A Legacy of Pollution:
The Need for Rapid Cleanup of Petroleum Contamination in California

Elizabeth Ridlington
Dan Jacobson

Environment California
Spring 2003

Acknowledgements

The authors would like to thank Kathryn Phillips of the Center for Energy Efficiency and Renewable Technologies and Susan Frank of the Steven and Michele Kirsch Foudation for their comments. Thanks to Teri Olle, Sujatha Jahagirdar, Brad Heavner, and Tony Dutzik for their assistance in the development and editing of this report.

This report was made possible through the support of the California Wellness Foundation and the Bauman Foundation.

The authors alone bear responsibility for any factual errors. The recommendations are those of the Environment California Research and Policy Center and do not necessarily reflect the views of our funders.

For additional copies of this report, sent $10 (including shipping) to:

Environment California Research and Policy Center
3435 Wilshire Blvd, Suite 385
Los Angeles, CA 90010

The Environment California Research and Policy Center, the new home of the CALPIRG Education Fund’s environmental programs, is a 501 (c)(3) organization that offers an independent, articulate voice on behalf of the public interest in California. Drawing upon 30 years of experience, our professional staff combines independent research and practical ideas to uncover environmental problems, develop pragmatic policy solutions, and engage citizens in our work for meaningful results.

For more information about Environment California, please call 231-251-3688 or visit our website www.EnvironmentCalifornia.org.

Table of Contents

Executive Summary

Production, distribution, and use of petroleum have polluted our air, water, and land. Our continuing reliance on petroleum adds to this contamination. Indicative of these problems are the air pollution caused by diesel engines, the contamination of drinking water by leaking storage tanks, and the abandonment of potentially polluted urban sites.

Petroleum pollution threatens our health and our economy.

Old, dirty diesel engines are a major source of air pollution.

- Diesel vehicles emit 40% of the state's total nitrogen oxide (NO_x) pollution, though only 5% of vehicles on the road are diesel-powered.
- Per unit of energy consumed, diesel engines emit three times as much particulate matter as coal-fired power plants. Particulate matter is a toxic air contaminant and health hazard.
- More than 21,000 diesel-powered school buses in California expose thousands of children to toxic air pollution every day.

Years of storing petroleum in leak-prone tanks has polluted drinking water supplies across the state with carcinogenic chemicals.

- MTBE, a petroleum additive, has been detected in 80 public wells and is thought to contaminate 1,000 to 5,000 private wells.
- Benzene, toluene, ethylbenzene, xylene, and MTBE are common constituents of gasoline that are frequently found in water; they can severely harm human health.
- Petroleum has polluted the ground, creating sites that are frequently abandoned and contribute to urban blight and sprawl. There are more than 90,000 brownfields in California, many of them contaminated with petroleum.

The state of California operates programs to address many of these problems.

- In its first three years, the Carl Moyer Program has replaced 3,500 dirty diesel engines with cleaner alternatives and thereby reduced daily production of NO_x by 14 tons and particulate matter by 800 pounds.
- The Lower-Emission School Bus Program replaced or retrofitted 450 buses in two years, providing thousands of children with a safer ride to school.
- The Underground Storage Tank Cleanup Program has helped tank owners clean up 22,500 leaking tank sites, thereby limiting groundwater contamination.
- State-funded programs have helped clean up 365 brownfields and create 20,000 new jobs.

Though these programs are effective in narrow areas, they are too small and underfunded to address the full scope of petroleum pollution in California.

- At historical funding levels, the Carl Moyer Program would need 35 years to replace just 5% of the diesel engines in California,

while it would take nearly a century for the Lower-Emission School Bus Program to replace all of California's diesel school buses at the current rate of 450 buses every two years.
- To treat all 1,800 sites currently affected by MTBE contamination would cost at least $100 million a year. However, as MTBE, a highly mobile contaminant, spreads it could affect as many as 6,700 drinking water wells and could dramatically raise the cost of cleanup.
- Of the approximately 90,000 brownfield sites in California, less than one half of one percent have been cleaned.

Petroleum pollution cleanup programs need reliable funding now.

Creation of a fund dedicated to paying for cleanup of petroleum contamination would provide money for cleanup now, alleviating threats to the environment and public health and reducing future cleanup costs.

- Greater funding for diesel engine programs would allow faster replacement of the dirtiest engines and improve air quality, particularly for vulnerable populations.
- Helping communities cope with the burden of treating MTBE-contaminated water would reduce the need for future treatment.
- Redeveloping just a fraction of the state's brownfield sites could add 25,000 jobs and increase tax revenues by $72 million.

In a time of severe budgetary shortfalls, money for cleanup is unlikely to come from the state's general fund. One alternative funding source is the polluters who played a role in creating the problem. In addition to covering the cost of cleanup, requiring polluters to pay—whether through a gas tax or a refinery fee—would encourage more responsible behavior in the future and help avoid additional pollution.

Introduction

Mention petroleum pollution and the first thing that comes to mind is an oil spill, black gunk oozing out of a tanker, covering pristine beaches. But petroleum pollution is more common and more widespread than just the occasional oil spill: it happens every day and affects air, water, and soil everywhere.

Consider the polluted air the average city resident inhales in the course of a day. Trucks, buses, cars, and power generators emit air pollutants that circulate throughout our surroundings. Especially obvious is the black exhaust from diesel vehicles. Riding on or driving behind a diesel-powered bus dramatically increases the amount of pollution inhaled. Children who ride a bus to school are regularly exposed to fine particulate matter that can become lodged in their lungs, impairing lung function.

Just as the chance of spills from oil tankers can be reduced by using double-hulled tankers and spills can be better contained through prompt action, more common petroleum pollution can be reduced and cleaned up. The state of California has begun pursuing the goal of reducing pollution with requirements for Low-Emission Vehicles and creation of a Renewables Portfolio Standard. The state also seeks to clean up ongoing or existing pollution through programs targeting diesel engines, tainted water, and brownfields.

Unfortunately, the programs that address common petroleum contamination are being eliminated through state budget cuts and the state's budget deficit makes it unlikely that lawmakers will restore funding soon. In the meantime, petroleum pollution in our air, water, and land is continuing—and in some cases will spread. This report describes the dangerous legacy of petroleum pollution, details how California is addressing it, and outlines the risks that will ensue—and the opportunities for a cleaner environment and improved public health that will be missed—if the state fails to adequately support efforts to clean up petroleum pollution.

Overview of Petroleum Production and Use

Petroleum is a naturally occurring solid, liquid, or gas that must be extracted from the ground and refined before it can be used. The first step requires pumping petroleum through on-shore and off-shore wells. Crude oil is then transported through hundreds of miles of pipelines or by tanker to a refinery.[1] At the refinery, petroleum is separated into its components. The various products—diesel, gasoline, jet fuel, asphalt, tar, lubricants—are then shipped to market and used.

Petroleum production and use damages the environment and health. Pipelines leak, tankers spill, and refining and combustion emit airborne pollutants. The products released include carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter (PM), antimony, and selenium.

Many of these compounds are dangerous to human health. Gasoline, one of the most widely distributed products, contains benzene, toluene, ethylbenzene, and xylene. Benzene is a known human carcinogen.[2] Low-level exposure to toluene can affect the nervous system, causing confusion, weakness, memory loss, nausea, and hearing and color vision loss. High doses can damage the kidneys.[3] Information on ethylbenzene's human health impacts is limited; however, animal studies show harm to the nervous system, liver, kidneys, and eyes.[4] Xylene damages the brain.[5]

California pumps nearly a million barrels of oil each day, making it the fourth largest producer in the country.[6] The state's refineries process 1.9 million barrels each day, more than 10% of the national refined petroleum supply.[7] Californians consume 1.5 million barrels of gasoline, diesel, and jet fuel each day.[8] Decades of this extensive production and use have damaged our environment and our health. This report will focus on three problems that are indicative of the pollution caused by petroleum in California.

Air

Replacing outdated diesel technology is the easiest route to cleaner air and protecting public health. The 1.25 million diesel engines in California emit more pollutants and pose a greater risk for vulnerable populations than do gasoline engines. Diesel engines are used in cars, trucks, buses, off-road vehicles, trains, ships, back-up generators, portable generators, and agricultural generators.[9] Such engines are typically kept in service for 20 or more years.[10]

Health Hazards of Diesel Emissions

Diesel engines produce a disproportionately high amount of NO_x relative to their numbers. Though only 5% of California's vehicles are diesel-powered, they produce more than 40% of the state's NO_x emissions.[11] NO_x produces ground-level ozone by reacting in sunlight with volatile organic compounds. Ozone can inflame airways and prolonged exposure can decrease the amount of oxygen available to the body with each breath. It is also a trigger of asthma attacks. In addition, a study by the University of Southern California found that active children who lived in high-smog areas were more likely to develop asthma than inactive children. Active and inactive children's asthma rates in low-smog areas did not differ.[12]

Diesel engines also are a major source of PM. Per unit of energy consumed, diesel engines produce three times as much particulate matter as coal-fired power plants.[13] Particulate matter can become lodged in the lungs, leading to a loss of heart and lung function. In addition to NO_x and PM, more than 40 other toxic air contaminants stream from diesel engines.[14]

Clearly, pollution from diesel is cause for concern. Children are especially susceptible to diesel pollution because they breathe faster and take in more air per pound of body weight, yet this is a population that is regularly exposed to high levels of diesel exhaust.[15] There are 21,000 diesel-powered school buses in California, which produce 13 tons of NO_x and half a ton of PM each day as they transport children to school.[16] Air quality inside the buses is poor. The Natural Resources Defense Council tested the air inside diesel school buses and found between 1.6 micrograms and 14 micrograms more diesel exhaust per cubic meter than average outdoor air in California.[17] That means that the air inside a school bus has up to four times the amount of toxic exhaust as air outside the bus. Riding inside a school bus, which should be safe, is a hazardous activity that exposes children to more than 20 times the cancer risk considered significant by federal standards.[18] This finding does not include how much pollution children are exposed to as they wait to board buses on the way to and from school; nonetheless, children's exposure is too high.

Diesel Clean Up Programs

Diesel engine replacement and retrofitting occurs in California through several programs overseen by the California Air Resources Board (CARB). The State Implementation Plan created in 1994 under the Clean Air Act Amendments of 1990 mandates short-term and long-term emissions reductions. Replacing dirty diesel engines helps meet the short-term goal.[19] The state has two diesel replacement programs: the Carl Moyer Program and the Lower-Emission School Bus Program.

Carl Moyer Program

The Carl Moyer Program has cost-effectively reduced NO_x and PM emissions by replacing or retrofitting old diesel engines. The program, created in 1998, seeks to reduce NO_x and PM emissions "by providing grants to cover the incremental cost of cleaner heavy-duty vehicles and equipment."[20] The Carl Moyer program pursues these goals in three ways.

By far the largest project is engine improvements in which the state pays for the incremental cost of purchasing less-polluting engines.[21] Eligibility is limited to on-road vehicles over 14,000 pounds gross vehicle weight (medium to heavy duty trucks and trailers such as city delivery trucks, refuse trucks, and dump trucks), off-road engines over 50 horsepower, marine engines, auxiliary power units, locomotives, stationary agricultural pump engines, forklifts, and airport ground support equipment.[22] In its first three years, the program helped buy 1,809 alternative fuel engines (such as natural gas engines), 1,653 cleaner diesel engines, and 209 electric motors.[23]

The second category of work is infrastructure demonstration, which funds alternative fuel infrastructure to support Carl Moyer Program-acceptable vehicles.[24] Just as cars need gas stations, electric vehicles need recharging stations and alternative fuel engines need appropriate fuel. The third and smallest project is advanced technology development to encourage creation of new emission-reduction technology.

Funds for the Carl Moyer Program come from the state and from regional air quality districts. In the period from July 1998 to June 2001, the program received $98 million from the state and $33.6 million from the districts.[25] Most of the money is spent on engine replacements and upgrades: $89 million to the engine program and $9 million to infrastructure and technology demonstrations.[26]

The Carl Moyer Program has had substantial impact in its first three years and those benefits are expected to last at least a decade.[27] The work of the program has cut daily production of NO_x by 14 tons and of PM by 800 pounds, and has done so cost effectively.[28] Program criteria require that projects reduce emissions for $12,000 per ton or less in the first two years, and $13,000 or less in the third year.[29] In the first three years, the average cost to remove one ton of NO_x from production was just $5,000.[30]

Lower-Emission School Bus Program

Though the Lower-Emission School Bus Program is so new that only preliminary results are available, the program appears to have reduced many children's exposure to emissions from the dirtiest diesel buses. The California Air Resources Board created the Lower-Emission School Bus Program in 2000 to reduce children's exposure to cancer-causing and smog-forming air pollution by replacing older buses with cleaner, newer ones and by paying for filters to reduce emissions from 1,800 more buses.[31] Of the $50 million disbursed in July 2001, $25 million was designated for purchasing alternative fuel buses, $12.5 million for cleaner diesel, and $12.5 million for filters on old buses. Pre-1977 buses, built before federal safety standards were imposed, are the highest priority to replace, followed by pre-1987 buses. In 2002, the program received $16 million for bus retrofits and replacement.[32]

Final numbers are not available for the impact of the program's first two years. An early approximation suggests that the program has replaced 450 buses.[33] Guidelines issued at the program's inception predicted that replacing 350 pre-1987 buses would reduce NO_x emissions by 870 tons and PM emissions by 73 tons over the next 15 years. The $12.5 million slated to be spent on retrofits would reduce PM by 151 tons over 10 years.[34]

Future Funding

Despite this progress, diesel emissions remain too high. More than 1.25 million diesel engines remain in use, including 21,000 school buses, producing 650 million tons of NO_x and 33 tons of PM each day.[35] Furthermore, CARB projects that from 2000 to 2010 the number of heavy-duty vehicles will rise by 12% statewide.[36]

Every year of delay in upgrading buses adds to our toxic pollution exposure. Diesel-powered vehicles, including buses, often operate for 20 years or more, so the natural replacement cycle for these buses is very long.[37] At the current replacement rate of 450 buses every two years, the Lower-Emission School Bus Program will have replaced only a quarter of the state's 21,000 diesel school buses in the next 20 years. The total cost to replace all diesel school buses will be $1.9 billion to $2.5 billion. This is based on an average cost of $92,000 for a new diesel school bus and $120,000 for a compressed natural gas school bus.[38]

The Carl Moyer Program faces an even longer timeline. If funded at $40 million per year—an average of the state and district funds in the program's first three years—replacing just 5% of California's diesel engines would take 35 years.

Yet the maintenance of even current levels of funding is uncertain for the Carl Moyer Program and the Lower-Emission School Bus Program. The fiscal year 2003 state budget has no money for either program.[39] Proposition 40, passed by voters in March 2002, directs that $50 million in bonds be allocated to CARB for air quality work as it impacts parks and recreation.[40] This money will be distributed over two years, with some going to the Carl Moyer Program. This will not be enough to maintain California's current efforts to clean up dirty diesel engines, let alone solve the problem of diesel air pollution.

Water

Underground storage tanks have leaked petroleum into drinking water supplies across California and much contamination remains in the ground with the potential to seep into drinking water. MTBE pollution is a prime example of the danger posed by petroleum contamination to California’s water supplies.

At more than 8,000 sites around California, petroleum has leaked into groundwater from underground storage tanks, which are widely used and often leak. (Underground storage tank (UST) is a general term; tanks that hold fuel are underground fuel tanks (UFTs).) There are 42,500 petroleum-filled UFTs currently in operation in California. At least 30,000 tanks have leaked and require repair or replacement.[41] The state has declared approximately 16,000 of those tank sites no longer a threat to health or groundwater, leaving more than 15,000 leaking UFT sites still a hazard. Of these cases still open for investigation and cleanup, over 8,000 have contaminated the groundwater, 71% of them with gasoline and almost 40% with methyl tert-butyl ether (MTBE), a petroleum refining byproduct and additive to gasoline.[42] The impact of this contamination is significant: groundwater provides over half of California's public water supply, providing water to more than 13 million people.[43]

More specifically, in the fall of 1998, California's Department of Health Services knew of 35 public drinking water wells with MTBE contamination. An additional 10,931 active wells had not been tested for MTBE and researchers at the University of California, Davis, estimated that 29-128 of those were contaminated with MTBE, bringing the total number of affected wells to 60-160.[44] In addition, the 1990 census reported on 464,621 private wells serving more than 4 million people.[45]

MTBE Case Study: Santa Monica

The City of Santa Monica’s experience with MTBE in its water demonstrates how disastrous a problem this can be. Santa Monica, with 90,000 residents and 200,000 daily visitors, relied on groundwater for much of its public drinking water supply, unlike most towns in Southern California, which import water.[46] That changed in 1995 when the city discovered MTBE in public drinking-supply wells at levels 50 times greater than the state standard.[47] This made the water potentially carcinogenic. In response, Santa Monica closed the affected wells, which represented 71% of its ground water supply. To compensate, the city began importing over 80% of its water at a cost of $500 per acre foot or $3.25 million per year.[48] The alternative was to pay several hundred million dollars to remove the MTBE from the water.[49]

The city, arguing that those responsible for the contamination should pay for its cleanup, filed a lawsuit against oil manufacturers, suppliers, refiners, and owners and operators of pipeline and gasoline facilities for allowing petroleum products and MTBE to leak from underground storage tanks.[50] In July 2002, ChevronTexaco and ExxonMobil tentatively agreed to a settlement in which the companies would pay to design, build, operate, and maintain a water treatment facility to remove MTBE from the city's water at an estimated cost of over $200 million.[51] The city continues its suit against other polluters.

The UC Davis researchers estimated that 1,000 to 5,000 of those are polluted by MTBE.[52] The total amount of groundwater affected statewide is approximately 100,000 acre-feet, enough to meet the water needs of over 800,000 people for a year.[53] (For county-specific MTBE contamination information, see Appendix II.)

Characteristics of MTBE and Their Consequences

Formed through the reaction of methanol with isobutylene, a refining byproduct, MTBE is a dangerous chemical.[54] It is a known animal carcinogen and has the potential to cause cancer in humans.[55] As a result, the state of California regulates MTBE as a water contaminant. MTBE's primary maximum contaminant level (MCL), established to protect health, is 13 parts per billion (ppb). The secondary contaminant level, set for taste and odor of water, is 5 ppb.[56]

Once released into the ground or water, MTBE is difficult to contain or clean up. First, it is not biodegradable, so it does not break down by itself. Second, and more importantly, it is highly water soluble and thus spreads quickly throughout an entire body of water.[57] It can contaminate water faster than any other component of gasoline.[58] A study of MTBE impacts requested by the Legislature and governor in 1997 modeled MTBE plumes and revealed that they grow three to four times larger than benzene plumes in the same place.[59]

MTBE Contamination: An Avoidable Problem

An important component of protecting public health and the environment is prohibiting companies from putting chemicals on the market with little or no public information on their health effects or environmental consequences. A brief history of how MTBE entered widespread use illustrates the importance of strengthening public disclosure requirements for companies seeking regulatory approval for new chemicals or different uses of existing chemicals.

MTBE is a byproduct of petroleum refining that is added to gasoline to help the fuel burn more cleanly. The oil industry has added MTBE to gasoline for decades, but its use soared after a 1992 EPA requirement that refiners produce "reformulated gasoline" that would enable states to meet requirements of the Clean Air Act.

In establishing standards for reformulated gasoline, the EPA required the use of oxygenates to make gasoline burn more cleanly. Relying in part on industry information about the safety of MTBE, EPA acquiesced to industry demands that MTBE be permitted as an oxygenate.[60] The oil industry had been aware for years of the ease with which MTBE traveled through water when released into the environment and the difficulty of removing MTBE from water, but did not share this information with the EPA.[61] As a result, EPA did not know of the extensive environmental damage and health risks that would result from intensive use of MTBE.

Had the industry been required to reveal to EPA and the public its studies of and experiences with MTBE, EPA likely would not have permitted widespread use of MTBE as an oxygenate.

The number of sites contaminated with MTBE and MTBE's solubility in water mean that MTBE will contaminate more drinking water. Currently, more than 10,000 locations in the state are affected by MTBE and of those, 6,700 are within a half mile of a drinking water well.[62] Further, a team at UC Davis estimates that of the 8,000 leaking UFTs that have contaminated groundwater with petroleum, 78% (or 6,240) will be found to have caused MTBE contamination. The researchers concluded that any UFT leaking gasoline with MTBE will almost certainly result in MTBE contamination. This adds up to 12,940 likely contaminated drinking water sites—6,700 sites where MTBE is near drinking water and 6,240 where petroleum already is in drinking water but MTBE has not yet been identified—but this underrepresents the potential extent of MTBE contamination because not all petroleum-polluted sites in California are checked for MTBE. In the Los Angeles area, for example, 17% of leaking UFT sites have not been tested for the additive.[63]

Private wells, which serve more than 4 million people, are particularly susceptible to MTBE contamination because they are shallower than public wells and MTBE plumes reach them sooner.[64] A 2002 analysis of 9,900 wells and 700 surface water sources showed that 23 sources exceed the primary MCL and 57 exceed the secondary contaminant level.[65] The UC Davis study recommended that “remediation at MTBE contaminated sites should proceed as soon as possible to prevent further migration of the contamination that will impact a greater volume of California's ground water resources.”[66]

Cleanup of Petroleum and MTBE in Water

With California’s arid climate, limited water supplies, and increasing water contamination, treating water to remove MTBE and other petroleum-derived chemicals is an expensive necessity. Local water districts struggle with this cost. Without state help, they face the choice of spending vast resources on cleanup or abandoning wells, leaving the water untreated and allowing contamination to spread.

Treatment

All publicly supplied water is treated for basic contaminants before it is distributed to consumers. First, turbidity is removed through basic filtration or settling. Then the water passes through finer and finer filters and is disinfected with chlorine or another chemical.[67] Further treatment may be required if the water contains more serious contamination, such as pesticides or MTBE.[68]

MTBE can be removed from water in several ways. Remediation of an entire plume in an aquifer requires pumping huge quantities of water; the alternative is to install MTBE treatment capacity at every possible drinking well site. Air stripping—mixing air into MTBE-laced water to push the MTBE into the air—is generally the most cost-effective strategy, though if the amount of MTBE released into air is great enough, treating the discharged air may be necessary. Adsorption of MTBE into activated carbon, synthetic resins, or clays occurs slowly because MTBE is so water soluble, thus making this method less attractive. The same is true of advanced oxidation. MTBE is not very reactive, so only a strong oxidizing agent in a system with high flow rate can remove MTBE from water. Biological treatment converts MTBE into CO_2, water, and cell mass. The feasibility of this method of treatment depends on the composition of the water.[69]

Underground Storage Tank Cleanup Program and Fund

The statewide programs for assisting with MTBE and petroleum cleanup focus on limiting further contamination of water. The Underground Storage Tank Cleanup Program and Fund, created in 1989, targets pollution from tanks. The Program establishes guidelines for cleaning up contaminated soil or water and oversees that work. The Fund provides financial assistance for investigation and cleanup, giving priority to individuals and small business owners. It does not pay for removal, repair, installation, or upgrades of tanks; that cost must be borne by the owner of the tank. The $180 million collected annually by the Fund comes from a per-gallon fee paid by owners of petroleum-filled UFTs.[70] Thus, the Underground Storage Tank Cleanup Fund provides financial assistance by collecting funds from all potential polluters. Since 1999, the Fund has spent $475 million and completed the cleanup of 2,439 claims.[71] The Program has overseen the cleanup of almost 22,500 leaking UST sites and has another 15,000 cases ongoing.[72] Though the current fee can pay for cleaning many sites of known contamination, as the problem of MTBE spreads costs will rise and the program may experience a shortfall.

Spills, Leaks, Investigations, and Cleanup Program

The Spills, Leaks, Investigations, and Cleanup Program (SLIC), created in 1991, is administered by regional water quality control boards in California to deal with contamination of water from sources other than leaking USTs, whether the problem is petroleum, MTBE, or other pollutants. The SLIC program becomes involved when water is polluted or when a release might pollute water. The program is a cost recovery program and receives no state funding. Polluters must pay for both remediation of the contaminated site and the salaries of SLIC staff overseeing the cleanup to verify it is done properly. Since 1999, 202 sites have been cleaned up under SLIC.[73]

Aboveground Tank Program

A much smaller program is the Aboveground Tank Program. Funded by a small fee on aboveground tanks, it pays for inspections of only a fraction of the 4,000 facilities around California each year. When spills are detected, SLIC oversees the cleanup. Fifteen sites have been cleaned up since 1999.[74]

Existing cleanup programs, while fairly effective in their specific program areas, fall short of the widespread treatment and cleanup effort needed. They are unable to remove petroleum from soil and water fast enough to keep the problem from spreading, and given the behavior of MTBE in particular, this cleanup shortfall will only widen and become more costly.[75]

Cost of MTBE Cleanup

MTBE remediation is expensive and delays in cleanup will only result in increased costs in the future.

MTBE's persistence in water makes it expensive to remove. Water polluted with MTBE costs 40-80% more to clean than water polluted with other hydrocarbons.[76] Depending on the treatment method used, purifying 1,000 gallons of MTBE-contaminated water costs $0.13 to $5.78. Applied to actual situations, the expense is staggering: cleaning a typical gas station costs $30,000-$250,000, but if the contamination is severe the total might be as high as $2.5 million. For a typical site, cleanup takes two to five years with an average of three years for both soil and water remediation. Pipeline ruptures release a bigger volume of gasoline and MTBE than do leaks at gas stations and so cleanup costs average $750,000-$1,000,000 per spill.[77]

Delaying cleanup makes the problem worse. A study at the University of California, Davis, concluded that "if MTBE groundwater plumes are allowed to migrate over a period of years or decades, remediation will be significantly more difficult and costly, owing to substantially larger plume size and diffusion into fine-grained materials that are ubiquitous within most California aquifers."[78]

Cleaning up all petroleum and MTBE-tainted groundwater will be very expensive. The estimated 1,800 contaminated drinking water sites in California will cost at least $100 million a year to treat to the secondary health standard level of 5 ppb. The characteristics of each site determine what treatment method is feasible and therefore what the cost will be, so the total expense may be higher.[79]

However, California has no other practical option than to intensify the cleanup of these sites. Relying on existing UST cleanup programs to deal with the MTBE problem will not completely address MTBE contamination and will allow the problem to spread and put more public and private water supplies at risk. Ultimately, California must decide whether to make the necessary investment in MTBE cleanup now, or pay a much greater financial and public health price in the future.

Table 1: Cost to Treat All MTBE-Contaminated Drinking Water Statewide

Treatment Method	**Statewide Cost (millions/year)**
Air Stripping	$100-500
Air Stripping with Gas Treatment	$200-2,200
Carbon Adsorption	$600-1,800
Advanced Oxidation	$400-1,800
Biological Treatment	$100-500

Land

Brownfields—abandoned, potentially polluted urban sites—harbor health hazards and contribute to sprawl. Redeveloping them can make neighborhoods healthier and cities more attractive.

Scope of the Problem

Brownfields are defined loosely as "abandoned, idled or underused urban properties where expansion or redevelopment is complicated by real or perceived environmental contamination."[80] There are more than 90,000 such sites in California, places that are not redeveloped into housing, offices, open space, or other new uses because the owners fear that they first would have to undertake an expensive cleanup of pollutants saturating the site.[81]

The exact number of brownfields contaminated with petroleum has not been determined but certainly petroleum pollutes many of them. Old industrial sites and closed military bases contain petroleum, arsenic, lead, solvents, and other metals and hazardous wastes.

Brownfield Cleanup Programs

Brownfields can be developed, but first they have to be tested for contaminants and, if necessary, cleaned so that they are not a threat to health. Those steps can be expensive. Though the state of California has a number of programs to encourage brownfield development, few of the programs help defray this cost. The brief descriptions below of each of the cleanup programs reveal how they address these issues.[82]

Voluntary Cleanup Program

The state's primary program for brownfield remediation is the Voluntary Cleanup Program (VCP), created in 1993. Under this program, the state does not cover any costs; the developer must pay for everything under supervision by the Department of Toxic Substances Control (DTSC), which ensures that the work is completed properly.[83] From 1993 to 1998, 264 sites came into the program.[84] Forty-eight site cleanups have been completed under the VCP since 1999.[85]

California Recycle Underutilized Sites

The California Recycle Underutilized Sites (CalReUSE) Program is a pilot program that provides loans to encourage brownfield conversion. Observing that uncertainty about contamination at a site is as much of an obstacle as contamination itself, the California Pollution Control Financing Authority (CPCFA) provides financial assistance to investigate possible pollution. It does so by partnering with local development agencies that have a track record of success in developing brownfields and providing loans funded through the sale of tax-exempt revenue bonds and a fee associated with them.[86] That money can be used for assessing the extent of pollution, gaining access to sites, and securing technical help.[87] CPCFA guidelines, carried out by the local partners, define eligible sites as those that could provide economic benefits if cleaned up but which are not being developed because of concerns about potentially immense cleanup costs. Priority is given to work in distressed communities.[88] The partners must match 25% of the state funds with their own money to ensure that they have a stake in successfully developing the site. Thus far, local development agencies in San Diego, Emeryville, and Oakland have received funds totaling $2.3 million.[89]

Cleanup Loans and Environmental Assistance to Neighborhoods

Another loan-based program is the Cleanup Loans and Environmental Assistance to Neighborhoods (CLEAN) Program, created in 2000 to offer low-interest loans to encourage cleaning and redevelopment of "urban properties where redevelopment is likely to boost property values, economic viability and quality of life of a community."[90] Developers or owners can receive up to $100,000 to determine if a site is contaminated and an additional $2.5 million for cleanup. The Legislature initially allocated $85 million to the program but slashed funding to $8 million later that year to deal with the statewide budget crisis.[91] The CLEAN program has loaned $5.2 million to six projects, ranging from a low-income housing development on the site of a former salvage yard in the San Francisco Bay area to a commercial, retail, residential, and open space mix in Los Angeles County.[92] No measurable results are yet available because the program is so new.

Expedited Remedial Action Program

The Expedited Remedial Action Program (ERAP) was created in 1994 as a pilot program to address regulatory, not directly financial, concerns about brownfield remediation. ERAP has some funds to pay for a share of cleanup at sites where not all the responsible parties can be found but most funding for the program's operation and oversight comes from the parties involved in the cleanup.[93] Three cleanups have been completed since 1999, and another three are expected to be finished by the end of 2002.[94]

Other state programs do not directly help with cleanup. Rather, they limit liability for purchasers of tainted land, reduce regulatory overlap during cleanup and certify the completed cleanup as adequate, or limit the liability of lenders who were not directly involved in polluting a site and are willing to help fund cleanup.[95]

Benefits of Developing Brownfields

Brownfield redevelopment brings substantial benefits: reduced sprawl, cleaner neighborhoods, and economic growth.

Brownfield remediation frees up scarce land in dense urban areas and limits sprawl. The U.S. Environmental Protection Agency estimates that for every acre of brownfield that is developed, 4.5 acres of undeveloped land are preserved.[96] More specifically, a survey by the U.S. Conference of Mayors noted that brownfield development can help control sprawl.[97] Almost 75% of cities surveyed reported that they could support additional urban residents using existing infrastructure if brownfield sites were developed.[98] In California's densely populated cities, where land is expensive, this is especially important. For example, an explosives manufacturing plant on 480 acres near crowded San Francisco was turned into 400 acres of open space and 600 homes.[99] In Sacramento, Southern Pacific Railroad's equipment maintenance yard, a 220-acre downtown site, has been undergoing cleanup since 1995. When completed, the site will increase Sacramento's open space by 35%, add 2,800 residential units, and create 10 million square feet of retail, entertainment, and office space.[100]

Brownfield development also protects the environment and human health by removing contaminants that could enter the air or water. It can also improve nearby residents' quality of life.

Redeveloped sites encourage economic activity and increase state and local tax revenues. One such example of this is a 24-acre site at the Port of Long Beach that was cleaned of petroleum-based wastes and metals. It is now a Toyota distribution center and a marine container terminal. Customs revenues and taxes from the site exceed $680 million each year.[101] Near Fontana, a Kaiser Steel mill site full of petroleum and metal was cleaned up and turned into the California Speedway. It generates $125 million in economic activity each year, including $2.5 million in additional tax revenue for the state and county.[102]

Businesses built on old brownfields bring jobs to the community. In addition to boosting tax revenues, the California Speedway example above created 1,200 new jobs.[103] An IKEA store built on the site of a steel plant in Oakland created 300 local jobs.[104] Throughout the state, more than 21,000 jobs have been created at 365 brownfield redevelopment projects.[105] The 23 California cities that responded to a survey by the U.S. Conference of Mayors estimated that development of their 731 brownfields would contribute an additional $72 million to $113 million in annual tax revenue and create over 25,000 jobs.[106]

Redevelopment of California's brownfields will benefit the state in multiple ways. Polluted sites will be cleaned up, protecting public health and improving communities, and development on those sites will create jobs and increase tax revenues. These benefits require an investment of funds for cleanup. Ninety percent of cities responding to a national survey by the U.S. Conference of Mayors cited lack of money as the key obstacle to cleaning and redeveloping brownfields.[107] (For city-specific development benefits, see Appendix III.)

Cost of Cleaning Brownfields

In California, developing the 731 brownfield sites reported by just 23 cities would cost as much as $600 million if cleanup and development costs are comparable to the $850,000 the CLEAN Program has spent thus far on each site. This might underestimate the real cost of cleanup: when the state legislature created the CLEAN Program, state spending per site was capped at $2.5 million. The CLEAN Program received only $8 million in the last fiscal year, enough money to clean just nine sites. Cleanup and redevelopment will not be cheaper if delayed. In fact, the cumulative benefits of redevelopment—jobs, neighborhood revitalization, tax revenues—will be greater the sooner cleanup is completed. Redevelopment now is a winning choice.

Preventing Future Brownfields

Petroleum-polluted brownfields imperil the environment, thwart urban redevelopment, and are costly to clean up. Clearly it would be better to avoid creating any more brownfields. One mechanism that could be used to reach this goal is greater corporate openness and accountability. Knowledge empowers the public to defend itself and the environment.

Manufacturing and industrial plants can bring jobs and economic growth to a community, but providing those benefits does not excuse corporations from being good citizens and neighbors. Citizens should have access to environmental information about a facility, be able to have independent experts inspect the facility, and have a say in what environmental protections the facility adopts.

Citizen access to and influence over a company's environmental practices can improve safety and reduce environmental threats. Review of corporate records allows the community to determine if the company is doing everything it can to reduce petroleum pollution. Inspections can reveal weak points in the manufacturing process where accidental releases of petroleum-based solvents or fuel are likely. With this information, citizens can push the company to improve its practices and reduce the risk of creating a brownfield.

Cleaning Up Petroleum Pollution: The Choices Facing California

Dirty diesel vehicles, MTBE contamination, and contaminated brownfields all endanger public health and our economy. Existing programs, while effective in narrow areas, are too small to make much progress. Additionally, budget cuts threaten to reduce the size of these programs even further. One solution would be to create a dedicated source of funding to fund cleanup of petroleum pollution.

The need for financial resources is large and pressing.

- Replacing all 21,000 diesel school buses in California would take nearly a century at current funding levels. Every year that dirty buses continue to transport children to school, thousands of developing lungs are exposed to toxic air pollution. Upgrading buses now would cost between $1.9 billion and $2.5 billion and would protect the health of the most vulnerable members of our population.
- Treating all MTBE-contaminated drinking water will cost at least $100 million annually. This is already a financial issue for many communities and, as existing MTBE plumes spread, water treatment costs will rise. Spending more on cleanup now will protect health, reduce future contamination, and cost less in the long run.
- Cleaning less than 1% of the state's 90,000 brownfields will require 20 years if funding is $30 million dollars annually.

Delaying cleanup threatens the environment and public health but does not reduce the costs.

There are three alternatives for addressing this legacy of petroleum pollution. The first is to continue cleanups at their current slow, sporadic rate that is closely tied to the state's economic situation. This approach will prolong the remediation process, imposing greater environmental and health hazards. Additionally, delaying cleanup will raise the overall cost as the problems, particularly in water, expand.

The second option is to allocate more money from the state general fund. This would involve a commitment to greater funding for cleanups and would more quickly reduce health hazards. However, during a time of state budget deficits, lawmakers will continue to face pressure to cut rather than expand program funding and thus cleanup programs will remain too small.

The third option is to find a new source of funding that can be dedicated to cleanup expenses. Such a fund could be established at the level necessary to protect health through cleanup work and would not be subject to the variability of the state's budget situation. Money for such a fund could come from those who caused the pollution—producers and consumers of petroleum products—rather than from those who suffer from its effects. A per-gallon fee earmarked for cleanup programs could be imposed on gasoline and diesel sold at the pump or on all products produced at refineries in the state, or a flat fee could be added to vehicle registration costs.

Having polluters fund cleanup has several advantages. It requires that those who make the mess clean up after themselves and it reduces the financial benefit received by improperly creating the contamination. Further, it creates an incentive for more responsible behavior.

Finally, an expanded right-to-know program would reduce future cleanup needs. Companies should not be able to put chemicals on the market with little or no public information on the chemicals' health effects. To reduce overall use of dangerous chemicals, all significant pollution sources should report their use, waste generation, and releases of toxics.

Appendix I

Distribution of Carl Moyer Program Funds by County

	Funds Received in Years 1-3		
Air District	**Alternative Fuel Engines**	**Diesel Engines**	**Notes**
Antelope Valley	$701,034	$305,292	
Bay Area	$820,000	$7,956,123	
Butte County	$0	$75,781	Participated in years 2 and 3 only.
Colusa County	$0	$0	
Feather River	$0	$295,554	Participated in years 2 and 3 only.
Glenn County	$0	$210,700	
Imperial County	$0	$213,800	
Kern County	$100,000		Participated for year 2 only.
Mendocino County	$0	$61,439	Participated for years 2 and 3 only.
Mojave Desert	$1,240,767	$34,678	
Monterey Bay Unified	$265,800	$568,338	
North Coast Unified	$0	$379,000	
Northern Sierra	$0	$294,939	
Northern Sonoma County	$183,900	$60,000	Participated in years 1 and 3 only.
Placer County	$0	$0	
Sacramento Metropolitan	$197,390	$7,113,991	
San Diego County	$1,107,611	$2,556,237	
San Joaquin Valley	$206,118	$14,146,786	
San Luis Obispo	$197,352	$214,482	
Santa Barbara County	$169,749	$341,004	
Shasta County	$0	$61,800	Participated in years 2 and 3 only.
South Coast	$29,511,385	$2,824,650	
Tehama County	$0	$150,000	Participated in year 3 only.
Ventura County	$1,390,353	$1,643,975	

Appendix II

Leaking UFT Sites and MTBE Contamination by County

County	Number of Drinking Water Sites with MTBE	Maximum Concentration of MTBE Detected in Drinking Water (micrograms/Liter)	Average Concentration of MTBE Detected in Drinking Water (micrograms/Liter)	Number of Times MTBE Has Been Detected	First Time MTBE Was Detected	Number of Leaking UFT Sites
ALAMEDA	7	5.50	2.41	19	11/15/1996	2,409
ALPINE	0	0.00	0.00	0	NA	13
AMADOR	0	0.00	0.00	0	NA	63
BUTTE	3	4.50	3.90	3	8/17/1999	247
CALAVERAS	1	5.30	4.13	3	9/8/1998	105
COLUSA	0	0.00	0.00	0	NA	57
CONTRA COSTA	2	1.30	0.91	2	12/4/1997	846
DEL NORTE	1	6.00	6.00	1	3/2/2000	142
EL DORADO	13	68.00	4.94	118	6/11/1996	168
FRESNO	2	5.00	3.80	2	7/10/2001	746
GLENN	0	0.00	0.00	0	NA	45
HUMBOLDT	0	0.00	0.00	0	NA	768
IMPERIAL	0	0.00	0.00	0	NA	245
INYO	0	0.00	0.00	0	NA	103
KERN	17	49.20	11.98	70	9/21/1997	1,016
KINGS	0	0.00	0.00	0	NA	175
LAKE	4	4.50	2.02	16	7/19/1997	86
LASSEN	0	0.00	0.00	0	NA	34
LOS ANGELES	42	610.00	42.14	123	8/28/1995	5,837
MADERA	2	13.00	6.00	3	9/2/1998	205
MARIN	0	0.00	0.00	0	NA	345
MARIPOSA	1	1.30	1.30	1	3/31/1998	87
MENDOCINO	3	4.90	3.62	6	7/6/2000	520
MERCED	4	7.20	3.80	6	9/11/2001	374
MODOC	0	0.00	0.00	0	NA	15
MONO	4	9.00	5.80	5	8/23/1999	67
MONTEREY	2	6.70	4.09	8	10/8/2001	420
NAPA	0	0.00	0.00	0	NA	332
NEVADA	1	2.29	1.82	4	6/21/1999	206
ORANGE	5	40.90	13.33	12	10/12/1995	2,726
PLACER	1	0.50	0.50	1	10/4/1999	404
PLUMAS	2	3.30	3.20	2	5/2/2001	59
RIVERSIDE	7	24.00	8.62	19	4/14/1996	1,213
SACRAMENTO	1	28.00	16.90	27	1/22/1998	1,165
SAN BENITO	0	20.00	16.36	11	4/24/2001	53
SAN BERNARDINO	4	11.00	7.14	7	1/7/1998	1,083
SAN DIEGO	14	25.70	3.44	57	5/6/1996	3,394

SAN FRANCISCO	4	500.00	44.45	15	10/13/1989	1,459
SAN JOAQUIN	1	2.80	2.80	1	7/31/1996	914
SAN LUIS OBISPO	1	85.00	20.86	5	4/11/2000	212
SAN MATEO	4	8.10	3.71	10	10/28/1998	1,145
SANTA BARBARA	0	0.00	0.00	0	NA	770
SANTA CLARA	7	9.40	4.01	11	5/13/1997	2,376
SANTA CRUZ	1	3.60	3.60	1	8/4/1999	322
SHASTA	4	6.90	3.20	10	9/3/1996	308
SIERRA	0	0.00	0.00	0	NA	13
SISKIYOU	0	17.00	14.15	4	9/4/2001	246
SOLANO	1	22.00	6.24	5	2/19/1999	478
SONOMA	2	8.10	2.90	5	8/7/1996	1,369
STANISLAUS	0	0.00	0.00	0	NA	436
SUTTER	0	0.00	0.00	0	NA	92
TEHAMA	0	3.30	3.30	1	1/19/2001	139
TRINITY	1	4.00	4.00	1	4/22/1999	120
TULARE	3	13.00	5.67	6	8/10/1999	478
TUOLUMNE	0	0.60	0.60	1	3/31/1998	132
VENTURA	5	4.00	2.08	7	2/25/1997	1,255
YOLO	0	0.00	0.00	0	NA	256
YUBA	2	234.10	30.35	22	1/15/1997	208

Appendix III

Brownfields Redevelopment Benefits as Estimated by California Cities Responding to U.S. Conference of Mayors Survey

City	Population	Estimated Number of Brownfields	Estimated Number of Acres Affected	Estimated Annual Tax Revenue Gained (Conservative)	Estimated Annual Tax Revenue Gained (Optimistic)	Potential Number of Jobs Created
Anaheim	288,945	11	78	*	$500,000	1,000
Azusa	42,124	3	60	*	*	1,000
Burbank	100,000	15	202	$4,400,000	$4,400,000	3,920
Colton	43,309	1	270	$200,000	$500,000	110
Gardena	53,104	45	100	$23,000	$29,000	250
Glendora	51,500	1	84	$3,000,000	$3,000,000	800
Huntington Park	57,251	3	30	$50,000	$150,000	66
Inglewood	111,040	1	6	$5,000	$50,000	50
Modesto	178,559	12	120	$100,000	$200,000	300
Montebello	60,281	1	66	$10,000	$100,000	2,000
Mountain View	70,619	3	24	$500,000	$1,500,000	2,000
Richmond	91,018	250	1,200	*	*	*
Riverside	255,069	2	30	$100,000	$500,000	200
Sacramento	376,243	100	1,500	$50,000,000	$75,000,000	5,000
San Diego	1,171,121	4	2	*	*	40
San Luis Obispo	42,433	1	400	$1,000,000	$2,000,000	2,000
Santa Clara	98,726	3	100	$7,600,000	$12,700,000	400
Santa Clarita	125,153	1	1,000	*	*	1,655
South San Francisco	57,357	5	169	$1,000,000	$5,000,000	2,500
Stockton	232,660	250	1,000	$1,000,000	$3,000,000	1,000
Sunnyvale	125,156	6	100	$2,000,000	$3,000,000	1,200
Tulare	39,927	3	20	$25,000	$100,000	75
Walnut Creek	62,786	10	6	$1,000,000	$25,000,000	200
Total	3,734,381	731	6,567	$72,013,000	$136,729,000	25,766

* City did not provide estimate.

Notes

[1] Western States Petroleum Association, *California Petroleum Industry Overview* (factsheet), downloaded from wspa.org/factcpio.htm, 20 September 2002.
[2] Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, *ToxFAQs: Benzene*, September 1997.
[3] Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, *ToxFAQs: Toluene*, February 2001.
[4] Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, *ToxFAQs: Ethylbenzene*, June 1999.
[5] Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, *ToxFAQs: Xylene*, September 1996.
[6] Million barrels: Western States Petroleum Association, *California Petroleum Industry Overview* (factsheet), downloaded from wspa.org/factcpio.htm, 20 September 2002; fourth largest producer: California Energy Commission, *Oil and Petroleum in California*, downloaded from www.energy.ca.gov/oil.html, 20 September 2002.
[7] 1.9 million barrels: California Energy Commission, *Oil and Petroleum in California*, downloaded from www.energy.ca.gov/oil.html, 20 September 2002; 10%: Western States Petroleum Association, *California Petroleum Industry Overview* (factsheet), downloaded from wspa.org/factcpio.htm, 20 September 2002.
[8] Jim Page, California Energy Commission, personal communication, 1 October 2002.
[9] California Air Resources Board, *California's Plan to Reduce Diesel Particulate Matter Emissions* (fact sheet), October 2000.
[10] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iii.
[11] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 1.
[12] Rob McConnell et al, "Asthma in Exercising Children Exposed to Ozone: A Cohort Study," *The Lancet*, 2 February 2002.
[13] Michael Picker, Tim Frank, Ileana Wachtel, Center for Energy Efficiency and Renewable Technologies, *Crude Reckoning: The Impact of Petroleum on California's Public Health and Environment*, August 2000, 23.
[14] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 1.
[15] American Academy of Pediatrics, "Ambient Air Pollution: Respiratory Hazards to Children," *American Association of Pediatrics News*, 1993, as cited in Michael Picker, Tim Frank, Ileana Wachtel, Center for Energy Efficiency and Renewable Technologies, *Crude Reckoning: The Impact of Petroleum on California's Public Health and Environment*, August 2000, 41.
[16] 21,000 buses: California Air Resources Board, *Lower-Emission School Bus Program: Final Guidelines*, April 2001; NOx and PM production: California Air Resources Board, *Air Board Starts Clean School Bus Program* (press release), 8 December 2000.
[17] Gina M. Solomon et al, Natural Resources Defense Council and Coalition for Clean Air, *No Breathing in the Aisles: Diesel Exhaust Inside School Buses*, January 2001.
[18] Gina M. Solomon et al, Natural Resources Defense Council and Coalition for Clean Air, *No Breathing in the Aisles: Diesel Exhaust Inside School Buses*, January 2001.
[19] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iv.
[20] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 5, 9.
[21] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 8.
[22] Gross vehicle weight types: Truck Trader Online, *Truck Class Definitions*, downloaded from www.trucktraderonline.com/adbrowsedefinitions.html, 4 October 2002.
[23] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 8.
[24] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 5.
[25] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iv, 15.
[26] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 7.
[27] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 33.
[28] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iii.
[29] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 9.
[30] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iii.
[31] California Air Resources Board, *Air Board Starts Clean School Bus Program* (press release), 8 December 2000.
[32] California Energy Commission and Air Resources Board, *Low-Emission School Bus Program Phase 2*, 19 December 2001.

[33] Earl Lamberg, California Air Resources Board, personal communication, 4 October 2002.
[34] California Air Resources Board, *Resolution 00-44*, 7 December 2000.
[35] California Air Resources Board, *Mobile Source Emission Inventory Program*, downloaded from www. arb.ca.gov/app/emsinv, 30 September 2002.
[36] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iii.
[37] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, iii.
[38] Earl Lamberg, California Air Resources Board, personal communication, 4 October 2002.
[39] California Senate Committee on Environmental Quality, *California Clean Communities and Petroleum Pollution Cleanup Act of 2002*, 22 April 2002.
[40] California Air Resources Board, *The Carl Moyer Program Annual Status Report*, 26 March 2002, 38.
[41] California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, 9.
[42] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 31.
[43] Orit Kalman and Jay R. Lund, University of California, Davis, "MTBE: Evaluation of Management Options for Water Supply and Ecosystem Impacts," *Health and Environmental Assessment of MTBE*, November 1998, 15.
[44] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 32.
[45] 100,000 acre-feet: Orit Kalman and Jay R. Lund, University of California, Davis, "MTBE: Evaluation of Management Options for Water Supply and Ecosystem Impacts," *Health and Environmental Assessment of MTBE*, November 1998, 21; annual water needs: U.S. Geological Survey, *Water Q&A: Water Use At Home, Water Science for Schools*, downloaded from ga.water.usgs.gov/edu/qahome.html, 4 November 2002.
[46] House Energy and Commerce Subcommittee on Environment and Hazardous Waste, *Statement of Craig Perkins, Director of Environmental and Public Works, City of Santa Monica*, 21 May 2002.
[47] House Energy and Commerce Subcommittee on Environment and Hazardous Waste, *Statement of Craig Perkins, Director of Environmental and Public Works, City of Santa Monica*, 21 May 2002
[48] 80%: House Energy and Commerce Subcommittee on Environment and Hazardous Waste, *Statement of Craig Perkins, Director of Environmental and Public Works, City of Santa Monica*, 21 May 2002; $500 per acre foot: Orit Kalman and Jay R. Lund, University of California, Davis, "MTBE: Evaluation of Management Options for Water Supply and Ecosystem Impacts," *Health and Environmental Assessment of MTBE*, November 1998, 15; $3.25 million: Martha Groves, "Santa Monica Settles Tainted Water Case," *Los Angeles Times*, 19 July 2002.
[49] House Energy and Commerce Subcommittee on Environment and Hazardous Waste, *Statement of Craig Perkins, Director of Environmental and Public Works, City of Santa Monica*, 21 May 2002.
[50] City of Santa Monica, *City Council Approves Tentative Settlement with Two Oil Companies in MTBE Lawsuit* (press release), 18 July 2002.
[51] Martha Groves, "Santa Monica Settles Tainted Water Case," *Los Angeles Times*, 19 July 2002.
[52] Department of Health Services, *MTBE in California Drinking Water*, 5 September 2002 and Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 32.
[53] Orit Kalman and Jay R. Lund, University of California, Davis, "MTBE: Evaluation of Management Options for Water Supply and Ecosystem Impacts," *Health and Environmental Assessment of MTBE*, November 1998, 15.
[54] Tancred C. M. Lidderdal, Energy Information Administration, *MTBE Production Economics*, downloaded from www.eia.doe.gov/emeu/steo/pub/special/mtbecost.html, 4 October 2002.
[55] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 26.
[56] Department of Health Services, *MTBE in California Drinking Water*, downloaded from www.dhs.ca.gov/ps/ddwem/chemicals/MTBE/mtbeindex.htm, 5 September 2002.
[57] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 48.
[58] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 17.
[59] Graham E. Fogg et al, University of California, Davis, "Impacts of MTBE on California Groundwater," *Health and Environmental Assessment of MTBE*, November 1998, 63.
[60] Testimony of ARCO Chemical Company's Manager of Business Development, downloaded from www.ewg.org/reports/withknowledge/pdf/013_001_excerpt.pdf, 30 April 2003.

[61] B. J. Nickelson, letter to V. M. Dugan, *MTBE Contamination of Groundwater*, 23 August 1984.
[62] Anne Happel, Brendan Dooher, Edwin Beckenbach, Lawrence Livermore National Laboratory, *Methyl Tertiary Butyl Ether (MTBE) Impacts to California Groundwater*, 25 March 1999.
[63] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 31.
[64] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 32.
[65] Department of Health Services, *MTBE in California Drinking Water*, downloaded from www.dhs.ca.gov/ps/ddwem/chemicals/MTBE/mtbeindex.htm, 5 September 2002.
[66] Graham E. Fogg et al, University of California, Davis, "Impacts of MTBE on California Groundwater," *Health and Environmental Assessment of MTBE*, November 1998, 63.
[67] California Department of Health Services, Office of Drinking Water, *Drinking Water into the 21st Century: Safe Drinking Water Plan for California, a Report to the Legislature*, January 1993.
[68] U.S. Environmental Protection Agency, *Ground Water and Drinking Water*, downloaded from www.epa.gov/safewater/dwh/treat.html, 4 October 2002.
[69] Orit Kalman and Jay R. Lund, University of California, Davis, "MTBE: Evaluation of Management Options for Water Supply and Ecosystem Impacts," *Health and Environmental Assessment of MTBE*, November 1998.
[70] State Water Resources Control Board, *Underground Storage Tank Cleanup Fund—History*, downloaded from www.swrcb.ca.gov/cwphome/ustcf/history.htm, 18 September 2002.
[71] California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, 6.
[72] California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, 9.
[73] California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, 8.
[74] California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, 9.
[75] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 48.
[76] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 47.
[77] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 48.
[78] Arturo Keller et al, University of California, Davis, "Summary and Recommendations," *Health and Environmental Assessment of MTBE*, November 1998, 48.
[79] Orit Kalman and Jay R. Lund, *MTBE: Evaluation of Management Options for Water Supply and Ecosystem Impacts*, 16 October 1998.
[80] California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 8.
[81] California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 4.
[82] The best-known programs for cleaning polluted sites are the federal and state Superfund programs. Those programs do not deal with brownfields; rather Superfund sites are places of known contamination and therefore this report will not discuss those programs. One notable provision of those programs, however, is their requirement that polluters, not taxpayers, fund the cleanup of contaminated sites.
[83] California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 3.
[84] Elizabeth G. Hill, Legislative Analyst's Office, *State Superfund Reauthorization: Expediting Hazardous Substance Site Cleanups*, 17 August 1998.
[85] California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, 6.
[86] Sherrie Wahl, California Pollution Control Financing Authority, personal communication, 30 September 2002.
[87] California Pollution Control Financing Authority, *California Recycle Underutilized Sites Program*, downloaded from www.treasurer.ca.gov/cpcfa/calreuse/summary.pdf, 25 September 2002.

88 California Pollution Control Financing Authority, *California Recycle Underutilized Sites Program*, downloaded from www.treasurer.ca.gov/cpcfa/calreuse/summary.pdf, 25 September 2002.
89 Centre City Development Corporation (CCDC), *CCDC Selected to Implement $1 Million State Brownfields Loan Program* (press release), 6 June 2002.
90 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 3.
91 California Department of Toxic Substances Control, Report as required by Health and Safety Code section 25395.32 for 2001, no date.
92 California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002.
93 Megan Cambridge and Angelo Bellomo, *Changes in California Regulatory Policy to Expedite the Development of Contaminated Properties and Reduce Subsequent Claims Litigation*, journal?? date??
94 California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002, p 6-7.
95 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 3.
96 U.S. EPA, *Whitman Announces $14.6 Million in Brownfields Grants to Assess the Contamination of Abandoned Properties in 80 Communities Around the Nation*, 20 May 2002.
97 U.S. Conference of Mayors, *A National Report on Brownfields Redevelopment, Volume III*, February 2000, 7.
98 U.S. Conference of Mayors, *A National Report on Brownfields Redevelopment, Volume III*, February 2000, 14.
99 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 14.
100 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 13.
101 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 10.
102 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 15.
103 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 15.
104 California Environmental Protection Agency and California Department of Toxic Substances Control, *Brownfields Remediation*, October 2001, 9.
105 California Environmental Protection Agency, *Brownfields Programs, Progress Report 1999-2002*, downloaded from www.calepa.ca.gov/Brownfields/documents/2002/ProgReport.pdf, 25 September 2002.
106 U.S. Conference of Mayors, *A National Report on Brownfields Redevelopment, Volume III*, February 2000, 21-26. Not all cities provided estimates for tax revenues or jobs: four did not respond about taxes and one did not project job creation.
107 U.S. Conference of Mayors, *A National Report on Brownfields Redevelopment, Volume III*, February 2000, 9.