesel instead of petrodiesel reduces net carbon dioxide emissions by 78%, particulate matter emissions by 32%, and carbon monoxide by 35%, but increased net nitrogen oxide emissions by 13% and hydrocarbon emissions by 35%. The study found that tailpipe emissions (which tend to occur in locations with potential for high human exposure) from 100% biodiesel use were greatly reduced: fine particulate matter (PM_{10}) reduced 68%, hydrocarbon reduced 37%, carbon monoxide reduced 46% (Sheehan, 1998).

4. Possible adverse impacts of project

- Possible increase in nitrogen oxides emissions
- Possible adverse impacts should large-scale farming of crops be used to generate biodiesel fuel base (*e.g.*, soy, canola).

5. Method(s) of measuring effectiveness
   Track municipality purchases of diesel and biodiesel

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Relatively easy to use as a substitute fuel
- Fuel filters need changing shortly after conversion, as biodiesel and biodiesel/diesel mixes tend to remove accumulated materials from engines (effectively the fuel cleans the engine fuel system). Similarly, biodiesel releases the deposits accumulated on diesel storage tank walls and pipes, so filters on converted tanks should be checked and changed regularly until this effect subsides (Howell, 1997).
- Biodiesel is from a renewable (vegetable) resource rather than a fossil fuel source, so it has a lower contribution to global warming.
- Government agency fleets offer an excellent opportunity for introducing diesel alternatives, because government fleets are usually centrally fueled, maintained in a controlled fashion, and operators and maintenance personnel can readily be trained (Manufacturers of Emission Controls Association, 2000).
- The ARB has passed an urban transit rule that will require transit fleets to transition to cleaner vehicles (it is uncertain whether they will convert to cleaner diesel or to alternative fuels). This rule does not apply to street sweepers, garbage trucks, and school buses (Garvey, 1999)—such government-owned vehicles represent a significant opportunity for conversions.
- Studies suggest no changes in fuel consumption or engine performance (Wang, 2000).

2. Barriers to implementation

- Questions about supplies—availability, reliability of supply
- Certain rubber or elastomer engine parts may not be compatible with biodiesel (especially pure biodiesel). Precautions are needed when using pure biodiesel or high percent blends to ensure that the existing fueling system, primarily fuel hoses and fuel pump seals are compatible with biodiesel (Howell, 1997).
- Biodiesel freezes at a relatively high temperature for a fuel; it must be stored at temperatures above 25 degrees Fahrenheit (National Biodiesel Board, 2000).
- Biodiesel spills can harm vehicle paint; they should be wiped up immediately (National Biodiesel Board, 2000).
- Biodiesel-contaminated rags can spontaneously combust; they should be stored in a safety can (similar to gasoline-contaminated rags) (National Biodiesel Board, 2000).

3. Possible methods to bypass barriers

Set up an ongoing fuel supply contract. Participate in a multi-agency fuel purchase pool.

4. Schedule/timing concerns

Can be implemented quickly using existing equipment

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities

- In its demonstration project, the City of Cincinnati paid $1.49 per gallon for a biodiesel consisting of 20% biodiesel/80% regular diesel. Cincinnati found that 100% soy diesel was available for about $2.50/gallon. The City's price for regular diesel at that time was $0.52 per gallon. Cincinnati staff note that biodiesel production hasn't yet experienced economies of scale, so the price may actually line up with regular diesel in the near future. Costs for biodiesel are steadily decreasing, and may soon be more competitive with regular diesel (Suits, 2000).
- In spring, 2001, the San Francisco Bay Area biodiesel retail outlet was selling biodiesel for about $3 per gallon; Berkeley's Ecology Center was paying about $3 per gallon for 100% biodiesel fuel (San Francisco Chronicle, 2001).

- One-time costs for fuel filter changing and fuel delivery system monitoring, if engines and fuel distribution systems are converted from ordinary diesel to biodiesel (based on information from Suits, 2000 and Howell, 2000).

2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

Oxydiesel

A. Describe Project

1. General description of how a project could be designed
   Oxydiesel could be used to fuel existing diesel engines (on-road, off-road and stationary engines). Oxydiesel is ordinary diesel fuel, modified with the addition of fuel oxygenates (usually ethanol).
2. Departments potentially involved within interested jurisdiction or agency
   Vehicle Fleet, Transit Fleet, Street Maintenance Fleet, Fire Department, Solid Waste Collection Fleet, Purchasing
3. Other possible participants or affected entities
   BAAQMD, ARB, drivers, school bus fleet manager, maintenance staff, and drivers, transit agency managers, maintenance staff, and bus drivers, private truck, bus, rail, and shipping operators.
4. Prior related activities—experience with project (local, regional, national) and results, if available
   No specific information identified, although tests appear to have been conducted by the Chicago Transit Authority and Archer Daniels Midland (University of Illinois Agricultural Engineering Department, undated; Pure Energy Corporation, undated). One supplier is seeking demonstration project sites—contact Irshad Ahmed, Pure Energy Corporation, (212) 938-6923

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No data regarding dioxins emissions reductions from oxydiesel use were identified.
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area
3. Other environmental or educational benefits
   No information identified (although benefits are likely since oxydiesel is being developed with the purpose of reducing diesel vehicle air pollutant emissions).
4. Possible adverse impacts of project
   Oxydiesel is expect to have a somewhat lower per-gallon energy content than ordinary diesel fuel (because ethanol has a lower energy density than diesel fuel), which means that more fuel will be needed, increasing refueling frequency and fuel storage and transportation requirements (which have associated environmental impacts). Since ethanol would make up at most about 15% of the fuel, the effect is expected to be relatively small.

- Possible adverse impacts of large-scale farming of crops used to generate ethanol (*e.g.*, corn).

5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Some call this “green diesel;” environmentalists critical of this moniker and concerned that use of “cleaner” diesel will preclude more environmentally significant changes
- Government agency fleets offer an excellent opportunity for introducing diesel alternatives, because government fleets are usually centrally fueled, maintained in a controlled fashion, and operators and maintenance personnel can readily be trained (Manufacturers of Emission Controls Association, 2000).

2. Barriers to implementation
   Fuel availability
3. Possible methods to bypass barriers
   Create a fueling contract; participate in a multi-agency fuel purchase pool.
4. Schedule/timing concerns
   Oxydiesel will probably not enter the general market for a few years.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   When it is commercially available, oxydiesel is expected to cost 2 to 15 cents more per gallon than ordinary diesel fuel, most likely in the range of 5 to 7 cents more (Pure Energy Corporation, undated).
2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

Diesel Engine Retrofits

A. Describe Project

1. General description of how a project could be designed
   Existing diesel engines (on-road, off-road and stationary engines) could be retrofitted to reduce particulate formation during engine operation. Engine modification can relate to fuel delivery, air intake, and engine surfaces. Various types of retrofits are available, the simplest of which are add-on devices (*e.g.*, turbocharger-type devices, replacement fuel injectors, catalytic coatings for combustion chambers). More complicated retrofits can “repower” an engine or significantly modify an engine to provide for use of alternative fuels (CNG retrofits are considered in the CNG section). Many available retrofits treat or collect diesel particulate emissions (which would be expect to include dioxins), rather than preventing dioxins formation (these include diesel oxidation catalysts, selective catalytic reduction systems, and diesel particulate filters). Since this project focuses on pollution prevention, only retrofits that prevent dioxins formation are considered below.
2. Departments potentially involved within interested jurisdiction or agency
   Vehicle Fleet, Transit Fleet, Street Maintenance Fleet, Fire Department, Solid Waste Collection Fleet, Purchasing
3. Other possible participants or affected entities
   BAAQMD, ARB, drivers, school bus fleet manager, maintenance staff, and drivers, transit agency managers, maintenance staff, and bus drivers, private truck, bus, rail, and shipping operators.
4. Prior related activities—experience with project (local, regional, national) and results, if available

- The ARB has tested numerous retrofits and has participated in many demonstration projects.

- According to the Manufacturers of Emission Controls Association, stand-alone electronic superchargers (a turbocharger type of device) have been installed and are successfully operating on refuse trucks, transit buses, line haulers and water tankers in the U.S., Canada, Mexico, England, Germany, France, Russia, Brazil and New Zealand (Manufacturers of Emission Controls Association, 2000).
- San Francisco Muni is testing diesel/electric hybrid buses (not certain these are retrofits).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No specific data on dioxins releases was identified. Retrofits typically create cleaner burning conditions that reduce emissions of particulate matter and would be expected to reduce formation of dioxins. For example, electronic turbocharger systems monitor the demand for power and instantly supply additional air to the engine during acceleration. With more oxygen available, engine operation during acceleration (which is when most diesel particulates are generated) is cleaner, generating significantly less particulate emissions.
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area and any other region where retrofitted vehicles are driven
3. Other environmental or educational benefits

- Engine repower retrofits are designed to reduce particulate emissions (ARB, 2000).
- ARB's evaluation states that fuel injector retrofits reduce particulate emissions and slightly increase fuel economy (ARB, 2000).
- Turbocharger-type retrofits reduce fuel use and reduce carbon monoxide, hydrocarbon, and particulate matter emissions (Zendehel, 1998; Page, 1997).

4. Possible adverse impacts of project
   Some diesel engine modifications increase emissions of pollutants other than particulate matter (*e.g.*, nitrogen oxides, hydrocarbons).
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- The ARB Carl Moyer program will offer funds for diesel engine retrofits.
- Government agency fleets offer an excellent opportunity for introducing diesel retrofits, because government fleets are usually centrally fueled, maintained in a controlled fashion, and operators and maintenance personnel can readily be trained (Manufacturers of Emission Controls Association, 2000).
- The ARB has passed an urban transit rule that will require transit fleets to transition to cleaner vehicles (it is uncertain whether they will convert to cleaner diesel or to alternative fuels). This rule does not apply to street sweepers, garbage trucks, and school buses (Garvey, 1999)—such government-owned vehicles represent a significant opportunity for conversions .

2. Barriers to implementation
   Most commercially available retrofits are still untested and have not been broadly deployed.
3. Possible methods to bypass barriers

- Certain retrofits are well-respected, particularly those supplied by or tested in conjunction with major diesel engine manufacturers.
- Retrofits that improve or maintain engine performance and reliability are preferred by fleet managers.
- Certain retrofits (*e.g.*, turbocharger style) improve the vehicle's acceleration performance (Zendehel, 1998; Page, 1997).

4. Schedule/timing concerns
   Tremendous activity is occurring in this area in response to ARB's listing of diesel particulate emissions as a toxic air contaminant.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
- According to ARB, engine "repower" retrofit costs are as follows: $4290 for a 40 hp engine, $7,000 to $19,000 for a 100 hp engine, $12,000 to $32,000 for a 275 hp engine, $23,000 to $48,000 for a 400 hp engine, and $187,000 for a 1400 hp engine (ARB, 2000).
- ARB estimates for fuel injector replacement costs are $200 to $1400 per engine, depending on engine size (ARB, 2000).
- According to the Manufacturers of Emission Controls Association, current prices for retrofit electronic superchargers (a turbocharger type of device) for medium and heavy-duty vehicles range from around $3000 to $4000. However, once mass production commences, manufacturers anticipate a cost of $1500 to $2000 per unit (Manufacturers of Emission Controls Association, 2000).

2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

Natural Gas

A. Describe Project

1. General description of how a project could be designed
   Diesel engines (on-road, off-road and stationary engines) could be replaced with natural-gas powered engines. Replacements can burn 100% natural gas or a majority of natural gas and a small amount of diesel. Kits to retrofit existing diesel vehicle to burn natural gas are also available. Most vehicles use compressed natural gas (CNG).
2. Departments potentially involved within interested jurisdiction or agency
   Vehicle Fleet, Transit Fleet, Street Maintenance Fleet, Fire Department, Solid Waste Collection Fleet, Purchasing
3. Other possible participants or affected entities
   BAAQMD, ARB, drivers, school bus fleet manager, maintenance staff, and drivers, transit agency managers, maintenance staff, and bus drivers, private truck, bus, rail, and shipping operators.
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Palo Alto has an alternative fuels policy under which the City reviews all vehicle and equipment purchases to consider whether they can be operated on CNG or electrical power instead of gasoline or diesel. The Palo Alto City Council considers the extra cost due to the alternative fuel separately from the purchase/replacement costs (Moran, January 1999). Palo Alto has, for the last several years, been purchasing Cummins retrofit kits for city-owned diesel vehicles to convert them to CNG/diesel operations. The fleet manager has found these converted engines to be reliable. Contact: Keith LaHaie, Palo Alto Fleet Manager.
- Many San Francisco Bay area municipalities operate one or more fleet vehicles on CNG on either a trial or a permanent basis. The Bay Area Air Quality Management District is encouraging such activities through its Transportation Funds for Clean Air Grant program. Examples of jurisdictions using CNG vehicles include Alameda County and San Francisco, where MUNI is testing CNG buses.

- Safeway/Vons, Ralph's Grocery and Albertson's have agreed (as part of a Proposition 65 lawsuit settlement) to add 150 alternative fuel trucks to their fleets by 2003. Most of these trucks will use a combination of diesel and natural gas (San Francisco Chronicle, April 2000).
- In the San Francisco Bay Area, there are about 2,200 urban transit vehicles, only 20 of which run on CNG. Los Angeles, Sacramento and San Diego have a significant portion of their fleets running on CNG. About 20% of Bay area school buses current operate on CNG (Garvey, 1999).
- SCAQMD has adopted a rule that will prohibit purchases of diesel buses and garbage trucks in four Southern California counties, and is considering a rule to restrict diesel vehicle purchases by public fleets (CEI, 2000).
- San Francisco Airport is implementing a fee structure intended to provide incentives for all airport vehicle operators (like shuttles and taxis) to use alternative fuels. The airport has also set a goal of 100% clean vehicle operations (including tenant vehicles and airport-owned vehicles) as part of its December 1999 Clean Vehicle Policy (San Francisco Airport, 2000).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- No data regarding dioxins emissions reductions from natural gas combustion was identified.
- Because natural gas combustion is inherently cleaner than diesel combustion, it is expected to create negligible amounts of dioxins (far less than combustion of heavier fuels like diesel under typical engine operating conditions), so replacing diesel vehicles with natural gas vehicles would be anticipated to reduce or eliminate dioxins emissions associated with those vehicles (Westbrook, 2000; Johnson, April 14, 1999).
- Petrodiesel contains small quantities of dioxins (Truex, 1998). It is uncertain whether these dioxins contribute to tailpipe emissions. A U.C. Riverside study found that its estimates of dioxins emissions from diesel engines were understated due to deposition of dioxins-containing particulate in the test system; this could explain the apparent disagreement among various other studies and was said by report authors to mean that the results of the U.C. Riverside study were low (Truex, 1998). To the extent that petrodiesel is replaced by another fuel, dioxins would be displaced both in the fuel and in tailpipe emissions. The amount of dioxins reduction would depend on the amount of dioxins created by combustion of the alternative fuel source (which is unknown).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area
3. Other environmental or educational benefits

- Could result in lower emissions of fine particulate matter and of a variety of compounds of environmental concern, including oxides of nitrogen (NO_x), and possibly polyaromatic hydrocarbons (PAHs) (NREL, 2000).
- Reduction in use of diesel fuel would reduce associated toxic air emissions (*e.g.*, benzene, 1,3-butadiene), and could reduce noise and odors associated with diesel engine operations (NREL, 2000).

4. Possible adverse impacts of project

- Possible increase in greenhouse gas emissions, although CNG promoters believe that any increases in methane releases (*e.g.*, during fueling) would be offset by decreases in carbon dioxide releases (fewer carbons per energy unit in CNG than in diesel) (NREL, 2000).
- Safety concerns exist about handling of CNG and transport of CNG in vehicle tanks (no specific examples of problems were identified).

- CNG vehicles typically have a shorter driving range before requiring refueling than similar diesel vehicles. While most municipality diesel vehicles do not exceed the typical range of a similar CNG vehicle, some operations involve longer trips where refueling would be inconvenient. In the event of an emergency like an earthquake, the shorter range could be an issue, as the shorter range could have the potential to limit equipment functionality prior to refueling and refueling opportunities are more limited for CNG than for diesel fuel. It should be noted that both fuels require power to pump; municipalities typically have backup power supplies for their vehicle fueling facilities.

5. Method(s) of measuring effectiveness
   Number of CNG vehicles that replace diesel vehicles.

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- The ARB has passed an urban transit rule that will require transit fleets to transition to cleaner vehicles (it is uncertain whether they will convert to cleaner diesel or to alternative fuels). This rule does not apply to street sweepers, garbage trucks, and school buses (Garvey, 1999)—such government-owned vehicles represent a significant opportunity for conversions .
- Certain CNG retrofits are well-respected, particularly those supplied by or in conjunction with major diesel engine manufacturers.
- Government agency fleets offer an excellent opportunity for introducing diesel alternatives, because government fleets are usually centrally fueled, maintained in a controlled fashion, and operators and maintenance personnel can readily be trained (Manufacturers of Emission Controls Association, 2000).

2. Barriers to implementation
   Some CNG retrofits reduce the vehicle's acceleration, which some drivers do not like
3. Possible methods to bypass barriers
   Retrofits that improve or maintain engine performance and reliability are preferred by fleet managers. Use of CNG tends to reduce the need for oil changes and extends the life of the engine between rebuilds; however, the spark-ignited design of 100% CNG engines requires more maintenance than diesel engines (NREL, 2000).
4. Schedule/timing concerns
   The current high level of activity due to increased regulation of diesel vehicle emissions creates a good climate for projects that implement diesel alternatives.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities

- Existing heavy-duty vehicles can be converted from diesel fuel to compressed natural gas (CNG). The conversion cost is the range of $3,000 to $8,000 per heavy duty vehicle. The biggest expenditure is for installing a CNG fuel tank ($3,000 to $5,000 per heavy duty vehicle) (Westbrook and Smith, 2000).
- Less expensive retrofits involve modifying diesel engines to burn a combination of diesel fuel (for ignition) and CNG. These retrofits can use existing diesel engine ignition technology; they do not require engines to be spark-ignited (as CNG does).
- CNG buses cost about $25,000 to $50,000 more than a conventional diesel bus (depending on model), but CNG fuel is less expensive than diesel fuel. The National Renewable Energy Laboratory (NREL) believes that a typical 25 cent per gallon fuel savings would cause a CNG bus to pay for its extra cost in about 3 years of operation (after which, operating such buses would save money) (NREL, 2000).
- Costs include installation of fueling tanks, which are a significant one-time investment.

2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

Reduce trips/change modes

A. Describe Project

1. General description of how a project could be designed
   Municipalities could reduce use of diesel vehicles and switch to other methods of transferring goods and people (*e.g.*, rail). Reducing engine emissions by reducing idling times and avoiding heavy acceleration is included in this section. (Note: this section does not address off-road engines and stationary engines.)
2. Departments potentially involved within interested jurisdiction or agency
   Vehicle Fleet, Transit Fleet, Street Maintenance Fleet, Fire Department, Solid Waste Collection Fleet
3. Other possible participants or affected entities
   BAAQMD, ARB, drivers, school bus fleet manager, maintenance staff, and drivers, transit agency managers, maintenance staff, and bus drivers, private truck, bus, rail, and shipping operators.
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Trip reduction activities have generally focused on light-duty vehicles.
- Air quality requirements limit diesel vehicle idling times (these are not well enforced).
- Safety/Vons, Ralphs Grocery and Albertson's have agreed (as part of a Proposition 65 lawsuit settlement) to modify their trucks so that they idle for no more than 3 minutes at a time (San Francisco Chronicle, April 2000).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- No data regarding dioxins emissions reductions was identified.
- Eliminating trips and idling time would eliminate some dioxins emissions and would eliminate use of some dioxin-containing diesel fuel.
- During heavy acceleration, combustion conditions are created that produce the bulk of diesel particulate emissions—such conditions would also be likely to favor dioxins formation. Limiting heavy acceleration would, therefore, be expected to reduce dioxins emissions (Westbrook, 2000).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area
3. Other environmental or educational benefits
   Reduction in use of diesel fuel would reduce associated toxic air emissions.
   Eliminating idling and modifying driving practices could reduce noise and odors associated with diesel engine operations.
4. Possible adverse impacts of project
   None identified for driving/idling practice changes.
   If materials are hauled by rail, dioxin and other air pollutant emissions would be released from engines (not certain how these emissions would compare).
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
   Government agency fleets offer an excellent opportunity for introducing alternative diesel vehicle operational behaviors, because government vehicle operators and maintenance personnel can be trained and monitored more readily than independent vehicle operators.
2. Barriers to implementation
   Local government agencies do little long-haul trucking, where rail is a viable option.
3. Possible methods to bypass barriers
   Focus on activities that can be controlled by local agencies, such as idle times, driving procedures, and transportation modes in town.
4. Schedule/timing concerns
   None identified

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   No cost information obtained. Cost would depend on alternative selected. Cost savings would result from changes that increase operational efficiencies (a likely outcome of examining materials flow).
2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

IV. Drum Reclamation

Use non-burning methods

A. Describe Project

1. General description of how a project could be designed
   Companies could change drum reclamation practices from those involving burning to use of caustics and solvents ("drum washing") and physical cleaning methods. The non-burning methods require greater operational sophistication, as the drum reclaimer must know what chemical was in the drum and what method (solvent or physical method) can remove the chemical.
2. Departments potentially involved within interested jurisdiction or agency
   Environmental, Health
3. Other possible participants or affected entities
   Drum reclaimers, labor unions
4. Prior related activities—experience with project (local, regional, national) and results, if available
   Communities for a Better Environment has developed a proposal with one identified drum reclaimer in the San Francisco Bay Area (in San Francisco) to research how to modify its operations to eliminate dioxins. No specific pollution prevention measures are included in the proposal, for which CBE has sought funding. Goals for CBE include preserving the jobs at the drum reclaimer.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   Unknown. At one facility in the San Francisco Bay area dioxins levels in runoff were relatively high (the highest measured in a San Francisco wastewater and storm water runoff survey; Rourke, 2000).

2. Where reduction would occur (which environmental media, geographic location)
   Near drum reclamation facilities (*e.g.*, in San Francisco)
3. Other environmental or educational benefits
   Burning-type drum reclamation methods probably emit many other air pollutants and may raise worker safety issues, especially if not conducted in very well-ventilated work spaces.
4. Possible adverse impacts of project
   Alternative methods may also pose worker hazards and release pollutants to the environment; for example, drum-cleaning solutions may be toxic, flammable, and/or corrosive.
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- One identified facility has significant environmental justice issues. Site visitors indicate that the working conditions may be unsafe, yet jobs are not plentiful in the geographic area where the facility is located. Dioxins levels in runoff from the site are relatively high, suggesting that dioxins (and probably other pollutants) are being released from the facility at environmentally meaningful levels, a concern for neighbors as well as for water quality.
- CBE is actively seeking funding for its research proposal, which is set up to involve the company, the workers, and the community.
- Compliance and safety issues may threaten continued operation of drum reclaimers that use incineration methods.
- U.S. EPA may consider developing wastewater effluent guidelines for drum reclamation activities in the next few years.

2. Barriers to implementation

- The San Francisco reclamation facility is small and lacks technical and monetary resources.
- Change to non-burn processes requires significant technical expertise to identify appropriate cleaning methods and to manage solvents, etc.

3. Possible methods to bypass barriers
   Training and funding for new equipment.
4. Schedule/timing concerns
   None identified.

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

V. Medical waste

Reduce medical waste volume

A. Describe Project

1. General description of how a project could be designed
   Medical facilities could use training, signage, product selection, and operational practices to reduce the amount of medical waste generated. Medical waste generating facilities include hospitals (the primary generators of medical waste), medical offices, and biomedical research facilities. This involves both source reduction and waste diversion from the medical waste stream to the solid waste stream.

2. Departments potentially involved within interested jurisdiction or agency
   Solid Waste, Environmental, Health
3. Other possible participants or affected entities
   Hospitals, DHS, Healthcare Without Harm, Medical Associations, Nurses, Unions, Healthcare Associations
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Healthcare P2 project--USEPA, California Department of Health Services (main grantee), DTSC, CIWMB, Contra Costa County, Alameda County, Healthcare Without Harm Coalition, Labor Organizations, other healthcare industry, community, environmental group representatives have worked together to carry out 6 multimedia pilot assessments of hospitals in the Bay Area, and to promote implementation of identified pollution prevention options (including medical waste reduction actions). One early finding of the Healthcare P2 project was that using recyclable sharps containers instead of single-use containers (that are typically incinerated) would dramatically reduce medical waste volumes, since such containers comprise about one third of a typical hospital's medical waste stream. For a 250-bed hospital, switching to recyclable sharps containers could save more than $50,000 per year (Kubo, 2000). Additional valuable findings are anticipated from this project. Contact: Pamela Evans, 510-567-6770, Alameda County Public Health Department
- The American Hospital Association (AHA) signed a memorandum of understanding (MOU) with EPA two years ago with the goal of reducing waste 33 percent in all hospitals by 2005 and 50 percent by 2010. (The MOU also calls for eliminating mercury by 2005.) U.S. EPA is providing support for implementation of the MOU. Contact: Kathy Svedman, AHA staff liaison for the project, (312) 422-3861.
- Beth Israel Medical Center in New York City reduced medical waste generation by a million pounds a year, saving the hospital $600,000 per year in medical waste management costs. Concurrent solid waste reduction programs saved the hospital another $900,000 per year (Russell, 2000). Contact: Janet Brown, Beth Israel Medical Center.

<u>B. List Possible Project Impacts and Evaluation Methods</u>

1. Potential reduction in dioxins releases
   Many hospitals have historically adopted practices that favor disposal of wastes (including recyclables) with medical waste. Modifying practices to improve waste segregation and to provide recycling opportunities can significantly reduce medical waste volumes (Kubo, 2000; Battelle, September 2000.). Since non-medical waste in California is usually landfilled, this can reduce waste incineration, thereby reducing dioxins formation.
2. Where reduction would occur (which environmental media, geographic location)
   At incinerator location (San Francisco Bay Area incinerator in Oakland)
3. Other environmental or educational benefits
   Since medical waste reduction programs typically involve recycling and source reduction components, the ancillary benefits include reduced materials use and increased recycling.
4. Possible adverse impacts of project
   Diverted waste would add to landfill volumes (California medical waste volumes are small relatively to solid waste volumes).
5. Method(s) of measuring effectiveness
   Tracking waste destinations by hospital and waste volumes for hospitals that incinerate waste.

<u>C. List Possible Implementation Issues</u>

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

Currently there is significant interest in healthcare waste, due to the activities of Healthcare Without Harm and due to the EPA/American Hospitals Association agreement. Other efforts are "multi-media" in nature, so it would make sense to hospitals if a project included other hospital P2 issues (*e.g.*, mercury, solid waste reduction). Opportunities may exist to partner with other hospital P2 efforts to create multi-media programs.

2. Barriers to implementation

- Must fit changes conveniently into hospital operations; changes particularly difficult in surgery, where much medical waste is generated.
- Hospitals are preoccupied with issues other than reducing their environmental impacts. Even documenting cost reduction information is sometimes insufficient to get their attention. Hospital accreditation (by Joint Commission on Accreditation of Healthcare Organizations or JCAHO) and management issues (mergers, labor problems, funding sources) are the focus of attention (Evans, 2000).
- Concern about improper segregation of wastes, as there are potentially severe consequences for allowing medical waste to enter the ordinary solid waste or recycling streams (Evans, 2000; Kubo, 2000).
- Healthcare vendors are a force to be reckoned with (Evans, 2000).

3. Possible methods to bypass barriers

- Training, involvement of allies ("green teams") and senior management in hospitals, cost reductions, information, coordination with purchasing cooperatives and vendors.
- Tapping into existing internal interest in environmental protection, creating favorable media coverage of success stories, offering personalized, onsite, ongoing assistance.
- Labor is a critically important partner in assessing and implementing P2 opportunities.
- Need upper management commitment and bottom up commitment to make P2 work.

(Source of the above: Kubo, 2000; Evans, 2000).

4. Schedule/timing concerns

The activities mentioned above make this a good time to work on hospital pollution prevention.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities

Reducing medical waste volumes usually saves hospitals money, as medical waste management costs are usually significantly higher than solid waste management costs (Kubo, 2000).

2. Costs changes for other involved/affected entities

No cost information obtained.

3. Other possible costs

No cost information obtained.

Use non-incineration methods for waste management

A. Describe Project

1. General description of how a project could be designed

Medical facilities could switch medical waste management from incineration to an alternative disposal method such as autoclaving, chemical disinfection, sterilization, or microwaving. Medical waste generating facilities include hospitals (the primary generators of medical waste), medical offices, and biomedical research facilities.

- Autoclaves are essentially large pressure cookers that use heat and steam to kill pathogens. Steam sterilization units use the same processes, but have a different design. Once treated, the waste is usually shredded.

- Microwaves and radiofrequency irradiation units use irradiation to kill pathogens—the systems are somewhat analogous to home microwave ovens. Waste is usually shredded prior to such treatments.
- Chemical or mechanical/chemical treatment involves use of chemical biocides (disinfectants) to kill pathogens. Some such processes involve waste shredding prior to treatment and/or waste encapsulation after treatment.

For all of the above processes, after treatment, waste is usually disposed of in an ordinary landfill (however, at least one vendor incinerates waste after sterilization). Some of the above processes generate an aqueous waste stream (waste from steam or from air emissions control devices) that is usually discharged to the sewer system. (Most of the above information was compiled from U.S. EPA, 1992 and Huff, undated).

2. Departments potentially involved within interested jurisdiction or agency
   Solid Waste, Environmental, Health
3. Other possible participants or affected entities
   Hospitals, DHS, Healthcare Without Harm, Medical Associations, Nurses, Unions, Medical Waste Treatment Facilities
4. Prior related activities—experience with project (local, regional, national) and results, if available

- The Healthcare Without Harm campaign has stimulated hospitals around the U.S. to change medical waste management practices. Examples include Stanford University, which recently announced plans to end all medical waste incineration (except for the small fraction of its waste requiring incineration under California law).
- California has 9 licensed commercial medical waste management facilities, only one of which is an incinerator.
- Integrated Environmental Systems (IES), which operates the state's only medical waste incinerator, has initiated an effort to move customers to managing waste by alternative technologies (methods other than incineration). The company has a goal of shifting 50% of the waste it manages to non-incineration management methods by the end of 2001 (Schwartz, 2001). In August 2001, IES announced plans to reduce the volume of waste it incinerates by 70 percent. IES offers microwave and autoclave treatment technologies.

<u>B. List Possible Project Impacts and Evaluation Methods</u>

1. Potential reduction in dioxins releases
   No specific data obtained; however, to the extent that incineration was replaced by a non-incineration alternative, dioxins emissions from the waste management would be eliminated. Nationally, dioxins emissions from medical waste incineration are anticipated to decline as national regulations limiting pollutant emissions from incinerators are implemented. In the San Francisco Bay area, it is not clear what affect those regulations will have, as the one medical waste incineration facility is currently working with air quality regulatory agencies on permitting issues.
2. Where reduction would occur (which environmental media, geographic location)
   At the location of the medical waste incinerator (*e.g.*, in Oakland)
3. Other environmental or educational benefits
   In addition to dioxins, incineration releases many air pollutants (*e.g.*, carbon monoxide, nitrogen oxides, sulfur oxides, hydrogen chloride, fine particulate matter, polycyclic aromatic hydrocarbons, mercury, cadmium, lead). Nationally incinerators are major air emissions sources of both dioxins and mercury (McKone, 2000). To the extent that incineration is eliminated, such releases are reduced or eliminated from incinerators. Some air pollutant emissions may occur from the use of non-incineration technologies; however, no data was identified that allowed quantitative comparison of these emissions to incineration emissions. Generally, assuming waste treated with alternative technologies is not ever incinerated, air pollutant emissions are expected to be significantly lower.

4. Possible adverse impacts of project

- Autoclaves generate odorous air emissions. Autoclave steam emissions may contain toxic compounds like chloroform, formaldehyde, and acetaldehyde (Commoner, 1996.) Treating the steam to remove these compounds reduces human exposures, but diverts the pollutants into wastewater.
- Methods involving biocides could release the biocide (*e.g.*, bleach) to the environment.
- There is potential for pathogen release from certain medical waste treatment technologies. A 1993 U.S. EPA-commissioned study found no measurable releases from on-site or commercial autoclaving, but potential releases from microwave and mechanical/chemical biocide treatment (RTI, 1993). Waste handling practices may have been changed to address this issue, but no data was identified in this regard.
- Most alternative methods create a non-biohazardous solid waste that is landfilled with ordinary solid waste. This increases the overall solid waste stream, although it should be noted that in California medical waste volumes are small relatively to the total volume of solid waste.
- Methods that involve waste shredding prior to treatment can expose facility workers to pathogens released by the shredding process.

5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
   None identified
2. Barriers to implementation

- No blanket alternative exists. Certain wastes (pharmaceuticals, chemotherapy, and pathological wastes) must be incinerated under current California law; however, these are a small fraction of the waste stream. Colloquial information from current and former hospital waste managers suggests that these waste streams comprise a few percent of medical waste. Pathological waste comprises about 2% of the medical waste stream (Commoner, 1996). Based on its experience with medical waste management, IES has found that about 5-8% of medical waste requires incineration under California law (Schwartz, 2001).
- Certain sterilization facilities send sterilized waste for incineration.
- Treated waste still can look like medical waste, which makes its acceptance at landfills problematic. Careful management of waste streams is needed to ensure that medical waste is not released into the non-medical waste stream (these were problems for Beth Israel Hospital, New York City).

3. Possible methods to bypass barriers

- Obtain organized information about alternatives, including the pros and cons for each and vendor lists, obtain assistance from DHS regarding the efficacy of alternatives and permitting status of individual facilities.
- Autoclaves are easier to operate than incinerators (Commoner, 1996). Autoclaves can be operated by hospitals on-site.

4. Schedule/timing concerns
   None identified

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   Microwaving is more expensive than autoclaving (Commoner, 1996).
2. Costs changes for other involved/affected entities
   No cost information obtained.

3. Other possible costs
   No cost information obtained.

Eliminate medical PVC use

A. Describe Project

1. General description of how a project could be designed
   Medical facilities could substitute non-PVC products for PVC-containing medical devices like IV bags, tubing, gloves, ID bracelets, and waterproof sheeting. Alternatives for medical uses of PVC include glass, latex, chlorine-free plastics including polyethylene, polypropylene, polyethylene terephthalate, ethylene-vinylacetate copolymer, polybutylene terepthalate, block copolymers, and silicones (Thornton, 1997).
2. Departments potentially involved within interested jurisdiction or agency
   Environmental, Health, Purchasing
3. Other possible participants or affected entities
   Hospitals, DHS, Healthcare Without Harm, Medical Associations, Nurses, Unions
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Healthcare Without Harm has negotiated agreements to phase out use of PVC with Baxter International, Universal Health Services, Tenet and its group purchasing organization BuyPower.
- Kaiser Permanente plans to phase out use of PVC gloves.
- Catholic Healthcare West is developing a PVC phase-out policy.
- Maine's 39 hospitals have pledged to reduce use of PVC-containing medical supplies.
- Many medical and health associations have passed resolutions called for the phase out of PVC in medical products.
- Several Swedish County Councils have decided to phase out PVC use, including Stockholm's County Council, which focused energies on its healthcare operations. A brochure prepared by the Federation of Swedish County Council's documents Stockolm's progress in replacing PVC medical products and identifies both PVC alternatives and PVC replacement issues like cost, availability, and functional differences (Federation of Swedish County Councils, 2000).
- Some organizations have requests for PVC content and/or requests for vendors to identify PVC-free products in bid specifications (*e.g.*, State of Massachusetts, Catholic Healthcare West) (Sutherland, 2000).
- The Sustainable Hospitals Project provides resources for identifying and purchasing PVC-free medical products (www.uml.edu/centers/lcsp/hospitals). Contact: Catherine Galligan 9780934-3386.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No specific information identified. Benefits would be greatest in situations where medical waste is currently incinerated, since reducing PVC content of waste sent to a particular incinerator is likely to reduce dioxins formation in that incinerator. Although the relationship between the presence of PVC in a waste stream and dioxins emissions has been the subject of significant technical debate, a recently published study provides for the first time a carefully controlled comparison of various combustion conditions (including no added chlorine source, added PVC, and added inorganic chlorine) and dioxins releases (Yasuhara, 2001). That study identified a clear correlation between chlorine content and dioxins formation. Both inorganic chlorine (*e.g.*, table salt) and PVC increased dioxins formation. The procedures used in the Yasuhara study eliminate the problems endemic in previous studies, such as differences in emissions controls, combustion temperatures, and other

combustion conditions that precluded like-to-like comparisons of combustion of various materials with different chlorine contents (*e.g.*, Rigo, 1995; Gullett, 2000).

2. Where reduction would occur (which environmental media, geographic location)
   At PVC manufacturing site (outside of the San Francisco Bay Area) and at medical waste incineration location (if waste is incinerated)
3. Other environmental or educational benefits

- Other releases from PVC manufacturing have environmental effects.
- PVC often contains additives that are environmentally problematic—phthalates (common softeners for the otherwise stiff polymer) have been of particular concern for health care.

4. Possible adverse impacts of project
   Concerns about safety and efficacy of alternative products (*e.g.*, what if a glass IV bottle breaks?, latex allergies)
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
   Medical community concern about leaching of phthalates from PVC IV bags is increasing. Healthcare Without Harm's campaign on hospital use of PVC creates momentum for similar government agency activities. Health Care Without Harm is developing a model protocol for hospitals interested in moving away from PVC-containing devices.
2. Barriers to implementation

- PVC is the most common plastic used in health care, where it has been used for many years. The availability and practicality of alternatives (*e.g.*, glass IV bottles) is being debated.
- Convenient substitutes do not exist for all medical PVC uses. The lack of alternatives for certain uses is often raised as a barrier to replacing PVC for other, unrelated uses.

3. Possible methods to bypass barriers
   It is possible to implement demonstration projects involving use of convenient alternatives that are currently available. Focusing efforts on convenient substitutions and medically accepted alternatives can prevent debates about potential patient care impacts.
4. Schedule/timing concerns
   None identified

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

VI. Paper Bleaching

Elemental chlorine free

A. Describe Project

1. General description of how a project could be designed
   Elemental chlorine free (ECF) paper products (bleached with chlorine dioxide rather than chlorine gas) could be purchased. It should be noted that U.S. paper manufacturers plan to shift to ECF paper production in the next few years in response to U.S. EPA regulatory requirements, most of which took effect in April 2001 (*Federal Register*, 1998).

2. Departments potentially involved within interested jurisdiction or agency
   Purchasing
3. Other possible participants or affected entities
   Paper suppliers, all paper users at a government agency (particularly reproduction and janitorial)
4. Prior related activities—experience with project (local, regional, national) and results, if available
   ECF paper is widely used, although often not labeled as ECF.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
- Transition from chlorine-based bleaching to elemental chlorine free (chlorine dioxide) bleaching dramatically reduces (but does not eliminate) releases of dioxins[16] from paper mills (Paper Task Force, 1999; Shariff, 1996; N. McCubbin Consultants, 2000).
- A Paper Task Force report indicates that "[m]ills that move toward ECF effluent-free bleach plants may generate dioxin emissions from either the recovery boiler or the dedicated incinerator if organic compounds are burned in the presence of chlorides." (Paper Task Force, 1999).

2. Where reduction would occur (which environmental media, geographic location)
   In vicinity of paper mills, outside the San Francisco Bay area.
3. Other environmental or educational benefits
- ECF bleaching processes reduce formation of chlorinated organic compounds; a recent study showed that use of ECF bleaching reduced mill wastewater effluent levels of chlorinated organic compounds (measured as adsorbable organic halogen, or AOX) in by a factor of 10. Wastewater effluents maintained some toxicity, but were less toxic than effluents generated by mills using chlorine gas bleaching processes (Tarkpea, 1999).
- ECF paper production reduces water use by 5 to 15% as compared to chlorine bleached paper production (MacFadden, 1996).
- Energy use for ECF and TCF/PCF paper processing is lower than for most chlorine processes; the savings are greatest if wastewater is recycled (Paper Task Force, 1999).

4. Possible adverse impacts of project
- ECF bleaching generates chlorinated organic compounds (measured as adsorbable organic halogen, or AOX) in wastewater effluents, and effluents from mills using ECF bleaching processes do retain some toxicity. While these represent reductions as compared to effluents from mills using chlorine bleaching, the use of totally/process chlorine free paper bleaching methods (see below) provide greater reduction in environmental impacts (Tarkpea, 1999).
- ECF paper bleaching processes reduce formation of chlorinated organic compounds (measured as AOX) by about 80%; dioxins production is reduced, but dioxins are still formed by the reactions of a small amount of elemental chlorine generated by chemical reactions in the chlorine dioxide bleaching step (Commoner, 1996).

5. Method(s) of measuring effectiveness
   Monitor paper purchase records

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
- ECF alternatives are readily available for many paper products.

[16] The definition of dioxins in this section is consistent with the definition of dioxins used elsewhere in this report (see page 2). This definition, which is based on the I-TEQ scheme, includes not only TCDD (which some paper industry documents commonly refer to as "dioxins"), but also all other dioxins and furans assigned TEFs in the I-TEQ scheme.

- ECF processes have been shown to increase pulp yield and quality (thereby requiring fewer trees to produce the same amount of paper; U.S. EPA, 1995).

2. Barriers to implementation
   Products are often not labeled as ECF; not all sales operations or distributors know how paper products are bleached (for example, see Moran, September 1998).
3. Possible methods to bypass barriers
   Bleaching information is often requested in RFPs for paper product purchase in situations where bleaching method is a consideration. Most manufacturers have hotlines where bleaching information can be obtained.
4. Schedule/timing concerns
   U.S. paper manufacturers plan to shift to ECF paper production in the next few years to respond to new EPA regulatory requirements.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   No cost information obtained. Informal information suggests costs are competitive to slightly higher than those for chlorine-bleached paper. Transition costs should be the same or lower than costs to transition to PCF/TCF paper (see below).
2. Costs changes for other involved/affected entities
   Switching to ECF production is costly for paper mills; however, using ECF (or PCF/TCF) processes will effectively be required by a recent U.S. EPA rule.
3. Other possible costs
   No cost information obtained.

Totally or Process chlorine free

A. Describe Project

1. General description of how a project could be designed
   Totally chlorine free (TCF) virgin paper products or process chlorine free (PCF) recycled paper products could be purchased. This analysis focuses on PCF products under the assumption that participating municipalities have current preferences for recycled paper.
2. Departments potentially involved within interested jurisdiction or agency
   Purchasing
3. Other possible participants or affected entities
   Paper suppliers, all paper users at a government agency (particularly reproduction and janitorial)

4. Prior related activities—experience with project (local, regional, national) and results, if available

- After testing various paper supplies and developing a purchasing specification for 100% recycled PCF papers (including office papers and sanitary papers) (Weiss, 2000), the City of Palo Alto has switched to the new paper for letterhead and copy paper uses (City of Palo Alto, 2001).
- Examples of organizations that purchase or have a purchasing preference for chlorine-free papers include the City of Chicago, City of Seattle, City of Ann Arbor (10% price preference), Time, Inc., U.S. EPA Region III, and Patagonia.
- Ben & Jerry's and UPS are switching to unbleached packaging (AEI, 1999).
- The State of Vermont has been using PCF paper exclusively for 4-5 years. Although the state experienced some copier performance problems when the PCF paper was first introduced, they have not had any problems in years (Guillemin, 2000). Contact: Ken Feld, kenneth.feld@state.vt.us.
- The Chorine-Free Products Association has developed chlorine-free product certification process for TCF and PCF paper products. Contact: Archie Beaton, 847-658-6104.

- American Institute of Graphic Arts, San Francisco Chapter (AIGA/SF) created an Arbor Day poster and an associated poster/mailer called the "Guide To Ecological Papers" that provided information about commercially available environmentally preferable papers (for bleaching, it lists primarily PCF papers), with specifications and vendor information. The Guide was mailed to San Francisco Bay Area graphic artists. One barrier to its use can be perception that a graphic artists' clients are not interested in using "environmentally friendly" papers. A way around that is for the artist to recommend or specify such papers as part of the design, by integrating the features of the papers into the graphic art product.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- Use of TCF processing eliminates dioxins formation, since TCF bleaching processes eliminate formation of chlorinated organic compounds by eliminating addition of chlorine in the paper manufacturing process.
- Since it starts with recycled fibers from paper that may contain dioxins (from previous bleaching or from dioxins collected during prior use), PCF paper production may release dioxins into the environment, even though dioxins would not be formed by such processing (Cooper, 1999).

2. Where reduction would occur (which environmental media, geographic location)
   In vicinity of paper mills, outside the San Francisco Bay area.
3. Other environmental or educational benefits

- TCF bleaching processes eliminate formation of chlorinated organic compounds (however, some such compounds could be released when recycled paper fibers are processed to make PCF paper). A recent study showed that use of TCF bleaching eliminated the presence of chlorinated organic compounds (measured as adsorbable organic halogen, or AOX) in mill wastewater effluent. Wastewater effluents from paper mills using TCF/PCF processes were found to be the least toxic of effluents from mills using the three typical paper bleaching methods (Tarkpea, 1999; similar, but not identical, conclusions in CERF, 2000; Paper Task Force, 1999). It should be noted that these results apply to the entire effluent from the paper mills tested—they are not tests of effluent from the bleaching process alone (Pryke, 2001) and therefore these results may also reflect process differences other than differences in bleaching processes (Tana, 1996).
- In addition to dioxins in recycled pulp, dioxins from air deposition can also be incorporated into virgin pulp sources (trees) and paper processing solutions, so no paper manufacturing (even PCF/TCF) is truly "dioxin-free" (Commoner, 1996).
- Wastewater from TCF/PCF paper production is relatively easy to recycle (unlike wastewater from ECF or chlorine bleached paper production, which contains high concentrations of difficult to remove chloride ions), making a cost-effective near closed-loop process possible (Cooper, 1999).
- Energy use for ECF and TCF/PCF paper processing is lower than for most chlorine processes; the savings are greatest if wastewater is recycled (Paper Task Force, 1999).
- PCF paper products are often made with high recycled content, reducing use of trees.

4. Possible adverse impacts of project

- Only one PCF/TCF paper plant exists in the U.S., which means that paper may need to be transported long distances (*e.g.*, from Canada, where most North American PCF/TCF mills are located) to reach users, creating air pollution and other transportation-related environmental impacts. The U.S. TCF paper plant is in Samoa, California (Katz, 2000).
- TCF paper production requires more trees to make the same quantity of paper (Deardorff, 1997; CERF, 2000). No information was identified to suggest whether making PCF recycled paper affects resource use.

5. Method(s) of measuring effectiveness
   Monitor paper purchase records.

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

None identified

2. Barriers to implementation

- PCF paper is not as readily available as chlorine-bleached and ECF paper, but still readily available to government purchasers (Guillemin, 2000). Few North American mills have converted to PCF/TCF processing; most of these are in Canada (however, in 1996 about 40% of European mills had converted to PCF/TCF; MacFadden, 1996).
- May have darker appearance, different texture, or different surface.
- Pulp (and therefore paper) quality, strength and brightness may be lower with TCF/PCF processes. Reduced pulp quality may affect paper recyclability (CERF, 2000).
- Products are often not labeled as PCF/TCF; not all sales operations or distributors know how paper products are bleached (for example, see Moran, September 1998).
- Manufacturer questions regarding environmental value of PCF as compared to ECF paper. Industry is moving to ECF processes, making arguments that ECF is at least as good environmentally as PCF/TCF, and opposing some PCF/TCF purchasing efforts (Deardorff, 1997; Folwarkow, 2000; Pryke, 1997; Guillemin, 2000).

3. Possible methods to bypass barriers

- A good technical analysis, considering dioxins and other environmental issues, would provide information needed for agencies to make the cost/benefit decision appropriate for their community.
- Providing assistance to purchasers through a network or an event. For example, the Chlorine Free Products Association has offered to assist with holding a Chlorine Free Summit for this purpose (Beaton, 2000).
- Use purchasing cooperatives like the Recycled Products Purchasing Cooperative (which offers chlorine-free office papers; see www.recycledproducts.org).

4. Schedule/timing concerns

U.S. paper manufacturers plan to shift to ECF (not PCF/TCF) paper production in the next few years to respond to new EPA regulatory requirements, most of which took effect in April 2001 (*Federal Register*, 1998).

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities

- Prices are higher than prices for chlorine-bleached or ECF paper. According to the Connecticut State Environmental Purchasing Coordinator, price is the most significant barrier to purchase of PCF/TCF paper (Guillemin, 2000). For a small purchase, Connecticut paid almost 50% more for PCF paper than for ordinary 30% post-consumer content recycled paper.
- The City of Palo Alto uses about 17,000 reams of office paper a year; based on that purchase rate, it estimates that PCF paper will cost about 30 to 40% more than the ECF paper it had been using (price increase from about $2.30 to about $3.05-$3.20 per ream) (Weiss, 2000).

2. Costs changes for other involved/affected entities

- Significant capital investment is required to shift paper manufacturing processes from chlorine gas to other bleaching methods. In its rulemaking, U.S. EPA agreed with the paper industry perception that the cost to shift to TCF/PCF processes (which involves changes in delignification as well as changes in the bleaching process) to be substantially higher than the cost to shift to ECF bleaching (Commoner, 1996; CERF, 2000; *Federal Register*, 1998).
- Barry Commoner (among others) notes that purchasing practices are likely to play a significant role in paper manufacturing process decisions (Commoner, 1996).

- Canadian data suggest that the cost differential between ECF and TCF/PCF paper is entirely due to the capital investment needed for conversion to the chlorine-free process, as the operating costs of producing chlorine free pulp are similar to the operating costs for producing ECF pulp. For new pulp mill system construction, the capital cost for installing chlorine free processes is said to be slightly lower than for a new ECF system (N. McCubbin Consultants, 2000).

3. Other possible costs
   No cost information obtained.

VII. Pentachlorophenol

Use non-wood alternative utility poles

A. Describe Project

1. General description of how a project could be designed
   Non-wood alternative products could be purchased instead of pentachlorophenol-treated wood. Generally, the only new wood products that contain pentachlorophenol (PCP) are utility poles. Common alternative utility pole materials include steel, fiberglass, and concrete. Undergrounding utilities is also an alternative (due it the expense of undergrounding, it is not considered in detail below).
2. Departments potentially involved within interested jurisdiction or agency
   Purchasing, Utilities
3. Other possible participants or affected entities
   Private Utilities
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Both northwest utility companies and island utility companies have made extensive use of non-wood utility poles.
- The Navy has found that non-wood materials (recycled plastic) provide excellent performance in piers (TetraTech, 1999).
- Many geographic areas have relocated utilities underground.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- Reduction is unknown, but has the potential to be meaningful, since there are probably tens of thousands of pentachlorophenol-treated utility poles in the San Francisco Bay Area. The City of Palo Alto (population 60,000) has about 6,000 utility poles and purchases about 100 to 200 new poles each year (Johnson, April 23, 1999).
- Dioxins can be released from poles into the air, into soil, and into storm water runoff (directly from the pole or indirectly via soil around the pole). An industry-sponsored study suggests that release to the air is not a significant release pathway for dioxins in pentachlorophenol-treated wood (Weinberg Group, 1998). U.S. EPA completed an evaluation of releases from PCP-treated utility poles, which are estimated to comprise about 80 percent of the PCP in in-use wood products (Winters, 1999). Results of the study supported the hypothesis that utility poles can serve as a reservoir source for dioxins. This study was limited in that it only addressed dioxin mobility during a pole's useful life, and did not address the question of dioxin mobility or environmental release as a result of pole disposal practices (Battelle, August 2000).
- Environment Canada estimated that annual releases of dioxins from in-service pentachlorophenol treated utility poles to be larger than releases from municipal wastewater treatment plant sludge (one of the top 10 US release sources according to US EPA) (Environment Canada, 2000; U.S. EPA, September 2000).

- While the U.S. EPA dioxins inventory does not include dioxins in commercial products like pentachlorophenol-treated utility poles, its inventory document notes that dioxins in pentachlorophenol treated wood appears to be the largest flow of dioxins that U.S. EPA has quantified at about 8,400 g per year in 1995, more than twice the total 1995 estimated dioxins releases (U.S. EPA, September 2000).

2. Where reduction would occur (which environmental media, geographic location)
San Francisco Bay area, wood treatment location, and pentachlorophenol manufacturing location

3. Other environmental or educational benefits

- A U.S. EPA draft risk assessment reviewing the human health and environmental risks of pentachlorophenol use found significant health risks for workers that apply pentachlorophenol to wood, workers who work with treated wood products (*e.g.*, utility workers), and children who play near treated poles (U.S. EPA, 1999). While these results are from a draft risk analysis and therefore are subject to change, it is important to note that the risk assessment only considered risks from pentachlorophenol itself; risks from contaminants (dioxins and hexachlorobenzene) are still to be evaluated, as are risks from several exposure scenarios for which the U.S. EPA did not have risk information.
- Pentachlorophenol is itself an environmental concern, so reducing its use would have environmental benefits. The end-of-life fate of pentachlorophenol-treated wood is of particular concern, since re-use and disposal can create opportunities for release of dioxins and other pollutants in the treated wood. Both industry and environmental groups are working to address pentachlorophenol-treated wood waste management (Wilkinson, 2001; Feldman, 2000).
- Reducing wood use may have environmental benefits relating to logging impacts and global warming.
- Steel poles can be recycled when they are decommissioned.
- Non-wood poles are not subject to damage by woodpeckers, which is (in some regions of the U.S.) a major source of pole deterioration (Harness, 2000).

4. Possible adverse impacts of project

- Worker safety may be an issue for metal poles (conductivity) and heavy concrete poles (accidents during installation).
- Because concrete and steel poles are more conductive than wood poles, they must be designed to minimize shock hazards (Harness, 2000). In treeless areas with plentiful food for raptors, electrocution of raptors on utility distribution poles has been a problem that is exacerbated by typical steel and concrete pole design (this does not appear to be an issue in urban areas like the San Francisco Bay Area). Modifications are available to address this issue, which also occurs on wood poles (Harness, 2000).
- Manufacturing of materials for alternative poles has impacts (*e.g.*, mining, smelting) that are partially offset by the longer lifetime of alternative materials as compared to wood.

5. Method(s) of measuring effectiveness
Track purchasing records for purchases of utility poles.

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Reuse of pentachlorophenol treated poles that are taken out of service is common in the U.S. (uncertain of California status) and may pose significant environmental concerns. In addition to reuse of whole or partial utility poles, treated wood waste may be managed by landfilling or incineration (an alternative being actively promoted by the American Wood Preservers Institute).
- Managing pentachlorophenol-treated wood waste is perceived as a hassle by agency and utility staff.

2. Barriers to implementation

- Utility staff and managers are used to wood poles. Some utilities consider pentachlorophenol-treated poles to be the "industry standard" (Moran, December 1998).
- It is possible to "climb around" wood poles; accessing alternative poles is more limiting (to hand & foot holds and to aerial truck access) (Battelle, September 2000; Moran, December 1998). Working on wood poles near the top is easier than working on alternative poles, even though the alternatives have built-in steps; this is particularly problematic where poles cannot be accessed with equipment (*e.g.*, a cherry picker) (Moran, December 1998).
- Workers are concerned about the safety of steel poles, because they are conductive. This issue can be addressed through proper insulation, but it remains a concern among workers (Moran, November 1998).
- Modifications to steel and concrete poles are difficult to make. Strength and longevity are issues for fiberglass poles.
- Steel poles are subject to corrosion, so they must be monitored and maintained properly. Utilities have experience with such monitoring and maintenance since high voltage power distribution systems (like those that line the western shore of South San Francisco Bay) are normally constructed of steel.

3. Possible methods to bypass barriers

- Educate staff about worker safety concerns relating to exposure to pentachlorophenol.
- Enact stringent procedures for using personal protective equipment, managing waste wood, drilling remains, etc. for pentachlorophenol-treated poles.
- Alternative poles typically last longer than wood poles.
- Alternative pole materials generally do not require regular maintenance or pesticide treatments, like wood poles.
- Fiberglass poles are lightweight, making them convenient to install in awkward locations.

4. Schedule/timing concerns

U.S. EPA is currently reviewing the pesticide registration that allows pentachlorophenol to be used in the U.S. The preliminary outcome of the review is anticipated in 2002. Such a review has the potential to restrict or eliminate use of pentachlorophenol.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities

- While the average cost of a treated wood pole is about $200 to $400, a steel pole costs about $250 to 300 (Johnson, April 23, 1999). Steel has additional cost advantages in that steel poles last about twice as long as wood poles, and they have some residual recycling value when they are decommissioned.
- A Technical Bulletin prepared for the utility industry details measures to prevent raptor electrocutions on utility distribution lines (Harness, 2000). It concludes:

  > "When comparing different pole types, additional materials required to frame poles in a raptor-safe manner should be included in a cost analysis. The cost to provide established engineering criteria such as Basic Impulse Insulation Level [BIL] should also be considered. Because steel and reinforced concrete poles are more conductive than wood or fiberglass, additional costs are required to provide adequate BIL and raptor protection."

  According to the report, the added cost (per pole) to provide recommended protection measures for non-wood poles ranges from about $100 to $300 per pole. It is not clear whether raptor protection is an issue in urban areas like the San Francisco Bay Area.
- Maintenance costs for alternative poles are lower, as are decommissioning costs, since special handling is not required.
- Undergrounding is very expensive (no cost figures obtained), but reduces utility maintenance requirements.

2. Costs changes for other involved/affected entities
   Costs above would also apply to private utility companies.
3. Other possible costs
   No cost information obtained.

Use different wood preservatives

A. Describe Project

1. General description of how a project could be designed
   Outdoor wood products that are not treated with pentachlorophenol could be purchased. Generally, the only new wood products that contain pentachlorophenol are utility poles. Secondary markets (for purchase or donation) may make used pentachlorophenol-treated poles available for reuse. A wide variety of alternative wood preservatives are used; however, three other products comprise a majority of the preserved wood market: creosote, chromated copper arsenate (CCA), and "ammoniacal copper quat" (ACQ).
2. Departments potentially involved within interested jurisdiction or agency
   Purchasing, Utilities, Parks & Recreation, Public Works
3. Other possible participants or affected entities
   Private Utilities
4. Prior related activities—experience with project (local, regional, national) and results, if available
   The primary utility in Ontario (Ontario Hydro) uses copper chromium arsenate to preserve its utility poles (Battelle, August 2000).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- Reduction is unknown, but has the potential to be meaningful. Dioxins can be released from poles into the air, into soil, and into storm water runoff (directly from the pole or indirectly via soil around the pole). An industry-sponsored study suggests that release to the air is not a significant release pathway for dioxins in pentachlorophenol-treated wood (Weinberg Group, 1998). U.S. EPA completed an evaluation of releases from PCP-treated utility poles, which are estimated to comprise about 80 percent of the PCP in in-use wood products (Winters, 1999). Results of the study supported the hypothesis that utility poles can serve as a reservoir source for dioxins. This study was limited in that it only addressed dioxin mobility during a pole's useful life, and did not address the question of dioxin mobility or environmental release as a result of pole disposal practices (Battelle, August 2000).
- Environment Canada estimated that annual releases of dioxins from in-service pentachlorophenol treated utility poles to be larger than releases from municipal wastewater treatment plant sludge (one of the top 10 US release sources according to US EPA) (Environment Canada, 2000; U.S. EPA, September 2000).
- While the U.S. EPA dioxins inventory does not include dioxins in commercial products like pentachlorophenol-treated utility poles, its inventory document notes that dioxins in pentachlorophenol treated wood appears to be the largest flow of dioxins that U.S. EPA has quantified at about 8,400 g per year in 1995, more than twice the total 1995 estimated dioxins releases (U.S. EPA, September 2000).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area, wood treatment location, and pentachlorophenol manufacturing location

3. Other environmental or educational benefits

- Pentachlorophenol is itself an environmental concern, so reducing its use would have environmental benefits. The end-of-life fate of pentachlorophenol-treated wood is of particular concern, since re-use and disposal can create opportunities for release of dioxins and other pollutants in the treated wood. Both industry and environmental groups are working to address pentachlorophenol-treated wood waste management (Wilkinson, 2001; Feldman, 2000).
- A U.S. EPA draft risk assessment reviewing the human health and environmental risks of pentachlorophenol use found significant health risks for workers that apply pentachlorophenol to wood, workers who work with treated wood products (*e.g.*, utility workers), and children who play near treated poles (U.S. EPA, 1999). While these results are from a draft risk analysis and therefore are subject to change, it is important to note that the risk assessment only considered risks from pentachlorophenol itself; risks from contaminants (dioxins and hexachlorobenzene) are still to be evaluated, as are risks from several exposure scenarios for which the U.S. EPA did not have risk information.

4. Possible adverse impacts of project
   Creosote, CCA, and ACQ all have potentially significant environmental impacts. ACQ is considered less toxic than the other two commonly available alternatives (Johnson, April 23, 1999).
5. Method(s) of measuring effectiveness
   Track purchasing records for purchases of utility poles.

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Reuse of pentachlorophenol treated poles that are taken out of service is common in the U.S. (uncertain of California status) and may pose significant environmental concerns. In addition to reuse of whole or partial utility poles, treated wood waste may be managed by landfilling or incineration (an alternative being actively promoted by the American Wood Preservers Institute).
- Managing pentachlorophenol-treated wood waste is perceived as a hassle by agency and utility staff.

2. Barriers to implementation
   Alternatives are generally toxic or have relatively short lifetimes, requiring frequent maintenance.
3. Possible methods to bypass barriers

- Educate staff about worker safety concerns relating to exposure to pentachlorophenol.
- Enact stringent procedures for using personal protective equipment, managing waste wood, drilling remains, etc. for pentachlorophenol-treated poles.

4. Schedule/timing concerns
   None identified.

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

VIII. Petroleum Refining

Refining process modifications (to be determined)

A. Describe Project

1. General description of how a project could be designed

Before a project could be conducted, it would be necessary to explore how to modify refinery operations to eliminate creation of dioxins in refinery processes and/or refinery waste management. While the specific process and waste management changes that would be needed were not identified in this review (no readily available information was found), the following investigations and actions would appear to be beneficial:

- Processes that involve combustion or elevated temperatures where at least trace chlorine levels are present (*e.g.*, coking, cracking, catalyst regeneration, and refinery heat and energy production) would be the most likely targets for investigation (Carman, undated).
- Reducing or eliminating the presence of chlorine in critical operations could reduce formation of dioxins in refineries. Literature reviewed for this summary suggests that chlorine enters refineries via two major pathways:
    - With the crude oil. Refineries operate "desalting" processes to remove salts (including chlorine-containing salts), trace metals, and other solids that are normal impurities in raw crude oil (OSHA, 1999). Note that while "desalting" may be able to remove more than 90% of chlorine in crude oil, complete elimination of such chlorine would be technically impossible.
    - In refining catalyst and catalyst regeneration processes. At least certain refining catalysts must contain chlorine for catalytic reactions to occur. When the catalyst is regenerated, chlorine gas or a chlorinated inorganic or organic chemical is used (U.S. EPA, July 1996).
- Since accidental fires may also release dioxins, actions that modify refinery design and operations to reduce accident risks may also serve as dioxins pollution prevention measures.
- Certain refinery products (*e.g.*, diesel fuel) contain dioxins (Truex, 1998). A complete refinery pollution prevention program would include actions to prevent creation of dioxins in products.
- Preventing releases of dioxin-containing products and wastes (like ash), while not pollution prevention, would reduce environmental releases of dioxins.

2. Departments potentially involved within interested jurisdiction or agency

Environmental

3. Other possible participants or affected entities

Refineries, Western States Petroleum Association (WSPA), BAAQMD, DTSC, US EPA

4. Prior related activities—experience with project (local, regional, national) and results, if available

Evergreen Oil of Newark, CA has modified its process waste management/energy production to eliminate a process that may create dioxins. A re-refinery for used oil, Evergreen historically burned a chlorine-containing volatile fraction of the waste oil it receives as an energy source. The combustion of this waste stream was eliminated at the site, and the material is now being collected for off-site waste management (for which cost, dioxins releases, and other information were not obtained) (Wahbeh, 2001). Evergreen Oil also plans to add a new process to reduce the chlorine content of its fuels (Wahbeh, 2001).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No information identified, because refinery dioxins sources have not been characterized to date (U.S. EPA, July 1996; Ingham, 2000; CBE, August 2000, and Exponent, 2001). Dioxins have been detected in refining catalyst regeneration system emissions, refinery storm water runoff, refinery wastewater treatment plant discharges and sludges, and diesel fuel. Opportunities for reductions are likely (given general experience with pollution prevention in other settings); however, specifics are unknown.
2. Where reduction would occur (which environmental media, geographic location)
   At refinery locations (several in the San Francisco Bay area)
3. Other environmental or educational benefits
   None specifically identified. Since pollution prevention typically reduces the hazard level of manufacturing processes, benefits are likely, but it is possible that new, environmentally adverse releases could occur or that worker safety could be an issue.
4. Possible adverse impacts of project
   Unknown
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
   The California Department of Toxic Substances Control is initiating a refinery pollution prevention program. The voluntary program seeks to involve refineries and surrounding communities statewide. Although dioxins have not been made a specific target of the program, community interest in dioxins pollution prevention could influence program activities to address dioxins (Ingham, 2000).
2. Barriers to implementation

- To date, refinery dioxin emissions sources have not been characterized, nor have P2 options been specifically identified (U.S. EPA, July 1996; Ingham, 2000; CBE, August 2000, and Exponent, 2001).
- Participating municipalities have little or no authority over refineries and limited influence (*e.g.*, their fuel purchases comprise a negligible portion of refinery output).

3. Possible methods to bypass barriers
   Refineries and state or federal government agencies could identify and demonstrate implementation of dioxins pollution prevention measures. The ability of refineries to implement dioxins pollution prevention measures (in terms of technical feasibility, effectiveness, cost, and other factors) is currently unknown. Municipalities have little direct authority over refinery process modifications. It is possible for municipalities to seek voluntary action from refineries or to ask relevant regulatory agencies to seek voluntary reductions or to implement dioxins pollution prevention requirements for refineries.
4. Schedule/timing concerns
   The San Francisco Bay Area environmental community is conducting an active campaign to reduce dioxins releases from refineries. Activities at the Regional Water Quality Control Board regarding the Ultramar (Tosco) permit reissuance and the release of a report (CBE, Summer and August 2000) have generated significant press interest.

D. Compile Information about Costs

No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

IX. PCBs

Note: Polychlorinated biphenyls (PCBs) are unique in that they are a group of compounds that include several dioxin-like congeners. Unlike dioxins, PCBs were at one time deliberately manufactured for use in a wide variety of applications that dispersed them throughout the world's environment. Mixtures of PCBs typically contain traces of dioxins as well as dioxin-like PCBs. Since new PCBs are not being manufactured, there are not really any available pollution prevention options available. However, most PCB applications have involved enclosed (*e.g.*, in electrical equipment) or encased (*e.g.*, in sealants) applications, so their removal from service is different than the typical hazardous waste remediation—the activities involved are more like prevention activities than like control or cleanup activities. Because of this odd situation, even though removal of PCBs from service is actually "remediation" rather than "prevention," it is included as an option in this report.

Remove from service (all uses including coatings and sealants)

A. Describe Project

1. General description of how a project could be designed
   Polychlorinated biphenyls (PCBs) were widely used as dielectric fluids in capacitor and transformer, heat transfer fluids, hydraulic fluids, lubricating and cutting oils, and as additives in pesticides, paints, copying paper, carbonless copy paper, adhesives, sealants, and plastics (Erickson, 1997). While the preponderance of PCBs were used in capacitors and transformers (and therefore contained), other uses, like uses in paints, sealants, and hydraulic fluids are now uncontained and potentially uncontrolled (Johnson, 1997). Some of the largest direct releases to the environment have come from the use of PCB hydraulic fluids (*e.g.*, in metal casting machines), since many hydraulic systems were designed to leak slowly to provide lubrication. Lesser-known PCB sources include submersible well pumps (residences and at parks) and oil-filled cable (Ross & Associates, 2000). Identifying PCBs—particularly uncontrolled PCBs—and removing them from the environment would prevent releases of dioxins and dioxin-like PCBs.
2. Departments potentially involved within interested jurisdiction or agency
   Facilities, environmental (hazardous waste management)
3. Other possible participants or affected entities
   Private property owners, businesses with structures and equipment, utility companies
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Both U.S. EPA and Environment Canada have sent PCB reduction commitment letters to major companies with PCB transformers and capacitors within the Great Lakes basin.
- General Motors plans to eliminate all of its high concentration PCBs in electrical equipment by the end of 2001. General Motors' commitment to reduce PCBs was driven by business decisions, primarily related to energy efficiency. General Motors was also motivated by the finding that replacing PCB-containing equipment saved money—it provides a payback period of about 5 years.
- Georgia Pacific plans to eliminate all of the high concentration PCBs from all of its facilities by 2000. Georgia Pacific's environmental strategy and decisions to remove PCBs considered management support, conservation, promoting community awareness, and protection of health and the environment.

(Source for the above: Great Lakes Binational Toxics Strategy PCB Work-Group, 1999 and 2000)

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No information identified; reduction depends on source identification
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area
3. Other environmental or educational benefits

- Reducing releases of PCBs themselves would provide significant environmental benefits. For example, the Regional Water Quality Control Board has designated San Francisco Bay as impaired by elevated PCB levels (currently plans for resolving this impairment are uncertain, but could involve new requirements for local governments). To the extent that releases to the Bay are reduced, Bay water quality and fish safety could be improved.
- Energy efficiency is one benefit of removing PCB containing equipment and replacing it with newer non-PCB equipment.

4. Possible adverse impacts of project
   Removing PCB-containing materials could create short-term PCB releases and could cause exposures for workers and neighbors at a removal site.
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- The Regional Water Quality Control Board is initiating activities to develop a Total Maximum Daily Load (TMDL) for PCBs.
- As part of the Binational Toxics Strategy with Canada, U.S. EPA has committed to seek by 2006, a 90% reduction nationally of high-level PCBs (>500 ppm) used in electrical equipment.
- EPA's green lights program seeks to encourage and support local governments that switch out fluorescent lights to modern, energy-saving alternatives.

2. Barriers to implementation

- No surveys have been performed to identify where PCBs exist. Known locations include fluorescent light ballasts, private transformers and other private electrical equipment, coatings, sealants.
- For fluorescent light changeouts, the EPA's Green Lights program could provide significant assistance. Unfortunately, some agencies have difficulty joining Green Lights due to its multi-year commitment requirement. Also, some facility managers prioritize other facility projects above fluorescent light change-outs.
- High cost of PCB disposal.
- Regulatory Barriers: for certain PCB uses or users, there are no phaseouts, many unrestricted uses, and no management requirements (Ross & Associates, 2000).

3. Possible methods to bypass barriers

- Educate agencies and facilities managers that upgrading fluorescent lights has a relatively short payback period, making it a financially attractive activity.
- Public education on benefits to removal (reduced liability for PCB-containing equipment owners).
- Educate PCB-containing equipment owners on how to decommission transformers, and about spill prevention and proper management techniques.
- Provide recognition or other incentives for facilities that conduct audits, inventories, and accelerate PCB removal.
- Use supplemental environmental projects (SEPs) to obtain increased PCB removal.
- Create mentoring programs (e. g., larger utilities share expertise with smaller companies or smaller coops join together to reduce PCBs).

- Conduct a pilot inventory of PCBs in use at a facility or municipality.
- Work with trade organizations to identify potential PCB owners.
- Have disposal amnesty programs similar to pesticide "clean sweeps."
- Offer a PCB-containing ballast rebate program.

(Source for most of the above items: Ross & Associates, 2000).

4. Schedule/timing concerns
   None identified

D. Compile Information about Costs
   No cost information obtained.

1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

X. PVC

Purchase non-PVC materials and products instead of PVC

A. Describe Project

1. General description of how a project could be designed

Non-PVC products could be purchased where alternatives exist. PVC is commonly used in building construction, interior furnishings, packaging, office supplies, and vehicles. PVC, commonly known as vinyl, is the second largest volume plastic produced in the world (Vinyl Institute, undated). The table on the next page provides some examples of PVC-containing products and alternatives. (Note that medical PVC use is considered in Section V.)

2. Departments potentially involved within interested jurisdiction or agency
   Purchasing, Facilities, Planning, Building, Environmental
3. Other possible participants or affected entities
   Suppliers, all municipality departments, developers, architects, interior designers, and construction firms
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Greenpeace and other environmental organizations have urged elimination of PVC use (Thornton, 1997). A Greenpeace report includes the following examples (Thornton, 1997):
  - More than 200 communities in Europe -- including major cities in Austria, the Netherlands, Germany, Sweden, Luxembourg, Denmark, and Norway -- have policies to restrict or avoid the use of PVC in public construction projects; many have successfully built major new buildings without PVC. In transportation, the Euro-Tunnel, and subway systems in London, Vienna, Bilbao, Dusseldorf, and Berlin are PVC-free.
  - The British, German, and U.S. Navies do not employ PVC for ship-board uses.
  - The Olympic stadium and other parts of the Sydney 2000 Olympic village are being built with a commitment to avoid or minimize the use of PVC.
  - Volkswagen has stopped using PVC in its vehicles, and Mercedes, BMW and Opel have adopted similar policies.
  - Sony-Europe, AEG, Ikea furniture, Herlitz, and Tarkett have adopted PVC phase-out policies for their lines of appliances, furniture, office equipment, flooring, and product packaging.
- Some organizations have requests for PVC content and/or requests for vendors to identify PVC-free products in bid specifications (*e.g.*, State of Massachusetts; Sutherland, 2000).

Examples Of PVC Products And Alternatives

Common PVC Use	Alternative Material
Pipes (note: In California, PVC pipe is not legal for potable water use in residential or commercial construction with very limited exceptions)[17]	Concrete, steel, galvanized iron, copper, clay, chlorine-free plastics, including high-density polyethylene (PE), polypropylene (PP), acrylonitrile-butadiene-styrene (ABS), crosslinked polyethylene (PEX),[18] and polyisobutylene.
House siding	Wood, stucco, brick, aluminum, fiber cement
Flooring	Linoleum, wood, stone, rubber, bamboo, cork, PE and PP
Carpet backing	Jute, urethane
Window profiles	Wood, aluminum, fiberglass
Wall coverings	Paint, tiles, paper-based wallpaper, PE, polyester, and natural fiber-based wallpapers.
Roof-sheeting	Synthetic rubber, polyolefin sheeting, EPDM (ethylene propylene diene monomer, a synthetic rubber), traditional materials made from tar, wood, and other materials.
Gutters	Galvanized iron, copper.
Wire and cable coatings	PE, ethylene-vinylacetate copolymer (EVA); polyamide, silicone, and other thermoplastic elastomers.
Shutters and blinds	Wood, aluminum, and chlorine-free plastics.
Furniture	Wood, metal, textiles, leather, and chlorine-free plastics such as butadiene-polyamide copolymer.
Packaging	No packaging at all, glass, paper and cardboard, PP, PE, and polyethylene terephthalate (PET).
Office supplies	Metal, wood, PP, PE.
Automobile Parts (body side moldings, interior upholstery, floor mats, dashboards, etc.)	Metal, textiles, chlorine-free plastics, including polyolefins and ABS.

Source: After a table in Thornton, 1997, modified with information from Johnson, April 23 1999a and Lent, 2001.

- The European Union (EU) is currently evaluating PVC safety, in response to consumer concerns about both PVC-related pollutant releases and hazards associated with PVC additives like phthalates (Short, 2000). In July, the EU issued a “Green Paper” on the Environmental Issues of PVC (Commission Of The European Communities, 2000).

[17] A regulatory proposal that would have allowed broad use of chlorinated polyvinylchloride (CPVC) pipe and an associated Environmental Impact Report prepared by the State of California were withdrawn. Current California law only allows cities to approve use of CPVC for potable water pipe under such limited circumstances that CPVC is essentially not used for potable water pipe in the San Francisco Bay Area.

[18] Not yet approved by the State of California for potable water use in residential or commercial construction.

- A common component of "green building" projects is to avoid use of PVC-containing construction and interior finishing materials. For example, when the City of San Francisco remodeled office space for the Department of the Environment's office, it employed a "green building" approach that included alternatives to many products that are typically made with PVC. San Francisco is continuing to explore PVC alternatives in its 10 green building pilot projects.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

   No specific information was identified, although it is known that dioxins are formed and released during PVC manufacture, during fires where PVC is used, and when PVC is disposed of by incineration (not an issue for the San Francisco Bay Area except for medical wastes, considered above). An industry estimate of dioxins releases from accidental structural fires (Carroll, 1996) is consistent with USEPA's estimate that dioxins releases from all accidental structural fires is less than 20 grams per year (USEPA, March 2001), which would put such releases in the same order of magnitude as other sources that are estimated to be prominent in the San Francisco Bay Area (*e.g.*, diesel fuel combustion, see Appendix B).

2. Where reduction would occur (which environmental media, geographic location)

   At locations where PVC is manufactured (outside of the San Francisco Bay area), and at locations where structure fires occur in the San Francisco Bay area.

3. Other environmental or educational benefits

- Other releases from PVC manufacturing have environmental effects.
- PVC often contains additives that are environmentally problematic, including heavy metals (common in electrical cables) and phthalates (common softeners for the otherwise stiff polymer).
- Due to the low cost of virgin PVC and the technical problems for recycling caused by the presence of other polymers and a diverse array of additives in PVC products, post-consumer PVC products are infrequently recycled (Plinke, 2000).

4. Possible adverse impacts of project

- Alternative materials may create environmental impacts during manufacturing, use, and disposal. The impacts depend on the alternative selected. For example, copper water pipe could be used as an alternative to CPVC pipe for potable water or wastewater purposes, although (as noted above), use of CPVC for potable water is severely limited by the California Building Code and use of copper for non-potable water is limited by the high cost of copper as compared to other alternatives like ABS. Nevertheless, if such substitutions occurred, copper releases to surface water could increase, contributing to the identified copper impairment of San Francisco Bay (SWRCB, 1999).
- PVC products may have certain properties that provide environmental advantages over certain alternatives during the useful life of the product. For example, PVC window profiles generally offer better insulating properties than aluminum window profiles (but not generally better than wood windows).

5. Method(s) of measuring effectiveness

   Track purchasing.

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

   Public interest in this issue is being stimulated by Healthcare Without Harm, Greenpeace, and EU activities, as well as U.S. consideration of safety issues regarding additive use in children's PVC toys.

2. Barriers to implementation
- Very difficult to determine which products contain PVC, which makes identifying both problem products and alternatives difficult (Johnson, April 23 1999a).
- For certain products, alternatives may be difficult to find in the marketplace. These include credit cards, computer components, telephones and other small appliances, and large products with PVC-containing components (*e.g.*, automobiles).
- For some products, PVC-free alternative may not be readily available.
- Certain PVC products have properties that are convenient for consumers (*e.g.*, durability, easy to maintain) that are not shared by all alternatives.

3. Possible methods to bypass barriers
- Product specification guides exist, such as the Environmental Building News Green Spec Binder and Directory and the Architects/Designers/Planners for Social Responsibility Northern California Chapter Architectural Resource Guide.
- The Healthy Building Network offers assistance to health care institutions to develop PVC-free construction specifications (Lent, 2001).
- Inform, Inc. will offer support to government agencies seeking to purchase alternatives to PVC containing additives that are persistent, bioaccumulative, or toxic (like di(2-ethylhexyl) phthalate [DEHP]) (Sutherland, 2000).
- It is possible to implement demonstration projects involving use of convenient alternatives that are currently available.
- Government agencies can obtain information from suppliers using well-designed purchase order specifications.

4. Schedule/timing concerns
   None identified.

D. Compile Information about Costs
   No cost information obtained.
1. Anticipated cost changes for agency/other affected entities
2. Costs changes for other involved/affected entities
3. Other possible costs

Dispose of PVC by methods other than incineration

In the San Francisco Bay Area solid waste is not incinerated, so this is only an issue for medical waste, which is considered above.

XI. Wood Burning

Summary Background

In 1989, the California Air Resources Board (ARB) adopted a Suggested Control Measure for residential wood combustion (McCormack, 2000). This measure serves as a recommendation to local air districts, but is not required. The elements of the Suggested Control Measure recommended by the ARB and examples of locations where those actions have been implemented are as follows:

Implementation Examples for Elements of ARB Suggested Control Measure for Residential Wood Combustion

Recommended Action	Examples of locations where this measure has been implemented
Public Education	BAAQMD ARB (provides literature to all California air agencies) Aspen, CO State of Idaho Missoula, MT State of Oregon Puget Sound Region, WA Washoe County , NV Denver region, CO State of Vermont British Columbia, Canada Mammoth Lakes, CA Sacramento, CA Placer County, CA Palo Alto, CA
Replacement or removal of non-certified wood stoves on property transfer	Mammoth Lakes, CA Washoe County, NV
Wood moisture content limit (promotes more efficient burning, can be measured in field with $300 device)	Telluride, CO
Prohibit burning of garbage, treated wood, plastic, rubber, waste petroleum, paints, and coal with more than 1% sulfur	State of Washington Telluride, CO BAAQMD model ordinance
Voluntary or mandatory burn bans during air pollution episodes	BAAQMD model ordinance and voluntary "Spare the Air Tonight" program Mammoth Lakes, CA Denver, CO Jackson County, OR Lane County, OR Washoe County, NV
Economic incentives for replacing wood stoves	Placer County (APCD), CA State of Montana
Limits on number of fireplaces per new residence or multi-unit structure	Placer County (APCD), CA Lake Tahoe Area (Regional Planning Agency) Mammoth Lakes, CA
Fireplace offset requirements (removal of old units as a condition of new development)	None identified
Visible emissions limits on residential wood burning (opacity requirements), enforced by air district personnel at night	Washoe County, NV Juneau, AK

Sources: ARB, 1989; Ono, 2000; Nishikawa, 2000; BAAQMD, undated; Bray, 2000.

EPA-certified wood stoves

A. Describe Project

1. General description of how a project could be designed

- Municipalities could promote use of EPA-certified or EPA "exempt" wood stoves in lieu of non-certified wood stoves or open fireplaces. Program design can involve education, incentives, or regulation. Three types of EPA-certified or "exempt" wood stoves exist; all are likely to reduce dioxins formation as compared to old wood stoves or open fireplaces:

  - Advanced combustion stoves—designed to create conditions for more complete wood combustion.
  - Catalytic stoves—route exhaust gases through a catalytic combustor that completes the burning process, using the catalyst to reduce the combustion temperature to improve the burning conditions
  - Pellet stoves—burn wood pellets, which burn more cleanly than wood pieces under the controlled conditions present in a pellet stove. (These stoves have such low emissions that EPA exempts them from its requirements.)

  (Source: British Columbia Ministry of the Environment, 1994)
- About 10% of wood stoves currently in use in the U.S. are EPA-certified models (Houck, 1999).
- Promoting installation of catalyst retrofit kits in existing wood stoves could also be considered. Such kits exist at relatively low cost (in the range of $125-250 in 1989) (ARB, 1989). These kits are not as effective as new wood stoves in reducing particulate emission—they provide an "overall" emissions reduction of 25 to 30% as compared to the 70 to 80% "overall" emissions reduction from new stoves (Energy Efficiency and Renewable Energy Network, 2000).

2. Departments potentially involved within interested jurisdiction or agency
   Planning, Environmental

3. Other possible participants or affected entities
   BAAQMD, residents, wood stove vendors, real estate industry (if requirements to upgrade on property transfer or limits on new construction are proposed)

4. Prior related activities—experience with project (local, regional, national) and results, if available

- It has been a Federal requirement for vendors to sell only EPA-certified wood stoves since 1992. No such requirement applies to fireplaces, as there is no EPA-certified alternative for open fireplaces. The requirement does not include any retrofit provisions, so wood-burning stoves installed prior to 1992 may not meet current EPA certification standards.
- Adoption of the BAAQMD model ordinance by San Francisco Bay Area local governments promotes use of EPA-certified wood stoves (see the subsection discussing the BAAQMD model ordinance for more information).
- Both the Town of Mammoth Lakes California and Washoe County Nevada require replacement or removal of non-certified, non-exempt residential wood stoves at the time of property transfer.
- The State of Montana had (until recently) tax incentives for wood stove replacement.
- The Placer County Air Pollution Control District has a financial incentive program for wood stove replacement.
- The Great Lakes Wood Stove Changeout program (a pilot program in Traverse City, Michigan in February, 2000) was co-sponsored by the Michigan Office of the Great Lakes, Michigan Department of Environmental Quality, Grand Traverse Bay Watershed Initiative, Steel Recycling Institute, Hearth Products Association, and local hearth retailers, with support from Region 5 of the United States Environmental Protection Agency, with the goal of gauging regional response, level of participation and potential impacts of a wood stove changeover. A pilot wood stove changeout program was conducted in eastern Ontario in early 1999; another is planned in Green Bay, Wisconsin. In these programs, those turning in old conventional wood stoves receive a 10 to 15% rebate on the purchase of a new stove (as based on an agreement between the manufacturers and the dealerships). Wood-burning workshops are also organized as part of changeout programs for those interested in learning how to make their wood-burning systems more effective and cleaner burning.

Sponsors are also contemplating expanding the changeover projects, pending an assessment of the success in these two areas. Other aspects of the project potentially include partnering with steel industry groups to pick up the old stoves for use as scrap steel, and a certification of destruction requirement from the scrap yard to verify that the old stoves are not being put back into service. Preliminary assessments show that about one-third of those changing over are switching to liquid fuel or gas units, suggesting that gas utilities, insurance companies, and fire departments may be valuable partners in future changeover efforts. (Battelle, August 2000 and U.S. EPA Great Lakes National Program Office, 2000).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- No specific data for dioxins was identified; however, the BAAQMD believes that implementing its ordinance will reduce particulate emissions (likely related to dioxins emissions) by 75 percent when an EPA-certified wood stove is used instead of an open fireplace (Barry, 2000).
- Additional data on the nature of dioxin/furan releases from wood stoves is currently being gathered in a Canadian wood stove testing program underway to assess the dioxin reduction potential of EPA-certified stoves. The study will compare emissions from old conventional and new certified wood stoves; in addition, it is hoped that the results of the study will help to determine if there is a correlation between particulate matter (PM) and dioxins/furans in wood stoves. EPA-approved stove technology has been shown to reduce particulate matter emissions by up to 90%; therefore, determining the relationship between PM and dioxins would allow inferences on dioxin reductions (Battelle, August 2000).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay Area
3. Other environmental or educational benefits

- Potentially significant reduction of benzo(a)pyrene emissions. A persistent, bioaccumulative toxic chemical, benzo(a)pyrene is a polycyclic aromatic hydrocarbon that (like dioxins) occurs primarily as a product of incomplete combustion; it is not manufactured or used commercially (U.S. EPA Great Lakes National Program Office, 2000).
- Reductions in emissions of other PAHs, carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter (Burning Issues, 1999).

4. Possible adverse impacts of project
   None identified
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Catalytic combustors have a finite lifetime (1 to 10 years) and can be ruined by burning plastics, paint, colored paper, and other similar materials (Energy Efficiency and Renewable Energy Network, 2000).
- The ARB recommended requiring wood stove vendors to distribute public education literature.
- U.S. EPA's Great Lakes National Program Office has designated residential wood combustion as a high priority for dioxins pollution prevention. Work groups on both dioxins and benzo(a)pyrene are seeking to implement residential wood combustion pollution prevention programs. One program proposal is to expand wood-stove changeout programs that offer 10-15 percent discounts on new wood- or gas-burning stoves to customers who trade in their old wood-burning stoves to be recycled (Battelle, August, 2000).

2. Barriers to implementation
- Cost of replacing stoves can be significant. Real estate industry may oppose requirements linked to property transfer.
- Most pellet stoves require electricity to operate their fans, so they do not work during a power outage. Pellet stoves also need relatively regular service, but they provide easy loading, convenient automatic operation, and precise control over heat production (British Columbia Ministry of the Environment, 1994). Pellet stoves typically have much lower particulate emissions than EPA-certified wood stoves.

3. Possible methods to bypass barriers
Use of voluntary or incentive programs prior to or instead of mandatory programs.

4. Schedule/timing concerns
Wintertime is the burning season in the San Francisco Bay area, so any voluntary campaigns should target the winter season.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
Limited costs for implementing agencies if included with other existing programs for environmental public education, or permitting for new construction. Costs for a retrofitting incentive program could be significant, since the cost of a wood stove is relatively high.

2. Costs changes for other involved/affected entities
In 1989, ARB estimated that the purchase and installation cost for EPA-certified wood stoves would be $1,400 to $1,800. Small annual cost savings if wood stove is used for heating, as EPA-certified wood stoves are more efficient (ARB estimated this savings to be about $70 per year, assuming burning of 1.9 cords of wood per year) (ARB, 1989).

3. Other possible costs
No cost information obtained.

BAAQMD model ordinance

A. Describe Project

1. General description of how a project could be designed
Municipalities could adopt all or part of the BAAQMD model ordinance on wood burning. The BAAQMD model ordinance includes three elements:
   - Prohibits installation of a new wood burning fireplace or wood stove unless it is an EPA-certified woodstove or a pellet stove (this effectively bans new open fireplaces)
   - Prohibits wood burning when the BAAQMD issues Spare the Air Tonight alerts
   - Prohibits burning of garbage, plastics, and other problem fuels.

2. Departments potentially involved within interested jurisdiction or agency
Planning, Environmental

3. Other possible participants or affected entities
BAAQMD, residents

4. Prior related activities—experience with project (local, regional, national) and results, if available
- All or modified portions of the BAAQMD ordinance have been adopted by Los Gatos, San Jose, and Petaluma.
- Palo Alto adopted a modified version of the BAAQMD ordinance, which prohibits installation of new wood-burning fireplaces in homes, but allows existing fireplaces to be repaired, modified, and event relocated in the same house. The ordinance does not apply to wood burning stoves used for cooking or outdoor fireplaces. Contact: Julie Weiss, Palo Alto, 650-494-7629.
- San Luis Obispo County and Sonoma County have ordinances that prohibit installation of conventional fireplaces (BAAQMD, undated).

- The State of Colorado's Air Quality Control Commission has regulations similar to the BAAQMD model ordinance applicable to Denver metropolitan area counties (Colorado Air Quality Control Commission, 1995).
- The City of Chico, like many counties in the Central Valley, permits only EPA-certified wood stoves in new construction (Williams, 2000; BAAQMD, undated). This does not prohibit open fireplaces, but does expand the EPA prohibition, which only applies to the sale of new woodstoves (not to the installation of relocated stoves).

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No specific data for dioxins was identified; however, the BAAQMD believes that implementing its ordinance will reduce particulate emissions (likely related to dioxins emissions) by 75 percent for an EPA-certified wood stove and 99 percent for a natural gas unit (Barry, 2000). The total dioxins reduction depends on the number of new residential units being constructed and the number of fireplaces within those units (typically 1 to 1.5 per unit, Barry, 2000).
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay Area
3. Other environmental or educational benefits

- Potentially significant reduction of benzo(a)pyrene emissions. A persistent, bioaccumulative toxic chemical, benzo(a)pyrene is a polycyclic aromatic hydrocarbon that (like dioxins) occurs primarily as a product of incomplete combustion; it is not manufactured or used commercially (U.S. EPA Great Lakes National Program Office, 2000).
- Reductions in emissions of other PAHs, carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter (Burning Issues, 1999).
- Reduce the harmful health effects from wood smoke (Barry, 2000).

4. Possible adverse impacts of project
   None identified
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
   BAAQMD has an active program to promote its ordinance. It provides assistance to municipalities considering ordinance adoption.
2. Barriers to implementation

- Freedom of choice concerns—no EPA-certified fireplace is available, only wood stoves.
- Compliant natural gas and wood burning units can be costly, which concerned Petaluma homeowners (Barry, 2000).
- Real estate industry opposition has occurred (Barry, 2000).
- Some members of the public have criticized the ordinance because they have the mistaken belief that it requires removal of existing non-compliant fireplaces in homes not being renovated (Barry, 2000).
- Palo Alto learned that there is tremendous skepticism regarding how much dioxin is generated from woodsmoke and its impacts. Palo Alto relied on BAAQMD information (Information Update, 12/98 and Woodsmoke Fact Sheet, 12/98) as references (Weiss, 2000).

3. Possible methods to bypass barriers

- Ordinance modifications to placate opponents have occurred. These typically reduce the effectiveness of the restrictions by reducing the rate of removal of non-certified, non-exempt wood burning units. Severe weakening (*e.g.*, limiting new fireplaces to one per unit) simply slows the rate of new fireplace installation, rather than decreasing the number of fireplaces in the region.
- Costs for EPA-compliant units have dropped and selection is expanding (Barry, 2000).

4. Schedule/timing concerns
   Recent public interest in this issue has elevated, making adoption of such ordinances more likely.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   Contra Costa County estimated that the cost of implementing the BAAQMD ordinance would be minimal because its implementation can be integrated into existing plan check operations (Barry, 2000).
2. Costs changes for other involved/affected entities
   Home buyers and remodelers would bear the expense for purchase of an EPA-compliant unit, if a fireplace is installed. Such units cost about $1000 more than the cost of a typical "zero-clearance" (open) fireplace (Barry, 2000).
3. Other possible costs
   No cost information obtained.

Natural gas fireplace

A. Describe Project

1. General description of how a project could be designed
   Municipalities could promote use of natural gas fireplaces in lieu of wood stoves or wood-burning fireplaces. Program design can involve education, incentives, or regulation.
2. Departments potentially involved within interested jurisdiction or agency
   Planning, Environmental
3. Other possible participants or affected entities
   BAAQMD, residents, gas fireplace vendors, real estate industry
4. Prior related activities—experience with project (local, regional, national) and results, if available
   Encouraging gas substitutes or retrofits is part of most of the educational and regulatory programs described above. In municipalities where new wood-burning fireplaces are prohibited, gas fireplaces are a common alternative in new construction.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No specific data for dioxins was identified; however, the BAAQMD believes that implementing its ordinance will reduce particulate emissions (likely related to dioxins emissions) by 99 percent for a natural gas unit (Barry, 2000).
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay Area
3. Other environmental or educational benefits

- Potentially significant reduction of benzo(a)pyrene emissions. A persistent, bioaccumulative toxic chemical, benzo(a)pyrene is a polycyclic aromatic hydrocarbon that (like dioxins) occurs primarily as a product of incomplete combustion; it is not manufactured or used commercially (U.S. EPA Great Lakes National Program Office, 2000).

- Reductions in emissions of other PAHs, carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter (Burning Issues, 1999).

4. Possible adverse impacts of project
- Natural gas is a finite resource that contributes somewhat to global warming. It is not renewable like wood.

5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
- Proper ventilation is recommended to minimize indoor air quality concerns (American Lung Association, 1999).
- U.S. EPA's Great Lakes National Program Office has designated residential wood combustion as a high priority for dioxins pollution prevention. Work groups on both dioxins and benzo(a)pyrene are seeking to implement residential wood combustion pollution prevention programs. One program proposal is to coordinate with gas utilities to provide financial or other incentives to customers for converting traditional fireplaces to natural gas. (Battelle, August, 2000). Information and resources from the Great Lakes effort could be available to support related San Francisco Bay Area activities.
- Manufacturers of kits to turn wood-burning fireplaces into natural gas fireplaces have expanded marketing and have been using environmental benefits and convenience elements in their marketing efforts.

2. Barriers to implementation
- The 2000-2001 energy crisis has tremendously increased the price of natural gas, which discourages its use as an alternative to wood.
- Most older California fireplaces do not have gas lines installed. While such lines can be installed, this can double the cost of the retrofit and complicate the retrofitting process.
- For some people, natural gas fires are not as aesthetically pleasing as wood fires.
- Natural gas fireplaces can provide heating, but many natural gas fireplace retrofits do not generate significant heat (this should not be a major issue in the San Francisco Bay Area).

3. Possible methods to bypass barriers
- Education explaining that gas fireplaces are very easy to light and use, and they do not generate any waste ash to manage. Stressing convenience may promote conversions.
- Partner with gas utilities to offer rebates for gas fireplace installation (Weiss, 2000).

4. Schedule/timing concerns
   Wintertime is the burning season in the San Francisco Bay area, so campaigns should target the winter season.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   Costs for an education or ordinance-based program would be relatively low once the program was adopted, assuming program activities could be integrated into existing operations. Meaningful financial incentives could be somewhat costly, as the retrofit units are not inexpensive.
2. Costs changes for other involved/affected entities
   Costs include a retrofit kit (on the order of $300 to 500) and the cost to run a natural gas line to the fireplace, if no such line exists.
3. Other possible costs
   No cost information obtained.

No burning

A. Describe Project

1. General description of how a project could be designed
   Education could be conducted, or temporary or permanent bans of wood burning at residences could be enacted.
2. Departments potentially involved within interested jurisdiction or agency
   Planning, Environmental
3. Other possible participants or affected entities
   BAAQMD, residents
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Temporary burn bans on polluted days are common in areas with air pollution episodes, *e.g.*, BAAQMD model ordinance and voluntary "Spare the Air Tonight" program, and such bans in Mammoth Lakes, CA, Denver, CO, Jackson County, OR, Lane County, OR, and Washoe County, NV.
- Outdoor residential garbage burning is already prohibited by the BAAQMD.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases
   No information obtained, although to the extent that burning activities were eliminated, dioxins emissions would be eliminated.
2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay area
3. Other environmental or educational benefits

- Potentially significant reduction of benzo(a)pyrene emissions. A persistent, bioaccumulative toxic chemical, benzo(a)pyrene is a polycyclic aromatic hydrocarbon that (like dioxins) occurs primarily as a product of incomplete combustion; it is not manufactured or used commercially (U.S. EPA Great Lakes National Program Office, 2000).
- Reductions in emissions of other PAHs, carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter (Burning Issues, 1999).

4. Possible adverse impacts of project
   None (slightly more garbage would probably be send to landfills).
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)
   According to the ARB, temporary burn bans are best suited for making short-term reductions in emissions of a particular pollutant. Unless they occur frequently, temporary burn bans would not be expected to make significant long-term changes in overall emissions quantities. ARB found that burn bans provide an excellent public awareness tool for the general problems associated with wood burning (ARB, 1989).
2. Barriers to implementation
   Mandatory burn bans often meet resistance from the public (ARB, 1989).
3. Possible methods to bypass barriers

- Starting with a voluntary program reduces public resistance and can form the basis for a future regulatory program.
- Making a burn ban part of a package of other control measures can help the public understand its importance and increase acceptance.

- Burn bans can improve visibility and reduce odor and “brown clouds” that occur in some areas, so there is visual feedback for the public about the benefits of burn bans.
- Providing exemptions for small groups that could be drastically affected by the ban (*e.g.*, residences that use wood as a primary source of heat and/or low income residences) can reduce opposition. Some programs provide exemptions for residences with EPA-certified wood stoves (ARB, 1989).
- Since few San Francisco Bay Area residents use wood fireplaces for heating purposes (BAAQMD, 2000), resistance may be lower in the San Francisco Bay area than in certain other locations.

4. Schedule/timing concerns
   Wintertime is the burning season in the San Francisco Bay area, so campaigns should target the winter season.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
- Educational programs involve relatively small costs for participating municipalities, if they are combined with existing environmental education programs.
- According to ARB, mandatory burn bans are resource intensive to enforce, and therefore costly (ARB, 1989).

2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

"Better" wood burning practices (firelogs, "better" wood)

A. Describe Project

1. General description of how a project could be designed
   Municipalities could promote use of “better" wood burning practices in lieu of ordinary wood burning patterns in wood stoves and wood-burning fireplaces. Program design can involve education, incentives, or regulation.
2. Departments potentially involved within interested jurisdiction or agency
   Planning, Environmental
3. Other possible participants or affected entities
   BAAQMD, residents, firelog vendors
4. Prior related activities—experience with project (local, regional, national) and results, if available

- Most public education programs (see summary table) include this topic as an element. For example, the ARB literature distributed by BAAQMD provides a great deal of information on “better” burning practices.
- The BAAQMD model ordinance includes a prohibition on burning garbage and other problem fuels. The State of Washington and Telluride, CO have similar requirements.
- Telluride CO requires “better” wood fuels because it has set maximum moisture content levels for firewood.
- Palo Alto has been conducting an educational campaign (including elements like utility bill inserts and movie theater ads) to promote better burning practices and to educate residents about the environmental problems from wood burning.

B. List Possible Project Impacts and Evaluation Methods

1. Potential reduction in dioxins releases

- For dioxins prevention, actions that prevent burning of garbage and wood waste could have significant benefits, if such wastes are currently being burned (the extent that such burning occurs in the San Francisco Bay area is unknown). In one study, dioxins air emissions from garbage burning were found to be approximately 1000 times greater than burning ordinary wood. Burning waste wood (derived from building demolition) emitted about 100 times more dioxins than burning ordinary wood (Schatowitz, 1994). A recent US EPA study showed significant dioxins emissions from garbage burning (Gullett, 2000).
- No data regarding dioxins emissions from burning of various fireplace fuels was identified. It is, however, rational to assume that measures that reduce emissions of particulate matter and other related air pollutants would be likely to reduce dioxins emissions.
- ARB indicated that the lower moisture content in firelogs may reduce air pollutant emissions, but ARB did not find data to quantify this assumption (ARB, 1989).

2. Where reduction would occur (which environmental media, geographic location)
   San Francisco Bay Area
3. Other environmental or educational benefits
   Possible reductions in emissions of PAHs, carbon monoxide, toxic volatile organic hydrocarbons, and particulate matter (Burning Issues, 1999).
4. Possible adverse impacts of project
   Other pollutants of concern may be emitted from firelogs (unknown).
5. Method(s) of measuring effectiveness
   Not addressed

C. List Possible Implementation Issues

1. Non-quantitative factors, such as technical or social issues (including opportunities like partnering, grants, regulatory activities)

- Firelog manufacturers have begun to promote their products as more environmentally sound. Firelogs are readily available at San Francisco Bay Area retail outlets. Logs are heavy as compared to ordinary firewood (but each firelog burns much longer). Such products generally use wood waste in their manufacture, which could reduce burning of virgin wood. When firelogs burned according to instructions (and for aesthetic purposes), less material volume and less wood is burned in the same time period as compared to burning ordinary firewood.
- U.S. EPA's Great Lakes National Program Office has designated residential wood combustion as a high priority for dioxins pollution prevention. Work groups on both dioxins and benzo(a)pyrene are seeking to implement residential wood combustion pollution prevention programs. One program proposal is to educate consumers on the hazards of wood combustion emissions, proper wood-burning techniques that minimize emissions, and low-emission alternatives to wood-burning devices. The preliminary concept is to solicit assistance from local health and fire departments, economic development offices, environmental compliance bureaus, other community groups and gas companies (Battelle, August, 2000). Information and resources could be available from the Great Lakes effort to support related San Francisco Bay Area activities.

2. Barriers to implementation

- Regulations regarding residential burning practices are nearly impossible to enforce.
- Consumer identification of "better" wood products is difficult, since such products are not labeled, and many different firewood types are available.
- According to ARB literature, the best fire building technique involves a combination of hardwoods and softwoods that may not commonly be available to consumers and that would require a relatively high level of education to implement (ARB, 1992).

3. Possible methods to bypass barriers

- Educational or incentive programs are generally more feasible than regulation for indoor home burning practices.
- Program design can be simplified to promote methods that do not require significant education.
- Firewood labeling could be required (but would require a companion public education program to be useful).

4. Schedule/timing concerns
   Wintertime is the burning season in the San Francisco Bay area, so education and enforcement campaigns should target the winter season.

D. Compile Information about Costs

1. Anticipated cost changes for agency/other affected entities
   Palo Alto's wood smoke education campaign included publication and distribution of a fireplace brochure ($2,800), movie theater ads ($5,600), and an elementary school poster design contest ($1,500).
2. Costs changes for other involved/affected entities
   No cost information obtained.
3. Other possible costs
   No cost information obtained.

APPENDIX B. DIOXINS SOURCE INFORMATION

I. Background and Caveats

The information below summarizes what limited data are available about dioxins sources. The data below are generally highly uncertain because they are based on limited source testing and extensive extrapolation of that limited data (please see pages 5 to 7 for additional details regarding the shortcomings of this information). Many potential dioxins sources have not been tested and are therefore omitted. Also, current source inventories do not account for much of the world's annual dioxins deposition. Currently, global dioxins inventories account for only about one sixth to one twentieth of all of the dioxins deposited annually on the earth's surface (Eisenberg, 1998). Remaining sources are unknown. Because of the weaknesses in these inventories, U.S. EPA has stated that it is unlikely that emissions of dioxins from known sources (those identified in the national dioxins inventory, which are included in the estimates in this Appendix) correlate with general population exposures to dioxins (U.S. EPA, September 2000).

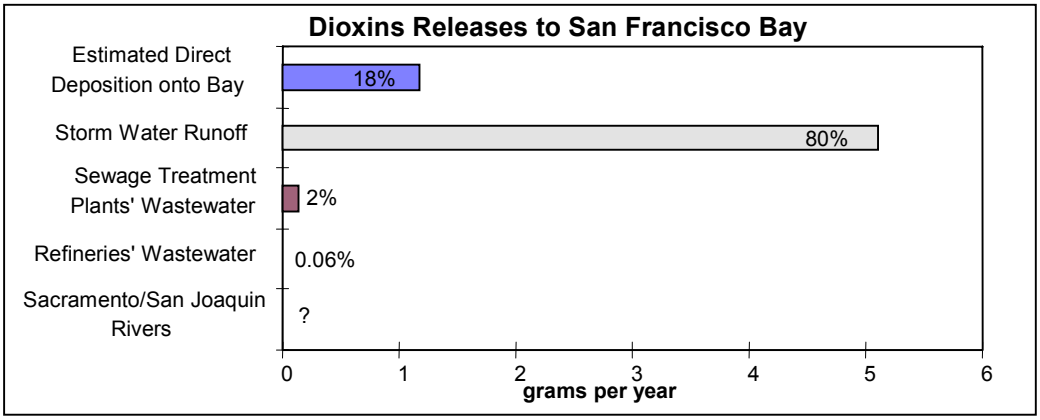
II. Available San Francisco Bay Area Dioxins Release Estimates

Bay Area Air Quality Management District
Estimate of San Francisco Bay Area Dioxins Air Emissions Sources

Source	Release (g TEQ/yr)
Residential Wood Burning	0.8
Diesel Engines (Vehicles, rail, ships, and stationary sources)	0.7
Landfill Gas Combustion	0.2
Gasoline Vehicles	0.1
Fires	0.1
Hazardous Waste Incineration	0.06
Petroleum Refining (Catalyst regeneration)	0.05
Iron and Steel Foundries	0.03
Cement Kilns	0.02
Sewage Sludge Incineration	0.01
Drum Reclamation (Furnaces)	0.009
Medical Waste Incineration	0.005
Coal and Coke Combustion	0.006
Industrial Wood Waste Incineration	0.002
Crematories	<0.001
Total	**About 2**

Source: Bateman, 1998.

Regional Water Quality Control Board
Estimate of Dioxins Discharge Sources to San Francisco Bay



Source: Gervason, 1998.

III. National Dioxins Release Estimates

U.S. EPA Dioxins Inventory

Source	1987 Release (g I-TEQ/yr)	1995 Release (g I-TEQ/yr)
Rural Soil Erosion to Surface Water	?	About 2700
Garbage Incineration	7915	1100
Landfill Fires	?	About 1000
Backyard Trash Burning	573	595
Medical Waste Incineration	2440	461
Secondary Copper Smelting	966	266
Forest and Brush Fires	?	About 200
Urban Runoff to Surface Water	?	About 190
Cement Kilns Incinerating Hazardous Waste	110	145
Municipal Wastewater Treatment Sludge	103	103
Residential Wood Burning	90	63
Coal-Fired Power Plants	51	61
Electric Arc Ferrous Furnaces	?	About 40
Commercial/Industrial Coal Combustion	?	About 40
Diesel Trucks	26	34
Accidental Vehicle Fires	?	About 30
Residential Coal Combustion	?	About 30
Paper Bleaching	356	28
Secondary Aluminum Smelting	15	27
Industrial Wood Burning	25	26
Iron Ore Sintering	29	25
Ferrous Foundries	?	About 20
Accidental Structural Fires	?	Less than 20
2,4-D Manufacturing	21	18
Cement Kilns	13	17
Sewage Sludge Incineration	6	15
Primary Magnesium Production	?	About 15
Ethylene Dichloride/Vinyl Chloride Manufacturing	?	12
Municipal Wastewater Treatment Plant Discharges	?	About 10
Other “Quantified” Sources	Each less than 35	Each less than 10
Total of Estimated Sources	**About 13,000**	**About 3,000**

Notes:

- “?” indicates that U.S. EPA did not provide an estimate for that source in 1987.
- Dioxins also occur in products that may not all be released to the environment (and hence cannot be included in the above table). U.S. EPA estimated that the U.S. 1995 pentachlorophenol production contained 8,400 g of dioxins. The only other US product with notable dioxins content is bleached chemical wood pulp, the 1995 production of which contained an estimated 40 g of dioxins.
- Data do not include dioxin-like PCB data (which is not available for most sources)
- Sources estimated less than 10 g per year (1995) or 35 g per year (1987) are omitted in this summary table.
- Data represent releases to all environmental media.

Source: U.S. EPA, March 2001.

IV. Examples of Dioxins Air Emissions Sources That May Have Special Importance for Communities Neighboring Such Facilities

- Landfill Gas Combustion
- Petroleum Refining
- Cement Kilns
- Drum Reclamation
- Coal Combustion
- Scrap Metal Furnaces
- Industrial Wood Waste Incineration
- Hazardous Waste Incineration
- Iron and Steel Foundries
- Sewage Sludge Incineration
- Medical Waste Incineration
- Crematories
- Chlorinated Chemical Manufacturers

APPENDIX C. PUBLIC REVIEW OF DRAFT REPORT

I. Public Review Process

In the winter of 2000/2001, a draft version of this report was completed and released for public review and comment. The public review period was intended to obtain information from the public on the various dioxins pollution prevention options reviewed in this report, while providing an opportunity for the public to express its views on the various options. The public views expressed in the comment will be considered by the individual municipalities participating in the Bay Area Dioxins Project as they select which dioxins pollution prevention projects they wish to pursue.

Between December 2000 and May 2001, the draft report was circulated for public review. A well-publicized public meeting was held in April 2001. Representatives of many of the municipalities participating in the Bay Area Dioxins Project attended the public meeting. The Bay Area Dioxins Project received oral and written comments from individuals as well as from environmental, industry, and trade groups. A total of 39 individuals and groups provided comments containing hundreds of substantive points. Comments covered a wide variety of topics and perspectives. All written comments were copied and mailed to participating agencies for their review.

II. Comments and Responses

At the close of the public comment period, the Bay Area Dioxins Project directed TDC Environmental to revise this report to incorporate technical comments received during the comment period, and to update report findings based on new information available between completion of the draft report and the close of the comment period.[19] Project participants also carefully reviewed public comments regarding selection of dioxins pollution prevention demonstration projects; these comments will be considered further as individual participating municipalities select which dioxins pollution prevention projects they wish to pursue.

Several comments the Bay Area Dioxins Project received were not of a technical nature, but rather questioned aspects of Bay Area Dioxins Project process. These included decision-making and local agency project selection criteria. The Bay Area Dioxins Project's community liaison—the Center for Environmental Health—was charged with compiling the list of "process" comments for the project. Such comments are included in a separate report on the public participation process.

Other comments were directed towards the nature of the Bay Area Dioxins Project, its purposes and scope, and the relationship of the project to the approach to this report. The following sections address the concerns raised by these comments.

III. General Comments Regarding the Bay Area Dioxins Project

1. ***What is the geographic scope of the project? A number of people inquired as to why the Bay Area Dioxins Project was interested in pollution prevention initiatives for dioxin sources outside of the San Francisco Bay Area. Why, for instance, is the Bay Area Dioxins Project evaluating whether to purchase chlorine free paper when there are no paper mills nearby?***

[19] For instance, U.S. EPA's Science Advisory Board published its review of the draft U.S. EPA dioxins reassessment in May 2001.

Dioxins releases are not strictly a local issue. Because of their chemical nature (they are "semi-volatile" chemicals) and their persistence, dioxins may be transported large distances away from the location that they are released to the environment, as explained on page 4. For example, a research team lead by Barry Commoner documented the connection between elevated dioxins levels in food supplies as far north as the Arctic Circle, and dioxins emissions sources several thousand miles to the south (Commoner, 2000). The general phenomenon of global dioxins transport is well documented (Wagrowski, 2000; Lee, 1999; Commoner, 1996; Eisenberg, 1998).

The issue for municipalities participating in the Bay Area Dioxins Project is to determine what they can do to reduce overall dioxins formation and releases, not merely to identify dioxin-producing sites within any individual city or county limits. Project participants are "thinking globally and acting locally." While the Bay Area does not have factories that manufacture PVC or bleach paper (two of the options evaluated), Bay Area governments purchase large amounts of paper and PVC-containing products. Resolutions from several participating municipalities call for the study of alternatives to products manufactured in such a way that dioxins are generated.

Furthermore, local pollution prevention efforts follow established federal precedents. The U.S. is currently engaged in international efforts to reduce persistent, bioaccumulative and toxic chemicals (PBTs), including the recently negotiated Persistent Organic Pollutants (POPs) Treaty and, developed under auspices of the North American Commission for Environmental Cooperation, regional action plans on DDT, chlordane, PCBs, and mercury. On April 19, 2001, President George Bush announced his commitment to the international POPs treaty, stating:

> "Concerns over the hazards of PCBs, DDT, and other toxic chemicals covered by the agreement are based on solid scientific information. These pollutants are linked to developmental defects, cancer, and other grave problems in humans and animals. We must work to eliminate, or at least to severely restrict the release of these toxins without delay."

2. *Why Pollution Prevention? Why is the Bay Area Dioxins Project focusing on this approach?*

As explained on pages 7 and 8, pollution prevention encompasses a range of strategies and practices designed to keep pollutants out of the environment. Pollution prevention includes practices such as equipment or technology modifications; process or procedure modifications; reformulation or redesign of products; substitution of raw materials; and improvements in housekeeping, maintenance, training, or inventory control.

The dioxins resolutions adopted by various San Francisco Bay Area municipalities specifically call for using pollution prevention strategies to reduce or eliminate dioxins releases. It is seen as preferable to eradicate ongoing sources of dioxins rather than to clean up accumulating deposits on a continuous basis. This approach is in keeping with federal precedents. The U.S. EPA has been promoting pollution prevention since Congress passed the Pollution Prevention Act in 1990.

In the late 1990s, U.S. EPA identified the reduction of persistent, bioaccumulative toxic substances (PBTs) like dioxins as a priority. It named pollution prevention as its preferred strategy to address PBTs. The U.S. EPA began funding PBT pollution prevention efforts conducted by others in 2000, with the PBT Challenge Grant program.

U.S. EPA has begun to compile information on the successes of PBT pollution prevention. The reports and data from the Bay Area Dioxins Project will be added to this body of knowledge.

Once municipalities participating in the Bay Area Dioxins Project select and implement the pollution prevention projects of interest, the project consultants will document the costs, barriers to implementation, and success of the projects.

3. *How did the Bay Area Dioxins Project select the various pollution prevention projects options that are evaluated in this report?*

As a first step to implementing dioxin pollution prevention efforts, the Bay Area Dioxins Project asked TDC Environmental to review possible projects that local governments could undertake to reduce or eliminate dioxins releases. The scope of the review was to compile information about possible dioxins pollution prevention projects and to evaluate the same set of criteria for each possible project, including possible impacts, implementation issues, and costs (see Table 2 on page 10).

As explained on page 8, the list of options selected for evaluation were compiled as "most likely" to be implemented by the local government agencies participating in the Bay Area Dioxins Project. "Most likely" options were projects that had been implemented by one or more local government agencies (in the region or elsewhere in the U.S.), possible projects identified in local government dioxins resolutions, or possible projects identified subsequently by participating municipalities based on local interest. The list is inclusive of Bay Area Dioxins Project participant recommendations, not exclusive. The list is intended to give municipalities an informational aid to help make informed decisions about potential projects; it is not a list of recommended projects.

When options were discussed, TDC Environmental made the participating municipalities aware that each would have implementation issues, some more complicated than others. As explained on pages 8 and 9, some options considered by the Bay Area Dioxins Project were not researched further. Once the study was underway, new ideas were presented to Bay Area Dioxins Project participants; additional ideas were presented by the public during the public comment period. Because the Bay Area Dioxins Project has reviewed a range of options reasonable for local government dioxins pollution prevention activities and members are eager to begin implementing projects under the PBT challenge grant, the project is not, at this time, investigating further options.

4. *Some of these projects could get pretty expensive. Who's going to pay? Who's tracking how much they will cost?*

Because most of the pollution prevention projects surveyed have scant cost information, the likely project implementation costs cannot currently be projected down to the last dollar and cent. To the extent relevant cost information was available, it is included in Appendix A (see Section D for each evaluated dioxins pollution prevention option). The Bay Area Dioxins Project is fortunate to have received U.S. EPA funding to assist with the implementation of demonstration projects that will help to clarify the costs of various dioxins pollution prevention options. When municipalities select projects, the next task to consultants will be to research in greater detail the costs associated with the project.

Each municipal government has different budget priorities and different mandates for participation in dioxins pollution prevention activities. Individual municipalities will make individual decisions as to what dioxins pollution prevention activities they wish to pursue, either individually or in conjunction with the Bay Area Dioxins Project. Municipalities will make these decisions based on their own specific priorities. In some municipalities, elected officials (*e.g.*,

city council or county board of supervisors) may have to approve funding for implementation of dioxins pollution prevention activities.

A common aphorism in the field of pollution prevention is "high front end costs, quick pay back." For example, it may cost a lot in the short run to replace a working diesel garbage truck with a compressed natural gas truck. However, the lower cost of the purchasing natural gas over the next several years when coupled with somewhat lower maintenance costs may mean that in only a few years the costs are equal and in future years the compressed gas vehicle is less expensive.

The technical consultant to the project will monitor the demonstration projects throughout the project implementation period and will compile cost information as part of case studies at the end of the grant period. Other municipalities—in the Bay Area or elsewhere—will then be able to take advantage of the work of the Bay Area Dioxins Project.

5. *The Screening Evaluation mentions a lot that there is poor data on dioxins sources. I have heard that dioxins is one of the most studied chemicals there is, how can there be such poor data? If the data is so poor, why is the Bay Area Dioxins Project finalizing this document?*

The scientific community has studied the dioxins problem from many different angles over many years. As noted on page 6, most available environmental data on dioxins provides information on dioxins levels in humans or the environment, about dioxins conveyances (not actual sources or prevention measures), or about the toxicity of dioxins. While there is a wealth of data regarding the human health and environmental effects of dioxins (which, in this regard, are among the most well-investigated chemicals), very little data has been collected on actual sources of dioxins, and virtually none on the dioxins release from likely pollution prevention alternatives.

As explained in detail on pages 6 and 7, because collecting and analyzing dioxins samples is quite expensive and very technically challenging, there are significant limitations to all available San Francisco Bay Area data. The data on San Francisco Bay Area dioxins sources presented in Appendix B are generally highly uncertain because they are based on limited source testing and extensive extrapolation of that limited data. No quantitative or semi-quantitative dioxins release inventory that considers all environmental media has ever been attempted for the San Francisco Bay area. The dioxins inventory prepared by the Bay Area Air Quality Management District in 1998 relies on very limited data; most estimates were made on the basis of extrapolation of a very small number of measurements (often with results that differed by a factor of 10 or more) made elsewhere in the U.S. or the world.[20]

When evaluating available dioxins source information, it is also important to note that current source inventories do not account for much of the world's annual dioxins deposition. Currently,

[20] For example, the BAAQMD's diesel vehicle emissions estimates were made on the basis of U.S. EPA evaluation of the tiny amount of data available prior to 1998. That data included only two U.S. tests (of exactly two U.S. trucks) and several sets of European results differing by a factor of more than 1,000. The data set included no data whatsoever for off-road vehicle sources (almost half of the BAAQMD diesel emissions estimate) (Bateman, 1998; U.S. EPA, April 1998). Additional studies conducted since 1998 continue to show significant scientific disagreement about the magnitude of diesel dioxins emissions (Geuke, 1999; Gertler, 1998). The values used in the BAAQMD estimate are not at the low end of the range of available diesel dioxins emissions data. Detection limit problems and methodology problems probably account for the tremendous differences in diesel vehicle emissions estimates (Truex, 1998). Wood burning estimates are also based on extremely limited data—extrapolation from two measurements of dioxins emissions from combustion in wood stoves (not fireplaces) in Europe.

global dioxins inventories account for only about one sixth to one twentieth of all of the dioxins deposited annually on the earth's surface (Eisenberg, 1998). Remaining sources are unknown.

In the near term, no significant new data on dioxins sources is anticipated either locally or nationally. In the long-term future, available data on dioxins sources is expected to improve. For example, a collaborative study by U.S. EPA, the California Air Resources Board, and the Bay Area Air Quality Management District is just beginning to test the ambient air in the Bay Area for dioxins levels. While data on ambient air levels does not provide information on dioxins sources, the planned second phase of this project (should funding be available) will be to study specific San Francisco Bay Area dioxins sources.

While existing data on dioxins is not absolutely comprehensive, there is sufficient information to proceed with pollution prevention programs. In the cover letter for the U.S. EPA Science Advisory Board's recently completed a peer review of the draft U.S. EPA dioxins risk assessment (U.S. EPA, May 2001), the Review Panel stated:

> "Since neither knowledge breakthroughs nor fully developed techniques for producing more unbiased risk assessment procedures can be expected to be available in the near future, the [Dioxins Reassessment Review Subcommittee] DRSS recommends that the Agency proceed expeditiously to complete and release its Dioxins Risk Assessment Review….Consistent with basic environmental policy, and recognizing the very long biological and environmental persistence of dioxins, the Subcommittee believes that it is important that EPA continue to try to limit emissions (and human exposure) to this class of chemicals. It is also critical for EPA to closely examine current data and modeling gaps, and to develop a research plan to remedy them."

The Bay Area Dioxins Project brings a similar mindset to its work. Project participants want to contribute in a positive way to stopping dioxin pollution based upon the local agency resolutions and scientific evidence. The purpose of the project is not find or write the most comprehensive study of dioxins ever undertaken, but to compile and understand what is currently known and where future inquiries are needed.

The Bay Area Dioxins Project holds periodic meetings with regulatory agencies in the San Francisco Bay Area, including locally based state and Federal agencies. Project participants also monitor the actions of other agencies and the findings of research by U.S. EPA and others, which they share through an e-mail listserver. Through these meetings and electronic updates, project participants keeps abreast of new data, and continue to monitor initiatives, studies and progress made towards curbing PBTs locally and nationally.

6. *Why does this report recommend so many actions?*

As explained on page 1, this report presents local governments with crucial information needed to evaluate possible pollution prevention projects, including project impacts and possible barriers to implementation. The report was designed to present the facts about potential projects, but not to weigh the relative merits of each option. It does not endorse or recommend dioxin pollution prevention projects, nor does it recommend against projects. Some project options may have more relevant scientific or financial data than others, some will prove more expensive, and in most cases the dioxin reduction potential is unknown. Local governments will weigh this information (along with local interests, needs, and capacity) as each selects dioxins pollution prevention projects to pursue.

7. *This report includes a variety of information sources, including many that are not peer-reviewed publications. Is this appropriate?*

As explained on page 1, this report relied on a wide variety of credible information sources. Certain types of information included in this report could be obtained from the peer reviewed literature; for example, data regarding air pollutant emissions from use of biodiesel in diesel engines was obtained from an article in the well respected American Chemical Society journal *Environmental Science & Technology*. In general, however, practical information about implementing pollution prevention alternatives is not available in peer-reviewed publications; therefore, it is necessary to obtain such information from credible primary sources, like municipalities that are implementing similar projects. For example, information about the City of Cincinnati's experience implementing a biodiesel demonstration project was obtained from Bruce Suits, Cincinnati's Pollution Prevention Manager (who is the former co-chair of the National Pollution Prevention Roundtable's Local Government Work Group, and thus a known credible source).

In every case, sources were selected to be appropriate for type of information provided. Only credible sources were selected. Each source was carefully reviewed technically and compared to information from other sources on the same topic. Sources may contain a wide variety of information; however, they were only relied on for the specific information provided where the source is cited in this report.