RC 2001

Southern California Environmental Report Card 2001

UCLA INSTITUTE OF THE ENVIRONMENT

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From the Editor

STATUS OF THE IOE REPORT CARD

Now in its fourth year, the Southern California Environmental Report Card, produced under the sponsorship of the UCLA Institute of the Environment, is a well-established mechanism for examining critical environmental problems facing the region, and for grading how agencies, the private sector and the public are addressing these concerns. Written by UCLA faculty experts, the sixteen articles published to date have examined a wide range of environmental issues, with particular emphasis on air and water quality problems that directly or indirectly have major impacts on public health and the ecosystem in Southern California. While past editions have covered topics as diverse as environmental education, wildfires, the status of coastal wetlands and household pollution, the current RC 2001 addresses such topical issues as environmental justice, particulate pollution and greenhouse gas emissions.

With the publication of RC 2001, we are now about two-thirds of the way through the major environmental topics we feel require examination and evaluation in this region. Next year, and in the issues to follow, we hope to cover these additional challenges facing the Southern California environment. Among the topics still to be addressed are water conservation; land and open-space preservation; the transportation challenges facing the region; how to ensure adequate water supplies in the future; the impacts of invasive and exotic species of flora and fauna; environmental problems specific to Native Americans in this region; novel approaches to greening the built environment; and solid waste management.

Once most of these topics have been addressed, we intend to revisit on a seven or eight year cycle certain of the long-term metrics of regional environmental health, including, for example, photochemical smog and ground-water quality. With each new edition of the Report Card, we hope to provoke informed dialogue from different points of view and appropriate self-evaluation by the relevant agencies, the public and the business community. In that spirit, we welcome constructive responses from any readers or organizations who wish to share their views.

The major environmental issues facing Southern Californians are complex and will not yield to simplistic or one-dimensional solutions. Along with technological advances and technical fixes must come changes in human behavior and mitigation of socio-economic constraints. Clearly, all of us in the region have a stake in working together to find cost-effective, multi-disciplinary and societally acceptable approaches to solving these critical problems.

Arthur M. Winer, Ph.D.
Editor
Southern California Environmental Report Card

From the Director

A TURNING POINT AT THE START OF A NEW CENTURY

It has been a remarkable year since the 2000 Southern California Report Card was issued last fall. A new Administration sits in Washington—one with a vastly different view of the environment than the previous cabinet. The U.S. has abandoned the Kyoto climate treaty after years of negotiations and, it appears, plans to go it alone with regard to carbon dioxide emissions. The popularity of SUVs has grown exponentially, flying in the face of energy conservation. Meanwhile, California and other western states have recently suffered blackouts under a continuing energy "crisis." Efforts to reduce diesel soot emissions are compromised even as the occurrence of asthma among children soars. According to the national census just released, the population of Los Angeles continues to grow unchecked. We seem to be moving backward in time, no longer recognizing the essential need for a healthy, sustainable environment. There is a glimmer of commitment to increased quantity and quality of open space in the region. Yet we seem to have gotten sidetracked off the main road to a livable future.

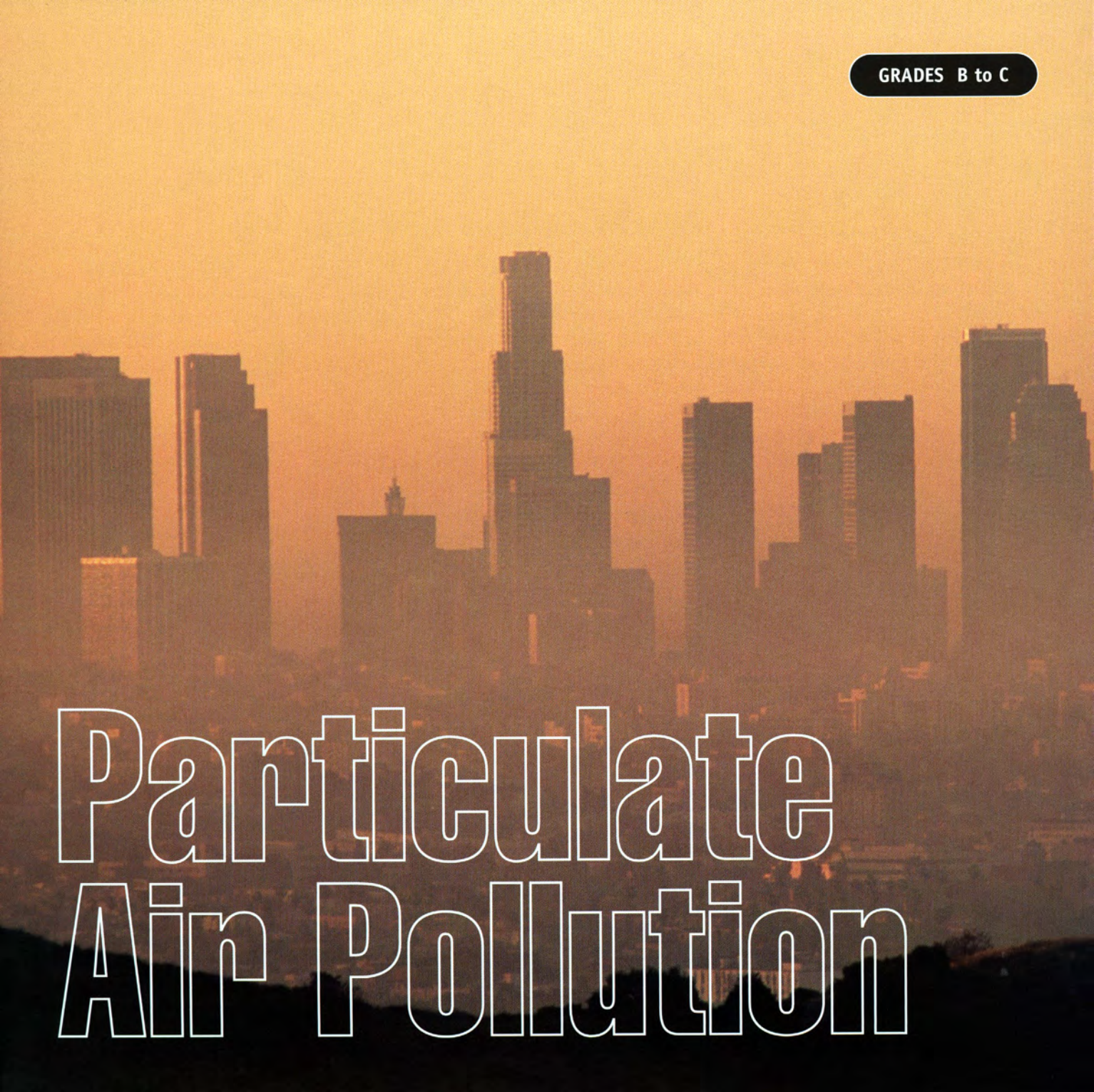
There has been a positive turning point for the Institute of the Environment this past year. A generous donation by Mr. Morton La Kretz (UCLA '48) has laid the foundation, literally, for a new IoE building on the UCLA campus, which will be occupied in 2003. La Kretz Hall, situated along the Science Quadrangle, will house the administrative core of the Institute. From this command center, faculty and staff will search for, scrutinize, and assess regional environmental problems, including those noted above, and many others. Indeed, La Kretz Hall itself will emphasize "green" architectural concepts, and will house a public exhibit of campus environmental projects. We at the Institute are excited about the growing presence of environmental studies at UCLA as a result of such gifts. It is clear that support from the community is central to building an effective program at a public university, and we thank Mr. La Kretz for propelling the Institute of the Environment to center stage in the arena of environmental research.

The current Report Card reflects the range of interests of the UCLA faculty, which in turn mirrors the variety of impacts society can have on the environment. Separate articles discuss California's role in contributing to the emissions of greenhouse gases and associated climate change; review recent studies of diesel engine exhaust and the impacts of airborne particles on human health; describe situations of environmental injustice in the Los Angeles area; and evaluate the quality of bottled water so frequently consumed by health conscious Californians.

We hope these articles prove stimulating and informative, and we invite your comments on them.

Richard P. Turco, Ph.D.
Director
UCLA Institute of the Environment

GRADES B to C



Particulate Air Pollution

by William C. Hinds, Sc.D.

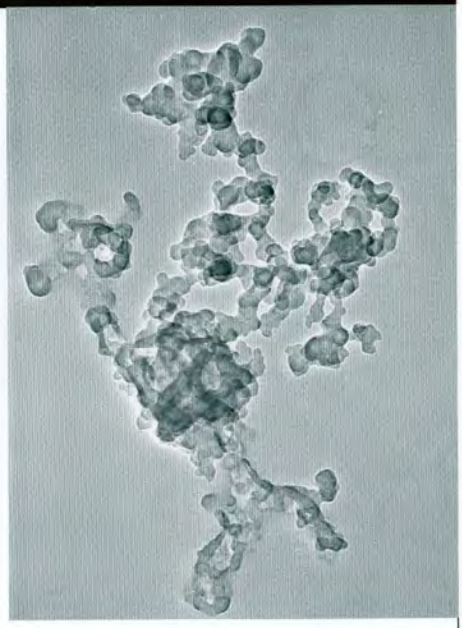
Professor, Department of Environmental Health Sciences

INTRODUCTION

On a typical day in Southern California the average person outdoors inhales more than 10 million microscopic and submicroscopic particles with each breath. Indoors concentrations may as much as ten times higher, or they may be lower than outdoor concentrations. The particles are emitted from motor vehicles, especially diesel vehicles, and industrial sources; resuspended by the wind; or formed in the atmosphere from gaseous pollutants. Atmospheric particles occur in a wide range of sizes and shapes; some are droplets and some are solid. Although individual particles are invisible to the unaided eye, the collective effect of high concentrations of these particles in the ambient environment can be a dramatic reduction in visibility. In fact only these airborne particles, or particulate pollution, significantly affects visibility in the Los Angeles basin. Gaseous pollutants play a minor role in visibility reduction, although nitrogen dioxide can contribute to a yellowish color in the atmosphere.

Only in the past 10 years have we begun to understand the magnitude of the health effects associated with particulate air pollution. Historically airborne particles were considered more of a nuisance than a health risk. Early regulations restricted visible plumes from smokestacks and were concerned about soot and soiling. Particles were not perceived as causing any "acute" health effects and thus were not controlled as stringently as sulphur dioxide, carbon monoxide, or ozone and its precursors.

The effects of airborne particles on visibility and health depend on the size of the particles and their chemical composition. However, current air quality standards for particulate matter do not distinguish between particles of different chemical composition, and only with the introduction of PM-10 sampling in 1987 was particle size featured in the monitoring of particulate air pollution. PM-10 refers to particles less than 10 micrometers (μm) in size. A micrometer is a thousandth of a millimeter or about a fiftieth of the width of the finest human hair. It would take approximately 130,000 1-micrometer particles to cover the dot over this "i." The use of PM-10 sampling and air quality standards helped reveal health effects of particulate matter that were obscured by earlier and less precise sampling methods. Recently new air quality standards and sampling methods have been implemented to focus on PM-2.5, particulate matter less than 2.5 micrometers. But currently there is debate concerning which particle size fraction best reflects the health risk to the public.



Typical atmospheric soot particles.

This article reviews the increasingly important role of particle size in our understanding of the health effects of particulate air pollution, the sources and trends in ambient levels of airborne particles in Southern California, and current research findings on particulate pollution health effects.

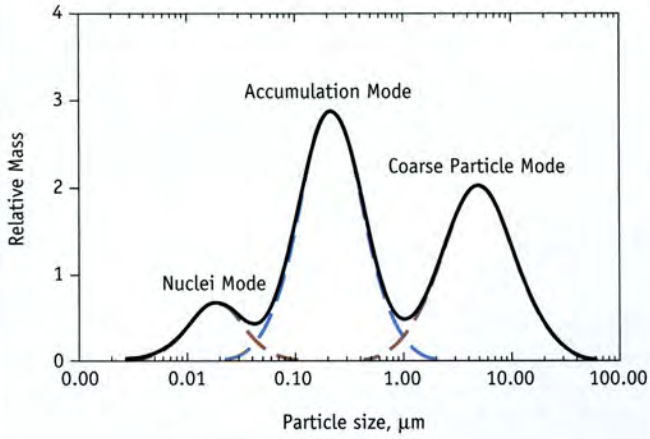


Figure 1: Typical urban particulate matter size distribution.

Transportation, including motor vehicles and paved road dust, accounts for about 40% of PM-10 in the Los Angeles area.

ROLE OF PARTICLE SIZE

Figure 1 shows the distribution of particle sizes typically found in urban environments. Although the particles are all mixed together in the air, we characterize them as occurring in three well-defined modes: the nuclei, accumulation, and coarse particle modes. The particles in each mode have different sources and chemical compositions. The nuclei and accumulation modes together constitute *fine particles*, or *fine particulate matter*. The shape of the particle size distribution shown in Figure 1 is multimodal, having more than one peak, because it represents a mixture of particles from many different sources whose size distributions have been modified by growth processes, evaporation and removal mechanisms that favor one particle size range over another.

The *nuclei mode* consists primarily of combustion particles emitted directly into the atmosphere from motor vehicles, especially diesel vehicles, as well as particles formed in the atmosphere by gas-to-particle conversion. Significant concentrations of particles in the nuclei mode are not always present, but are usually found near freeways. These very fine particles attach rapidly to particles in the accumulation mode.

The *accumulation mode* includes combustion and photochemical smog particles and attached nuclei mode particles. Removal mechanisms, such as settling, deposition to surfaces, or attachment to rain droplets, are weak for this size range. The accumulation mode particles are about the same size as the wavelength of visible light, consequently these particles scatter and absorb visible light and account for most of the visibility effects of urban particulate pollution.

The *coarse-particle mode* consists of windblown dust, salt particles from sea spray, and mechanically generated particles such as from construction sites. These large particles settle out relatively quickly and so have lifetimes in the atmosphere of hours. Fine and coarse particles have quite different chemical compositions, sources, and lifetimes in the atmosphere, and there is little mass exchanged between the particles in these two modes.

Particle size is important for health because it controls where in the respiratory system a given particle deposits (see Figure 2). Particles as large as a few micrometers are able to reach and deposit in the sensitive, gas-exchange region of the lung (also called the alveolar region or deep lung) where they are removed slowly. Some fraction of inhaled particles larger than about 2 micrometers deposit in the airways leading to the gas exchange region. These airways are "self-cleaning" tubes that remove deposited particles in a few hours. Specifically, these airways are lined with a layer of mucous that is constantly migrating to the back of the throat where it is swallowed. The rapidly cleared regions, including the nose, throat, and airways, serve to protect the more vulnerable gas exchange region. While exercise changes the pattern of deposition

The average person outdoors inhales more than 10 million microscopic and submicroscopic particles with each breath.

somewhat, the more important factor is the greater volume of air inhaled when exercising, up to five times as much as when at rest.

SOURCES

Figure 3 shows the relative importance of the different sources of PM-10 particulate matter. Transportation, including motor vehicles and paved road dust, is the most important source of PM-10 in the Los Angeles area, accounting for about 40% of PM-10. Particles formed photochemically in the atmosphere from *gaseous* motor vehicle and industrial emissions account for about 20% of PM-10, with nearly all occurring in the May through October summer period in the Los Angeles basin.

Airborne particles are divided into primary particles, those that are emitted directly into the atmosphere, and secondary particles, those that are formed in the atmosphere by chemical reactions of gases and vapors from various sources. Stationary emission sources are primarily smokestack industries that have been the focus of control efforts for many years. Household sources are associated with home activities, such as home heating, barbecuing, wood fireplace fires, and lawn mowing. These have come under increased attention as other sources have been controlled. Emissions, such as dust from dirt roads, resuspended tire dust from paved roads, and wind blown dust from arid land, are primarily in the coarse particle mode. They are heavily dependent on meteorological conditions.

The most important sources of particles in Southern California are motor vehicles, including cars, trucks and buses, often referred to as mobile sources. Controls on gasoline-powered vehicles, such as catalytic converters, improved engine design, reformulated gasoline, and evaporative emissions controls, have been in use for many years. These controls have substantially reduced both direct particle emissions from gasoline powered vehicles and the emission of hydrocarbon and oxides of nitrogen (NO_x) gases that contribute to secondary particle formation.

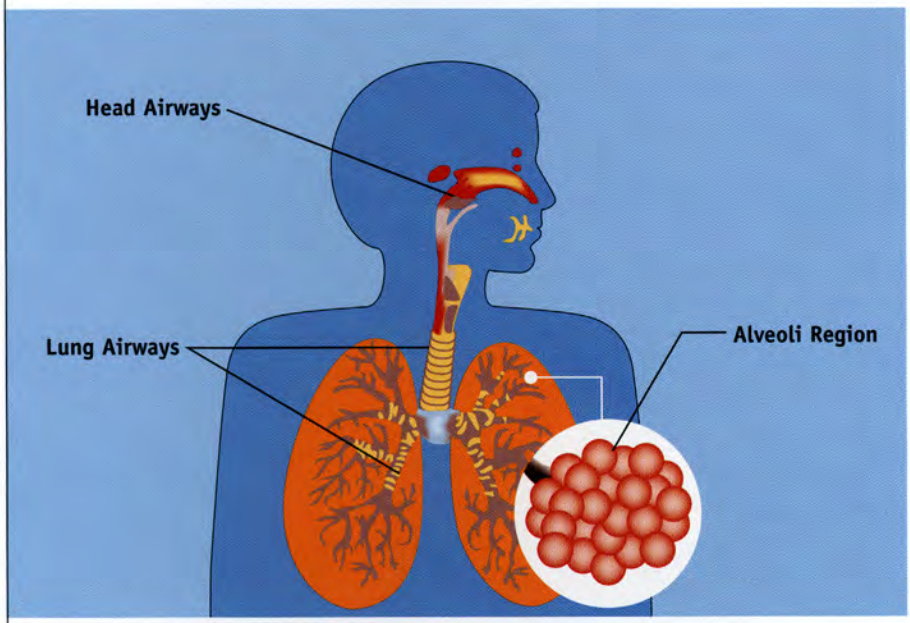
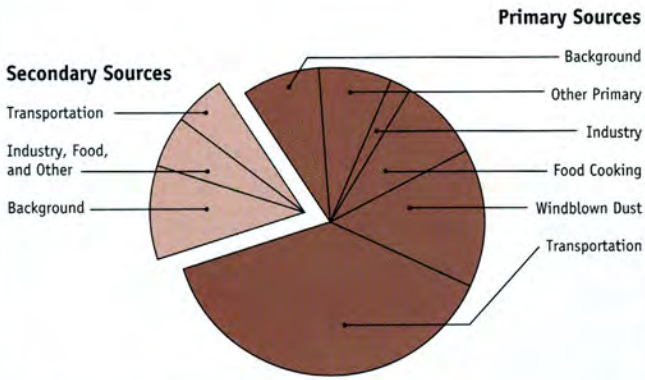


Figure 2: Human respiratory system.



Source: Kleeman and Cass, Atmos. Env. Vol. 32, pp. 2803 (1998)

Figure 3: Sources of PM-10 in the Los Angeles area.

The Federal standard for PM-2.5 is exceeded at 15 of 16 monitoring sites in the Los Angeles basin.

Similar approaches are now being undertaken for diesel powered vehicles. Diesel vehicles are major emitters of fine particulates, including soot, a major source of polycyclic aromatic hydrocarbons (PAHs), which are potential cancer causing materials. The South Coast Air Quality Management District (AQMD) estimates that currently diesel-powered motor vehicles are responsible for a substantial portion of the cancer risk from mobile sources in the Los Angeles basin.

As noted above, secondary particles include particles formed by gas-to-particle conversion, that is by chemical reactions in the atmosphere, such as the conversion of nitrogen dioxide to nitrate particles. Thus secondary particles are one component of photochemical smog formed by the action of strong sunlight on hydrocarbon vapors and NO_x. As discussed in RC 1998, photochemical smog has been a problem in the Los Angeles region for many years. However, while compounds such as ozone have been reduced about 65% from peak levels in the 1960s and 70s by the concerted efforts of governments and citizens over the past three decades, there has not been as significant a reduction in particulate levels.

TRENDS IN AMBIENT LEVELS

Currently the annual average concentration of PM-10 in the South Coast Air Quality Management District exceeds the Federal air quality standard at eight of the 21 monitoring sites. For PM-2.5 the Federal standard is exceeded at all but one of 16 monitoring sites. Figure 4 shows the trend in the percent of days each year the Los Angeles basin has exceeded the Federal standard for PM-10 since 1985. The improvement observed over this period is a result of the control of industrial and motor vehicle sources, discussed above, and the reduction in emissions of hydrocarbons and oxides of nitrogen, the precursors of photochemical smog.

California has the highest per capita motor vehicle ownership of any state or nation and the steady progress in the control of particulate air pollution is remarkable considering the large increase in motor vehicles and vehicle miles traveled since 1985. This trend in lower particle concentration is expected to continue with the introduction of emission controls on diesel powered vehicles and the decrease in the number of high-emitting vehicles from our roads over the next few years. High emitting vehicles are passenger cars that, because of age, poor maintenance or faulty pollution control equipment, emit abnormally high amounts of pollutants, especially carbon monoxide and particles. These high-emitting vehicles represent less than 10% of the vehicles on the road, but produce 90% of the particulate emissions from passenger cars.

The State of California in conjunction with 13 other states has adopted a plan to reduce diesel emissions by 75% by 2010. The plan includes requirements for lowering the sulfur content of diesel fuel by 97%, retrofitting existing diesel engines with particulate filters, and a 90% reduction of par-

Less than 10% of the vehicles, so-called high emitters, produce 90% of the particulate emissions from passenger cars.

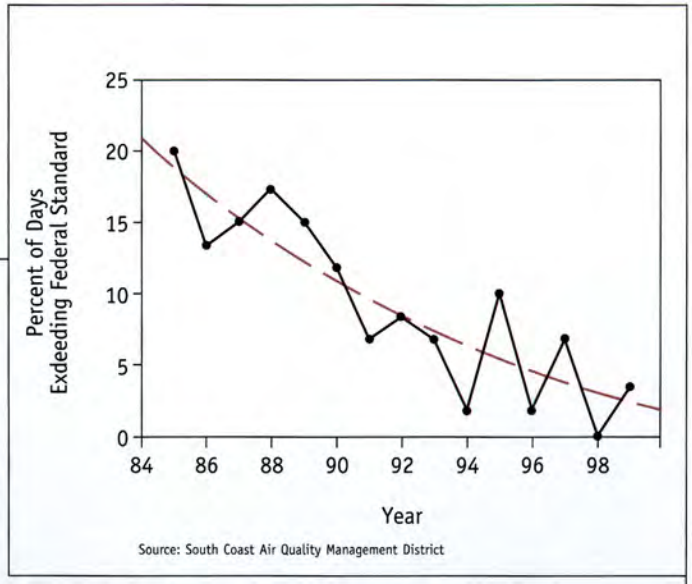


Figure 4: Trend in the annual percent of days exceeding the Federal PM-10 standard (24-hour) in the Los Angeles basin, 1986-1999.

ticulate emissions from new diesel vehicles. These requirements would be phased in starting in 2002.

In general the finer the particles the more difficult they are to control. A substantial reduction in total suspended particulate (TSP) or PM-10 may result in a negligible reduction in PM-2.5. While the Los Angeles basin meets the PM-10 (24-hour) standard more than 95% of the time, meeting the standard for PM-2.5 will be much more difficult. Currently, about two-thirds of the Los Angeles basin meets the annual average for PM-10, but most of the basin exceeds the annual average PM-2.5 standard of 15 $\mu g/m^3$. The maximum 24-hour and annual average PM-2.5 concentrations in the Los Angeles basin are about two times the corresponding Federal standard. These fine particles cannot be easily filtered out of vehicle exhaust and will require changes in engine design and fuels to meet the standards in the Los Angeles basin. Furthermore, the secondary particles formed in the atmosphere are also primarily in the PM-2.5 size range.

HEALTH EFFECTS

The early focus for health risk from particulate air pollution was on chronic conditions such as lung cancer. That shifted in the 1990s when data from PM-10 sampling became available to health effects researchers. The greater precision and specificity of PM-10 data allowed epidemiologists to distinguish health effects of particulate air pollution that were masked by the variability and dominance of large particles of TSP sampling. Some studies have shown that cities with higher particulate air pollution experience more respiratory disease than cities with lower levels. This is especially true when PM-2.5 concentration is used instead of PM-10 concentration as a measure of particulate air pollution. These studies, however, were conducted in cities in the East and Midwest which have particles of different chemical compositions than those found in the Los Angeles basin. Some studies have estimated that particulate air pollution in the United States causes an average loss of life expectancy of one to three years. Other studies have found an association between PM-10 and increases in infant mortality from respiratory causes.

A critical finding is that daily increases in particulate air pollution are associated with increases in hospital admissions and mortality. This holds true for mortality due to respiratory disease and cardiovascular disease, and also holds true for a wide range of cities throughout the U.S. with different climates and pollution mixes. In Southern California this effect has been observed in Los Angeles, San Bernardino, and Santa Ana-Anaheim. It also holds true for particulate air pollution levels that are less than the current standards for PM-10. An analysis by the Natural Resources

History of PM Air Quality Standards

Air quality and sampling standards for particulate matter in the United States were first set in 1971. The standard sampling method collected what is known as *total suspended particulate (TSP)* by sampling with a high-volume (hi-vol) sampler that drew air through a large filter at about 50 cubic feet per minute. The air quality standard required an annual average concentration of less than 75 micrograms of particulate per cubic meter of air ($\mu g/m^3$). A microgram is a millionth of a gram or about one tenth the weight of a single eyelash. Particulate matter standards, unlike those for other criteria pollutants, are not specific to a particular chemical, but simply specify the particulate mass concentration regardless of chemical composition. The sampling pump and filter used for TSP sampling were enclosed in a peaked-roof enclosure to protect it from the weather. The filter had high efficiency for all particle sizes, but the enclosure caused a variable collection efficiency of larger sized particles, those in the range from 20 to 50 micrometers, that was dependent on wind velocity and direction. This gave variable measurements of particulate mass concentration that did not reflect the health risk to humans.

To overcome this problem US EPA promulgated PM-10 ambient air quality standards and sampling criteria in 1987. Particles that meet the PM-10 criteria are those less than 10 micrometers (μm) and represent a portion of the TSP particles. An aerodynamic separator in the sampler inlet selects those particles that meet the PM-10 criteria while they are still airborne. The PM-10 standard requires communities to achieve an annual average concentration of PM-10 particles of less than 50 $\mu g/m^3$. PM-10 sampling has two advantages: a well defined upper limit which is not affected by wind velocity or direction; and a well defined health basis, namely collection of particles able to pass though the mouth, nose and throat and reach the lungs. This more precise type of measurement permitted the discovery of health effects due to particulate air pollution that had been masked by the variability of the TSP method.

One limitation with PM-10 is that the sampled particles contain all of the fine particle mode and a portion of the coarse particle mode. Because these two modes have different sources and chemical composition it is difficult to separate the role of different chemicals in particulate air pollution and to determine the sources of those particles that cause the health effects, information needed to implement effective control strategies. In 1997 the US EPA adopted additional standards and sampling methods for particles less than 2.5 micrometers, called PM-2.5. The new standard for PM-2.5 is an annual average of 15 $\mu g/m^3$. The cutoff at 2.5 micrometers is approximately at the saddle point between the coarse and fine particle modes (see Figure 1) and thus provides samples of fine particles relatively uncontaminated with coarse particles.

The more recent standards defined in terms of particle size can be thought of as a subset or fraction of earlier standards. Thus, PM-2.5 is a subset of PM-10 and PM-10 is a subset of TSP. Each new sampling method focuses in more closely on those particle sizes and chemical compositions that are believed to affect human health.

Defense Council (NRDC) based on these research findings concluded that up to 8,800 people die each year in the South Coast Air Basin as a result of exposure to particulate air pollution. This is about four times the number of people killed in automobile accidents each year in the same region. Other estimates of annual mortality due to particulate pollution in Southern California range from 1,500 to 6,000.

While the elderly are most frequently harmed by increases in particulate levels, other studies in Southern California have found associations between PM-10 levels and increases in asthma episodes and respiratory symptoms and a slowing of the rate of lung growth in children. Although we have learned a great deal about health effects of airborne particles in the past decade, we still do not know what chemical compounds or what aspects of particulate air pollution are causing these morbidity and mortality effects. To address these serious gaps in our understanding of the health effects of particulate air pollution, the U.S. EPA has established five national research centers to investigate all aspects of urban atmospheric particles, including health effects. One of these centers is based at the UCLA School of Public Health. It also receives research support from the California Air Resources Board.

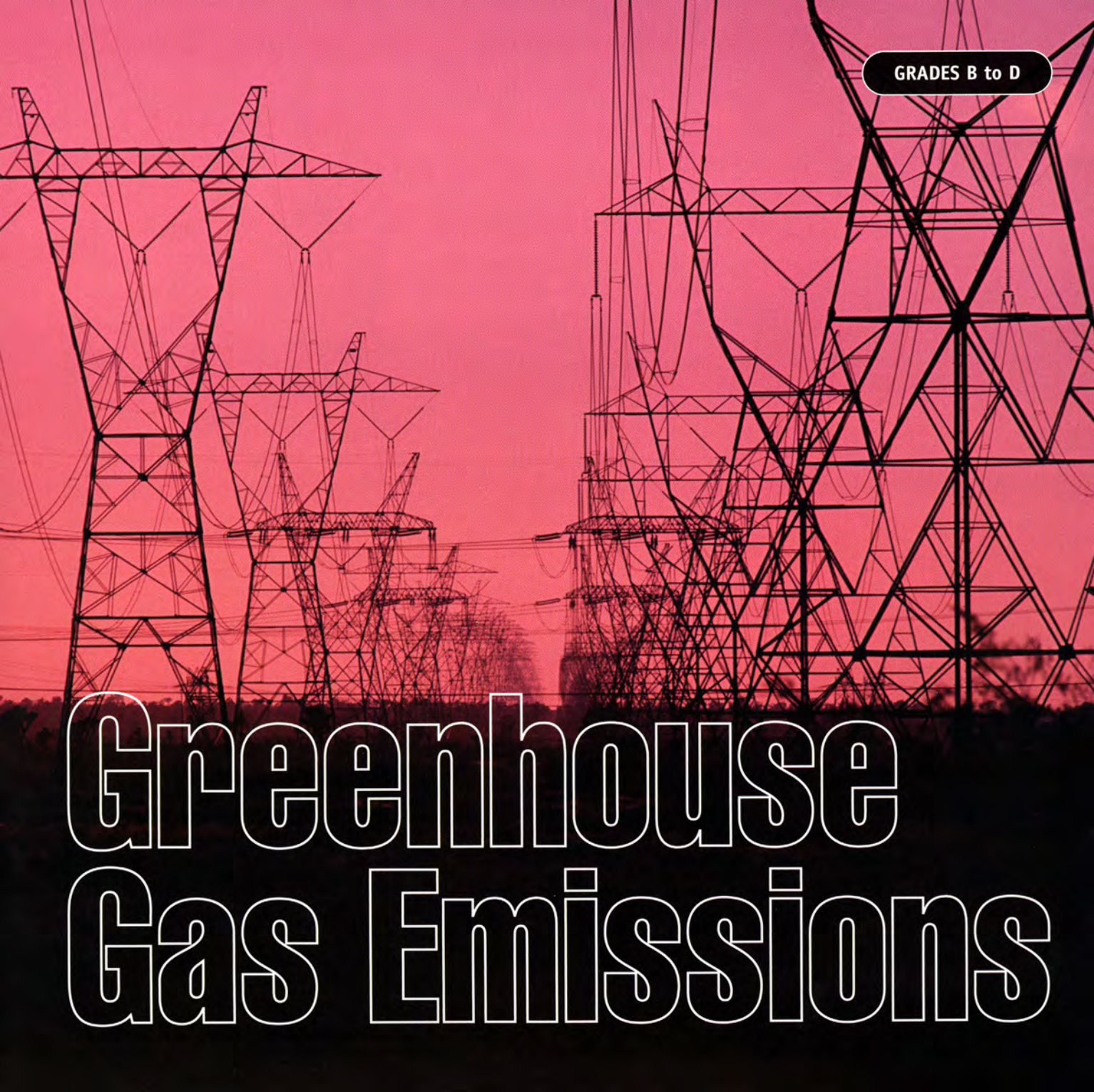
Daily increases in particulate air pollution are associated with increased hospital admissions and mortality.

CONCLUSION AND ASSESSMENT

Evaluation of progress toward meeting environmental goals for particulate pollution is difficult because of changing standards and, perhaps more important, changing metrics of assessment. Specifically, both the air quality standards and type of measurements used to evaluate progress have changed over the past thirty years. This creates a moving target that makes evaluation difficult for particulate pollution. Nevertheless, by all of the various metrics, we have made substantial progress in reducing particulate levels despite increases in population and motor vehicles. Until recently, regulators have been slow to crackdown on diesel trucks and buses, but now more stringent regulations are being phased in. These new regulations for diesel motor vehicles, especially for trucks and buses, are expected to continue this improvement in air quality. However, despite this progress, more than one third of the Los Angeles basin exceeds the annual average standard for PM-10. This warrants a grade of **C** for progress in meeting the annual average particulate standards. Furthermore almost all of the region exceeds the annual average standard for PM-2.5, but it is too early to assign a grade to efforts to meet this standard. The commendable reduction in the percent of days exceeding the Federal 24-hour standard, as shown in Figure 4, warrants a grade of **B**.

Because of our uncertainty of the mechanisms of health impacts of particles and changing assessment metrics and standards, only a grade of **Incomplete** can be assigned to our progress in the protection of human health with respect to particulate pollution.

William Hinds has been a Professor in the Department of Environmental Health Sciences and the Center for Occupational and Environmental Health in the UCLA School of Public Health since 1982. Prior to coming to UCLA he was an Assistant and Associate Professor at the Harvard University School of Public Health. Dr. Hinds's research interests include fundamental and applied research related to aerosols (airborne particles) including properties, behavior, and measurement of aerosols, characterization of aerosols for workplace hazard evaluation, respiratory deposition of aerosols, aerosol formation, and aerosol measurement instrumentation; environmental tobacco smoke, performance and evaluation of respiratory protective devices; and industrial control of airborne contaminants. He has more than 80 publications in this field including a standard textbook on aerosol technology. Dr. Hinds received a bachelor's degree in Mechanical Engineering from Cornell University in 1962 and an M.S. and doctorate in Environmental Health in 1969 and 1972 from Harvard University. He is director of the UCLA Industrial Hygiene Program, director of the Southern California NIOSH Education and Research Center, and co-director of the UCLA component of the NIEHS Southern California Environmental Health Center. He is also a member of the EPA Southern California Particle Center and Supersite.



GRADES B to D

Greenhouse Gas Emissions

by Richard P. Turco, Ph.D.

Professor, Department of Atmospheric Sciences

WHAT ARE GREENHOUSE GASES?

Certain gases emitted into the atmosphere can result in the warming of Earth via the so-called "greenhouse" effect, in which these gases trap radiant heat near the surface. Carbon dioxide (CO_2), which is associated to a large extent with energy production and thus seems to be an unavoidable byproduct of modern civilization, is the "greenhouse gas" most in the news today. However, other greenhouse-active compounds include methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), ozone (O_3), and water vapor (H_2O). Except for the CFCs, all of these gases have natural as well as human sources. Since in such a brief article we cannot review all of the facts concerning these compounds and their greenhouse effect, we will summarize the essential aspects of this critical environmental issue emphasizing the role that California plays.

Carbon dioxide is the most important of the human-influenced greenhouse gases. It has a background concentration in air today of about 375 parts per million (ppm, where one ppm would be equivalent to one carbon dioxide molecule for every one million molecules of air). However, prior to the industrial revolution, its concentration was closer to 280 ppm, as deduced by analyzing the composition of air bubbles trapped in ancient glaciers. This rise in background CO_2, amounting to roughly 100 ppm over the last century or two, is closely correlated with increasing rates of combustion of fossil fuels; namely oil, natural gas and coal.

The "natural" gas used as fuel consists mainly of methane. However, methane is also emitted by bacteria living in swamp muds and rice paddies, and is expelled by fauna varying from cows to termites. Most of the methane emissions associated with human activity are connected with cultivation of rice and raising of livestock, especially cattle and sheep. Extraction and concomitant leakage of natural gas is a major industrial source of methane; when burned, methane releases carbon dioxide, further increasing its overall greenhouse impact.

Nitrous oxide, also known as "laughing gas" owing to the lightheadedness it induces when employed as an anesthetic, is a less important greenhouse gas. It is emitted in small quantities during fossil fuel combustion, and as a byproduct of the breakdown of fertilizers in soil.

Chlorofluorocarbons (CFCs) are synthetic compounds once widely used for refrigeration and air conditioning, and as solvents. It is now understood that CFCs attack and destroy ozone in the stratosphere, and so threaten life by allowing deadly solar ultraviolet radiation to penetrate Earth's ozone shield. Accordingly, the production of these compounds has been banned worldwide—in developed countries as of 1995, and in developing countries by 2005. Replacement

compounds, which are designed to be ozone-safe, also happen to be greenhouse gases, although they are not as potent in this regard as the original CFCs. Owing to controls imposed on the production of CFCs, their atmospheric concentrations are expected to decrease slowly over this century.

Ozone, both in the stratosphere and in air pollution, is a secondary greenhouse gas; therefore we will not consider it further.

The rise in atmospheric carbon dioxide over the last century is closely correlated with increasing rates of fossil fuel combustion.

Similarly, while atmospheric water vapor is the most abundant greenhouse gas, it is not directly influenced by human activity to any significant degree.

An important property of greenhouse gases is their generally long lifetime in air. For example, carbon dioxide, once emitted, may remain in the atmosphere for more than a hundred years. Likewise, nitrous oxide and chlorofluorocarbons have residence times of roughly 100 years. Methane is less persistent, remaining in the atmosphere for only about one decade on average. The implication is that greenhouse gas emissions represent a legacy for many future generations.

GREENHOUSE GASES AND "GLOBAL WARMING"

The climate of Earth appears to be changing. In particular, the planet as a whole seems to have warmed significantly over the last century. Careful analysis of temperature records fix the temperature increase at about 1 degree Fahrenheit (0.5 degrees Centigrade). Natural drifts in average global temperature of this magnitude are expected, but only over time spans of thousands of years. Hence, the present warming trend is much more rapid than normal, and seems to be clearly correlated with the intensity of human activity. Increasing population, production, and consumption during the past century caused a parallel increase in CO_2 emissions. The result is perhaps the warmest climate Earth has experienced in the last several million years.

This year, the Intergovernmental Panel on Climatic Change (IPCC), a team of scientists and other specialists from around the world, assessed past climate variations and projected likely changes into the future. The panel concluded that global warming due to the "greenhouse effect" is already well underway, and estimated that half of the observed warming to date is associated with carbon dioxide. In the future, CO_2 will have an even greater role, accounting for perhaps two-thirds or more of the overall predicted greenhouse effect. Methane explains much of the rest. Soot, often associated with diesel engines, may also have a more important role than once realized.

An international panel of experts has now concluded that global warming due to the "greenhouse effect" is already well underway.

What is the relationship between energy usage and carbon emissions?

The intensity of carbon dioxide emissions associated with each type of energy end-use (for example, trucking, electric lighting, heating, and cooling) depends on the composition and quantity of the fuel used to generate the energy. Fuels with higher hydrogen contents relative to carbon emit less CO_2 for the same amount of energy produced. On this basis, natural gas creates the lowest carbon dioxide emissions per unit of energy generated, oil is higher, and coal is highest. Sources of energy such as nuclear power plants, wind turbines, and solar panels do not directly utilize fossil fuels, and so are not direct sources of CO_2. However, the manufacture, transport, construction, and maintenance of these alternative energy sources involve the consumption of fossil fuels and lead to small carbon emissions. For the current worldwide mix of energy sources, including alternative electrical generating techniques, about one metric ton of fossil carbon is given off (in the form of C in CO_2) for every 17,000 kilowatt-hours of generated energy.

HOW MIGHT CLIMATE CHANGE AFFECT CALIFORNIA?

California, and Southern California in particular, enjoys a generally mild Mediterranean climate. This has led to building and living practices that leave society vulnerable to extreme weather events and shifts in climate. For example, heavy rains associated with El Niño (a phenomenon related to warming of surface waters in the eastern Pacific Ocean) can result in mudslides, flooding, and destructive debris flows. Similarly, serious heat waves and droughts, often accompanied by severe wildfires, plague the intrinsically arid regions of Southern California. Regional climate change associated with global warming is expected to increase the risks connected with many of these hazards, and perhaps introduce new threats to human health and biodiversity.

Sea level is forecast to rise by 1-3 feet (0.3-1 meter) in the next 100 years, with significant consequences for a state with one of the longest coastlines in the nation. Such a rise would lead to further erosion of beaches, with inundation of harbors and low-lying areas driven by extreme tides and storm surges. Heavy economic losses might be expected in coastal communities such as Malibu and Newport Beach, and around San Francisco Bay. More than three-quarters of all Californians live within 30 miles of the coast.

Effects like those described above would have far reaching implications for natural ecosystems, for agricultural productivity, and even for the status of California as a tourist destination. Long-standing patterns of biodiversity could be disrupted by invasive species that thrive in modified climate regimes. Even now, ecological disturbances occur during El Niño years, in which marine animals and fish are displaced northward or southward with warming or cooling currents. On the other hand, some climate forecasts indicate that increased precipitation may enhance California's agricultural productivity and extend the range of farming to more arid zones; at the same time, negative impacts on California's fresh water supplies seem plausible. Temperatures across California would rise on average, exacerbating energy use and creating widespread health hazards. Thus, on balance the disadvantages to California in a world experiencing a warmer climate are likely to outweigh any potential advantages.

WHAT IS CALIFORNIA'S CONTRIBUTION TO GREENHOUSE GAS EMISSIONS?

California is one of the largest states in the country, with some 35 million people, and is currently the fifth largest economy in the world, just ahead of France. The corre-

On a warmer Earth, California could expect an eroding coastline, unprecedented heat waves, and disruptions in water supplies, among other impacts.

Gross Domestic Product and Greenhouse Gas Emissions

The gross domestic product (GDP) for a region represents the total value of all the goods and services produced in that region. Without attempting to make adjustments for local customs, climate, or laws, the GDP is taken as a reasonable measure of total consumption in a region. This assumes that, at least crudely, value earned locally is reinvested locally. Moreover, it is presumed that GDP as a measure of consumption correlates with energy use and carbon emissions. Differences between productivity, consumption, energy intensity, and carbon dependence across different economic sectors will, on average, tend to compensate, such that the GDP is a reasonable aggregate measure. The validity of these relationships will vary from region to region, but is probably more accurate for larger areas.

sponding consumption of energy (ranking 11th in the world) and production of goods and services, is associated with enormous emissions of carbon dioxide and other greenhouse gases, notably methane. Direct greenhouse gas emissions occur, for example, from power plants, most vehicles, homes, commercial enterprises, agriculture, and industry. In short, the sources of greenhouse gas emissions in California are large and have a global reach.

The total quantity of greenhouse gases assigned to California should include emissions generated outside the state as a result of economic activity occurring in California. An obvious example is the production of electricity by coal-fired power plants in Nevada, say, with transmission to California over high-voltage lines. The CO_2 emissions at these out-of-state facilities should fairly be assigned to the consumer of the energy. In this sense, the effective reach of California in its use of resources, and associated release of greenhouse gases, defines the state's worldwide emissions "footprint." Likewise, when California exports excess energy, the corresponding greenhouse emissions should be attributed to the out-of-state end-users. A similar situation holds for other consumable products, including durable goods, food, gasoline, chemicals, and so on. Often the sources are geographically distributed, although the usage is local, or vice versa.

For a particular greenhouse gas, the aggregate emission attributable to California, or more locally to Los Angeles county, is the sum of the emissions associated with all of the individual sources and activities within the borders of that region. However, the characterization of every source and activity, and each footprint, would be tedious, if not impossible. It would be difficult, moreover, to ascertain the accuracy of the details.

Since the purpose of this article is to provide a rough estimate of the relative impact of California on global greenhouse gas emissions and climate change, we will take a simpler approach based on aggregate measures that reflect our behavior as a population. The particular measures adopted here are total economic activity, or gross domestic product (GDP), and total consumption of energy in all forms. To the extent that, for example, information on energy consumption could be disaggregated on a regional basis, emissions could be assigned on the same basis. In this approach, the relative contributions to global carbon emissions are then determined simply by taking the ratios of the corresponding regional economic and energy measures against world totals. When expressed as a per capita figure, each of these measures, while not applying to any individual, demonstrates how we are behaving relative to other world citizens. The goal is to illustrate that personal actions—collectively, even within a relatively small region like Southern California—can have serious unintended consequences thousands of miles away, affecting billions of people.

In California, transportation accounts for roughly half of all energy consumed, and 80% of energy generated from petroleum.

CALIFORNIA'S ENERGY CONSUMPTION

California, as a social and economic unit, is one of the largest energy consumers in the world. The state obtains nearly two-thirds of its energy from outside its borders. Half of our primary energy is derived from petroleum, a third from natural gas, and most of the rest (about 14%) from energy sources that do not emit greenhouse gases (hydroelectric, geothermal, wind, solar, and nuclear). Coal supplies only about 1% of all of California's energy needs. As a result, the state's carbon dioxide emissions are not as intense per unit of energy as in some parts of the world where coal is a major fuel (China, for example). In terms of end-use, roughly half of all the energy available in California is consumed for transportation, amounting to nearly 80% of the energy derived from petroleum. Electricity accounts for one-seventh of all end-use energy. Since most of California's electric power is generated from natural gas, with the rest produced by non-carbon-emitting processes, electricity is by far the cleanest energy sector with respect to greenhouse gas emissions.

For the purpose of this discussion, all quantities of energy will be stated in equivalent kilowatt-hours (kwh). While this is the common unit for electric power usage, all other sources of energy can be stated in kilowatt-hours. Natural gas, for example, is normally measured in therms, where one therm equals 30 kwh. Petroleum and its liquid products are quantified by the barrel (each containing 42 U.S. gallons). A barrel of oil is equivalent to about 1,800 kwh, where the exact energy content depends on the composition, or origin, of the oil.

WHERE DOES CALIFORNIA RANK WITH RESPECT TO GREENHOUSE GAS EMISSIONS?

We can judge California's greenhouse gas emissions relative to the rest of the world by considering total energy use and gross productivity statewide. We can also express these measures on a per capita basis. The current population of California, extrapolated to January 2001 using the latest census data, is roughly 35 million people. Of this total, about 60% (21 million) reside in Southern California. Southern California is defined here as consisting of all of the counties from Los Angeles southward, plus Ventura and Santa Barbara counties to the north. Rather than attempt to quantify greenhouse gas emissions and possible global

While Californians utilize relatively "clean" and carbon-efficient fuels at home, two-thirds of the state's primary energy is imported, with most of that generated from fossil fuels.

California's mix of alternative energy sources—hydroelectric, nuclear, geothermal, wind, and solar.

California has one of the most diverse mixes of energy sources and resources in the world. Even so, about 86% of our primary energy (in 1994) was derived from fossil fuels (mainly oil and natural gas). Of the balance, 6% was obtained from nuclear power plants, 5% from hydroelectric facilities, 3% from geothermal wells, and a smaller amount from solar and wind generators. Co-generation, or the use of waste heat from fossil power generation or conversion, is also growing. While not increasing the total primary energy production, co-generation increases the energy available to end-users, and thus increases the efficiency of energy utilization. Nonetheless, considering all applications, overall energy efficiency is fairly low, with about two-thirds ultimately wasted. The least efficient applications are transportation and space heating of buildings.

It has been suggested that nuclear reactors could be employed to increase energy resources quickly and efficiently, without increasing greenhouse gas emissions. Although the "nuclear option" is not popular in the U.S., France, India and several other countries have embraced nuclear power as a long-term energy solution. Among other things, bringing reactors online reduces dependency on fossil fuels. The main problems associated with nuclear power plants involve radioactive waste and accidental breakdowns. For each nuclear reactor brought on-line, tons of radioactive debris are created that must be safeguarded for tens of thousands of years.

Biomass fuels, which are referred to as renewable fuels because their carbon is naturally recycled through the environment, have not yet captured a significant share of the California energy market because of their higher costs, lack of production and distribution infrastructure, and the absence of standard designs to utilize such fuels. Nevertheless, the use of ethanol in blended gasoline in California has been proposed. If implemented, millions of gallons of ethanol would reduce California's net fossil carbon emissions.

Over the past few years, wind and solar power generators—both clean alternative energy sources—have proliferated across California, in part as a response to the state's electricity shortage and soaring electric and gas prices. These modes of energy production may have considerable potential to displace fossil fuels in the long term. Costs per kilowatt-hour of wind and solar power are becoming competitive with more traditional sources of energy, and conversion efficiencies continue to improve. Greater emphasis could be placed on developing these technologies to ensure energy independence and to reduce greenhouse gas emissions.

impacts separately for Southern California, we will ignore regional differences in per capita energy consumption and productivity. The implication is that effects are simply proportional to population. This neglects differences between the northern and southern regions of the state in terms of climate, occupational mix, commercial emphasis, and so on. Some of these differences are offsetting; for example, while more heating energy is utilized (per capita) in the north, more air conditioning is used in the south; and while agricultural usage of energy is higher in the north, transportation consumption (per capita) is greater in the south.

Several measures of consumption for the world, the United States, and California are shown in Figure 1. The current world population is about 6 billion individuals. Of this total, somewhat less than 5% live in the U.S., and close to 0.6% in California (with about 0.35% in Southern California). In terms of gross domestic product, the power of the U.S. economy becomes apparent, accounting for roughly one-third of the total output of goods and services worldwide. California alone accounted for more than 1.3 trillion dollars of economic activity in 2000, which required a requisite amount of energy, as indicated in Figure 1. The U.S. consumes roughly a quar-

California, with only 0.6% of the world's people, consumes as much as 4% of all goods and services, and emits nearly 2% of all greenhouse gases.

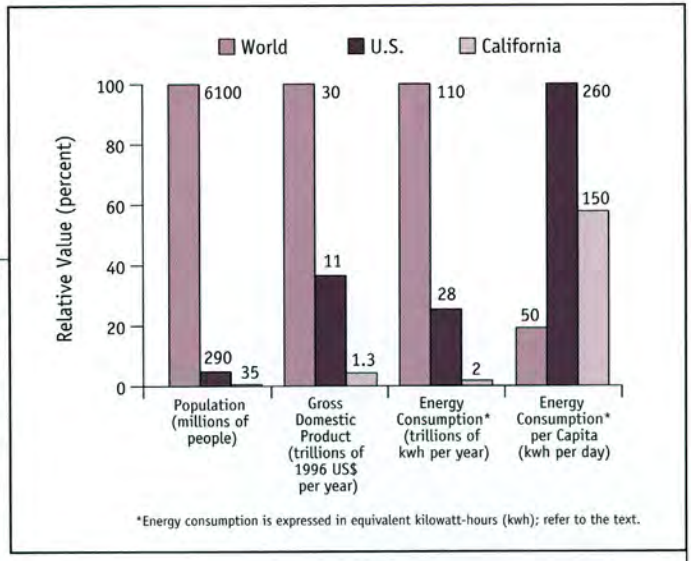


Figure 1: California Relative to the World (2001)—Population, gross domestic product (GDP), and energy consumption are compared for the world, the United States, and California. All comparisons are made in terms of the percentage of the world value. Energy consumption is expressed in equivalent kilowatt-hours, as explained in the text.

ter of all the world's energy production. In this regard, California is more energy efficient than the United States as a whole, using about one-third less energy per unit of GDP (despite a relatively inefficient usage of fuels for transportation, as discussed below).

Most telling is the comparison of energy consumption per capita (the last set of entries in Figure 1). Here, U.S. individuals are more than five times as energy intensive as the average person on Earth. Californians, by comparison, are three times as energy intensive. When we consider the developing countries alone, U.S energy consumption rates per capita are typically 10-20 times larger. The apparent energy efficiency of California is related in part to a milder climate and greater dependence on non-industrial economic sectors.

Estimates of the total "carbon" emissions from different parts of the world are summarized in Figure 2. The data dramatically illustrate the dominance of Americans in adding carbon to the atmosphere. The pattern here is very similar to that in Figure 1 for per capita energy consumption. Noteworthy is the lower per capita emissions attributable to Californians, who are comparable to Germans in this regard. But even so, we are energy wasters and heavy carbon emitters in our own right. If current trends continue, Californians alone will contribute as much as 2-3% to the global greenhouse gas budget by 2020. On the other hand, with a commitment to energy efficiency and sustainability, California's contribution could be reduced significantly over the next two decades through a combination of energy conservation, increased vehicular fuel economy, and utilization of alternative energy sources.

WHAT CAN WE DO TO CONTROL OUR IMPACTS ON CLIMATE CHANGE?

International efforts are underway to limit climate change associated with human activities, and greenhouse gas emissions in particular. The Kyoto treaty—first established in principle in 1995—represents the most ambitious effort to control emissions on a country by country basis. If all of the developed nations were to meet the goals defined by the treaty, and developing countries were to rely on cleaner, more efficient technologies over time, the carbon burden of the atmosphere, and global warming, could be stabilized by the middle of the century. The U.S. recently rejected the treaty, which called for an overall reduction in carbon emissions to 90% of 1995 levels by 2010. For the U.S., this would have required an equivalent reduction of 30% from the emissions projected for 2010. The U.S. government has in effect taken a position that rejects any constraints on the U.S. economy, while repudiating energy conservation and

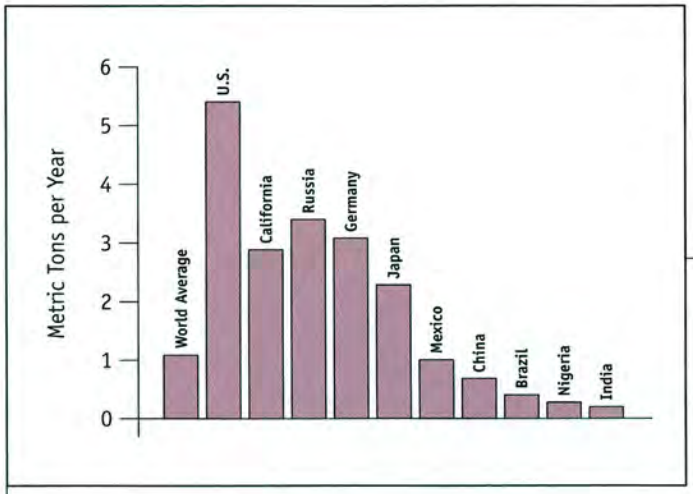


Figure 2: Per Capita Carbon Emissions—Annual carbon emissions per individual for the countries indicated. The emissions are primarily in the form of carbon dioxide, but are specified as metric tons of carbon (where 1 metric ton equals 1000 kilograms, about 90% of an English ton). These data apply for the late 1990's.

In terms of energy conservation and clean air, the recent proliferation of gas-guzzling sport utility vehicles is a step backwards.

renewable energy resources. These positions have been highly controversial nationally and internationally.

At the state and regional level, it is obvious that a wide range of effective programs are possible to meet emission goals similar to those proposed by the Kyoto treaty. California, in the past, has encouraged efficient energy use and alternative energy sources to a greater degree than most other states. There have been tax incentives for installing insulation in attics and solar collectors on roofs. That California's programs have been successful to a significant degree is demonstrated by the fact that the state ranks fifth nationally in terms of the lowest energy consumption rate per capita, and second lowest in energy consumption per unit of economic output (as of 1994). California's moderate climate has certainly helped achieve this efficiency. On the other hand, the recent electric power shortages in California underscore continuing growth in energy demand (and waste), especially for air conditioning in hot, dry regions where land development is booming. The massive statewide dependence on cars and other vehicles has also led to enormous inefficiencies in the consumption of gasoline and diesel fuels, with the undesirable side effects of heavy air pollution and its attendant health impacts.

While efforts to control air pollution (and hence limit carbon emissions) have been successful in the past, the recent proliferation of large, gas-guzzling sport utility vehicles (SUVs) is a step backwards. Moreover, attempts to raise fuel mileage (the Corporate Average Fuel Economy, or CAFE, standards) have been met with resistance from domestic car manufacturers, and have been largely circumvented by classifying SUVs as light trucks. In the past seven years, the fuel economy of domestically manufactured fleets has declined substantially, a trend in the wrong direction.

Solving the global warming problem is not only about government policy and international treaties; it is also about personal choices. Improving the insulation in one's home, driving a more fuel-efficient or low-emissions vehicle, riding public transit when possible, car pooling, installing alternative energy devices such as solar panels for water heating, replacing older less energy efficient appliances with newer models, and so on, are all small, positive steps. It is perhaps encouraging that during the recent electric energy "crisis" Californians quickly responded by cutting statewide power usage by 12% year-to-date. This points to the latent potential for efficiency and conservation in reducing overall energy consumption. The wise consumer should also keep in mind that as energy costs continue to increase—as they have recently and undoubtedly will in the future—energy conservation will eventually pay big dividends. And these small actions will ultimately reduce greenhouse gas emissions and ameliorate human impacts on the climate.

Climate change associated with current emissions of greenhouse gases represents an environmental legacy that will persist for many generations.

GRADES

The following grades apply to California as a whole.

	1990's	Current
Energy conservation	C	B-
Renewable energy sources	B	B
Fuel economy	C-	D
Emission of greenhouse gases	C	C-

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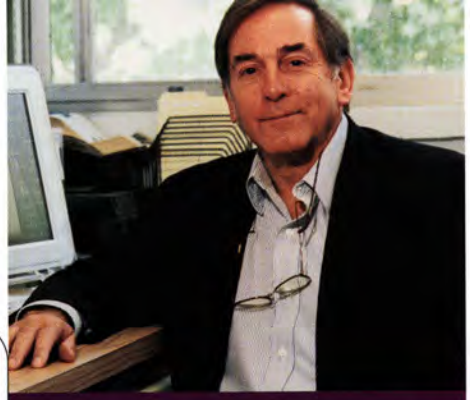
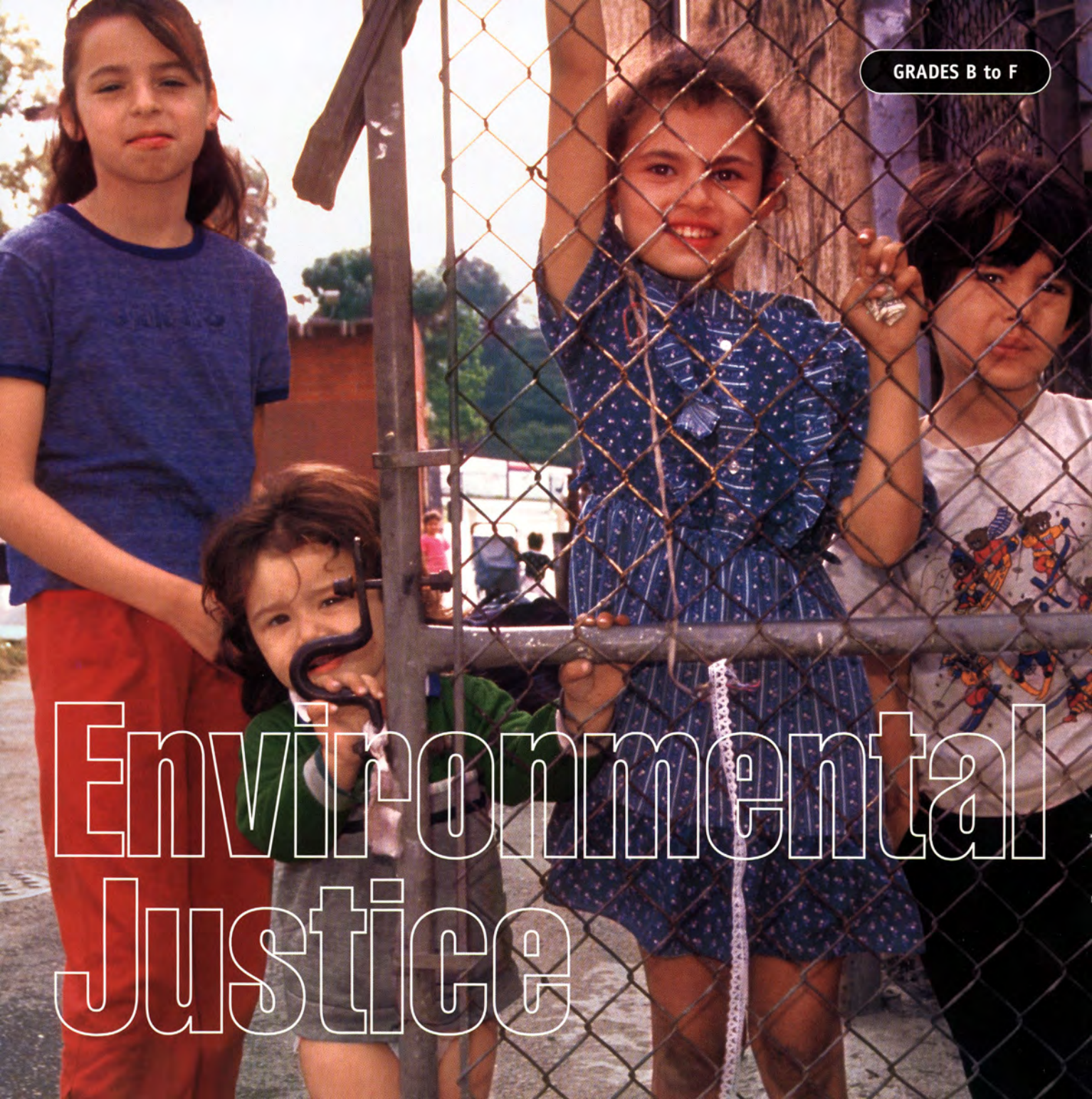


Richard Turco is the current Director of UCLA's Institute of the Environment, Professor and past Chair of the Department of Atmospheric Sciences, and a member of the Institute of Geophysics and Planetary Physics. He received his Ph.D. in Electrical Engineering and Physics from the University of Illinois in 1971. Dr. Turco's work includes research on the stratospheric ozone layer and the ozone "hole," the causes of climate change on Earth, regional air pollution and airborne particulates, and global chemical cycles. In 1983, working jointly with several colleagues, he developed the theory of "nuclear winter." Over the last decade, Dr. Turco has headed a research group building an advanced air quality model for the Los Angeles basin. The Surface Meteorology and Ozone Generation (SMOG) model was the first to explain the formation of dense elevated layers of pollution over Los Angeles. Dr. Turco's publications include more than 240 scientific papers and reports, including a textbook on current environmental issues, "Earth Under Siege: From Air Pollution to Global Change" (Oxford University Press, 1997). He was honored with a MacArthur Fellowship in 1986, and was awarded the Leo Szilard Prize for Physics in the Public Interest by the American Physical Society in 1985.



GRADES B to F

Environmental Justice

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THE PROBLEM

Even though we have made enormous strides in reducing *overall* pollution levels, until recently we have spent less time considering whether some groups of people face higher pollution levels than others (what many call "environmental justice.") The State of California now defines environmental justice as "the fair treatment of people of all races, cultures and incomes with respect to the development, adoption, implementation and enforcement of environmental laws, regulations and polices."

Merely stating this definition, however, tells us very little. Instead, we need to ask questions of both substance and process:

Substance: Do lower income populations and ethnic and racial minorities suffer a disproportionate share of various forms of pollution (water, air, toxic substances)?

Process: Do proper procedures exist to consider whether new pollution sources (new factories, for example) will be placed in neighborhoods that already contain more than their fair share? Can residents of heavily affected communities ensure that their rights are protected?

These questions have particular relevance in a community like Los Angeles, which has among the highest levels of air pollution in the country (although it is important to acknowledge, as discussed in the 1998 Report Card, that our air quality has improved dramatically since the passage of the Clean Air Act in 1970).

BACKGROUND

Environmental justice first emerged as a political issue in the late 1980's, after the United Church of Christ (UCC) issued a report arguing that low-income communities, and particularly communities of color, suffer a disproportionate share of the burden of environmental hazards. The UCC report focused on the siting of hazardous waste facilities, and suggested that prejudiced policymakers victimized low-income communities of color because of their relative lack of political power. Many activists refused to use the term "environmental justice" and instead used "environmental racism" as a way of connecting their concerns to the civil rights movement.

The UCC report did not go unanswered. Many states, including California, and the federal government responded by enacting laws and executive orders requiring that government agencies identify and address environmental harms that disproportionately affect low income and minority communities. Some scholars, however, questioned the findings of the UCC report, arguing that more sophisticated techniques would reveal a lack of disparate impact. Any disparate impacts that did exist, they argued, were the result not of siting bias but rather the workings of the housing market: low-income people live in areas near Locally Undesirable Land Uses (or LULUs) because housing is less expensive in those areas. Finally, they rejected the racial bias claims, arguing that to the extent African-Americans and Latinos suffer disproportionately, they do so due to their socioeconomic status, not their race or ethnicity.

DO CERTAIN COMMUNITIES SUFFER A DISPROPORTIONATE SHARE OF AIR POLLUTION?

The UCC study and several others have focused on the location of facilities that handle and store toxic and hazardous wastes. One study found, for example, that Southern California hazardous waste facilities are located disproportionately in poor, predominately Latino and African

Our most striking finding is that the neighborhoods surrounding the top 100 air polluting facilities contain a significantly higher percentage of Latino residents than similar neighborhoods throughout Los Angeles County.

American communities. In order to contribute to the debate, we investigated an area studied less frequently by academics: facilities emitting air toxics. Focusing on air toxics has obvious importance. The health effects of exposure to air pollution are well known and evidence suggests that children in urban areas are facing epidemic levels of respiratory illnesses such as asthma.

The South Coast Air Quality Management District (SCAQMD) recently examined whether toxic "hot spots" exist around the region by monitoring various neighborhoods, including low income minority communities, for the emission of a number of toxic chemicals. The SCQAMD found that no such hot spots exist at the sites they monitored. We provide a different measurement by looking at the location of the largest industrial emitters of air toxics. Federal law requires companies that handle large amounts of chemicals to report how much of each chemical they release into the air, water and land. The federal government compiles the reported information into the Toxics Release Inventory (TRI). We took the reported data in the TRI for the 100 companies in Los Angeles County that release the largest amounts of air toxics. We then analyzed their location by surrounding population, race and ethnicity, and housing value, specifically examining population groups within a half mile radius of each TRI facility and within a quarter mile radius.

THE IMPACT OF RACE AND ETHNICITY

What do the data tell us about whether certain racial groups are disproportionately affected by air toxics? Our data suggest that the debate concerning whether environmental justice is a racial issue has so far been cast too simplistically. The TRI information suggests that with respect to African Americans and Asian Americans and their location near Southern California air toxic facilities, there does not appear to be a significant environmental justice problem. The percentage of African Americans living near the TRI facilities is consistent with the countywide average. Asian Americans are actually slightly underrepresented in the TRI neighborhoods compared with their countywide average.

Latinos, however, fare much worse. Our most striking finding is that the neighborhoods surrounding the top 100 facilities contain a significantly higher percentage of Latino residents than similar neighborhoods throughout Los Angeles County. The Latino population in L.A. County is 44 percent, yet 60 percent of residents surrounding the top 100 TRI facilities are Latino. Even when controlling for income we find that Latinos are still substantially overrepresented among those affected by air toxins.

We can also examine the racial aspect of environmental justice by asking how Caucasians are affected. The most general answer is: very little. Thirty-one percent of the population of L.A. County is white but the residents who live near the polluting facilities are only 18 percent white.

Moreover, on an absolute basis the same finding holds true. As Figure 1 demonstrates, we found that 60 of the 100 facilities are surrounded by neighborhoods (within a 1/2 mile radius) that contain a greater percentage of racial and ethnic minorities than the countywide averages. Only 21 facilities are located next to neighborhoods with a higher percentage of whites than the countywide average. The remaining facilities either have fewer than 40 people living within a half mile radius or no data available.

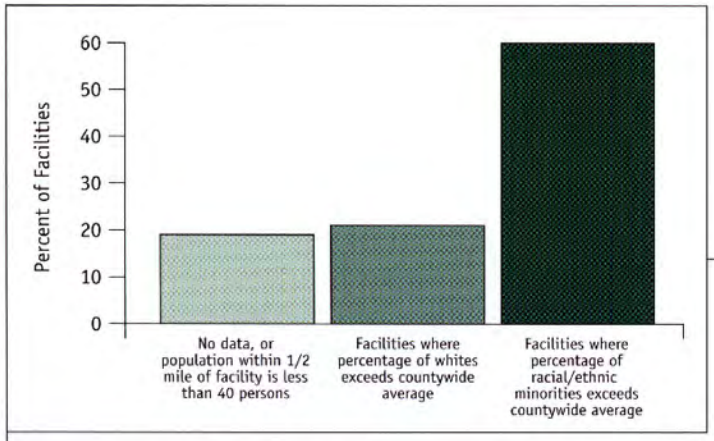

Figure 1: Percentage of facilities where racial/ethnic populations exceeds countywide average (1/2 mile radius).

ENVIRONMENTAL JUSTICE: THE PRIMACY OF SOCIOECONOMIC CLASS

Our findings that African Americans and Asian Americans do not bear more than their fair share of exposure to major air toxics facilities while Latinos do hardly means that Southern California does not have an environmental justice problem. We also found that the neighborhoods around the top 100 facilities are, on average, poorer than the County at large, measured by median gross rent/month and median housing value. The median gross rent on a countywide basis in 1990 was $689/month whereas the median rent in the neighborhoods within a 2 mile of the facilities was $650. Similarly, average property values in neighborhoods closest to the facilities were well below the countywide average: $196,583 for the neighborhoods close to the facilities and $246,325 for the county as a whole. (2000 census data are not yet available.)

In sum, then, we find that Southern California has a considerable problem in that low-income people are substantially more affected by air toxics than the rest of the population. While our data do not reveal that African-Americans and Asian-Americans suffer disproportionately, it does appear that Latinos bear a heavier burden than the population as a whole. We cannot confidently state that Southern California has a problem with "environmental racism," but "environmental classism" appears to be alive and well—at least as regards the *effects* of the placement of toxic facilities.

WHAT CAUSES THE ENVIRONMENTAL CLASSISM PROBLEM?

The causes of the disparities we uncovered are not clear. For example, our data do not show which came first, the companies that emit large levels of air toxics or the residential neighborhoods that surround them. In other words, it is possible that facilities first located in areas that were not heavily residential because land values were cheap and then lower income residential neighborhoods grew up around them. It is also possible that when facilities originally opened, the neighborhoods around them were not, at the time, disproportionately poor or Latino. Instead, it may be that as industry moved in, the neighborhoods became less attractive and hence less expensive, and attracted larger numbers of lower income residents. A third possibility is that facilities choose to locate disproportionately in lower income communities because they can buy land more cheaply or because the residents in these communities have less political clout and put up less resistance. This last factor would help explain why Latinos are disproportionately affected whereas African Americans are not. Since the Latino community has a large immigrant population, it has traditionally possessed less political power and less ability to resist siting decisions. Without data to assess the timing of the location of the top-100 facilities we cannot fully answer this question.

We note, however, that at least two other studies, including one of L.A. County, have found that the demographics of neighborhoods that host toxic storage and disposal facilities

We cannot confidently state that Southern California has a problem with "environmental racism," but "environmental classism" appears to be alive and well.

did not change materially after the facilities opened. Thus the host communities were disproportionately poor and minority at the time of siting, suggesting that the environmental justice problem does not appear to be caused by low income communities settling near preexisting environmental hazards.

HOW ARE WE DOING IN REMEDYING THE IMBALANCES?

In rating progress to address problems of environmental injustice, we focus on two separate questions. First, does a process exist to prevent already overburdened neighborhoods from playing host to new facilities with high levels of air toxic emissions? Second, does a process exist to ameliorate harms that poor, disproportionately Latino communities are currently suffering from already existing facilities? We conclude that governmental agencies are beginning to do a good job collecting data and studying whether certain areas of the Southern California region suffer disproportionately from high levels of air pollution. But overburdened communities facing the siting of new facilities or the expansion of existing facilities have few legal remedies to challenge governmental permitting decisions that will increase their exposure to air toxins. Moreover, the current political structure of state and local government prevents significant amelioration of environmental justice harms under the current system.

New Facilities

The SCAQMD: Before a new air-polluting facility can begin business in Southern California, it must typically receive a permit from the South Coast Air Quality Management District setting limits on the amount of pollutants it may emit. The SCAQMD, then, has the most significant role to play in ensuring that certain segments of the community do not bear more than their fair share of exposure to air contaminants.

The SCAQMD has recently shown interest in environmental justice issues. The agency has established an environmental justice task force and has conducted elaborate testing around the Southern California area to determine whether certain areas of the air district are "toxic hot spots." These are commendable steps in the right direction. A large problem in the SCAQMD permitting process, however, remains. In making a decision about whether to issue a permit to a new facility, the SCAQMD has no legal requirement to consider the cumulative effects of the new facility combined with all the other air pollution sources in the area in which the facility will be located (with one exception we discuss below). Nor must the agency take into account the social or economic effects of a permitting decision. In other words, the district pays no attention to the demographic characteristics of the surrounding neighborhood. Therefore the SCAQMD is not required in the permitting process to consider whether a neighborhood already contains many facilities that emit substantial amounts of pollutants or whether a neighborhood is poor or heavily Latino. Unless the proposed facility is also subject to the California Environmental Quality Act ("CEQA"), described below, no mechanism exists to prevent the disparities we identified above from worsening.

CEQA: On certain occasions, the SCAQMD must go beyond its permitting requirements and prepare an environmental impact report (EIR) under CEQA. CEQA requires government agencies to prepare an EIR and assess the environmental effects of any project if that project could have a significant effect on the environment. Some new facilities seeking air pollution permits will also be considered

Overburdened communities facing the siting of new facilities or the expansion of existing facilities have very few legal remedies to challenge governmental permitting decisions that will increase their exposure to air toxics.

"projects" for which CEQA review is required. Where CEQA review is required, the chances that the SCAQMD will mitigate environmental justice effects may be higher.

First, CEQA requires government agencies to analyze not only the environmental impacts of the individual project but also whether that project, combined with other existing or planned projects, will generate significant cumulative impacts. CEQA then requires the agency to mitigate significant environmental harm, if feasible. For neighborhoods with already existing air pollution sources the cumulative impacts analysis may lead SCAQMD to reduce or eliminate the air emissions proposed by a new facility.

Second, CEQA explicitly states that an agency must mitigate the social and economic effects of a project with significant environmental impacts. For example, if a governmental entity wishes to build a new highway through a working-class neighborhood (as was common during the 1950s in communities like Boyle Heights), it must not only analyze and mitigate the air quality impacts the highway will create but also do the same for the projected loss of affordable housing. If a manufacturer wants to build a new facility in a largely low income residential area that is heavily Latino, under CEQA the SCAQMD should consider the project's effect on the neighborhood's desirability.

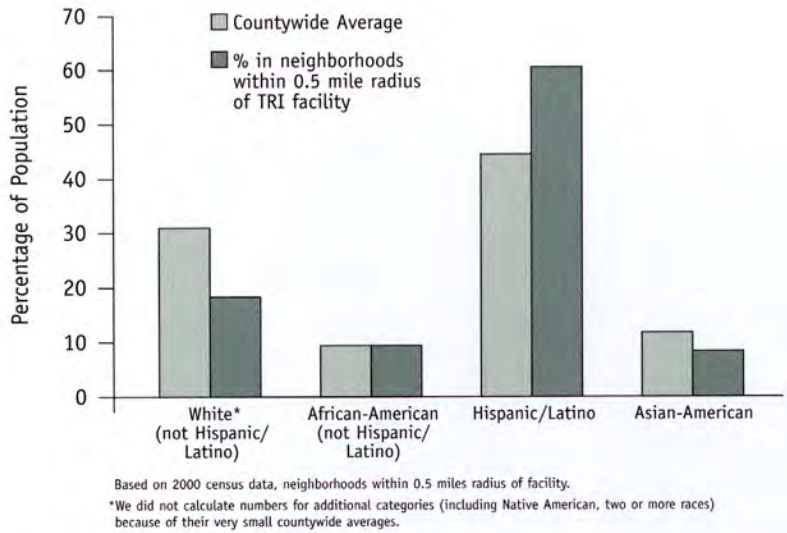

Figure 2: Comparison of TRI Neighborhoods and Countywide Averages by Race and Ethnicity.*

But CEQA also has significant shortcomings that undermine its best features. The statute only requires "feasible" mitigation of environmental harm; if significant environmental effects remain, a permitting authority can prepare a "Statement of Overriding Considerations" and issue the permit anyway. Though it makes sense to give permitting authorities this flexibility, the discretion can and has been abused.

Additionally, without more explicit guidance it is unclear whether governmental agencies will focus on environmental justice issues. While such concerns are part of CEQA, they do not lie at the heart of it: the statute is mostly concerned with traditional environmental impacts. Because of this shortcoming the state legislature

We commend the ARB's NAP program and SCAQMD's toxic hot spots testing as important information gathering measures.

passed a bill during the 1997-98 session that would have explicitly required agencies to consider environmental justice issues in preparing EIRs, but then-Governor Wilson vetoed the bill.

Finally, if government agencies fail to take into account CEQA's environmental justice policies, the only way to enforce them is through a lawsuit, and only after meeting significant procedural requirements. But the very factors that may lead to the inequitable distribution of environmental harms—lack of political and economic power—often work against responding effectively and quickly to a new source of pollution and against finding a competent attorney to advocate for underrepresented communities.

State Environmental Justice Initiatives: In the last two years, California has enacted new legislation to focus attention on environmental justice concerns. In general, the legislation directs the California Environmental Protection Agency to take environmental justice concerns into account when designing and conducting its programs, and improve data collection to better identify the effects of environmental programs on low-income communities and people of color. It also directs Cal EPA to establish an advisory group (comprised of representatives of planning agencies, air districts, environmental organizations, business, and community groups) and an interagency working group to recommend ways of coordinating and implementing environmental justice strategies. Many of these initiatives are not yet in full effect, making them difficult to evaluate.

The California Air Resources Board has responded to the new legislation by launching a "Neighborhood Assessment Program" ("NAP") designed to "investigate whether or not cumulative air pollution impacts differ between neighborhoods within a designated region." More specifically, the NAP will attempt to develop monitoring tools necessary to measure the cumulative effects of "neighborhood-scale" air pollution sources. Current monitoring efforts focus on larger geographic units than individual neighborhoods so the NAP is designed to provide the tools necessary to measure effects at a much more localized level.

We commend the ARB's NAP program and SCAQMD's toxic hot spots testing as important information gathering measures. As lawyers, however, we have serious concerns that the state has provided overburdened communities with few legal tools to prevent the siting of new sources of air pollution. The state's progress in this area is, at best, mixed.

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Existing Facilities

Though CEQA provides some mechanisms to consider environmental justice effects in the siting of new facilities, virtually no mechanisms exist to ameliorate the disproportionate harm that poor, disproportionately Latino communities are currently suffering from living near the top 100 facilities. These harms are admittedly difficult to address but government could clearly do more. For example, CEQA rarely applies to the re-permitting process of an already existing facility. If agencies were required to prepare an EIR in the re-permitting process, they might address the environmental justice concerns more effectively. Similarly, the SCAQMD does not take into account cumulative or environmental justice effects in its re-permitting process.

THE BIGGER PICTURE: LINKS BETWEEN ENVIRONMENTAL JUSTICE AND HOUSING POLICY

Finally, examining environmental justice solely through the prism of environmental policy obscures the links between the issue and the broader topics of housing, land use and regional planning. As noted above, scholars and policymakers skeptical of environmental justice claims argue that the mere location of polluting facilities next to low-income, minority communities has an obvious cause: housing next to facilities is undeniably likely to be cheaper, and hence residents in such neighborhoods are undeniably lower income and probably racial and ethnic minorities. The disproportionate effects of environmental siting decisions, they argue, are caused not by bias or political weakness but by the realities of the housing market.

The "housing market," however, is in large part an artifact of public policy: local governments substantially control (and restrict) the supply of housing through zoning and other land use regulations. Instead of dismissing environmental justice claims as the workings of the market, we need to ask whether policymakers have effectively addressed the region's need for affordable housing. Do we have enough affordable housing? And is there affordable housing spread across the region rather than concentrated in low income areas where it runs the risk of being placed alongside environmental hazards?

On both counts, the region's performance has been deeply disappointing. Land use control in California, as elsewhere, is a quintessentially local activity: for the most part, local governments make the critical decisions concerning land use planning. Local governments, however, face sharp political and fiscal disincentives for affordable housing. Current residents fear that affordable housing will reduce existing property values and bring "undesirables"—lower-income people and racial and ethnic minorities—into their neighborhoods. Any plans for affordable housing, therefore, typically generate intense NIMBY (Not In My Back Yard) sentiment and threaten the electoral base of local city officials. NIMBYism, moreover, tends to segregate affordable housing into low income areas. Furthermore, local governments frown on affordable housing because it reduces their tax base. This

Connecting the housing issue with environmental justice shows that low income families face the additional burden of breathing air toxics.

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condition is true throughout the United States but nowhere more so than in California, where the revenue rules enacted after the passage of Proposition 13 have resulted in the extreme fiscalization of land use: local governments obtain revenue primarily through local sales taxes, giving them powerful incentives to favor retail development over housing.

In the wake of NIMBYism and fiscalization, then, it falls to state and regional authorities to create a structure favoring affordable housing. On this score, we must give these authorities failing grades. Current law requires local governments to prepare a "Housing Element" of their "General Plan" every 5 years assessing housing needs for all income groups and setting forth a program to meet those needs. But since the local governments themselves are assessing their own needs, the same pressures that lead them to oppose affordable housing drive them to "find" that their needs are far lower than reality requires.

Regional and state authorities play roles in the Housing Element planning process, but they serve as extremely weak checks on the incentives described above. In Southern California, the Southern California Association of Governments (SCAG) predicts the likely future demand for housing in the various parts of the region it serves (Los Angeles, Ventura, Orange, Riverside, San Bernardino, and Imperial counties), and assesses the regional "fair share" of affordable housing for all jurisdictions within it. SCAG, however, is not truly a regional body. As its name suggests, it is a coalition of local authorities: its governing board comprises several local elected officials accountable to local voters. Not surprisingly, SCAG hardly serves to augment affordable housing.

Under current law, the state department of Housing and Community Development (HCD) must review all Housing Elements and determine whether they comply with state law. Local governments, however, are free to reject HCD's estimates, and often do so. In such an event, HCD can only withhold state money for affordable housing, which, given the nature of the dispute, hardly suffices as a credible threat. Advocates have proposed legislation to ameliorate the problem, but so far all efforts have been unsuccessful.

Little wonder, then, that throughout California fully one-third of municipalities are out of compliance with the Housing

Element law; given the multiple points at which local governments can reduce their fair share for affordable housing, it is not a stretch to say that even those "in compliance" are not building enough to meet demand.

California housing policy, then, remains a legal and political disaster. Our analysis reveals that this problem has become an environmental issue. No one likes the prospect of low-income families living in overcrowded or dilapidated housing: connecting the housing issue with environmental justice, however, shows that such families also face the additional burden of breathing air toxics. Refusing to address an adequate supply of affordable housing, in appropriate places, risks not only substandard housing conditions but the ongoing poisoning of vulnerable populations.

GRADES

Legal requirements to avoid siting of new facilities	C
Research efforts to assess cumulative impacts	B
Policies to ameliorate current harms	F

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GRADES A to C

Bottled Water

by I.H. (Mel) Suffet, Ph.D.

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INTRODUCTION

More than 50% of Americans drink bottled water. From 1988 to 1998, the sales of bottled water tripled to about 4 billion annually, according to the Beverage Marketing Association (LA Times, 4/23/98). Why is this, when bottled water costs from 240 to over 10,000 times more per gallon than tap water according to the 1999 NRDC, "Bottled Water" Report? Do customers believe that bottled water is safer than tap water because the ingredients are listed on the bottle, the image of the label projects purity, or is it just because consumers like the taste of bottled water?

Californians love their bottled water. In 1994, 33 % of the U.S. bottled water market resided in California. According to the Metropolitan Water District (MWD) of Southern California "Consumers Expectation Survey," bottled water usage increased from 29% to 38% between 1993 and 1997 in the area that tap water is supplied by MWD. The MWD survey also found that 38% of the population drink bottled water only, while another 32% drink both bottled and tap water. Demographically, the highest use of bottled water is in Los Angeles (43%) and San Diego (37%) counties; the lowest uses are in Orange Country (27%) and in the rest of MWD's service area (32%). Consumers over the age of 50 are more likely to drink only tap water (43%) and the least likely to drink bottled water (27%). Households with no children are the most likely to drink only tap water (27%). Newcomers to LA are the most likely to drink only bottled water (42%), apparently to blend into the Southern California scene.

Figure 1 lists the reasons why MWD consumers choose bottled drinking water in Southern California, with taste and then safety being of primary importance. Does the perception that bottled water is safer than tap water match the reality? Does bottled water contain more or less chemical or microbiological contaminants than tap water? Does the taste of the chlorine or other off-flavors in tap water cause people to drink bottled water? This article seeks to address these and other relevant questions.

PUBLIC PERCEPTION OF WATER QUALITY—IS IT CORRECT?

Until recently, most public drinking water utilities in the United States were concerned primarily with meeting primary drinking water standards and ensuring the public that the water is safe, i.e. there are no harmful chemicals or microorganisms present. This assumes the best water source available is used and the water is treated to meet all drinking water standards. However, consumers tend to correlate drinking water safety with water quality aesthetics. These two objectives are not the same. A water utility meeting health-based primary drinking water standards to lower the risk of water supply contamination must also address secondary aesthetic concerns, such as minimizing tastes and odors.

The taste and odor concerns appear more important to consumer confidence in Southern California than meeting standards (see Figure 1). This appears to be the case throughout the U.S., as a recent evaluation of seven consumer surveys by Torobin and coworkers[1], showed consumers who reported fair/poor aesthetic water quality were the same ones who had less favorable perception of the safety of their local tap water. Figure 2 shows that MWD's Southern California consumers are willing to pay for increased safety, improved taste and better information about water quality. Ironically, MWD has been a world leader in research on off-flavors of raw and finished drinking water and has developed early warning systems, analy-

Sidebar 1: Sources of Bottled Water—Ground water (artesian water, spring water) and tap water

AQUIFER The location of ground water.

WELL WATER A general term that means ground water is pumped to the surface. The term implies that a well has been dug to obtain the ground water. Pumped spring or artesian water can be called well water.

ARTESIAN A ground water type from a confined aquifer where the water level stands above the top of a ground water aquifer. It can be natural or pumped.

SPRING A ground water type that flows unassisted (natural) or by a pump (well) to a surface opening. The source may be stated on the label. Note: Spring water is protected from microorganisms.

STILL Water bottled without carbonation.

NATURAL WATER taken directly from nature that is unmodified by mineral additions or deletions.

MINERAL Water that contains dissolved at least 250 mg/L of dissolved solids. If the water is less than 500 mg/L (the EPA drinking water standard based upon salty taste), the water can be called low mineral content. If it is higher, it can be call high mineral content.

DE-MINERALIZED Water with low residual metals produced by processes such as reverse osmosis, ion exchange or distillation. De-ionized water is de-mineralized with the ions almost completely removed by the de-mineralized processes. Note: Soda water, seltzer, or club soda are not considered bottled water, but soft drinks.

CARBONATED So-called "effervescent" or "sparkling" water are spring waters containing high amounts of CO_2.

PURIFIED DRINKING WATER Treated water, usually tap water if the source is not named. The water treatments must remove total dissolved solids to below 10mg/L.

sis methods and source water protection to minimize off-flavor episodes. The Los Angeles Department of Water and Power (DWP) has also instituted these approaches to minimize off-flavors. Yet, some off-flavor episodes do occur and the taste of chlorine is present in Southern California drinking water. According to the MWD survey, the public remains concerned about the off-flavor of drinking water and remains willing to pay for improved taste of tap water.

In relation to the safety and taste and odor issues, when was the last time you observed a public drinking water utility advertise the healthy attributes of its drinking water? On the other hand, when was the last time you observed a bottled water advertised and, by innuendo, indicate it is purer, safer and better regulated than tap water? The Southern California press also reports consumer indignation about any off-flavors in the public's drinking water. This author knows of occurrences where bottled waters in Southern California were in violation of a bottled water regulation or an off-flavor and the company simply removed the water from the shelves. However, the press rarely, if ever, reports such events. "Bad press" in the public drinking water industry appears to be good press for the bottled water industry. In fact, the bottled water industry has an ally in the press, as any violation of U.S. EPA drinking water regulations must be reported to the press to inform the public, no matter how minor. The bottled water industry benefits from this free "negative advertising."

In MWD's 1998 Southern California survey, customer's perceptions of their tap water quality and flavor were examined. The survey showed that 56% of the customers rated their tap water as fair and poor. Taste problems were described as having increased significantly (11% higher on average), from 4 years previously. In fact, 77% of the consumers agreed that local water utilities "should be expected to provide tap water that looks and tastes as good as bottled water." Only 22 % were very satisfied with how their tap water "looks and tastes." Thus, Southern Californians seem to have a perception that bottled water is the standard for the purity and taste of drinking water. This suggests the taste of chlorine is the key factor for the choice of bottled water over tap water.

Anadu and Harding[2] have reported that the risk perception of drinking tap water is a subjective judgement based on taste and odor, and the feeling the type and amount of chemical and microorganisms in water are worse than those in bottled water. Social, cultural and psychological factors also play a role, including the level of distrust of government agencies. The latter is a major factor that translates into public uncertainty about safety and regulation of chemicals in tap water. Quantifiable risks and the true differences between bottled and tap water are apparently of secondary consequence to

Southern Californians seem to have a perception that bottled water is the standard for purity and taste of drinking water.

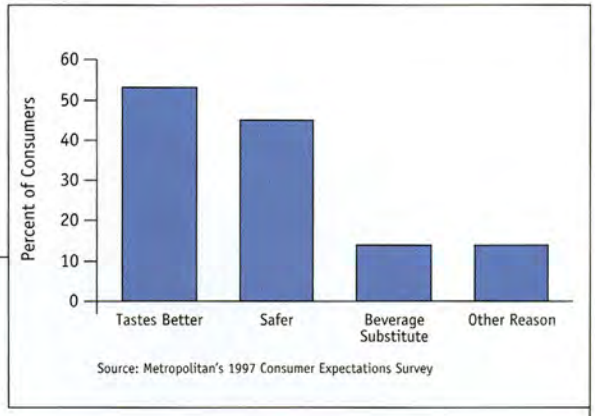

Figure 1: Reasons for drinking bottled water

the consumer. The perception of risk influences people to develop what they perceive to be a preventative action: drink bottled water. Are Southern Californian's perceptions about tap water and bottled water correct? What are the facts about the water quality and off-flavors of tap and bottled water? First and foremost, it is this author's opinion that apparent perceptions of the risk of drinking tap water that meets all U.S. EPA and California regulations are not justified. In fact, drinking water standards for tap water are more rigorous than for bottled water for some chemicals (Sidebar 3).

THE BOTTLED WATER INDUSTRY—FACTS AND FANCY

Everyone should know that tap water from different locations and during the changing seasons is different in mineral content, taste and potential contaminant levels of chemicals and microorganisms. Los Angeles drinking water that MWD processes from the Colorado River or the Sierra Nevada Mountains is different from that of drinking water the DWP processes from California's Owen's Valley. Why? Simply, the natural water sources have different inorganic minerals (e.g. calcium), nutrients (e.g. phosphate), and natural organic matter, and the treatment of these waters are different (See RC 2000). Why then do consumers think bottled waters have a more consistent water quality although different brands of bottled water also come from different source waters? This myth of bottled water consistency is dispelled in Figures 3 and the explanations in Sidebar 1, which presents a general classification of bottled water.

SOURCES OF BOTTLED WATER

Sidebars 1 and 2 show the different bottled water types available to consumers. These bottled waters can come from many different locations, such as artesian, spring or pumped well water, or previously processed local tap water from ground or surface water sources. The sources of bottled water are often used for marketing but may not have any bearing on the safety or taste of the water. Pristine settings such as natural springs are excellent sources if protected from contamination and treated properly. Spring water may contain natural minerals (natural mineral water) or be carbonated (natural carbonated water). The consumer should know that according to the National Resources Defense Council (NRDC) 1999 "Bottled Water" Report and government and bottled water industry estimates, about 25%-40% of all U.S. bottled water is from tap water. For example, Aquafina from Pepsi Cola and Desani from Coca Cola are nationally known bottled water brands according to Consumer Reports[3] that are primarily from drinking water sources, whereas Dannon's Natural Spring Water is described as coming from multiple springs. Some cities, such as Long Beach CA, are producing their own brand of bottled water from their tap water. Apparently, Long Beach has accepted, and is capitalizing on, the Southern California consumer's preference for bottled water.

Pure, purest, pristine, natural, naturally, premium, mountain water, and clean are advertising descriptors on bottled water labels that are misleading to the consumer. These terms do not realistically describe the source or purity, nor certify the water is safe,

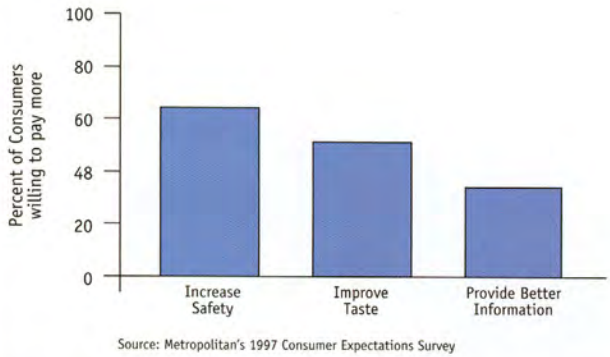

Figure 2: Willingness to pay for improvements

or taste-free. Yet, the label and these promotional materials must meet the U.S. Food and Drug Administration (FDA) truth-in-advertising rules.

WATER TREATMENT

Tap Water

Public drinking water treatment plants using the most pure and pristine water supplies are designed to control any microbiological or chemical hazards of the raw water, and to provide consumers with clear, taste and odor free, colorless tap water. The traditional U. S. water treatment consists of disinfection by chlorination at the head of the plant and a residual level of chlorine maintained throughout the water treatment plant and distribution system to control microbes and oxidize organic chemicals in the water. Some newer plants use ozonation instead within the plant [e.g. MWD and DWP (RC 2000)].

Bottled Water

Bottled drinking water in California is required to reveal its source water and treatment system to the state (see Sidebar 2). Treatment is designed as for tap water: to control any microbiological or chemical hazards of the raw water, and to provide consumers with clear, taste-and-odor free, colorless product. Treatment includes a minimum of filtration and disinfection by ozone or UV light. Then the bottle is sealed at the end of the assembly line which is maintained hygienically clean. Sometimes other treatment processes, such as reverse osmosis, UV, ozone or activated carbon filtration are used to remove minerals and trace organic chemicals. In reality, the bottled water plant is a small water treatment plant used in a mode that produces beverages from a water source. Each company producing bottled water is free to process the water as it sees fit, subject to oversight of the State of California, Department of Health Services, Food and Drug Branch (Cal DHS-FDB). In almost all cases, a form of ozonation disinfection is used, and no residual chlorine is added. Usually the bottle is sealed while ozone is still present in the water, but the ozone soon dissipates.

The bottled water vendors pay a licensing fee to distribute their water in California. The application to sell bottled water in California asks for a list of all product brand names of bottled water produced at the same bottled water plant. It is the author's experience that many product brands are bottled by the same facility. For example, does each Las Vegas Casino have their own bottled water plant? No!

Sidebar 2: California Licensing Requirement for Bottled Water Sold in California

SOURCE WATER TYPES Spring Artesian well Well (non-artesian) Carbonated (sparkling) Mineral	The source waters are licensed if not from an approved municipal drinking water.
WATER TREATMENT METHODS Distilled UV Activated carbon Microfiltration Ozonation Reverse osmosis	The use of any of these processes must be clearly labeled.
PRODUCT TYPE Drinking Carbonated (sparkling) Distilled Flavored Mineralized Fluoridated	Product types are usually labeled.

Most bottled and tap waters are of good quality.

WATER QUALITY HEALTH STANDARDS

Tap Water

The EPA Primary Drinking Water Standards are developed as a maximum contaminant level (MCL) for a chemical or a microbe (U.S. Safe Drinking Water Act of 1974; and amendments). The MCL is the concentration that will not produce adverse health effects after a lifetime of exposure based upon toxicity data and risk assessment principles. The goal is to ensure that even small violations for a period of time do not pose significant risk to the public's health by chemicals and microorganisms over the long run. Inorganic or organic chemicals, e.g. metals, disinfectants, disinfectant byproducts, microorganisms, and radionuclides, make up the primary MCLs. EPA drinking water standards and water treatment methods were summarized in RC 2000.

Bottled Water

Bottled water is considered a food product and is regulated by the U.S. FDA quality standards for bottled water adapted in 1973, and amended in 1996. The FDA states in the 2001 Federal Register: "In general the FDA believes that with few exceptions, EPA standards for contaminants in drinking water are appropriate as allowable levels for contaminants in the quality standards for bottled water when bottled water may be expected to contain the same contamination." Thus, FDA is recommending standards of quality EPA has already established as MCLs, including EPA's rule for disinfectants and disinfection byproducts for bottled waters made from tap water.

Sidebar 3 present specific details on the present similarity and differences between U.S. EPA tap water regulations and the FDA and Cal DHS-FDB regulations of bottled

Sidebar 3: A Summary of Differences in Rules for Tap and Bottled Water Sold in Other States and California
(Bottled Water Regulations: FDA, Title 21 and Cal DHS-FDB Health and Safety Code #111080)

EPA TAP WATER REGULATIONS	BOTTLED WATER REGULATIONS
MICROBIOLOGICAL	
1. No confirmed E. Coli or Fecal Coliform Organisms allowed.	Same for FDA and Cal DHS-FDB rule.
2. EPA Surface Water Rule: Surface water must be filtered and disinfected or source water protection instituted.	Same for Cal DHS-FDB. FDA rule is up to the state's discretion.
3. Coliform test—No more than 1 positive test of 100's of tests per month.	Less than 2.2 MPN/100 ml, weekly. (FDA and Cal DHS-FDB rule)
4. Repeated high heterotrophic plate count (HPC) and lack of disinfection can trigger an EPA violation.	High HPC will trigger inspections by FDA and Cal DHS-FDB.
5. Cryptosporidium and Giardia testing/ treatment method.	Same for Cal DHS-FDB; No FDA rule.
CHEMICAL	
1. Priority pollutants testing requires as for phthalates.	Same for Cal DHS-FDB; No FDA rule.
2. Apply EPA's Disinfection Byproduct Rule to bottled water (Disinfectant concentration, Disinfectant byproducts, e.g. bromate, chlorite and haloacetic acids and total trihalomethanes)	Same for Cal DHS-FDB; FDA. Proposed March 28, 2001; instituted July 5, 2001. (Federal Register)
GENERAL	
1. Any standard violation—enforceable.	Same for Cal DHS-FDB; No FDA rule. (Must be sold labeled as containing excessive chemicals)
2. Chemical and microbe testing, mostly 1 per quarter.	Chemical testing 1 per year; microbial testing weekly. (FDA and Cal DHS-FDB rule)
3. Certified lab tests required.	Same for Cal DHS-FDB; No FDA rule.
4. Tap water data and violations must be reported to the state and EPA.	Violations must be reported to Cal DHS-FDB. No FDA rule.
5. Trained system operators required.	Same for Cal DHS-FDB; No FDA rule.
6. Apply EPA Consumer "Right to Know" CCRs to Bottled Water.	Proposed February 2000, Federal Register, but not required by FDA or Cal DHS-FDB.

Sidebar 4: Problems Found with Bottled Water

1. NRDC 1999 Survey "Bottled Water"

- There are over 700 brands of U.S. bottled waters. NRDC tested 103 of them; 4% exceeded a U.S. FDA standards; 22% exceeded Cal DHS-FDB bottled water standards; most commonly for arsenic (5 ppb) or another specific potential cancer-causing agent.
- 17% of the bottled waters tested contained in at least one sample a high bacteriological heterotrophic plate count which is used by some states and the industry's own Bottled Water Association as a guideline.
- About 20% of the bottled waters tested contained a synthetic organic chemical in at least one sample; all the chemicals were below hazardous guidelines. Many bottles contained inorganic chemicals such as arsenic below any U.S. EPA standard.
- About 33% of the bottled waters tested violated an enforceable state standard or exceeded bacteriological guidelines, or both, in at least one sample.

2. Manitoba Canadian Survey (Pip, E., Environmental Health Perspective, 108: 863, 2000)

- Bottled water samples showed large variation in quality and some exceeded Canadian Water Quality Guidelines for drinking water for chloride, total dissolved solids and lead.

3. Metals in Bottled Water Survey (Allen, H. et al., Archives of Environmental Health 44, 102, 1989)

- 24 of 37 brands of bottled water drank in the U.S. had one or more metals or general water quality parameters that were not in compliance with U.S. EPA drinking water standards.
- A large variation in composition among brands that were tested and from lot to lot of a particular brand was observed.

water. Presently, the FDA "Bottled Water Quality Standards" are not as rigorous as the "EPA Drinking Water Standards." However, in the State of California, Cal DHS-FDB has proactively set bottled water standards for many chemicals below the FDA levels and sometimes even below the EPA tap water standards. Presently, EPA drinking water standards are stricter than FDA bottled water standards for some microorganism categories (e.g., giardia, legonella, and viruses) and over 22 metals and trace organic chemicals. The FDA is stricter than the U.S. EPA for three chemicals (copper, fluoride and lead). However, Cal DHS-FDB bottled water standards follow EPA drinking water standards and are even stricter for 20 metals, inorganic anions and trace organic chemicals. For example, California bottled water standards are stricter for trihalomethanes, lead, arsenic and chlorine than FDA standards or even the EPA standards.

Sidebar 4 presents highlights from a 1999 NRDC survey and two other surveys of the quality of bottled water. Bottled waters do show water quality problems. The bottled water industry has experienced recalls from the shelves of supermarkets for bacterial contamination, chemical contamination and taste and odor problems, such as plastic tastes. Bacterial re-growth can occur, and bacteria (such as those measured by heterotrophic plate count, which are usually harmless) can often be cultured from bottled water. The public may be notified when bottled water is recalled.

These bottled water quality surveys can be compared to a 1996 EPA survey of tap water that found 10% of the tap water serving 14% of the U.S. population violated EPA tap water treatment or contaminant standards. Thus, tap water has on occasions not complied with EPA and California Drinking Water Standards and the public has been notified about the problems and its resolution. A general overall evaluation indicates bottled water is generally as safe as tap water and visa versa.

THE FLAVOR OF TAP AND BOTTLED WATER

The EPA's secondary drinking water standards for aesthetics include taste and odor and dissolved salts. 500 mg/L of total dissolved solids is the limit to minimize the taste of salty water. Secondary standards are not legally enforceable in the U.S. However, in California secondary drinking water standards are enforceable and California is one of the few states to develop secondary standards based on taste and odor considerations. There are two specific chemical limits of off-flavors in tap water. One is for MTBE, the oxygenated fuel additive and the second is for a rice herbicide breakdown product in

Bottled waters can come from many different locations, such as artesian, spring or pumped well water, or previously processed local tap water.

the Sacramento Valley. The Cal DHS-FDB bottled water mineral standards includes limits for specific mineral salts that effect taste, (e.g. chloride, sulfate, and iron). These individual standards are also enforceable in California.

Some bottled water companies follow the tap water creed that the best tasting bottled water should taste clear and fresh and be free of all tastes and odors. Other bottled water firms believe certain natural or added minerals or carbonation is required. Consumer Reports of August 2000[3] rated bottled water on the basis of taste and odor, and presented information that plastic containers can cause off-tastes and odors (See Sidebar 5). PET bottled waters generally tasted better than HDPE bottled waters, even within the same brand. The PET bottle usually cost more. Off-flavors in bottled water can occur by reaction of the ozone disinfectant with chemicals in the water, the bottle or the cap. Also, as for tap water, off-flavors can occur if the raw water is not sufficiently treated to remove any off-flavor chemicals if present.

Taste is a personal decision. If all the water standards are met for purity of the tap or bottled water, and a consumer likes the taste of a bottled water versus the tap water, they will spend their extra money to buy it. Drinking water with a chlorinated taste may be the key decision point.

CONSUMER CONFIDENCE REPORTS

Beginning in 2000, drinking water purveyors in the U.S. provided to their consumers the public right-to-know, "consumer confidence report" (CCR). This landmark provision of the U.S. Safe Drinking Water Act Amendments was passed in 1996. In California, the CCR has been available since 1989, as the California Annual Water Quality Report. The CCR should reflect good management practice and address the public's need to know. Southern California CCRs present a general description of how well the water purveyor is meeting EPA standards, what this means for consumer safety in understandable terms, a candid discussion of the local water quality issues, and how the purveyor is addressing them. This allows the utility to advertise in a most professional manner. The growth of the bottled water industry clearly indicates that drinking water is a major health and aesthetic concern to consumers and needs to be addressed candidly in the CCRs for tap water.

Sidebar 5: Bottle Types and Corresponding Effects on Flavor and Health

PET (PETE)—Polyethylene Terephthalate—A clear strong plastic that can leave a "faint sweet or fruity plastic flavor". Ozonation of the water sources before bottling can form the sweet or fruity odor by forming a series of aldehydes. Also ozone or other disinfectants can release plastic odors from the container walls. Carbonated waters are usually bottled in PET probably because of more stability to a lower pH product.

HDPE (High Density Polyethylene)—An opaque, flexible material used in milk containers. Ozonation of the water sources before bottling can form a "slight melted plastic taste". Taste can be affected by excessive heat or flavors from nearby food.

Polycarbonate—A strong and rigid bottle that has been specifically singled out by the California regulations as a problem. Polycarbonate bottles should not contain in excess of 3 ppm methylene chloride or in excess of 200 ppm chlorobenzene. This translates to a 1 ppb limit in drinking water. Bisphenol A, a potential residue was seen in lab studies.

The FDA recommended in the Federal Register in August of 2000 that bottled water companies provide information on their product similar to that required by the CCR's that EPA requires for tap water. Some of the information could be provided on product labels, while the remainder could be obtained by phone/mail or on the web. The FDA report states that information on source of the water and method of treatment is of particular concern for consumers. Future regulations are being considered for requiring source, treatment and water quality information. This authors urges that this recommendation be made into law to protect and inform the public.

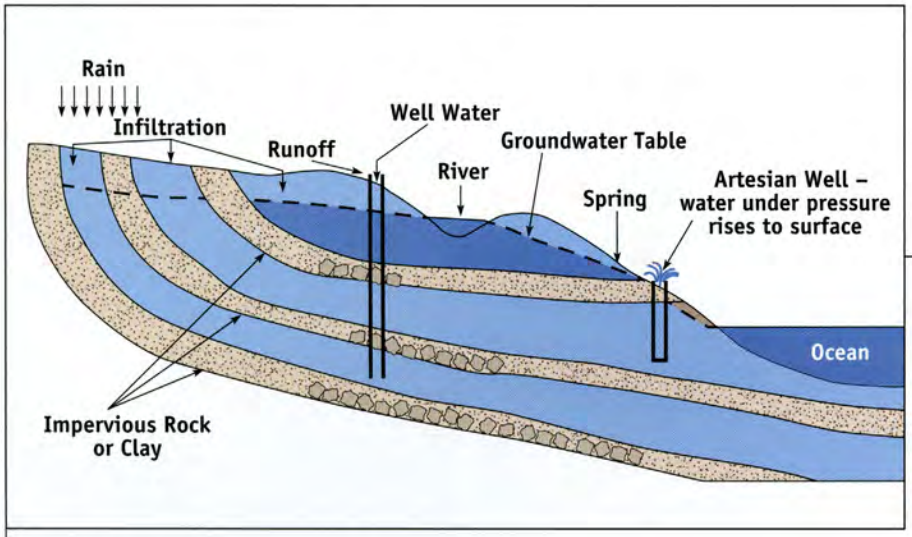

Figure 3: Groundwater supplies for drinking water

This author also recommends that if soft drinks and beer beverages have bottling dates and expiration dates; why not bottled water? Many people would not drink an out-of-date beverage; why should they drink an aged bottle of water? All beverages that reach the market are subject to potential storage problems, (e.g., hot warehouses). Dates are needed on the shelf life of bottled water to indicate safety. Some bottlers state expiration dates voluntarily.

Do you leave bottled water in the car after taking a sip and in the following days drink more of that water? Do you realize that under these conditions in a hot Southern California car, the plastic container can leach chemicals or bacteria can grow in the bottled water? A labeling statement could be added on bottled water, as on other drinks, to "refrigerate after opening," to protect consumers from potentially excessive microbial growth and chemical contamination.

HOW WELL ARE WE DOING?

Safe, inexpensive drinking water is considered a right by most U.S. citizens. Inexpensive drinking water will depend upon maintaining our natural water resources and minimizing microbiological and chemical contamination. However, the general public must be part of the debate of how to maintain water resources, how much to pay for new water treatment options, and how to help define what is good water quality.

People are voting with their purses and wallets when they buy bottled water. The common preference for bottled water seems convenience and aesthetically based: better taste and less odor, especially from chlorine. There is also a perception of greater safety, with an assumed lower concentration of microorganisms and chemical pollutants. However, tap water costs less and is at least as safe as bottled water. In fact, in the U.S.A., tap water drinking water standards are more rigorous than bottled water standards for chemicals. In California, Cal DHS-FDB standards are about as rigorous. Water purveyors should value tap water the same as any essential food product, and address off-flavors with the same effort as meeting drinking water standards.

Tap water costs less and is at least as safe as bottled water.

GRADES

The Cal DHS-FDB is graded **A** for proactively developing standards and licensing bottled water sold in the state. It is the author's observation that more on-site inspections are needed for bottled water plants. The MWD is given a grade of **A** for developing technical solutions to minimize off-flavors in their drinking water but a **C**, along with DWP, for not successfully advertising their product and addressing the consumers perception that tap water is less safe than bottle water. The city of Long Beach is given an **A** for trying to address the issue of the perception of tap water safety by supplying bottled water from the same source. The consumers thus

Like tap water, bottled water has its problems, as evidenced when bottled waters have been recalled from supermarket shelves.

have a healthy choice of safe water with or without a chlorine flavor.

The bottled water industry is given a grade of **C** for minimizing the information presented to the consumer about the source and purity of their product. For example, some of the bottled water industry does not have bottling dates and expiration dates on their product, has not developed a CCR system similar to the tap water industry, and has not uniformly provided the source of bottled water. The bottled water industry is graded **A** for effective advertising of their products. The FDA is graded **C** for not yet developing standards as rigorous for bottled water as the EPA's Standards for chemicals in tap water.

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Mel Suffet has been a Professor in the UCLA Environmental Science and Engineering Program and Environmental Health Sciences Department in the School of Public Health since 1991, after 20 years as a Professor of Environmental Chemistry at Drexel University. Dr. Suffet has conducted research on aquatic chemistry in the laboratory and in numerous field studies resulting in more than 150 research publications and seven edited books. He received a Ph.D. from Rutgers University, an M.S. in chemistry from the University of Maryland and a B.S. in chemistry from Brooklyn College. Dr. Suffet has received the American Chemistry Society Zimmerman Research Award, Drexel University's Research Achievement Award and the UCLA Public Health Student Association's Distinguished Teaching Award. Professor Suffet's research emphasizes chemical analysis and elucidation of how organic compounds that are hazardous, or cause off-odors in the environment, interact in natural aquatic or water treatment systems. His current research includes: treatment of MTBE by activated carbon water treatment, the fate of carcinogens and pesticides in storm water runoff into Santa Monica Bay, an understanding of resuspension of hazardous chemicals the cause of off-flavors in drinking water distribution systems.

About the UCLA Institute of the Environment

MISSION

The UCLA Institute of the Environment (IoE) is an academic unit devoted to interdisciplinary research and teaching focusing on key problems of the environment. The Institute is composed of faculty from a broad range of disciplines—the physical, life and social sciences, public policy, engineering, law, architecture and urban design, business, and public health and health sciences—working together to understand the nature of complex environmental systems, and to provide information for policy development and implementation.

GOALS

The principal goals of the Institute of the Environment, simply stated, are to:

1. Develop a world-class, broadly interdisciplinary environmental research and teaching program that addresses interrelated science and policy issues creatively and in-depth.
2. Support and extend continuing environment-oriented activities at UCLA, and in the community at large, by providing access to expert advisors, resources, and infrastructure.
3. Provide leadership in environmental problem solving that is based on science and technology with social consciousness and sensitivity.

TEACHING

The Institute of the Environment enhances the experience of undergraduate students by introducing them to many aspects of the environment within a broad yet consistent framework. Classroom work is augmented by student contact with the Institute's diverse research programs, including fieldwork at remote UCLA facilities such as the Stunt Ranch Natural Reserve in the Santa Monica Mountains and the Ocean Discovery Center at Santa Monica Bay. Graduate students participate directly in a wide range of ongoing research projects, both in the field (at Point Mugu Lagoon, for example) and in the laboratory, including "wet" experimentation, computer modeling, and geographic information systems applications.

The Institute is currently developing a series of multidisciplinary courses at all academic levels. Environmental Minors are being organized in several key areas, including environmental systems and environmental policy. A graduate degree program is in the planning stage.

RESEARCH

Institute of the Environment faculty, research scientists and students conduct a broad range of multidisciplinary investigations, all of which have an environmental theme, and many of which focus on Los Angeles and Southern California. For example, the Institute's Los Angeles Watershed project involves more than a dozen faculty from eight

UCLA Institute of the Environment

campus units, and seeks to understand the sources of pollutants in Santa Monica Bay and other coastal waters. Another program aims at air quality; its centerpiece is the Southern California Particle Center and Supersite, currently the largest university-based air pollution research project in Los Angeles.

Other research initiatives include:

- An Intel-sponsored Regional Environmental Assessment Laboratory and Geographic Information System (REAL/GIS) laboratory, in which integrated analyses of regional environmental problems are carried out.
- An EPA-funded project to identify the airborne sources and patterns of pollutant deposition to Santa Monica Bay for water quality management purposes.
- Various research projects focused on wetland characterization and remediation in Lower Malibu Creek and Lagoon, at Mugu Lagoon, and in Newport Bay.
- An Integrated Coastal Ocean Science and Management project, including the international Reef Check program, as well as ocean circulation and biogeochemical modeling along California's coast.

OUTREACH

The Institute of the Environment is reaching out to the community in a number of ways. The Southern California Environmental Report Card provides an annual assessment of the state of the local environment. Through the GLOBE in the City program, the Institute brings environmental science directly to K-12 classrooms across Los Angeles. The project recently teamed with the California Air Resources Board to set up air quality learning sites on school campuses. Seminars and colloquia are also sponsored, at which divergent interests and talents converge. In 1999, the Institute hosted the National Conference of the Society of Environmental Journalists. Topical events have included, "Environment, Commerce and Opportunity," "California's Biodiversity Crisis: The Loss of Nature in an Urbanizing World," "The Electric Vehicle: Retrospect and Prospect," and "Chimpanzees, Our Next of Kin: Language, Ethics, Conservation." In September, 2001, a major international conference on "Experimental Approaches to Conservation Biology" took place at UCLA with support from the IoE.

LOOKING AHEAD

Over the next few years, the Institute of the Environment will consolidate its interdisciplinary activities in teaching and research, and continue to support environmental initiatives throughout Southern California. We expect six new faculty to join the Institute in the next year or two. They, along with current members, will launch major projects in the areas of Tropical Ecology and Conservation, Coastal Ocean Resource Management, Air Quality Forecasting and Mitigation, Integrated Watershed Assessment, and Environmental Science and Policy. An undergraduate minors program is already underway, and a new graduate program that cuts across environmental disciplines is being proposed. The Institute will also publish a unique all-electronic journal of environmental research, *eNvironment*, in collaboration with the California Digital Library. This journal will eventually serve an international community.

RC 2000 Revisited

DRINKING WATER QUALITY

We are very pleased that our efforts to prudently proceed with advanced treatment technologies on a business-wise basis has earned Metropolitan high marks in the eyes of UCLA's Institute of the Environment. We also take to heart the B+ for our annual water quality report, while we make changes in the way we approach public involvement in decision making to improve our C grade in that area.

As we have gone through the process of redefining our agency's way of doing business, we are focusing on water quality more directly and are devising better methods to include public participation and input. By starting to listen carefully to our stakeholders, we are doing things very differently than we have in the past.

From our well-attended and well-covered workshops on climate change and the impacts of energy deregulation, we are trying to cultivate a more interactive and open culture at Metropolitan that is in tune with the concerns of our customers.

Joseph Tait
Executive Vice President and
Chief Operating Officer
Metropolitan Water District

It was good to see the L.A. Aqueduct Filtration Plant used as an example of U.S. drinking water treatment, getting an "A" for use of advanced technology. Although we did not score as well on our Consumer Confidence Report, we are committed to involving the public in many areas of decision making involving treatment and community master planning.

Reaching out to the larger populace is our goal in preparing a new Public Health Goal (PHG) report by July 2001 that will address contaminants and health issues that you identified in your RC 2000 article.

Gary Stolarik
Engineering Manager
Los Angeles Department of
Water and Power

I had the opportunity to read your excellently written paper about water quality. It is concise and very informative. My only concern is the assessment of DWP's consumer confidence report. Last year, we had a total make-over of our report for the calendar year 1999. Instead of a bill insert format, we distributed a full magazine-size report that includes not only the DHS required text and tables, but also pertinent consumer information about water quality issues, DWP programs. consumer notices, regulations, and things consumers can do to protect water quality. We even had a consumer survey using a reply card asking our customers what they think of the report, water quality, use of bottled water and home treatment devices. Judging from the unexpected number of responses (over 10,000) I would say it was quite successful and it opened another form of communication with our customers.

Cesar Vitangcol
Regulatory Affairs and Consumer Protection
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Southern California
Environmental Report Card 2001
UCLA Institute of the Environment

RC 2001

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