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Emerging Issues in Public Policy: The Environment, Water, and the Coast, 1977-1982

Institute of Governmental Studies

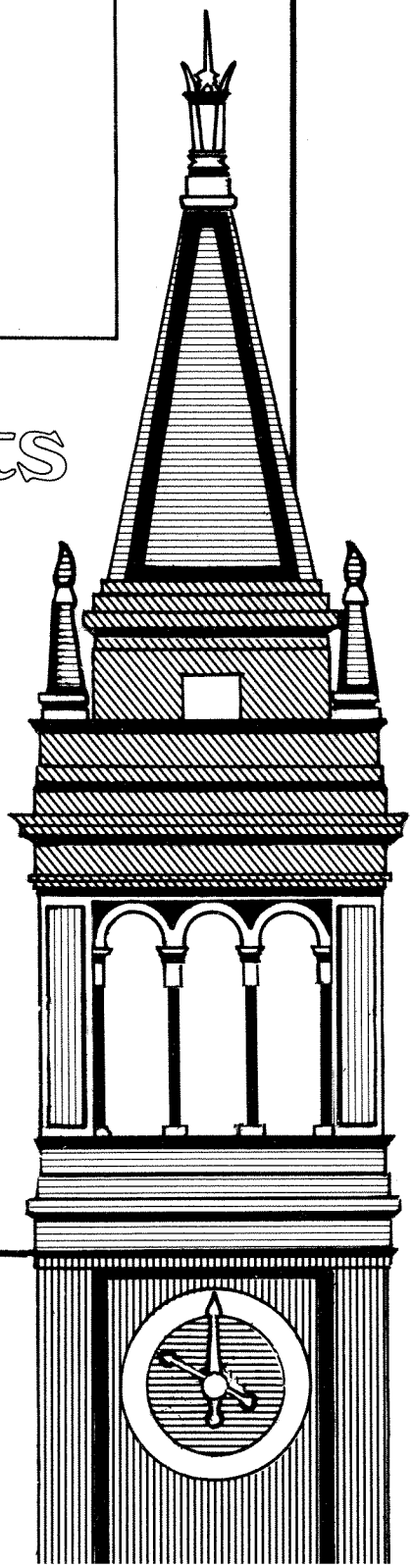
Emerging Issues in Public Policy:

THE ENVIRONMENT, WATER,

AND THE COAST

1977-1982

Research Reports and Essays



a collection of
Public Affairs Report
bulletin of the
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Harriet Nathan and Stanley Scott, editors

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INSTITUTE OF GOVERNMENTAL STUDIES

Eugene C. Lee, *Director*

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The professional staff includes faculty members holding joint Institute and departmental appointments, research specialists, librarians, editors, and graduate students. In addition the Institute encourages policy-oriented research and writing efforts by a variety of faculty members and researchers not formally affiliated with the staff. The Institute is also host to visiting scholars from other parts of the United States and many foreign nations.

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These programs and publications are intended to stimulate thought, research and action by scholars, citizens and public officials on significant governmental policies and social issues.

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Contents

Foreword

This collection, titled *The Environment, Water, and the Coast*, presents a selection of the Institute's *Public Affairs Report* on these topics for 1977-1982. Additional selections for the six years are being issued under the titles, *Health and Education; Urban Issues, Growth, and the Economy*; and *Politics, Government, and Related Policy Issues*. These subject-matter groupings depart from our previous format, which collected in a single volume *all* articles published in a span of several years, regardless of topic. The three earlier collections covered 1960-65, 1966-72, and 1973-76. The new format was adopted to allow readers to choose among subjects in selecting those of particular interest.

The *Public Affairs Report* is the Institute's official bulletin, published six times yearly since 1960. One of its principal purposes is to provide a vital link between academic research and public policy decisions facing California and the nation. Each issue features a brief, self-contained article/essay presenting the author's research findings, and usually discussing views and opinions on significant policy issues. The writers include University faculty and staff, as well as non-University experts. Findings and ideas are expressed in nontechnical language, for an audience that includes policymakers, academic faculty, researchers, students, and a large number of informed and interested citizens, many of whom indicate they find the articles a valuable resource.

Publication standards are rigorous. Before final acceptance, each manuscript is read by an expert review committee comprising both faculty members and practitioners. After revision, all qualifying articles are then edited for accuracy, clarity and style, and a bibliographic check is run on footnotes and references.

These four subject-matter compilations now being published join the three earlier chronological collections in providing readers a convenient reference source of these significant public policy essays.

Harriet Nathan and Stanley Scott
Editors

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MANAGING THE BAY AREA'S ENVIRONMENT: AN EXPERIMENT IN COLLABORATIVE PLANNING

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Introduction

The San Francisco Bay Area is mid-stream in a complicated process of planning for environmental protection and considering the consequent social and economic impacts. Paradoxically, the effort's principal hope for success seems to rest on its complexity and its heroic scale. Fuelled by federal funds, the collaboration brings together representatives of most of the governmental bodies in the 9-county region who are concerned with environmental matters, as well as citizen participants representing "the public." The Bay Area's leadership is in effect trying cooperation and innovative methods to accomplish effective environmental planning and plan implementation.

Earlier planning efforts and growing environmental awareness emphasized the many interconnections among problems. Thus it became clear that environmental quality depends on factors like land use and population distribution; design and location of housing, industries and businesses; and transportation methods and movements. Also crucially important are preservation or loss of nonintensive "natural" uses such as agriculture; regional parks and open spaces; hills, mountains and forests; and the Bay itself.

Confronted with these justifications for comprehensive plans, the region's response was halting. The Association of Bay Area Governments (ABAG)* tried its hand at overall planning but lacked power to implement. Each of the Bay Area's special purpose agencies had implementing power, but only for its own function and area. The very names of major regional bodies emphasized their functional scope and related limits:' Bay Area Air Pollution Control District; San Francisco Bay Regional Water Quality Control Board; Metropolitan Transportation Commission (MTC); and the San Francisco Bay Conservation and Development Commission (BCDC).

Improved regional machinery for comprehensive environmental planning was sought many times in Sacramento. So far, legislative efforts at such structural reform have not succeeded. The most prominent examples are the succession of regional "Knox bills" for the Bay Area (introduced in the California Legislature by Assemblyman John A. Knox of Richmond). The most recent Knox proposal would have established a single 9-county comprehensive regional agency for environmental planning and policy implementation. Despite their failure, these regional bills received substantial support from the Bay Area leadership and several seemed on the verge of passage. Although the measures fell short of enactment there is growing agreement that federal-state-regional environmental, social and economic objectives cannot be reached by ad hoc devices alone. In fact, some observers see separate, single-purpose agencies as compounding difficulties by generating a second level of problems related to policy coordination and implementation.

Seeing the failure of the Knox bills, Bay Area leaders explored other avenues. Meanwhile, state and federal initiatives have encouraged and required new methods of managing environmental problems. One of the most significant for Bay Area planning is the federal "208" program, made possible by new federal policies.

Recent Federal Laws: New Approaches

Growing public concern has brought greater sophistication in the federal government's approach to environmental protection. Thus several federal laws have sought stronger environmental controls, especially the two most important statutes, the Clean Air Amendments of 1970 and the Federal Water Pollution Control Act Amend-

* Several of the acronyms most frequently used are listed at the end of the paper.

ments of 1972.[2] Moreover, the National Environmental Policy Act (NEPA) of 1969 required a wide range of impact studies and statements on major projects affecting the environment. As for solid waste management, the progressive name changes of federal laws also reflected new approaches: from simple waste disposal (the Solid Waste Disposal Act of 1965), to recycling (the Resource Recovery Act of 1970), to more general conservation of materials otherwise lost in solid waste (the Resource Conservation and Recovery Act of 1976).

Under these and other acts, the national goals — ending water degradation by 1983 and providing cleaner air as "expeditiously" as possible (an interpretation of the 1977 deadline) — required the use of more stringent regulation and higher standards for pollutants discharged into the nation's air and water. For example, earlier water pollution control laws were weakened by using *receiving* water ("ambient" water) standards for enforcement, rather than *discharge* standards.[3] Since ambient standards specify a permissible quality level for an entire body of water, it is hard to link violations to the discharges of any one polluter.

Accordingly, the following are now required:

(1) controls over the quality of liquid wastes and polluted water discharged from *point sources* (e.g., municipal and industrial treatment plants) as well as *nonpoint sources* of water pollution (e.g., runoff from farms and city streets), the principal focus of Sec. 208 planning; and

(2) control of air pollutants at the places they are emitted (emission controls), and consideration of indirect sources of air pollution (e.g., land uses such as highways, shopping centers and other facilities that attract mobile sources of pollution).

The Federal "208" Program: A Brief Overview

In short, the Federal Water Pollution Control Act Amendments of 1972 provided an integrated program that gave the federal government major regulatory authority to control water pollution, a function previously considered the principal responsibility of state and local governments. Sec. 208 was by far the legislation's most important planning provision. Its purpose was to develop programs and harness resources needed to achieve a major water quality goal, i.e., "fishable and swimmable" water by 1983. It also required the use of land-use controls and other regulations in limiting pollution from point and nonpoint sources. Finally, 208 called for broad regional analysis of pollution problems, especially the study of future growth and its implications for water quality.

Other important sections included, for example, Sec. 201, which mandated planning, economic and engineering studies for construction of waste treatment facilities. Sec. 303 provided for (a) basinwide planning (covering a large area, e.g., a river basin drained by a river and its tributaries), and (b) water quality control, including regulating the quality of discharged wastewater. Sec. 402 required a permit system for wastewater discharge.

The federal Environmental Protection Agency (EPA) issued guidelines and regulations to help the states select areas whose water quality problems were most likely to require Sec. 208 planning. In 1975, when California's Governor named the State Water Resources Control Board to administer the 208 program, the board conducted hearings and, with the concurrence of the EPA, selected the Bay Area as one of seven California regions to receive priority attention. The choice was based on several considerations: the Bay Area's concentrations of population and industry and conditions adversely affecting water quality as shown, for example, in polluted shellfish beds in the relatively shallow South Bay. Further, there was evidence of major problems in solid waste management. Moreover the region had previously been designated an air quality maintenance area (one with critical pollution levels).

The state water board also named the Association of Bay Area Governments, a 9-county Council of Governments, as the "208 planning agency," i.e., the body responsible for carrying out the provisions of Sec. 208. The EPA then granted $4.3 million directly to ABAG, which established an Environmental Management Task Force (EMTF) currently composed of 45 members including elected local officials and representatives of the public and special interest groups (discussed below).

The program's timetable calls for seven plans, for: surface runoff; industrial discharges; municipal facilities; miscellaneous sources; water conservation, reuse and supply; air quality; and solid waste management, all to be ready by August 1977. This version will be a discussion document, a preliminary Environmental Management Plan (EMP). In the Bay Area, air quality is tied to 208 water quality planning, and EMTF's goal is also to reach and maintain federal and state air quality standards "as expeditiously as practicable." Accordingly, a management structure must be designed that will be capable of on-going planning and implementation.

As they push the plans along, officials are reminded that all 208 funds are to be used "not to make a study or report but rather to develop" an environmental management system "integrated with all Bay Area regional and local planning programs."[4] Clearly, such a directive implies a high level of cooperation among local, regional, state and federal agencies, and willingness to negotiate.

The following discussion briefly treats some earlier planning efforts related to Bay Area concerns, and summarizes the roles of local governments, ABAG, and the state and federal governments in the Bay Area's environmental protection. The focus then turns to ABAG's Environmental Management Task Force, reviewing regional planning efforts in the interest of air and water quality and solid waste management. Finally, the discussion attempts to provide both an interim assessment and possible guideposts for future evaluations.

Lessons from the Past and Evolution of New Efforts

In the past half century the San Francisco Bay Area

has seen the establishment of many agencies in response to environmental problems, but these single-purpose efforts suffered from uneven performance, as well as jurisdictional and functional limitations. Creation of single-purpose agencies has continued, but policymakers have also considered proposals for more comprehensive regional environmental governance, as noted earlier. Some would have had substantial powers, including regional land use controls, but none became law.

The 208 effort, seen as an alternative to the regional bills that failed, evokes serious questions such as these:

> If we are going to come out of this 208 process with a different set of rules for land-use decisions. . . won't someone or something have to change? . . . If we just rearrange the same old pieces of the governmental puzzle, will it make a new and better picture?[5]

Despite some misgivings about implementation, there is substantial agreement that the three major Bay Area problems in the EMP assignment — air and water quality and solid waste management — must be addressed *together* and that those problems have been intensified by the absence of common policy. Time constraints will force the EMP to focus first on technical, short-run preventive measures, designed to arrest and reverse harmful practices. Further in the future lie such considerations as major new regional policies for land use and transportation. Meanwhile, the EMP goal is to win conditional approval for an on-going planning and implementing mechanism.

As EPA regional administrator Paul De Falco, Jr. commented:

> . . .the existing water quality institutions. . . are taking pollution control as far as technology will carry it. But the problems that remain require programs that involve major *public policy choices regarding life style, land use, resource use and conservation, growth and tax base, and equity in the distribution of benefits and costs. . . .* [emphasis supplied][6]

De Falco further noted that:

> . . .the Clean Air Act requires land use and transportation controls to reduce growth in auto emissions to. . . maintain. . . air quality standards.
>
> It has become clear. . . that in some of our major metropolitan areas, such as Los Angeles or the Bay Area, the *long term solutions to the air quality problem must be solutions to the area's land use and mass transit problems. . . .* [emphasis supplied][7]

Consequently, implementation of the EMP may focus on both immediate and future improvement of water and air quality and solid waste management through back-up measures. These relate to controls by other agencies, and take into account the implications of land use and transportation. Note that air quality is included in the Bay Area's 208 program because the EPA regional administration's interpretation held that such inclusion would help promote integrated planning in the region.

Federal Initiative and Local Responsibility

While much of the Bay Area program's impetus comes from federal policy and funds, "208" is regarded primarily as a state and regional program requiring coordination among levels of government, the "critical element being local government and the people and interests it represents."[8] Implementation at all governmental levels is stressed, but major responsibility is assigned to local and regional bodies. To involve local citizens and governments, ABAG is allocating nearly $1 million in "pass through" 208 funds for local preparation of surface runoff plans, review of policies on land development, and efforts to stimulate citizen participation.

With respect to the regional approach, George Hagevik of the ABAG staff, noted that the authors of the Federal Water Pollution Control Act Amendments of 1972 sought to foster comprehensive regional agencies that could implement 208 mandates; but their intent was not realized. As for the possibility of creating a comprehensive regional agency in the Bay Area empowered to implement the EMP, Hayward Mayor Ilene Weinreb, chairperson of an ABAG policy committee, commented that the "Bay Area might be ready for such a move" after the 208 process is complete. She thought cities, counties and special districts probably would not "give up powers unless forced to do so," and suggested that agency leadership and ABAG staff meet to "look into ways to combine separate permit procedures" and administration.[9]

Dianne Feinstein, a San Francisco County Supervisor who chairs the EMTF, acknowledged that environmental decisions are political choices — tradeoffs — made by locally elected officials working together. She stressed the politics of plan implementation, and described local regional responsibility as the willingness to take appropriate actions to solve environmental problems.[10]

Focus on Three Critical Problems

Under the federal water pollution laws, EMTF planning will attack significant problems of air and water quality and solid waste management. Examples of *water quality problems* as outlined in a 1976 ABAG report include: (1) polluted Bay Delta outflows including contaminated agricultural drainage; (2) polluted runoff and overflows from sewage treatment plants that endanger water supplies; (3) significant annual fish kills; and (4) contamination in parts of the Bay, requiring bans on harvesting of shellfish.[11]

The ABAG report also outlined critical *air quality problems*, including such interrelated matters as (1) failure to meet air quality standards, especially in the Livermore and Santa Clara valleys (where federal and state standards were exceeded at least 90 days in 1975);

(2) pollution from stationary sources such as service stations; and (3) other motor-vehicle related pollution.

In addition, the report described the Bay Area's *solid waste management* problems including: (1) more than 10 million tons of unsightly, environmentally disrupting wastes produced annually in the region, with most current sites likely to be filled within less than 10 years; (2) pollution caused by disposal sites located near ground and surface waters; and (3) lack of regional management programs for disposing of hazardous and toxic wastes.[12]

ABAG's Selection for the 208 Assignment

ABAG was formed in 1961 to bring together cities and counties on a voluntary basis to deal with mutual problems. Since 1964 it has engaged in regional planning studies supported principally by federal funds under a variety of programs. This effort resulted in ABAG's existing Regional Plan, a policy guide for 17 different functions related to the region's environmental, social and economic well-being.[13]

A combination of desirable structure and effective performance gave ABAG visibility as a likely candidate for the 208 planning job. First, most 208 agencies nationwide are Councils of Governments (COGs). Further, like other COGs, ABAG had federal authority for the A-95 grant review, covering local governments' applications for nearly 200 federal aid programs. ABAG had made vigorous use of its discretionary review powers, particularly with respect to wastewater developments (sewage connections). Finally, ABAG had worked effectively against an ill-advised Las Positas "new town" proposal in smog-prone Livermore Valley.

When the time came to establish the scope of 208 planning and designate the 208 agency, the State Water Resources Control Board at first appeared reluctant to select ABAG. In any event it sought to limit 208 planning to two relatively tiny sub-areas: Richardson Bay in Marin County, and the Livermore Valley in Alameda County. When the EPA pressed for a larger scale, 208 planning was expanded to include virtually the entire drainage basin of San Francisco Bay, and the state water board agreed to ABAG's designation. Thereupon most of the 9 Bay Area counties passed resolutions of intent and all signed contracts to participate with ABAG in the 208 effort.

EPA's Special Interest in the Bay Area's Program

EPA had designated one hundred and seventy-six Sec. 208 programs nationwide by February 1977,[14] but in some ways the Bay Area program is unique. For example, Harry Seraydarian, 208 project officer for EPA Region IX including the Bay Area, noted that:

> Many agencies began before ABAG, and the earliest 208 plans concentrated largely on point sources of water pollution. The institutional analyses conducted for these studies were often rather mediocre, whereas financial analyses were sometimes more innovative. . . . [these] agencies which began work in advance of ABAG are not really ahead in concept, and. . . may need to look at ABAG's work instead.[15]

He suggested that several other combinations of characteristics were "not found in any other 208 program," including the degree of local governments' involvement, the complexity of the 9-county governmental network, the considerable industrial development ringing the Bay, the area's interest in comprehensive approaches, and the primary emphasis on implementation.[16]

According to Seraydarian, the older 208 programs (funded in 1974) and the Lake Tahoe 208 program (funded in 1975) lacked adequate money and had only interim guiding regulations. Further, tight schedules forced the use of consultants instead of regular staff, limited program and planning efforts, and worked against continuity.

The Bay Area 208 program, funded in 1975, benefited from a subsequent court-ordered release of 208 funds nationwide. Along with other financing, 208 monies had been impounded by the Nixon administration. The 1972 act also intended that plans for location of local waste treatment facilities under Sec. 201 proceed simultaneously with Sec. 208 and consider its land use planning implications. But all except two of the area's current 201 projects are already located and exempt from EMTF's initial 208 planning. All future 201 projects, however, must be included in the EMP, and approval of future federal grants for construction of treatment facilities is contingent on their conformity with the 208 plan.[17]

Court action also mandated a final completion date of November 1978 for the Bay Area's and all other 208 plans in the country. Finally, the court required EPA to issue improved regulations and policy statements; these were made available to 208 projects by November 1975.[18]

Organizing ABAG's Environmental Management Task Force

In September 1975, the Air Resources Board established a 9-county Air Quality Maintenance Planning Task Force to provide assistance in meeting court-ordered federal clean air requirements. The following January, ABAG modeled the 208 Environmental Management Task Force on the air quality group and included most of its membership. Headed by Supervisors Dianne Feinstein of San Francisco and John Tuteur of Napa, EMTF's membership of 45 includes city and county elected officials[19] and representatives of business, labor (especially the building trades), ethnic minorities, agriculture and civic and environmental groups.

Seven regional agencies are also represented: the Bay

Area Air Pollution Control District, the Central and the North Coast Regional Coastal Zone Conservation Commissions, the Metropolitan Transportation Commission, the San Francisco Bay Regional Water Quality Control Board, the San Francisco Bay Conservation and Development Commission and the East Bay Municipal Utility District. In addition, one person represents the Sub-Regional and Local Advisory Committee for the San Francisco Bay Area Wastewater Solids Study Group — a joint powers agency preparing a residuals (sludge) management plan for sewage dischargers.

In pursuing its work, the task force has established several technical advisory committees as well as four principal subcommittees for (1) work program and budget, (2) plan implementation, (3) assessment procedures (to look into social, economic and environmental effects of carrying out the EMP) and (4) public participation. As noted earlier, it was suggested that ABAG look into ways to combine the administration of regional agencies. In a small first step, an interagency management committee was established — with management personnel from ABAG, MTC and the Bay Area Air Pollution Control District — to meet every two weeks to review progress on the air planning element.

The 208 Environmental Management Plan

An EMTF staff report outlined the status of the Environmental Management Plan as of January 1977:

> *Surface Runoff:* Contracts have been signed with. . . [Bay Area] counties to prepare surface runoff plans. . . . Pass-through grants from ABAG will fund the planning effort and public participation.
>
> *Air Quality Maintenance Plan:* A base year of 1975 has been selected for air quality data input and LIRAQ [Livermore Regional Air Quality Model, designed by the University of California's Lawrence Livermore Laboratory] will be used as the prime computer model for developing this plan.
>
> *Solid Waste Planning:* County solid waste plans have been reviewed. . . as the basis for the solid waste portion of the EMP. An attempt will be made to integrate the State Solid Waste Board's study [Bay Area Solid Waste Management Project] and the county plans.[20]

As noted earlier, provisions for implementing the EMP may focus on both immediate and future changes:

(1) improvement of water quality, by (a) back-up measures promoting cleaner waste discharges and construction of treatment plants, (b) related measures like street sweeping and containment of dairy wastes to reduce runoff pollution, and (c) controlled location of new sewage facilities that indirectly allow addition of pollutants from industrial and housing developments;

(2) improvement of air quality, through (a) back-up measures promoting cleaner emissions, and (b) indirect means such as improvement of transportation facilities with consideration of motor-vehicle-related pollutants linked to developments, e.g., shopping centers with large parking lots; and

(3) improvement of solid waste management, through better practices such as (a) improved methods of disposal, especially of hazardous wastes, and (b) coordinated site location.

When the initial Environmental Management Plan is ready, ABAG will recommend to the Governor and to EPA (a) the methods of regulation, (b) the agencies to carry out the plan, and (c) the manner of funding. The plan will also specify the agencies that will be eligible for future water quality grants. Moreover, the total plan will be incorporated into ABAG's Regional Plan for future Bay Area urban and regional growth.

Processing the Plan

ABAG and the EMTF have designed a complex approval process for the Environmental Management Plan, including informational notice and review by affected parties, followed by action and approval. *Notice and information* consist of (1) sending an integrated draft plan to affected parties; (2) allowing up to 30 days for EPA review and comment by local governments including special districts, and informal review and comment by all other interested parties (federal, state, regional and local agencies and the public); and (3) in early 1978, presentation to the ABAG General Assembly and to regional agencies.

Action and approval include (1) hearings and approval by EMTF and ABAG's Regional Planning Committee; (2) public discussion and approval by ABAG's Executive Board; (3) approval by ABAG's General Assembly, tentatively scheduled for April 1978; (4) certification consideration by the State Water Resources Control Board by June 23, 1978; and (5) review and possible final approval by EPA by November 1978.

Federal Funds and State-Directed Water Quality Programs

The Bay Area's 208 water quality planning is not starting de novo, but builds on prior efforts by such agencies as the State Water Resources Control Board, the San Francisco Bay Regional Water Quality Control Board, the U.S. Army Corps of Engineers, EPA and the Bay-Delta Water Quality Control Program (completed in 1969), and by local agencies concerned with discharged wastes. Further, in addition to 208 planning, federal funds support several related state-directed water quality programs in the Bay Area. They include (1) *basin planning for water quality* (Phase 1 was adopted in 1975 as the S.F. Basin Water Quality Control Plan and may be amended by the 208 plan); (2) Sec. 201 *planning for*

waste treatment, as a basis for locating future sewage facilities and allocating future federal construction grants; and (3) continuing *waste discharge permit programs* under the National Pollutant Discharge Elimination System.[21]

State and Regional Authority Over the Area's Water Quality

The State Water Resources Control Board and the 9 regional boards have authority over California's water-pollution control programs. Before the 1972 federal program came along the state board had already taken responsibility for regional basin planning. In its first phase under the 1972 law, the Bay Area's basin plan dealt with water quality, and the nature and volume of discharged wastes acceptable under federal standards. It set priorities for constructing and modifying treatment plants to meet regional needs. Recognizing urban and nonurban runoff as heavy contributors to pollution, it did not yet identify this condition as a problem. Instead, the main thrust was to specify treatment levels that would protect "beneficial uses" of the Bay, its tributaries, and the region's ocean waters from pollution by discharges at specific locations (point sources), e.g., industrial or municipal sewage outlets.

As the second phase of basin planning begins, pollution problems are being addressed from additional quarters: ABAG's EMTF is focussing on surface runoff in urban and nonurban areas, and the implications for land use. 208 planning will also deal with miscellaneous sources of pollution, such as wastes discharged from water-borne vessels, oil spills, septic tanks and salt water intrusion. Finally, ABAG will recommend basin plan amendments to the regional and state water control boards. When the EMTF's Environmental Management Plan is completed and it has won EPA approval, under the 1972 law it will then have a life of its own.

The object is to provide adequate water quality for recreational use and aquatic-life protection by 1983. California anticipates reaching this goal through the combined contributions of the state's 208 programs, the construction of wastewater treatment facilities, and the operation of its permit program to control pollution sources.

An Intergovernmental Program for the Region's Air Quality

Air quality planning — one of the EMTF's three functional assignments — will continue and complement the work of the California Air Resources Board (ARB), the Bay Area Air Pollution Control District, ABAG and EPA. Several regional bodies, including the MTC and the air pollution control district, will help EMTF with air quality planning. If, however, the resulting plan fails to win ARB approval, under the 1970 clean air amendments either the state ARB or the federal EPA may prepare a plan for the region.

Further, EPA has the power to disapprove ARB's state implementation plan for California — which includes the Bay Area basin plan — a power it exercised in 1974. That disapproval was based on the plan's failure to designate a structure for implementation, and because emission controls were not considered effective for maintaining air quality. EPA's disapproval made the federal agency responsible for both the Bay Area and the statewide air quality programs with respect to federal standards. As indicated earlier, EPA has subsequently delegated some responsibilities to ABAG, some to ARB and some to the Bay Area Air Pollution Control District. Significantly however, ultimate authority in these matters remains with EPA.[22]

In compliance with the federal Clean Air Amendments of 1970 requiring air basin plans, the ARB has divided the state into 14 air quality regions (air basins), for the purpose of maintaining California and national air quality standards. EPA in turn, with ARB recommendations, named the Bay Area air basin an air quality maintenance area, based on findings that there are major air pollution problems in the five southern Bay Area counties (Alameda, Contra Costa, San Francisco, San Mateo and Santa Clara), with the remaining four counties (Napa, Marin, Solano and Sonoma) contributing substantial wind-driven pollutants.*

The Bay Area Air Pollution Control District's Related Activities

The Bay Area Air Pollution Control District is the region's principal regulatory agency for air quality. In recent years its measures have been tightened in response to increasing environmental concern. Thus under pressure from EPA and ARB, the district is implementing regulations to ban new stationary sources of pollution that would violate national ambient air quality standards. With ABAG it is studying trade-off measures that would permit development.

An example of the district's stronger stance is its rejection of Dow Chemical Company's proposal to build a large petrochemical complex in predominantly rural Solano County. Bolstered by ARB's pressure to consider environmental factors, in August 1976 Air Pollution Control Officer Jud Callaghan announced the district's preliminary denial of Dow's permit request:

> . . .emissions from the plant would interfere with the attainment of federal and state mandated air quality standards in the vicinity. The action was taken pursuant to the District's permit regulation [No. 2] which was adopted in accordance with state and federal requirements.[23]

In another example of outside pressure, in August 1976 the ARB responded to an EPA initiative by changing its Bay Area regulations to require that, before

* A NOTE ON TERMINOLOGY: Designation of a "state air basin" or "air quality region" does not necessarily imply the existence of pollution problems. On the other hand, designation of an "air quality *maintenance* area" means that observed pollution levels have become critical.

issuing permits, the district's control officer consider pollutants that might move to other air basins. That year, ARB also authorized $220,000 for a study of potential effects other major proposed developments would have on air quality in the Bay Delta area and the Central Valley.

In addition to the district's air regulations, and in the interest of better air quality, *transportation* measures are also being considered. Prime examples are MTC's Transportation Control Plan[24] and local parking plans like those of San Francisco, San Jose and Oakland.

Finally, in addition to these efforts to consider transportation's influence on air quality, the effects of the energy crisis and President Carter's proposed energy program must be acknowledged. In time these are sure to have major impacts on transportation and air quality in the Bay Area and elsewhere.

Solid Waste Management: The Third Program

The 1972 federal water quality act amendments and the EPA guidelines provide the framework for the EMTF's *solid waste planning,* which also coordinates work launched by California's Nejedly-Z'berg-Dills Solid Waste Management and Resource Recovery Act of 1972.[25] Although less generously funded than air and water planning, EMTF's solid waste effort will collect data on waste quantities as well as disposal sites, processes and needs. It will look at problems of hazardous and toxic wastes, and evaluate measures for recycling and recovery of resources. Finally it will take ABAG's growth policies into account in seeking to integrate solid waste policies with air and water quality programs.

Other Bay Area programs contributing to the 208 solid waste management element include: (1) individual county plans developed in compliance with the 1972 state solid waste act noted above; (2) a state-directed Bay Area Solid Waste Management Project; (3) the Sec. 201 wastewater solids (sludge) study by a group of major dischargers (the East Bay Municipal Utility District being the lead agency); (4) a study of sites for hazardous and toxic wastes, directed by the State Water Resources Control Board; and (5) the U.S. Army Corps of Engineers' management programs for dredging and for removing floating debris.

Further contributions may come from the national Resource Conservation and Recovery Act of 1976 noted earlier, although this must wait for congressional approval of funding. When implemented, the new federal act will require three types of waste disposal planning: *institutional,* to determine who does what; *regulatory,* to establish compliance controls for hazardous-waste disposal, especially on land; and planning for *facilities and services.* Presumably, this act's implementation will be coordinated with that of the Bay Area 208 program's solid waste element.

Program Review and Plan Approval

The Program Review Board is an important mechanism set up by the State Water Resources Control Board to assist EMTF and to monitor the 208 program. Meeting every two months, it brings together some of the principal policy people, including representatives of the state water resources, air resources and solid waste management boards, the state Office of Planning and Research, the regional water board, and the federal regional EPA office, with ad hoc participation by ABAG and EMTF. The group's principal contribution is probably its potential for resolving interagency conflicts. In the past, it has dealt with questions respecting 208 plan preparation, progress and scheduling, as well as representation, and coordination of multi-agency efforts.

ABAG and the EMTF have expressed concern about the power of the state water board and EPA to alter the plan after its submission for certification and approval. But the state agencies and EPA have assured ABAG that the initial plan will not be changed unilaterally. Instead the agencies will respond by indicating aspects they find inadequate or unacceptable. How the local governments and regional bodies will respond, or how they will agree on the necessary plan revisions, remains unclear.

Implementation

Noting the crucial roles of state and federal agencies in review and approval, ABAG President Lenard Grote also raised questions about the plan's implementation. He pointed out that the state air and water boards and the federal EPA actually function as "real regional governments," and that all three are "implementing law, and ABAG is not." Grote also foresaw the "distinct possibility" of state legislation giving these agencies further functions and powers:

> [Since] one of the major objectives of the 208 plan. . . [is] to redo the institutional arrangement in the Bay Area. . . some of the cities and counties might have some. . . functions curtailed and. . . other governments might have. . . powers added. . . .

Reacting to such wholesale shifts of power to higher level bodies, Grote urged local-regional alternatives. Thus instead of a paramount state-federal role in plan implementation, he seemed to contemplate legislation like the Knox bills, noted earlier, which proposed to strengthen ABAG. He suggested that

> a better way of rearranging the institutional relationship. . . would be to increase the powers of cities and counties and ABAG, and enable ABAG to play a role of coordinating an effective program in this environmental field.[26]

Further, while distribution of power and authority represent a major issue in structuring a management agency, the allocation of costs and benefits is equally

crucial if not more so. An experienced planner warned that "if. . . cost/benefits impacts. . . are uncertain" then a "push to retain power" can be expected.

A workable implementation system, he thought, would include at least one and preferably all three of the following "pieces of authority" at the regional level:

> (1) the authority to. . . guarantee an integrated areawide system,
> (2) the authority to finance the system, or
> (3) the authority to establish cost allocation rules.
>
> This authority may exist by state legislation, by joint powers action, or by contractual agreement among the local governments.
>
> The most important ingredient [however] is a commitment to do something — either from the top down as a federal/state commitment or from the bottom up as a citizen/local elected official commitment. Lacking both of these, nothing is going to be accomplished.[27]

To sum up, the Bay region still faces several implementation dilemmas. How much will the necessary measures cost, and how will the costs be distributed? Should the plan be implemented by existing governments through ad hoc arrangements? Should a stronger ABAG or regional agency be set up? Or should state and federal bodies play a greater role in charting the region's future?

In any event, the plan's ultimate effectiveness rests largely on the realism of the 208 decisionmakers in facing the problem of implementation. If major institutional reforms are needed, can agency anxieties and self-protective responses allow significant special-district "sovereignties" to be ceded to a stronger regional mechanism? If not, can 208 planners devise a means of multi-agency collaboration for sustained implementation, capable of surviving the controversies that inevitably surround important decisions on a region's future?

Future Planning and Broader Goals

It should be acknowledged that planning comprises a process, not an end product; thus plans are never really finished, but need regular revision, periodic rethinking and continued implementation. How can this essential process be handled when the current 208 work is ended? In short, 208 planners face twin institutional questions: (1) how can their plans be carried out, and (2) who will continue the planning process?

In seeking to free the region from pollution and waste, 208 planning is an early phase of the quest for long-term goals. The latter should be built on residents' social and economic aspirations, and quality-of-life concerns. These go far beyond achieving a clean environment, precious though this is.

Future plans will have to treat these broader issues. Meanwhile, if 208's environmental planning works reasonably well, it will be a big step ahead for the San Francisco Bay Area.

NOTES

Summary of major acronyms and abbreviated references used in this paper:

ABAG:	Association of Bay Area Governments
ARB:	Air Resources Board — state
BCDC:	San Francisco Bay Conservation and Development Commission
COG:	A voluntary regional Council of Governments, like ABAG
EMP:	Environmental Management Plan
EMTF:	Environmental Management Task Force — established by ABAG
EPA:	Environmental Protection Agency — federal
MTC:	Metropolitan Transportation Commission
NEPA:	National Environmental Policy Act
A-95:	directive from the federal Office of Management and Budget, implementing advisory review and comment on federal grant applications
Sec. 201:	Sec. 201 of the Federal Water Pollution Control Act Amendments of 1972. Concerns location, design and construction of sewage treatment facilities
Sec. 208:	Sec. 208 of the same federal act. Requires areawide and statewide planning to achieve federal clean water standards

[1] Their performance, vigor and effectiveness in protecting the Bay Area environment vary considerably. For example, observers have criticized the Bay Area Air Pollution Control District for moving into strong pollution control only after urging by the Environmental Protection Agency and others; and the MTC for failing to fulfill its direct legislative mandate to relate air quality concerns to transportation planning.

[2] Examples of environmental measures include the Clean Air Amendments of 1970 (Public Law 91-604), the Federal Water Pollution Control Act Amendments of 1972 — Sec. 208 (Public Law 92-500), the Resource Conservation and Recovery Act of 1976 (Public Law 94-580), and the National Environmental Policy Act of 1969 (NEPA, Public Law 91-100).

[3] Association of Bay Area Governments (hereafter ABAG), Environmental Management Program, *Water Quality Analysis and Pollution Control Strategies*, Issue Paper No. 1, Water Quality Management Plans (December 15, 1976), pp. 2-3.

[4] Paul De Falco, "What is 208? What Will It Do?" *Bay Area Monitor* (Berkeley: League of Women Voters of the Bay Area (hereafter LWVBA), Transportation Alternatives Project, with the assistance of the Metropolitan Transportation Commission, October 1975), p. 3.

[5] Holly O'Konski's remarks at the *Seminar 76: 208 Planning Conference, "Benefit or Boondoggle,"* Davis, California, March 24 and 25, 1976, pp. 2, 3, and 4 (variously paged) (State Water Resources Control Board in cooperation with U.C. Davis).

[6] De Falco's remarks, ibid., p. 6.

[7] Ibid., p. 7.

[8] "What is 208???" LWVBA, newsletter, *Bay Area Voter* (January 1977), p. 1.

[9] ABAG, Legislation and Governmental Organization Committee, *Minutes* (October 28, 1976), p. 2. ABAG, a Council of Governments, includes only cities and counties, not special districts.

[10] U.S. Environmental Protection Agency, Water Planning Division WH-554, *WQM: Highlights of September 1-2 [1976] Meeting* (undated) p. 1.

[11] ABAG, *Prospects: Environmental Management Program for the San Francisco Bay Region*, public information report (1976), p. 1. Shellfish harvesting has been prohibited in San Francisco Bay since 1930.

[12] Loc. cit.

[13] Prior to 208 planning, functions covered in ABAG's Regional Plan included: air quality, airport systems, community development, comprehensive health services, criminal justice, employment, growth management, housing, human services, ocean coastline use, open space, seaports, seismic safety, solid waste management, transportation, water quality and water resources. Updating will include housing, environmental quality, economic development, health, safety and recreation.

Re: ABAG, see also Victor Jones, "Bay Area Regionalism: Institutions, Processes, and Programs," in Advisory Commission on Intergovernmental Relations, *Substate Regionalism and the Federal System*, vol. II: *Regional Governance: Promise and Performance* (May 1973), pp. 75-110; Jones, "Bay Area Regionalism: The Politics of Intergovernmental Relations," in Kent Mathewson, ed., *The Regionalist Papers* (Detroit: Metropolitan Fund, Inc., 1974), pp. 128-148; and Jones, *Regional Home Rule for the San Francisco Bay Area: Concepts for Constructing a Workable Plan*, Regionalist Paper No. 2 (prepared for Associated Regional Citizens, September 1968), pp. 1-4.

[14] Interview with Harry Seraydarian, February 24, 1977.

[15] ABAG, Environmental Management Task Force Plan Implementation Committee, *Summary Minutes* (February 16, 1977), p. 1.

[16] See note 14 above.

[17] With EPA's concurrence, the State Water Resources Control Board has directed that EMTF not consider any ongoing Sec. 201 planning, because resulting interference might delay funds needed for Bay Area project construction. Thus, while the EMP is being drafted, it will not affect current 201 planning; but as noted, after completion all subsequent 201 planning must conform with the EMP. The management plan must also show how and by what agencies 201 planning will be carried out after the initial plan is completed.

[18] Court order issued in 1974 in *Natural Resources Defense Council, et al. v. Train, et al.*, District Court, D.C., Civ. Act. No. 74-1485. See Fed. Reg. 40 (230), Friday, November 28, 1975, p. 55321. Grants were ordered for designated areawide 208 water quality management planning, and states made responsible for assuring that 208 provisions are implemented in areawide and state planning areas. Plans are to be submitted to EPA by Nov. 1, 1978.

[19] Elected officials representing city and county governing bodies include: one city and one county official from 7 of the counties; in addition, at the recommendation of the task force, the two non-ABAG Bay Area counties of Solano and Sonoma were each allotted two city memberships because each of the other 7 counties had both a city and a county representative. (Subsequently, Solano County decided to join ABAG as of July 1, 1977.)

[20] LWVBA, newsletter, *Bay Area Monitor* (January 1977), "Update. . . Environmental Management Program," p. 3. EPA and the Air Resources Board have approved the EMTF contract with the Bay Area Air Pollution Control District for use of the 2-part LIRAQ Model. LIRAQ Part 1 is a "dispersion model" for measuring the generation and transportation of major air pollutants. LIRAQ Part 2 is for measuring photochemical pollutants, such as smog.

[21] The National Pollutant Discharge Elimination System (NPDES), authorized under Sec. 402 of the Federal Water Pollution Control Act Amendments of 1972, includes EPA-approved state permit programs. State and regional boards issue permits specifying levels of waste treatment.

[22] In 1974, EPA tried to implement its air quality maintenance plan in the Bay Area and elsewhere through control of indirect sources of air pollution, using parking regulations. Proposed regulations included on- and off-street facilities and extended to developments that involve parking, e.g., subdivisions, commercial buildings and shopping centers. Congressional and public pressure exerted locally and in five other affected areas nationwide — as well as fund limitations for fiscal 1975 — caused the EPA to suspend the program in July 1975.

[23] Bay Area Air Pollution Control District (BAAPCD), newsletter, *Air Currents*, 19 (8) (August 1976), p. 3. In one month's time the district studied the matter and denied the permit. Dow Chemical Company first appealed the denial, then withdrew the appeal and cancelled the project, with the intention of allocating the petrochemical activity among its existing plants. Subsequent reports, however, alleged that the district had stalled, and erroneously stated that Dow would therefore build a replacement facility in another country. A company spokesman later noted (in a telephone interview with IGS May 3, 1977) that some published accounts of the episode had been garbled, and that the plants Dow is building in Brazil and Canada had been under construction before the permit was rejected.

Although the air pollution district acted promptly, the full governmental review process for Dow's project was admittedly protracted and involved many agencies. Partly in response to such complaints of delay and at the request of the Governor's Office of Planning and Research (OPR), ABAG and OPR have joined to conduct an industrial location study of the Bay Area; ABAG has established a siting task force as a subcommittee of its Regional Planning Committee. The principal assignment is to survey available industrial sites and environmental standards for industrial development as well as existing environmental policies and permit procedures.

[24] Although no program has been proposed, the EMTF's ABAG/BAAPCD/MTC joint technical advisory committee on air quality planning could suggest a variety of programs to reduce air pollution: limit growth in environmentally vulnerable areas; encourage development patterns that reduce the number and length of auto trips; set criteria for the location, size and timing of major new growth areas; reduce automobile-related air polluting emissions; control types of fuel and methods of using it; and encourage the use of public transportation.

[25] SB 5, Cal. Stats. 1972, Ch. 342.

[26] ABAG, Executive Board Meeting #172 (July 15, 1976), *Summary Minutes*, pp. 17-18.

[27] Robert C. Einsweiller, "What is Needed to Implement the Management Plan?" distributed at a 208 workshop, Burlingame, Calif., May 5-7, 1976, sponsored by the National Association of Regional Councils (Washington, D.C.). Einsweiller is a planning consultant in Minneapolis and an observer of the Twin Cities region.

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AIR TRADE-OFFS: ATTEMPTING TO RECONCILE INDUSTRIAL GROWTH AND CLEAN AIR IN CALIFORNIA

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Introduction

California is currently wrestling with the question of how to accommodate industrial growth in parts of the state that still have not met federal clean air standards designed to protect public health. The dilemma confronts many areas throughout the nation where air quality standards are being violated, but at the same time industrial expansion is expected to provide new jobs. The growing intensity of the conflict, as seen in the San Francisco Bay Area, exemplifies the need for comprehensive ongoing planning and implementation related to "environmental protection and . . . consequent social and economic impacts."[1]

Meanwhile, however, the federal Environmental Protection Agency (EPA) has devised a short-to-middle-range approach to air pollution controls that it hopes will help reconcile the otherwise conflicting objectives of industrial growth vs. progress toward achieving clean air. Under this policy *emission offsets* apply to modifications of existing facilities, and *air quality trade-offs* to construction of new facilities. For the sake of simplicity, this paper will refer to both emission offsets and air quality trade-offs as "air trade-offs."

The general concepts behind air trade-offs are as follows: A new industrial facility, or an addition to an existing facility, may be built in an area where pollution levels violate air standards only if the new source (1) has the "lowest available emission rate" (roughly the lowest emission rate actually achieved anywhere by a similar plant), and (2) reduces air pollution from existing sources in the same region (i.e., by paying for the clean-up of existing sources) sufficiently that air quality is actually improved. In other words, there must be a net reduction in air pollution. Air trade-offs and other regulations governing new facilities are intended to prevent air quality from deteriorating further in already-polluted areas, while sufficient additional controls are developed for existing sources to achieve and maintain air quality standards.

In December 1976, the EPA issued an interpretative ruling that for the first time stated a policy on air trade-offs (discussed below). Individual air trade-offs have also been negotiated in some parts of the country, e.g., in Oklahoma, where a new General Motors facility is under construction after making plans to reduce pollution from nearby oil refineries.

California is the first state that has attempted to set up consistent statewide procedures for air trade-offs. Because this state has long been in the forefront of air pollution policy, the direction it takes in implementing air trade-offs is likely to have nationwide impact on the development of air trade-off policy. Accordingly this paper will examine provisions of an air trade-off bill currently under legislative consideration in California: Assembly Bill 471, authored by Victor Calvo, who chairs the Assembly Committee on Resources, Land Use and Energy.

The trade-off concept in turn raises questions about implementation. For example, what constitutes a net improvement in air quality, and within how large a geographic area will trade-offs be allowed? Will pollution become a valuable commodity, with industries in effect buying and selling the right to pollute?

Before dealing with these questions, and with the California bill, the following discussion examines the way air trade-offs fit into California's overall effort to meet federal clean air standards.

The Federal Clean Air Act

Air pollution control is a three-tiered system of regulation, with federal, state, and regional or local levels. The federal government sets certain clean air goals—national ambient air quality standards—and retains ultimate authority to implement them. States are allowed to set stricter standards than the federal requirements, but not weaker. A state must have a *state implementation plan* detailing how it will attain clean air standards.

[1] See Ora Huth, "Managing the Bay Area's Environment: An Experiment in Collaborative Planning," *Public Affairs Report*, 18 (2) April 1977 (Berkeley: Institute of Governmental Studies, University of California), p. 1.

In California, each of the 47 air pollution control districts submits to the California Air Resources Board plans for meeting state and federal air standards. The collection of air district programs forms the basis for the state plan, which also includes a statewide plan for controlling mobile pollution sources, e.g., cars and trucks.

The state can devise regulations for an air district, or revise the district's plan if it is considered inadequate. Similarly, the federal EPA has final review and approval authority over the state plan. California's implementation plan is currently under revision because the EPA judged that part of the procedures for meeting air standards was inadequate. Parenthetically, it should be noted that there are practical limitations to the EPA's authority. The EPA cannot force a state to implement a specific program if the latter choses not to do so. The EPA may itself implement such a program, but would probably find the administrative requirements prohibitive in terms of costs and personnel needed.

The federal Clean Air Act Amendments of 1970 specified certain air standards that were supposed to be met by 1975, but the 1975 deadline has now been delayed twice. First the EPA granted California and other states an extension until June 30, 1977. California, like many other states, did not meet clean air standards in 1977, so in the 1977 amendments to the Clean Air Act Congress granted another extension, this one until 1982; for areas with severe oxidant or carbon monoxide problems, the extension may last until 1987. The recent federal amendments also require states to submit new implementation plans by 1979 detailing how air standards will be met.

California is certain to have a problem meeting those standards, especially with respect to photochemical oxidants in both Southern California and the Bay Area, and particulates in Southern California. In addition, California must meet standards for sulfur dioxide, nitrogen dioxide and nonmethane hydrocarbons.

Some air pollution observers are concerned that if the 1979 version of California's state implementation plan provides controls that would be inadequate to meet air standards by the 1982 and 1987 deadlines, then further industrial growth would have to be prohibited after 1979. However, considering the political forces favoring continued industrial growth, it seems highly unlikely that Congress would proscribe all industrial growth after 1979 simply because air standards were not going to be met. After all, two deadlines for achieving clean air have already come and gone and industrial growth is still with us, although admittedly under certain restrictions.

In any event, each state implementation plan is already required to contain rules regulating the construction of "stationary sources" of air pollution such as industrial facilities, power plants, or the proposed oil terminal Standard Oil of Ohio wants to build at Long Beach in Southern California.

These rules constitute what is called *new source review*. More precisely, all state implementation plans must contain regulations requiring preconstruction review, and disapproval of new or modified air pollution sources that would interfere with the attainment or maintenance of air quality standards.

Industrial Growth in Dirty Air Basins

The implications of new source review led to the concept of air trade-offs. The EPA said that allowing additional industry to locate in an area whose air was already dirtier than federal standards would be a violation of the Clean Air Act. But many labor and business groups opposed the policy of refusing to allow further development in regions violating air standards, calling it a "no growth" measure.

The Clean Air Act did not specify how this conflict might be resolved. At the end of 1976, the EPA interpreted the act to allow the establishment of an air trade-off policy. As noted above, the EPA issued an interpretative ruling on air trade-offs in December 1976, and then held hearings around the country. The EPA said it hoped its ruling would focus congressional attention on the issue and lead to amendments to the Clean Air Act that would give guidance on how to allow trade-offs.

Meanwhile in California, the state Air Resources Board adopted new source review regulations for the South Coast Air Quality Management District.[2] Part of that rule was interpreted to mean that air trade-offs between different companies would be permitted. But the Bay Area Air Pollution Control District had its own regulations dating back to 1973, and those rules did not allow trade-offs between different companies. In short, California had a series of inconsistent air trade-off rules.

Pressure For A California Policy

Pressures soon developed for an integrated statewide policy on trade-offs in California. Concerns became more urgent when Dow Chemical Company withdrew its plans to build a huge petrochemical complex in Solano County, citing environmental roadblocks. There were several environmental problems with the Dow proposal, including worker health and safety questions. But much attention focussed on the Bay Area Air Pollution Control District's denial of an air quality permit. Largely in response to the uproar created by Dow's withdrawal, the state Legislature decided to move toward streamlining industrial siting regulations. One consequence of that effort was the development of air trade-off regulations that, under certain circumstances, would allow major industry to locate in an area where air quality standards are already violated. Of course, air trade-off rules enacted by the state will also require review by the EPA before they can be applied.

The most recent version (August 5, 1977) of the California trade-off bill leaves much of the decision-making on specific issues to individual air pollution control districts, thus continuing to give local rather than state government primary control over stationary sources of pollution. This policy is to the liking of the California Council for Environmental and Economic

[2] The Long Beach area, where (as mentioned earlier) Standard Oil of Ohio is negotiating for permission to build a huge terminal to receive Alaskan oil, is included in the South Coast Air Quality Management District.

Balance (CCEEB), a business-labor organization and one of the major groups lobbying on the bill. CCEEB prefers leaving development of regulations to local boards rather than to the state Air Resources Board, which has the reputation of devising stricter air pollution controls. Another provision tightens control of existing facilities by requiring that regulations will periodically be made more stringent to reflect advances in pollution control technology. This provision was backed by the Sierra Club, the other major group lobbying on the bill.

It may be helpful next to consider specific issues involved in implementing air trade-offs, along with provisions of the current version of AB 471. The suggestions of the Sierra Club and CCEEB wll also be noted.

Calculating Air Trade-Offs

How is the amount of pollution available for trade-offs to be calculated? Is it to be based on an existing facility's *actual* emissions, or its *allowable* emissions? The issue arises because some facilities are not currently polluting to the maximum extent allowed by law. For example, if a source were allowed to emit up to 500 tons per year of sulfur dioxide, but was emitting an average of only 460 tons per year, should the extra 40 tons be available to use as a trade-off? If so, a region could experience a net increase in actual air pollution as a result of a trade-off arrangement. The present version of AB 471 specifies that trade-offs will be based on actual or allowable pollution, which ever is less. In any event, defining a source's actual emissions remains a problem. One air pollution control official said that the determination would be technologically difficult, because refineries, for example, emit different quantities of air pollution from month to month and year to year, depending on the grade of crude oil being processed and the refined product being made.

As noted, EPA regulations state that each trade-off must have the effect of improving air quality. That is, the reduction in pollution must exceed the added pollution emitted by the new source—but how much greater must it be, i.e., how much must air quality be improved? CCEEB originally suggested a 1.5 to 1.0 trade-off ratio. Under this formula, if a new source emitted 100 tons of sulfur dioxide per year, it would have to reduce pollution from the old source by 150 tons per year. CCEEB later changed its position to advocate that each air pollution control district devise its own formula, taking into account the severity and frequency of violations of the particular air quality standard. The California bill contains such a requirement.

The Sierra Club suggested requiring a trade-off equal to what the new facility would emit, *plus* an increment equal to the proportion by which ambient air standards were currently exceeded. For example, if sulfur dioxide standards were being violated by 15 percent, a plant that would emit 100 tons of sulfur dioxide per year would be required to reduce another source's sulfur dioxide emissions by 100 tons plus 15 percent of 100 tons, or a total reduction of 115 tons per year. (The question of geographic boundaries within which a trade-off occurs is discussed below.)

A similar issue arose over how to set the baseline for air pollution trade-offs. Key questions were, how much pollution clean-up was required by law, and how much clean-up could be used for trade-offs? Setting the baseline was complicated by the fact that California's state implementation plan had been disapproved by the EPA as inadequate to meet federal air standards. A new state plan had not yet been approved, so it was unclear how much pollution clean-up would be required by law, and how much would be available for use in trade-offs.

This issue was resolved with the 1977 amendments to the Clean Air Act, which said that a state's current implementation plan would be the baseline, until 1979 when a new and presumably adequate state implementation plan must be prepared.

Only "Major" Sources Must Comply With Trade-Offs

Air pollution control districts are responsible for monitoring pollution emissions from individual sources, as well as general air pollution levels. This is done two ways: in-stack and ground level monitors measure the emissions of individual facilities, while ambient air quality monitors measure the general level of air pollution.

However, air pollution control districts do not have enough staff to monitor emissions for all small businesses. Moreover Congress and regulatory agencies have generally agreed that not all small businesses should be expected to spend the time, paperwork and money needed to meet trade-off regulations. Thus a determination must be made as to which new sources will be required to comply with trade-offs.

The State Air Resources Board adopted a 25 tons-per-year (250 tons for carbon monoxide) definition of a major source in the polluted South Coast air basin; EPA regulations require trade-offs for any source that emits 100 tons per year for any air pollutant for which there is an air quality standard (except for carbon monoxide, which can be emitted at the rate of 1000 tons per year). The EPA has strongly encouraged states to use a *lower* cut-off number "wherever resources permit," and is also considering reducing its cut-off figure to 50 tons per year (500 tons for carbon monoxide). The Bay Area Air Pollution Control District says it has enough staff to enforce the 50 tons-per-year figure.[3]

The Geographic Boundaries

How far away can the new facility reach to obtain trade-offs? The Sierra Club argues that a new facility should be required to obtain a trade-off from another facility at the same site or a contiguous location. Thus it says that a trade-off with a more distant location should be allowed only if the new source can prove that the emission reduction will have an actual effect at the site of the new plant.

In contrast, CCEEB proposes that a facility be allowed to obtain a reduction from anywhere within the

[3] Even the 100 tons per year figure would cover virtually all oil refineries and chemical facilities. For example, Bay Area Air Pollution Control District figures for 1975 show that Standard Oil of California's refinery in Richmond emitted more than 12 tons per *day* of sulfur dioxide. See Bay Area Air Pollution Control District, *Air Pollution and the San Francisco Bay Area* (June 1977).

same air quality control region, if it cannot find a trade-off in the immediate vicinity. If that is not possible, CCEEB says the source should be allowed to obtain a trade-off from a nearby air quality control region, if the reduction would have an impact on the air basin where the new source was being constructed. This suggestion would allow air at the site of the new facility to become dirtier, as long as air at another site in the same air basin became somewhat cleaner.

The Bay Area Air Pollution Control District has discussed still another plan. For primary contaminants—particulate matter, carbon monoxide and sulfur dioxide—trade-offs would be possible within a five-mile radius of the proposed new source. For hydrocarbons and nitrogen oxides, trade-offs could be possible anywhere within the air quality control region.

The state bill originally specified a five-mile radius, but later adopted the CCEEB proposal, allowing trade-offs outside of the immediate vicinity of the new source. However, the local districts must make a finding that a trade-off will not result "in any substantially adverse impact on the ambient air quality" in the immediate vicinity of the new source. This provision may still conflict with the EPA's current interpretative ruling, that the trade-off for pollutants such as sulfur dioxide, carbon monoxide or particulates must be made at the same site or in the immediate vicinity.

Exemptions and Pollution Credits

A concept called *banking* would allow a pollution reduction—in excess of that required by federal, state or local law—to be employed as an air pollution "credit" for future use by the same owner or operator.

The EPA's preliminary ruling does not allow banking because it does not represent progress toward clean air. The Sierra Club opposes banking for the same reason. On the other hand, CCEEB contends that banking is fair, and eliminates any possibility of deterring operators of existing sources from making improvements in their operations. The Bay Area Air Pollution Control District also favors banking. In its current version, AB 471 would allow the owner or operator of an existing source to hold onto pollution credits for banking purposes for five years.

There is agreement that facilities ordered to switch from gas to fuel oil should be exempted from the trade-off requirement. The Sierra Club holds that if air quality declines because of a fuel switch, the state implementation plan should require additional cut-backs from other sources.

CCEEB suggests that industries be exempted from the trade-off requirement whether the fuel-switching is voluntary or involuntary. CCEEB also originally argued that new power plants should be exempted if they could not find offsets, contending that supplying electricity is a necessary public service. But CCEEB later dropped that proposal.

California As Pace-Setter

Several political, technological and legal considerations should be kept in mind when considering air trade-off policy. For example, the Clean Air Act allows states to pass regulations that are stricter—but not weaker—than the federal regulations devised by the EPA. Thus, as noted, the EPA defines a major source as one that will annually emit 100 tons of a pollutant, but it also says that "States are strongly encouraged wherever resources permit to utilize a lower cut-off number." States considering bills considerably stricter than the federal rules may, however, face local political opposition. A strong nationwide constituency opposes a stricter air pollution law for a number of reasons, including the fear that jobs will be lost. The Clean Air Act amendments recently passed by Congress also reflect moves toward leniency in clean air regulation.

The air trade-off bill was proposed in part because California's regulatory climate had been labelled "anti-business," and it was hoped the bill would provide consistency in state regulation. But if California passes controls (as in AB 471) that are much stricter than the federal interpretative ruling, California may be accused of still being hostile toward business. Conversely, the state's affirmation of strict regulations may provide political support encouraging the EPA to do likewise.

Confrontation with the EPA

According to federal law, California's air trade-off regulation must be at least as strict as the EPA's rules, and if the EPA finds portions of the state rules weaker, they can be suspended. The EPA is itself in the process of reviewing its own air trade-off rules. If California, the state known to be the nation's toughest on air pollution, passed weaker rules than those of the EPA, the latter might find little political support for its policy and weaken its regulations.

For example, the EPA ruled out pollution credits—banking voluntary air pollution clean-up so that it can be used against future trade-offs. The EPA wants to see steady progress toward achieving clean air standards, and regards pollution credits as backsliding. But the California bill allows pollution credits. Thus either California or the EPA will have to back down on this issue.

Reaching the Limits of Technology?

Air trade-offs may provide an incentive for industry to devise technological innovations that reduce air pollution. Certainly little incentive exists today. But as technology reduces emissions, the cost of eliminating the remaining increment tends to rise. Moreover, there is likely to be a limit to major technological breakthroughs in reducing air pollution emissions. Thus the ultimate result of an air trade-off policy could theoretically be a no-growth policy. Realistically, however, there is no evidence to suggest that Congress is ready to sacrifice industrial growth for the sake of achieving strict air standards designed to protect public health. On the contrary, proposals for restrictive measures, other than improvements in technology, have been shortlived. For example, in 1973, under prompting from the EPA, the Bay Area Air Pollution Control District issued "indirect source review" regulations for projects such as shopping centers that attract large volumes of traffic. But the EPA

came under political pressure and backed away from indirect source review, and the Bay Area regulations were rescinded by the local district one week after their adoption. In the 1977 amendments to the Clean Air Act, Congress admonished the EPA not to require indirect source review, but told the local districts that they may do so.

Air Pollution As A Commodity

Another problem will arise if all existing sources should refuse to allow trade-offs by new enterprises seeking to locate in a region. In some cases, the new source might be a potential competitor of the existing source, or the latter might wish to retain its "extra" air pollution for future development. Such eventualities could put the existing business community in the awkward position of being labelled "anti-business."

Even more interesting is the question of whether a polluting industry could sell its right to pollute. If for example, two enterprises were trying to locate in the same region, could an existing facility sell its pollution to the highest bidder? Conversely, if nearby residents wanted to reduce pollution levels once and for all, could they pay for the installation of pollution control equipment, and then retain the pollution credit? As the air trade-off policy is applied in succeeding cases, less pollution will be available that can be readily traded off, and the value of the pollution still available will surely rise. Perhaps it is not absurd to foresee a day when pollution could become simply another commodity that is bought and sold.

Some Further Questions

Some observers of the air pollution scene have already expressed concern that an air trade-off policy may result in worsening air quality rather than reducing air pollution. For example, in Pennsylvania a Volkswagen assembly plant is under construction after receiving a rather questionable trade-off involving reduction of the solvent content of asphalt used in street paving. Many other states already use low-solvent asphalt and some air pollution officials believe this pollution control measure probably should not have been available for negotiating a trade-off. The net result is a pollution reduction that probably ought to have been required anyway, plus the addition of a new polluting facility.

Another potential problem concerns the geographic area in which pollution trade-offs can be negotiated. The current version of the California bill seems to allow a trade-off between a new source located at one spot and an existing source at another—if the local air district staff verifies that the region where the new source is locating will not suffer "any substantially adverse impact. . . ." The determination of what constitutes a *substantially* adverse impact is obviously open to argument. It will probably be left to the judgment of the local air district staff, who often come under heavy pressure from industrial facilities seeking to locate at a particular site.

Still another question remains to be resolved: How broadly should the emissions associated with a "new source" be defined? An important precedent may be set in the case of the SOHIO oil terminal proposed for the port of Long Beach. Both the South Coast Air Quality Management District Board and the California Air Resources Board are demanding that SOHIO offset the additional emissions caused by generating the electrical power requirements of the facility.

A Final Appraisal

The ultimate success of air trade-offs in reducing air pollution will depend on the specific regulations devised to implement the concept, and on the enforcement of the regulations. The roundabout nature of the trade-off approach points up the political difficulties in cleaning up the air. Logically, a more direct approach would require old facilities to install the best pollution control technology currently available, bring air up to standards, and then selectively allow new sources to build; but there are two problems with this.

First, existing sources argue that installation of such pollution control technology may be economically impossible unless financial inducements are offered through subsidies, tax write-offs and other means. Existing sources are supported by the convention that they have vested interests entitling them to due process before their rights (including the right to pollute) are revoked.

Second, government has depended on industries to develop pollution control technology. Regulations therefore need to be "technology-forcing" in nature, inducing technological improvements not otherwise likely to be developed and installed. Some hope that air trade-offs will provide such inducements. Once the effectiveness of the new technologies is proven, air pollution control officials can then require other existing sources to adopt them.

In short, a combination of trade-off policy and improved technology may make it possible to further mitigate some pollution while allowing limited additional industrial growth. However, a single-purpose regulation such as air trade-offs should not be expected to solve the underlying conflict between unlimited development of energy-intensive, polluting, industrial growth, and protection of public health and environmental values.

For example, a recent staff task force report from the Association of Bay Area Governments anticipated some decrease in Bay Area smog under current regulations until 1985. After that, however, the report noted that growth will cause smog to rise rapidly until it reaches almost twice the national federal oxidant standards. (This estimate is based on the pollutants emitted by autos and other mobile sources as well as stationary sources.)

Accordingly questions need to be asked about achieving future land-use patterns and population distribution that can facilitate shorter journeys to work and greater use of mass transit. Questions should also be addressed to the kinds of economic growth that regions or localities want to encourage.

Energy planners in industry, government and environmental circles are now debating how best to deal with the nation's future energy needs. Should energy needs be met by high-technology, capital-intensive nuclear reactors and coal power plants, or by using "soft"

energy technologies such as solar and wind, as well as by conservation?

The same kind of debate can focus on future economic growth. Should emphasis be placed on high-technology, energy-intensive, polluting development, or low-technology, labor-intensive, low-polluting forms of economic growth? What forces tend to encourage each type of growth?

These are the kinds of questions that need to be addressed in considering the future of air quality. The controversy over air trade-offs may help shed light on the basic unresolved issues now emerging, issues we are likely to confront "head on" in the next five to ten years.

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THE CALIFORNIA DESERT: MULTIPLE USES AND CONFLICTING DEMANDS*

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Introduction

Traditional views of deserts have often dismissed them as desolate wastes having little or no value, and consequently expendable for whatever purposes humans might wish to put them to. Thus the California Desert[1] has been the site of such activities as large-scale military maneuvers and races between off-road vehicles, which are severely damaging to desert environments unless carefully managed to limit destruction and minimize long-term harm.

We are learning now that far from being only barren, useless wilderness, desert lands are in fact valuable resources that are also highly vulnerable to injury and slow to recover. Thus recognition is growing concerning the California Desert's great intrinsic worth, which may be irreplaceably lost through inadequately regulated impacts of man and machines on the fragile, arid environment.

For some years, the Bureau of Land Management (BLM) has been surveying the desert's physical and biological characteristics; the kinds, places, and duration of human activities there; numbers of persons involved; use conflicts; and the nature of impacts on the natural environment. Although the BLM planning process has been underway since the late 1960's, until now there has been little information on uses of the desert in teaching and research.

This article attempts to provide some of the additional information needed to evaluate the California Desert and its future.

Emphasis is placed on use of the desert for teaching and research, and on its related values for scientific pursuits. These in turn, can also have highly practical applications. For example, as we shall see, botanical research in the desert promises to provide valuable alternatives to resources that are endangered or in short supply. Moreover desert research may help in the development of plants and practices that can make arid lands more productive. While these possibilities deserve further exploration, they are only mentioned here and acknowledged.

In addition to teaching and research uses, the article also touches on such other multiple-use demands and claims upon the desert as recreation, including both traditional uses (e.g., hiking) and new-style mechanized uses (e.g., off-road vehicles—ORVs). Not discussed are industrial and residential uses, as well as the significant impact of the grazing of livestock, which in many desert areas can have a very destructive effect.

The article assesses compatible and conflicting activities, and examines some of the consequences of conflicts. Finally, it summarizes some of the measures that can improve desert management, and suggests several further steps urgently needed if the desert environment is to be safeguarded from man-caused deterioration.

Life Forms Characteristic of the California Desert

The California Desert is a region of unusually diverse natural terrain. It contains over 1,200 species of higher plants, and over 350 species of wild native vertebrates. More than 100 of the plant species are unique to the region; those of lower plants (fungi, lichens, and the like) and the invertebrates number in the thousands, but have been little studied. The variety of life forms is due to

*This report is adapted from "Teaching and Research in the California Desert," Research Report 78-1, forthcoming, Institute of Governmental Studies.

climatic and historical factors, as well as the varied topography and soils of the desert. The region contains remnants of an ancient hydrologic (water drainage) system that existed during the last pluvial period (a time of substantial runoff from precipitation or glaciers), when rivers and lakes occupied the area.

Many desert organisms are highly specialized to withstand extremes of aridity, temperature and light. The seeds of some annual plants may lie dormant for many years until conditions of moisture and temperature are suitable for germination. Then spectacular wildflower displays occur.

Of great interest to the evolutionary biologist are the many isolated remnant populations of plants and animals—fish, amphibians, reptiles, mammals and invertebrates. These populations often occur at remote springs, on humid mountain tops, or in the sand dunes or playas (desert lakes—usually dry). Some are classed as rare or endangered.

Sand dunes, now a favorite playground for dunebuggy enthusiasts, are among the most interesting desert habitats. They contain specialized sand-burrowing insects, lizards, snakes and unusual plants adapted to life in shifting sands. On the dry lakes, eggs of fairy shrimp (primitive crustaceans) can withstand a decade of desiccation, then hatch into beautiful translucent aquatic creatures when the playas fill after rare storms.

The desert records much history, from prehistoric to recent, in its rocks and land forms. Many fossil deposits have yielded remains of plants, shells and vertebrates—camels, sabre-tooth cats, three-toed horses, mastodons—and lesser forms. Signs of human occupancy stretch back some 12,000 years and hint that man may have been present 50,000 to 80,000 years ago. These earlier occupants left a rich archeological heritage. The California Desert appears to contain the world's largest collection of prehistoric art.

Thus, the desert provides extraordinary opportunities for both basic and applied research. Some examples drawn from zoology, botany and paleontology are described briefly below.

Research in Zoology

Studies conducted by students and staff of the University of California Museum of Vertebrate Zoology at Berkeley provide much of the available base-line information on the distribution and habits of land animals (terrestrial vertebrates) in California. The Museum's collections of California vertebrates are the world's largest and constitute a major resource for studies in vertebrate evolution and for monitoring effects of environmental changes on wildlife. For example, the Museum's wild bird egg collection helped document the eggshell-thinning effect of the pesticide DDT, and contributed to the studies that led to its ban.

Despite many years of exploration, new species and varieties and isolated populations of known forms continue to be found in California, as, for example when a new species of salamander was discovered in 1973 in the arid Inyo Mountains. The Gila Monster was discovered recently in the little-studied eastern Mojave, the first convincing evidence for naturally occurring populations of this animal in the state.

The Museum's research program includes studies aimed at the protection and conservation of the state's vertebrate animal life, with special concern for isolated small populations. Some are officially classed as threatened, rare or endangered. Others remain to be discovered.

In addition to distributional and natural history studies, many zoological investigations have focused on the physiological adjustments made by desert animals in coping with environmental extremes, e.g., thermoregulation and water metabolism. Professors and students at the University of California at Los Angeles and Riverside and Fullerton State University have been particularly active in such research. In addition, the work of UCLA's Raymond Cowles and his student Charles Bogert, who studied the role of temperature in the lives of California Desert reptiles, stimulated a major investigation of temperature in the physiology, behavior and evolution of vertebrate animals. Thermal studies in the California Desert provided advances in understanding mechanisms of temperature control, and contributed to the understanding of such diverse phenomena as the evolution of fur and feathers and the extinction of the dinosaurs.

The invertebrate life of the desert is abundant, varied and different from that of most other arid lands of the southwest. Much speciation (development of different species) is still occurring. There are often major differences in species populations from canyon to canyon in many desert mountain ranges, and from dune to dune.

Of particular interest are the ants. There are many species and they occur virtually everywhere in the desert. They are extremely important in food chain relationships. Studies of ants are being conducted at the Deep Canyon Desert Research Center of the University of California, Riverside, and by researchers at U.C. Berkeley and elsewhere.

Important interactions occur between ants and plants. In the Vizcaino Desert of Baja California, we found that cactus (*Opuntia*) roots appeared to selectively penetrate the nests of the harvester ant (*Pogonomyrmex*) where moisture and nutrients were concentrated. A similar relationship perhaps exists between ants and plants in the California Desert.

Invertebrate studies are also important in the development of biological pest controls. In the desert, experiments have shown the desirability of large natural buffer zones, about 10 miles wide, around agricultural areas. Wild, free-living predatory and parasitic insects move into the agricultural lands and attack the crop pests. A great reservoir of natural control species is thus available to cope with pest flare-ups.

Research in Botany

The dearth of information on desert plants is so great and the probable benefits of their study so promising, that the National Science Foundation has given extensive support to the New York Botanical Garden for a major study of vegetation of the southwestern United States.

Studies of the creosote bush, a dominant desert shrub, conducted by Frank Vasek, Hyrum Johnson, and Leonel Sternberg, University of California, Riverside, are of special interest. Aerial photographs reveal that some creosote bushes are arranged in rings. The rings appear to have originated from a central point by vegetative segmentation, and the individuals that compose them are members of a clone (asexually reproduced offspring of a single individual). Cloning seems to be facilitated when the root crown is covered by wind or water-borne soil. The center of the bush dies, presumably due to drought, and new growth develops at the periphery. Ring expansion is very slow and is estimated to be less than 1 millimeter (mm.) a year, even under optimal conditions. Undecayed wood at the center of a ring 30 centimeters (cm.) in diameter was found to be approximately 580 years old;[2] another contained wood approximately 700 years old (radiocarbon dating). A ring 20.7 meters (m.) in diameter, or about 68 feet, has been observed, estimated to be over 5,400 years old.[3] It is speculated that some of the rings go back to the time when the creosote bush was first establishing itself following the last ice advance, some 10,000 years ago. The slow growth rate and plant fragments in fossil middens of woodrats,[4] which indicate vegetation changes in the desert, have contributed to this theory. Painstaking biochemical studies have been performed to determine whether or not the members of a ring are all parts of an original fragmenting and expanding plant. These tests have required repeated trips to the desert to study the same rings.

Desert botanical research has important practical aspects. Deserts are the largest remaining uncultivated land areas with potential for agricultural expansion. Much of the world's arid lands research is going on in Australia and the southwestern United States, especially in the Mojave and Colorado Deserts. Many desert plants may prove to be important crop species. An example is jojoba (*Simmondsia chinensis*) under cultivation in Israel and the U.S. as a livestock forage plant and as a source of liquid wax from its seeds.[5] The wax can replace sperm whale oil (obtained from an endangered species), an oil used in machinery that operates at high speeds and temperatures. At this stage all desert varieties of jojoba are considered important because it is not known which may prove most suitable for crop development.

Also of interest is the photosynthetic process in "four-carbon" plants.[6] Many desert species are of this type, including the salt-bushes (*Atriplex*). Four-carbon plants utilize a four-carbon cycle of photosynthesis, and have certain anatomical differences from three-carbon plants. The four-carbon plants appear to represent an evolutionary adaptation that provides high-efficiency photosynthesis, and enables many of these plants to function in climates that are hot and dry. Experts suggest that four-carbon plants now found in desert environments could play a central role in developing agricultural practices and crop varieties especially adapted for use in areas having limited water supplies.

Halophytes are also under study. They are salt-tolerant plants that take up salts from soils and exude the excess, or remove it by dropping parts of their structure as they dry. The desert box thorn (*Lycium*) and *Mesembryanthemum* are examples. Salt tolerance is valuable to arid-land agriculture in the development of crop species, weed control and soil desalinization. The U.S. Salinity Laboratory at Riverside is investigating such tolerance in crop plants. Halophytes can be grown to remove salts from soil, thereby preparing the soil for more productive species with less salt tolerance. The alkali flats are important desert research areas for the study of halophytes, but the sites are also attractive to ORV recreationists.

The University of California at Riverside and the Australian National University have undertaken a joint study of the ecology, physiology and biochemistry of cacti in native and favorable exotic environments. One aspect of the study pertains to the action of cactus stomates, the "breathing pores." The stomates open at night when cacti take in most of their carbon dioxide, storing it in an acid medium, for use the next day in photosynthesis. In the daytime, water loss is minimized by closing the stomates. Cacti are used as forage plants. In some areas (Africa, Australia, portions of the southwestern United States) cacti constitute pests, and knowledge of their physiology is important for control purposes.

Research in Paleontology

Some of California's richest vertebrate fossil faunas are found in the Barstow and Ricardo formations. These are famous, internationally known sites, about 12 miles north of Barstow, and near Red Rock Canyon, respectively, containing priceless scientific and educational resources that cannot be duplicated anywhere else on earth. Paleontological exploration of these areas goes back to 1911, and study of the rocks at Ricardo to 1871. (The Barstow Formation is the namebearer for one of the 17 major subdivisions of mammalian evolution over the last 60 million years in North America.) Each yielded approximately 100 kinds of extinct plants and animals, and additional new material is coming to light. The Barstow beds contain over 200 localities; those of the Ricardo over 450.

Studies on fossil animals in the desert have been conducted by the University of California, California Institute of Technology, the American Museum of Natural History, the Los Angeles County Museum, and the U.S. Geological Survey. The desert has also contributed greatly to the paleobotanical investigations of Daniel Axelrod, Professor Emeritus, at the University of California, Davis. More-

over paleontological research in the desert is growing in importance as new sites are discovered and old ones are more intensively worked.

Teaching in the Desert

In the desert as elsewhere research and teaching are closely allied and major educational centers located in the desert itself attract many students and teachers: notable are (1) the Philip L. Boyd Deep Canyon Desert Research Center, (2) the Living Desert Reserve at Palm Desert, Riverside County, (3) the Barstow Unified School District Research Station near Hinkley and (4) the California Desert Studies Consortium station at Soda Springs, San Bernardino County. Participants in the programs of these centers work not only at the centers themselves, but often range widely into other parts of the desert.

To ascertain one recent year's use of the desert for teaching and research, the writers conducted a survey (including elementary, junior high school, high school, college and university use as well as special groups) from October 1975 to June 1977.[7]

With respect to colleges and universities, approximately 500 questionnaires were sent to nearly all California state colleges and universities, all campuses of the University of California, most community (or junior) colleges, and most private universities and colleges, with a focus on life science departments.

(1) One hundred and ninety respondents estimated a total of 47,617 person days (p/d) of use in teaching and 12,522 in research. (Information is inadequate to estimate statewide use.)

(2) A total of 201 sites were visited.

(3) Common topics taught were biology, natural history, ecology, plant taxonomy, herpetology, ornithology, entomology, environmental studies and mammalogy.

In addition, of the 41 State Chapters of the National Audubon Society contacted, 14 reported desert use and estimated a total of 8,838 p/d. We also surveyed desert use by 9 museums, natural history organizations, and other nature-oriented groups; they reported 3,997 p/d for a combined total of 12,835 person days.

Perhaps more unexpected is the extent to which California's public and private schools make use of the desert for teaching purposes. At this level, the survey and its results were as follows:

(1) Most of the public and private schools in 8 Southern California counties in or near the desert (part of Los Angeles County excepted) were queried as to teaching use. Approximately 3,000 questionnaires were mailed. Three hundred and thirty-five respondents estimated a total of 132,374 person days of use. We project *actual* use to have been at least 182,000 p/d. Adding spot-check returns from elsewhere in the state to projected use, brings the total to over 183,000 p/d. (There are insufficient data to estimate statewide use.)

(2) Many additional schools would go to the desert if funds, transportation and other needs were met. Out of 1,082 negative returns, 683 (63 percent) expressed such a desire.

(3) A total of 187 specific sites of use, widely distributed over the desert, were reported.

(4) Topics most commonly studied were general science and biology by elementary schools and biology and geology by junior high schools and high schools.

Total Estimate for Desert Educational Use

Combining information reported by precollege, higher education and the organized groups, we obtained a figure of 207,328 p/d; adding to this our *projected* public and private school use, we estimate a minimum of 256,892 p/d of educational use of the desert by this group of respondents (548 persons) during a recent average year (since 1975). We calculate our margin of error in interpreting results as less than 4 percent. The public and private schools and colleges and universities together, visited a total of 272 sites in the desert.

Human Impacts and Demands Upon the Desert

Until quite recently the desert remained relatively undisturbed by man's activities. But now the pressure of rapid growth and economic and recreational demands threatens natural environments. The desert faces the same fate that has befallen many other natural places in the United States and elsewhere. Situated near high density population areas in Southern California, the desert serves as a safety-valve, relieving some of the effects of crowding and the pressures of city life. Its own rigors and the fact that its values were little known, once protected it from substantial intrusion by civilized man. However, with the popularization of campmobiles and off-road vehicles which provide comfort and mobility, the desert has become readily accessible even in remote areas, and is attractive for outings to large numbers of people.

Moreover, increasing demands for energy have intensified the search for sites for solar, geothermal and atomic plants. Powerlines, housing and agriculture are on the increase, and overgrazing has seriously disturbed natural environments in some parts of the desert. Many of these developments conflict with each other, as well as with traditional, usually benign, uses of the desert, such as "on foot" recreation, sight-seeing, picnicking, tent-camping, nature study, and teaching and research.

Desert lands are particularly vulnerable to mechanical disturbances, overgrazing, and other kinds of human-related impact. Activities that damage or destroy soil structure and vegetation increase water erosion and wind erosion.

Dust can be expected to increase,[8] accompanied by property damage, soil loss, and perhaps increased health hazards.[9] Following the Barstow-Vegas motorcycle race, November 30, 1974, dust fall in one area was recorded as approximately 30 percent above normal during a period of one month.[10] Plant cover-damaging activities may increase the ground surface albedo (reflectivity), so that light reflection from the desert surface may increase, with possible significant effects on local climate.

In the open unobstructed terrain of the desert, environmental features lie exposed, readily visible, accessible and vulnerable. The desert's antiquities are especially in danger. These include ancient creosote bushes; rock pavements that have remained undisturbed and exposed to the sun for 2,000 years; rare plant and animal species, remnant populations found nowhere else; fossil deposits; and prehistoric and historic human artifacts.

Effects of Conflicting Uses

Survey respondents were asked to note any disturbances that interfered with their educational pursuits in the desert. Off-road vehicles were ranked as most disturbing by all educational groups, followed by vandalism (noted by schools and college and university groups) and urban and housing expansion (noted by organizations). Vandalism, which includes damage to study sites and equipment, and destruction of the natural objects of study, is aided by the mobility of ORVs.

Of the 17 respondents who ranked disturbances, 14 scored ORVs as highest. Reasons for the high scoring of uncontrolled ORVs are apparent. ORVs damage, and sometimes completely destroy, the subjects of study—geologic features, soil, plants, animals, fossils, and archeological sites.[11] They make it difficult to find protected sites for field observations and research. People who are interested in nature study avoid areas where cross-country ORVs occur because of the noise, dust and threat of injury to persons on foot.

Many desert studies require months or even years of close attention, and a researcher's investment in his project grows with time. This emphasizes the vulnerability of desert research to the impact of vehicles.

Vehicles off-road can quickly degrade natural environments. A single motorcycle travelling 20 miles impacts one full acre of soil; an average four-wheel drive vehicle affects one full acre in only 6 miles of travel. Even a single pass by an ORV, under some conditions, can start deleterious changes in a natural community by spreading weeds. Tumbleweeds (*Salsola*) have been found growing in single motorcycle tracks. In some areas these plants have significantly altered the entire biotic community. F. R. Fosberg, an authority on alien plant species, has warned that unless it is desired to change the character of the vegetation and thus much of the landscape of the desert, vehicular traffic in the desert must be limited to established roads. A number of studies have now documented the decline in abundance and diversity of native plants and animals in ORV areas in our wild lands.

Fossil sites are also highly vulnerable. Deposits of bones, shells, petrified wood and leaf impressions have been ripped apart, scattered and pulverized. Tell-tale "signs," small fragments of bone and other fossil materials on the surface, that may lead a scientist to a new fossil discovery, are obliterated. ORVs have entered the famous Ricardo deposits, the Coso beds, and other important fossil-yielding areas.

There are more subtle damaging effects. The behavior of resident animals that are still present in ORV use areas may be altered. There may be damage to their hearing, interference with their communication signals, and physiological stress induced by the noise, sight, ground vibrations and fumes of vehicles. Desert iguanas experimentally subjected to motorcycle sounds at sound pressure levels found in the vicinity of ORV "pits" (areas of concentrated ORV "play") have suffered losses in hearing.[12] The sounds are transmitted with damaging force even into their burrows.

Many desert animals have daily routines of activity and rest that provide little margin of safety if disrupted. In warmer weather some desert lizards are active only about six hours a day. Prolonged inactivity is necessary for survival when temperatures are high and humidity low. ORVs disrupt patterns of foraging, breeding, thermoregulation and rest. They cause burrows to collapse, destroying refuges that are crucial to desert animals in escaping environmental extremes. By breaking desert crusts they make burrow construction for some animals difficult or impossible in some areas, because an intact crust is required to prevent collapse of burrows near the surface.

Any natural area is a complex mosaic of unique biotic features. No two square meters are quite the same. On a quarter-mile walk in the desert, for example, one might intersect a communal egg-laying site for lizards; a hibernation site for snakes; an amphibian breeding area; special soil conditions supporting growth of a community of rare plants; a wash bank containing burrows of tortoises; an isolated population of lizards found nowhere else in the area; a fossil site; and many features unseen and unknown. All are fragile and readily damaged by cross-country ORVs. Many are uncommon and several attract prime, breeding adults to a limited area. Such a range in biotic variety along short stretches in natural environments is not uncommon. Every time a vehicle is driven off-road in such lands there is the risk of damaging or destroying unique biological resources.

Moreover unregulated motorized intrusions do more than damage the scientific and educational resources of the desert. They also destroy important visual and esthetic values. Thus a desert defaced by the long-lasting tracks of off-road vehicles is no longer primal desert, but has lost some of its worth as an undisturbed wilderness resource. While environmental disfigurement is usually abundantly clear to the layman's eye virtually anywhere mechanized

equipment is used in the desert, it is perhaps most visually obvious during the periodic blooming of desert wildflowers.

Management Responses: Plans for the Desert

Since the late 1960's, the BLM has been studying the environment and use patterns in the desert. Environmental damage in many areas was obvious, and problems of sanitation, littering, vandalism, traffic and personal safety of desert users were pressing. The planning effort was, in considerable measure, prompted by the very rapid increase in off-road vehicle recreation that began in the late 1960's. In 1973, President Nixon issued an Executive Order, no. 11644, pertaining to ORV regulation and control (it was recently amended but without much change). The Order called upon federal agencies to prepare regulations controlling ORVs on lands under their custody.

The planning process for the desert is now far advanced: Areas have been set aside for ORV recreation; a BLM public education center has been established at Barstow, California; and many critical habitats and species populations have been identified and protection areas designated. Maps have been published showing places for recreational vehicle use. The BLM now has police power and a staff of desert rangers. Planning for the entire desert is to be completed by 1980. However, at this date, rapid deterioration of the desert continues, chiefly because many people using it lack understanding of its fragile ecology and some are indifferent to its natural values. Consequently adequate regulatory policies and policing measures are essential. This is principally the job of the BLM.

In addition to the desert, other BLM concerns include the regulation of grazing, mining and other land uses as increasing numbers of people strain the capacity of the desert to withstand human impact.

Special Areas Needing Protection

There are now far more data available on the desert's natural values and on the effects of various kinds of human impact than when the BLM first began publishing its management plans. The present report adds further to this expanding data base.

The natural lands of the California Desert constitute a *unique* teaching and research facility. There appears to be no other place on earth where such a biologically and historically rich desert environment has been subjected to such breadth of study over such a long period by a variety of academic disciplines. The desert is logistically well situated for such investigations.

The arid lands of the southwestern United States, Mexico, and in particular, the California Desert, and the desert lands of Australia and Israel are emerging as important foci for arid lands research. These are the areas where manpower, funding and proximity provide unmatched opportunities and where research and teaching programs are exerting important guiding influences on the use and management of desert lands throughout the world.

Our survey has helped identify a number of areas that we believe should be set aside primarily for their wild land values and long-term use for non-mechanized recreation, nature-study, teaching and research. These areas, which already have a long tradition of such use, include:

(1) The *Kelso Basin*, including Kelso Dunes, Soda Dry Lake, and flanking mountains—the Providence Mountains and the Granites. This is an outstanding natural area, as yet little disturbed by man. It may well qualify for National Park or Monument status. The area presently vies with Death Valley, Joshua Tree National Monument and Anza-Borrego State Park in frequency of use by school groups. Eighty-one respondents reported use of the area—more than listed for either Death Valley or Anza-Borrego State Park.

(2) The *Pisgah and Amboy lava flows*. These lava areas contain alternating patches of pale wind-blown sand and black lava, resulting in a remarkable mixture of sand and rock-dwelling organisms.

(3) *Jawbone Canyon* area. This and nearby Red Rock Canyon contain major fossil deposits.

(4) The *Algodones Dunes* and adjacent mesas. The area has one of the richest dune biotas in the world—containing many endemic plants and animals. Major sections of it should be designated for teaching and research and non-mechanized recreation.

Conclusion: Second Thoughts on Multiple Use

Finally, it seems essential to re-examine the multiple use concept as applied to open natural terrain, such as is found in arid lands. It is not possible, in our judgment, to protect wild land values while at the same time allowing a geographically fine-grain interplay of many uses. The broad desert expanses notable for their silence, the delicate and precariously situated biota, the lack of screening vegetation, which in forests impedes sights and sounds of human and vehicle activity, all call for special planning. It is evident from our studies that off-road vehicle recreation is incompatible with teaching and research in the desert. The two activities must be well separated physically.

We have found that teaching and research in the environmental sciences have been major activities in desert use for many years. Like traditional forms of recreation—hiking, camping and sight-seeing—educational use usually leaves the land unmarred. The academic interests grade into the traditional recreational ones; both are oriented toward the land and its natural features. The knowledge and appreciation of the desert gained through teaching and research fosters respect for the land and develops the wisdom to provide for its proper management.

The extensive use of the desert by nature-oriented visitors and by school classes and researchers, which is documented here, argues strongly for conservation of the desert's natural features.

The future of our wild lands depends upon the development of a land ethic in which all citizens see themselves as part of the earth's community of living beings, and assume a moral responsibility for that community's welfare. There is also need for vigilance in seeing that governmental agencies and other institutions adopt and implement the protective policies necessary.

NOTES

[1] For simplicity this article uses the term "California Desert" to describe a 25-million-acre area in California that includes portions of three major desert regions: The northern part is in the Great Basin, the southern portions include the Sonoran Desert lowlands, and the Mojave Desert lies in between. This desert (along with other arid lands of the southwestern U.S.) comprises a large portion of the remaining unbroken wild lands of the continental United States. Of all the states, only Alaska has a larger share. The desert occupies about one-quarter of California's territory, nearly half of it being in public lands administered by the Bureau of Land Management (BLM) of the U.S. Department of the Interior.

[2] F. C. Vasek, H. B. Johnson and D. H. Eslinger, "Effects of Pipeline Construction on Creosote Bush Scrub Vegetation of the Mojave Desert," *Madroño*, 23 (1): 1-13 (January 2, 1975), see p. 11.

[3] L. Sternberg, "Growth Forms of *Larrea tridentata*," *Madroño* 23 (8): 408-417 (October 1976), see p. 415.

[4] P. V. Wells and R. Burger, "Late Pleistocene History of Coniferous Woodland in the Mojave Desert," *Science*, 155 (3770): 1640-1647 (March 31, 1967).

[5] H. S. Gentry, "Plant a Seed and Save a Whale," *California Native Plant Society Newsletter* (October 1972), originally published in the *Saguaroland Bulletin*, 25 (4): 44-47.

[6] O. Björkman and J. Berry, "High-efficiency Photosynthesis," *Scientific American*, 229 (4): 80-93 (October 1973).

[7] See full description in "Teaching and Research in the California Desert," IGS Research Report 78-1. It is important to emphasize that our study has covered thoroughly the desert use of public and private schools only in Southern California. Although college and university coverage was statewide, we emphasized life science departments. We hope that the present study will be expanded; it would be of interest to determine use of the California Desert by educational institutions in contiguous Nevada and Arizona and in other parts of the country, as well as by such college and university departments as geology, geography, archeology and many others.

[8] L. W. Bowden, J. R. Huning, C. F. Hutchinson and C. W. Johnson, "Satellite Photograph Presents First Comprehensive View of Local Wind: The Santa Ana," *Science*, 184 (4141): 1077-78 (June 7, 1974), see p. 1078.

[9] J. C. Loofbourow and D. Pappagianis, *Coccidioidomycosis: An Occupational Hazard for Archeologists* (Society for California Archeology, December 1971), see p. 4. Special Report No. 2 of the Society for California Archeology, Riverside.

[10] M. L. Villalobos, "Dustfall of the 1974 Annual Motorcycle Race, Barstow to Las Vegas," San Bernardino County Air Pollution Control District Report TSD-TR-75-1 (February 22, 1975), in U.S. Department of the Interior, Bureau of Land Management, *1974 Barstow-Las Vegas Motorcycle Race Evaluation Report* (March 1975), Appendix 6, see p. 13.

[11] See H. G. Wilshire and J. K. Nakata, "Off-road Vehicle Effects on California's Mojave Desert," *California Geology*, 29 (6): 123-132 (June 1976), a publication of the California Division of Mines and Geology; Geological Society of America, Committee on Environment and Public Policy, *Impacts and Management of Off-Road Vehicles* (May 1977), report of a panel convened by the Geological Society of America on September 12 and 13, 1976, at Asilomar, California; and R. C. Stebbins, "Off-Road Vehicles and the Fragile Desert," *American Biology Teacher*, 36 (4-5): 203-208 and 294-304 (April 1974).

[12] M. C. Bondello, "The Effects of High-Intensity Motorcycle Sounds on the Acoustical Sensitivity of the Desert Iguana, *Dipsosaurus dorsalis*," California State University, Fullerton, master's thesis, 1976, see p. 31.

Coastal Planning

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COASTAL CONSERVATION AND DEVELOPMENT: BALANCING LOCAL AND STATEWIDE INTERESTS

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Introduction

Under the California Coastal Act of 1976 the 68 cities and counties of the state's Pacific shore are required to draft plans for the conservation and development of the coast. In preparing, adopting and implementing plans, the local governments must relate not only to their usual local constituencies, but also to a new statewide constituency. While admittedly some members of the new constituency reside in or own property within the jurisdiction of coastal local governments, this larger group is not confined to coastal cities and counties. By definition the statewide constituency includes *all* the people of California. The coastal zone has been declared a resource to be managed for the benefit of this larger constituency.[1]

The California Coastal Commission has been established to see that statewide interests in the conservation and development of the coast are protected. The commission relates to the coastal cities and counties through a planning and permit process—a process in which primary responsibility for balancing statewide and local interests has been placed upon the local coastal governments.

The conservation and development of the coastal zone is further complicated by federal requirements that must be met to assure continued funding under the Federal Coastal Zone Management Act of 1972. In fact, there may be "national constituency" pressures, in addition to those from local and statewide constituencies.

The zone's ecology is declared by the state act to be especially fragile and in need of extraordinary protection. On the other hand, within this protective framework, development is also to take place. Furthermore, development is intended to benefit the new, larger statewide constituency by contributing to its economic well-being, as well as meeting some of its recreational needs.

Proposition 20—the California coastal initiative of 1972—set up a temporary state coastal commission. That commission was empowered to regulate coastal development (1973 through 1976) while it prepared a plan for California's coastal zone and adjacent territory. The plan was submitted to the Legislature in December 1975, setting forth a land use map and calling for the creation of a permanent successor agency. In 1976, after debate and compromise in which the Governor played a significant role, the Legislature did establish a permanent state coastal commission, and inserted it into the existing web of government, effective January 1, 1977. However, the Legislature did not adopt the plan or the accompanying land use map. Generalized though they were, the plan and map were more specific than the environmental elements in most city and county plans. Thus, if the California coastal plan and map had been adopted, they would have had a strong, official role in the future planning of the coastal zone. This would have placed the coastal commission in a position comparable to that of the San Francisco Bay Conservation and Development Commission (BCDC) with respect to the Bay and local governments around the Bay.

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From the formation in 1973 of the North Central Coast Regional Commission—including coastal portions of San Francisco, Marin and Sonoma counties—he has been a member of that commission, serving as the appointee of ABAG.

In 1976-77, while on sabbatical leave from Diablo Valley College, he spent some time in the Institute of Governmental Studies, reading and reflecting on the implications of coastal governance as observed and interpreted from his vantage points as a local elected official, president of a council of governments, and member of a regional coastal commission. This article outlines some of his principal conclusions.

The new law requires coastal cities and counties to develop their own local plans for their coastal areas, under guidelines laid out by the state commission. The local coastal plans (LCPs) must be reviewed and certified by the state commission.[2] During the transitional period prior to certification the state commission has permit review authority over developmental proposals in the coastal zone. It will also provide permanent back-up controls over future modifications of local plans, over near-shore and sensitive areas, and as a guard against failures in local plan enforcement that would threaten statewide interests.

While it may appear that the powers of the state coastal commission make it the governing body for the coastal zone, this is not really true. Legislative and administrative power for implementing the LCPs will be returned to the local governments.

Traditional Land Use Planning and Zoning

Land use planning and zoning has grown in complexity as new demands have been made on it. Traditionally, the principal function was to sort out private and public uses of land and integrate them so that the developing diversity of land uses could proceed with a degree of what the planners and decisionmakers consider to be rationality. The state delegated the power to carry out the planning and zoning to cities and counties, as an expansion of the local governments' police powers to guard and promote the community's health, safety and general welfare.

In the case of planning and zoning, each local government has its own body politic within the boundaries of its jurisdiction. Accordingly each local government has historically planned and zoned for its own constituency, not for the health, safety and welfare of the population of the state. This is the very essence of local home rule. Until the coastal law came into effect, state government had never established regulatory agencies or other machinery to monitor the contents of local general plans.

Relation of Planning/Zoning to Local Government Revenue

As local planning and zoning proceeded in California, its effects on the land market soon became apparent and impinged upon local governments' property tax resources. Every local government is expected by its constituency to provide services and finance them. The property tax rate is applied against the jurisdiction's tax base—the sum of the assessed valuation of all parcels of property within the jurisdiction. Those values ultimately depend upon the development that takes place on each parcel, which in turn depends upon the planning and zoning policies applied to each parcel.

Those who deal in the land market—and this includes a great many people—have either a direct or indirect economic interest in local plans and zoning. At the same time, local governments have a continuing interest in maintaining and expanding their property tax bases. In this process there are windfalls and wipe-outs for individuals, as well as great debates over what is in the public interest for the local constituency.

These conflicts are likely to continue to accentuate the competition between different possible uses of land. Usable land is finite, and will grow scarce, especially in the coastal zone, as additional ecological constraints are imposed. This emphasizes the urgent need to find a new balance between and among the uses of land.

> It is frequently asserted that the private sector uses land as a commodity, while the public sector preserves it as a resource. To these assertions are often added the judgment that land as a commodity is "used up" in pursuit of self-interest, whereas land held publicly is retained as a resource for generations to come. At least these are the arguments of political confrontation, but they do not help illuminate man's relation to the land.
>
> Virgin land is a source from which parcels are drawn for many kinds of uses. For example, some of it may be converted to agriculture and diligently worked as farms. Other portions may be enjoyed in a leisurely way as beaches for recreation. In both cases, the land used becomes a commodity—serviceable in the processes of *production* and/or *consumption.*
>
> There is no necessity for land to be laid waste. Thus, if land is used so that its essential properties are preserved, it may be used again and again for either production or consumption, and remain a resource. The use of land makes it a commodity; its *careful* use makes it a resource.
>
> If land is not mistreated, the resource may be serviceable for generations. Through time it may be owned in a variety of ways—by individuals or groups, including the public. But the essential requirement is that it be protected against destructive misuse, and not treated as an expendable commodity.
>
> Land planning—including policymaking by elected and appointed officials—is an evolving art that attempts to systematize the careful use of both privately and publicly owned land. If the art matures and is universally practiced, all land, including the coastal areas of California, may be retained as a resource.

Local governments are clearly in competition with each other in trying to attract the kinds of land development that fit into their zoning patterns and enhance their property tax bases. Such competition was augmented when the state adopted its formula for subventing a portion of the state sales tax to cities and counties. The formula gives each local government a share of the total sales tax gener-

ated by the stores, markets, warehouses, and other commercial activities within its jurisdiction. The local governments compete with each other for private facilities—especially regional shopping centers—to locate within their boundaries. Since retail stores, for example, can only locate on land zoned for such activity, each city and county must work such zoning into its land use plan and zoning ordinances.

For each city and county there is a relationship between revenue from the property tax and the sales tax. Given a level of expenditure for facilities and services, property tax rates can be lowered only if sales tax revenue increases, other things being equal. Again, every local government is in competition with neighboring governments for available development, while a continuing set of arguments with private developers goes on. Local governments hope to gain public revenue from each development, but also to put such constraints and conditions on developments as are necessary to achieve the public goals laid out in the general plan. All of this has been referred to as the "planning game."

Mandated Responsibility to Protect the Environment

To the complex set of planning and zoning practices, the state has added another function: protecting ecological relationships. Through the technique of Environmental Impact Reports (EIRs), required by the California Environmental Quality Act (CEQA), each proposed development must be analyzed from the standpoint of its impact on the environment. All significant impacts must be mitigated to a degree in one way or another. Such requirements increase the incidence of wipe-outs for some private developers and add to the costs of development. On the other hand, the requirements charge each local jurisdiction to plan for the protection of the environment within its area.

Some local governments—depending upon who had been elected to local office—had been moving in this direction prior to CEQA. With the mandating of this function, all local governments *must* be concerned, but there is still wide variation among the many cities and counties. This aspect of planning and development also enters into the local political arena as a basis for much debate over the degree of environmental concern that is in the constituency's interest. Once again, however, it should be noted that the state has not established a statewide agency to set specific environmental standards, or to monitor the content and quality of city and county environmental planning; nor has it declared the environment within city and county boundaries to be a resource for all the people of the state.

Disenchantment with City/County Planning Within the Coastal Zone

The responsibility of cities and counties for regulating land usage has gradually increased, and the goals to be achieved by planning and zoning have expanded. City and county responses to this responsibility have also varied increasingly. Perhaps this tangle of responses—plus the competition already noted—contributed to some Californians' disenchantment with local governments' ability to plan and zone for the environment's protection. Or, perhaps it was the growing realization that ecological relationships are not confined to the boundaries of cities and counties, but instead spread out in a seamless web across geographic regions. At any rate, fueled by dissatisfaction with city and county performance, environmentalist groups united and campaigned successfully for Proposition 20. The measure took ultimate planning and development decisions affecting the coastal zone (i.e., in the permit area) away from the cities and counties and gave it to a temporary coastal commission.

Thus for four years, 1973 through 1976, cities and counties lost power to control development in the zone's permit area and the traditional planning game was interrupted. While private owners and public agencies could still initiate development proposals, ultimate governmental control was exercised by the state commission. That commission had no motivation to advance the goals contained in the 68 general plans and zoning ordinances of the coastal cities and counties, nor any responsibility or power to provide services and facilities within the zone. It was not accountable to voters in the 68 jurisdictions, nor for that matter to the voters of the state; members of the state commission and its six regional commissions were appointed in a variety of ways and were responsible for applying the criteria contained in Proposition 20.

Motivation for each permit application came from a developer. Environmentalists or others could oppose the application at public hearings conducted by the regional and state commissions. In short, environmentalists had a new political arena that was comparatively free from local governmental, financial and other trade-off considerations.

Proposition 20 contained planning goals which for four years were used in lieu of a general plan for the zone. The fundamental approach of Proposition 20 was to leave to the Legislature the final determination of how the coastal zone was to be controlled. The temporary commission had the power to allow environmentally sound development, and to prepare a plan for the zone for the Legislature's consideration. The plan was to recommend a permanent governmental and financial structure for the zone. On schedule, in December 1975, the plan was laid before the Legislature.

Coastal Act of 1976 Restores the Planning Powers of Coastal Cities and Counties

From the opening of the 1976 legislative session it was obvious that there was well organized opposition to the commission's proposal as introduced. Included was a coalition of developers and labor unions, as well as the statewide organizations of counties and cities. Later the League of California Cities supported the coastal legislation, after changes were amended into the bill. The first bill containing the plan, though amended many times, was killed in a Senate committee. A second bill was also amended many times.

The legislation finally enacted—The Coastal Act of 1976—does not include a state-adopted general plan for the zone. Thus, in effect it lacks the fundamental planning tool submitted by the temporary commission. However, many of the policies upon which the temporary commission based its coastal map are found in the coastal act, and coastal cities and counties are directed to incorporate these into their local coastal plans.

Whatever its reasons, the Legislature in effect restored to the 68 local jurisdictions coastal planning and zoning responsibility. The coastal act's innovative steps are to outline the planning goals and policies the coastal cities and counties should include in their LCPs, and to establish a permanent commission to monitor their initial drafting and future amendment. Also the concept of a permit procedure, with a public hearing for each coastal zone development, is retained but will be conducted in the first instance by local cities and counties. A limited appeal procedure to the state commission is retained. But the new process cannot avoid the trade-off considerations in which all local governments are involved.

Among the many policies coastal cities and counties must consider in developing their LCPs are these concepts: (1) the coastal zone has a particularly fragile ecology that needs protection; (2) it constitutes a resource that must be conserved, restored, and where appropriate, developed for all of the people of the state; (3) agricultural use of land is to be encouraged and aided; and (4) visitor-serving facilities are also to be encouraged. The act provides no additional funding for cities and counties to accomplish any of this.[3] In fact, the Legislature offers little money to the cities or counties, or to the new commission, to pay for costs of developing the LCPs, but instead looks to the federal government for planning funds—assuming that such grants will be available in the years ahead.

Probable Consequences of the Restoration

During a transition period the state commission and the six regional commissions will continue to exercise permit control over development in the zone. In this period, 68 coastal cities and counties will work on LCPs, trying to meet a strict time schedule, but many cities and counties already appear to be behind schedule. While the Legislature can amend the "due dates," even scheduling probably will become a political question. As in all such matters, some cities and counties may have fallen behind schedule deliberately as a matter of strategy. In the interim, the commission does not perceive its role to be the actual drafting of a plan to reflect statewide interests. Rather, it will be attempting to see that each of 68 LCPs reflects such interests—encouraging each local government to interpret the act's policies for the benefit of a statewide constituency, as well as for the benefit of each local constituency. This is a monumental task.

The pressures of the old planning game still operate on each coastal city and county government. Each must still view every parcel of land in its jurisdiction, and existing or potential development on it, in light of the government's financial position. Each is still in competition with its neighbor for potential beneficial development. Each act of a local official is still accountable to the local voters. Few, if any, could gain political strength locally by championing the rights of a statewide constituency in the development of an LCP, if it runs counter to important local-constituency interests. Consequently as the 1981 certification time draws near, the commission will probably be confronted by countless debates with many if not most coastal cities and counties. How decisively can the commission act as these debates unfold?

Weakness in the Coastal Commission's Position

In effect the Coastal Act of 1976 injects the state commission into the planning games of 68 coastal jurisdictions. (Proposition 20 did not do so.) Furthermore, the 1976 act gives the commission only limited ability to prevail in the impending debates. It is important to remember that the Legislature in 1976 almost failed to act—the planning and permit procedures established by Proposition 20 almost came to an end. Since then, the Legislature is widely believed to have become more anti control. This is frequently referred to as the emergence of the "Dow Syndrome"; an impatience with environmental controls that might discourage private development. Many people involved in the act's administration seem to fear that the Legislature will weaken the act if the commission even appears to be discouraging development. Also to the point, there is still apparent opposition to the commission as a threat to "home rule" of cities and counties.

The act itself contains another threat to the commission's effectiveness. By law, the six regional commissions will soon terminate. In addition, another round of appointments to the state commission is soon to begin. Six members of the state commission will continue to be chosen directly by the Legislature and the Governor. The remaining six, however, will be appointed through a complicated process involving nominations of city councilmen and county supervisors by coastal city and county representa-

tives, with final selections to be made by the Governor and Legislature from among the local officials nominated.

When the new appointment formula is fully operative after the regional commissions have gone out of existence, a significant shift in the composition of the state coastal commission will occur. Presently it numbers only one locally elected official in its membership. The new appointment formula, however, will mean that at least six of the 12 voting members are locally elected officials. This will be a major change that is likely to have a substantial effect on the state commission's voting pattern.[4]

Presently, some of the state commissioners already favor weak control over the LCP process. After the next round of appointments, this position will probably prevail. If the appointment process and the commission's composition thus influence the certification of LCPs, the commission will undoubtedly continue to have a major influence thereafter. Once an LCP is certified, the permit approval process passes from the commission to the local governments. At that point local governments' interpretation of the LCP and its application to each permit proposal becomes paramount and, once again, development along the coast will be returned to the control of 68 competing local governments. After certification, certain kinds of appeals can still be taken to the state commission, but the numbers of permit decisions appealed to the state level will depend on the actions of applicants and so-called "watch dog" environmental groups. In any event, a gloomy prediction is that not many appeals carried by environmentalist groups will be successful before a commission dominated by those sympathetic to local control.

The Consequences of Inadequate Funding

The temporary commission established by Proposition 20 had no powers of acquisition, development or taxation. It had no ability to undo coastal development that had damaged the environment. It was not intended to have such ability; it was a holding device, a means of arresting trends for four years until a permanent mechanism was created by the state.

The absence of implementing powers was understandable for a temporary agency, but even the plan submitted in December 1975 was deficient in recommendations as to how an effective restoration program for the zone could be paid for. The proposed plan analyzed the damage already done and outlined policies which, if instituted, would prevent further damage. There were, however, no estimates of the money needed to undo the development already in place, nor recommendations of sources for such money. Furthermore, the plan, through its recommended policies, asserted that new acquisitions and public facilities were needed to achieve goals for the statewide constituency, but once again, no reliable source of revenue such as new taxing power was proposed. The Coastal Act of 1976 does not address these financing needs.

Furthermore the state has not provided sufficient funds to finance, or even to match the enormous sums of federal assistance that might be available to finance the public transportation systems, low cost housing, subsidies to farmers, additional sewer and water systems, and all of the other facilities that are required to convert the coast into a usable resource for all of the people of the state. In fact, the permanent coastal commission really does not even have state funds adequate to support the preparation of state-mandated LCPs. Two possible sources that might provide significant financial help—whose dimensions and future are unknown at this writing—are Governor Brown's Urban Strategy, and President Carter's forthcoming urban programs.

In 1976, the Legislature also created, by separate act, the state Coastal Conservancy, with power to acquire land and to grant and lend money. It may purchase agricultural lands that are in danger of falling to other uses, as well as land within Resource Protection Zones. The conservancy may make grants to local governments, or to the state Department of Parks and Recreation, to do some kinds of restoration work and to develop public access to regionally significant portions of the coastline. The conservancy can also lend money to the Department of Parks and Recreation to preserve some kinds of sites.

Significant sums of money spent annually over a sustained period of time could address many problems. To date, however, the funding of the new agency has consisted only of a small portion of a state bond issue passed in 1976. While the conservancy is not now funded adequately, the situation might change in the future. In fact, if some of the financing mentioned above materializes, it may come through the conservancy. If such funding attains significant proportions, however, one must also note that the use of this separate agency would further divert power away from the coastal commission. Moreover, a new set of actors—the five-member board of the conservancy and its staff—will in any case be added to the already complex governmental equation. In any event, so long as the conservancy has little money at its disposal, the agency will not have much effect.

Most assuredly, coastal cities and counties have acquired no new source of funds for achieving statewide goals. Of course, the act charges the cities and counties with planning for such statewide goals in their LCPs, but is silent on new sources of revenue. Even if the coastal city and county governments could persuade their local constituencies that the zone ought to be used for statewide purposes, it is doubtful that they could ever persuade local voters that funds from the local property tax and sales tax should be used to pay for such facilities. In fact, few if any coastal city council members or county supervisors would approve such procedures.

Instead, it is predictable that local leaders will try to construct LCPs that reflect local goals more than they do state goals, and later will also probably interpret certified LCPs to local advantage. They will resist any attempt to use local monies to finance facilities for statewide use, and will contest the coastal commission if it tries to force them to do otherwise. They will battle the commission by lobbying in Sacramento to change the act, and by seeking the appointment to the commission of sympathetic commissioners; in brief, by co-opting the commission.

Needed: A Balance of Powers

As things stand, effective provision has not been made to undo the considerable damage already done to the coastal environment by years of unwise development. True, the trend toward further damage was changed at least temporarily by Proposition 20's coastal commission, and this policy is being continued by the present interim commission. But as basic control of the zone passes back to cities and counties, the policy of conservation, restoration and development, with a balance of local and state interests, is likely to be blunted because of the conditions under which cities and counties must operate.

If the Legislature had a strong majority that was determined to secure environmental and developmental balance in the coastal lands, it might have created—and could still establish—mechanisms sufficient to accomplish the complex task. If the coastal zone is to be a statewide resource, then sufficient and reliable statewide funds should be provided to finance the facilities and services entailed by that statewide designation. Such funds could be channeled to cities and counties, if it is desired to retain power for their governments within the zone. This would seem appropriate in order to have a means of balancing the rights and interests of the local constituents against the rights and interests of the state constituency.

To insure that the local city and county officials use such funds for state purposes, however, the state funds should come through the coastal commission. Coastal cities and counties would then receive funds from the commission on demonstrating that their LCPs contained policies that would advance state goals, as well as local goals. This would give the commission an effective means of maintaining its end of the balance.

Finally, the membership of the commission should be as fully responsible to the state constituency as local officials are responsible to their local constituencies. The threat of co-optation should not hang over it. Perhaps the membership of the state commission should be reduced to the six clearly state-level positions now filled by the state appointing authorities. Or perhaps the number of state-level positions should be increased, maybe to nine or 11, in order to insure a broader base. But the additional positions should be filled in the same manner as the basic six *state* seats are now, i.e., chosen by state appointing authorities, without requirements that any members be locally elected officials.

The Basic Change: The Shift Back Toward Home Rule

Both Proposition 20 and the coastal act made a basic change in local home rule in the coastal zone. That change requires a governmental structure that recognizes a new, larger constituency with coastal rights and interests that should be actively advanced.

First, the state spelled out, as never before, how the environment was to be protected from certain kinds of development. Second, local coastal governments were directed to carry out the LCP process. But the state law did not relieve those governments of their local involvements and responsibilities. As a result, some important questions remain: How can local government be faithful to its role in community representation, while also being responsible to a second, statewide constituency? How can any government be responsible to two constituencies, especially when the two have conflicting interests?

If the Legislature had been willing to take coastal zone control from cities and counties, it might have established a structure similar to the Bay Conservation and Development Commission in its relationship to the cities and counties around San Francisco Bay. By adopting a plan submitted by BCDC and making the latter—a regulatory agency—the administrator of the plan, the Legislature permanently transferred power over the Bay and a narrow band of Bay frontage from the cities and counties to BCDC.

Admittedly, there are significant differences in the two situations. In the case of the Bay, the principal target for control is the Bay waters. The100 foot strip of bayshore was transferred to BCDC's regulatory jurisdiction as a means to that end. In the case of the coastal zone, the target for control is not the ocean as such, but the land in the zone itself—a little under 1,000 yards wide on the average, although narrower in some places and much wider in many areas of recreational or environmental significance.

BCDC was given powers adequate to achieve the objectives for which it was established, i.e., to conserve the Bay and its immediate shoreline, while allowing appropriate non-damaging development. On the other hand, the coastal commission has *not* been given adequate power to conserve the California coastal zone and guide its restoration and development "in a manner that protects the irreplaceable resources of coastal land and waters."[5]

A state commission so constituted could be expected to represent effectively the statewide constituency which the coastal act brought into the governance of the coastal zone. Cooperation between governments more or less equal in power is the only alternative to the domination of one over the other. By returning planning, zoning and permit issuance to cities and counties through the LCP process,

the state is giving those governments and their constituents a strong voice in coastal policy. We need assurance that the commission also has a strong voice in coastal policy, adequate to protect the interests of the statewide constituency.

NOTES

[1] *California Public Resources Code*, secs. 30000 et seq. As defined in the 1976 statute, the coastal zone includes land and water areas of California extending seaward to the state's outer limit of jurisdiction, and including all offshore islands. The zone extends inland generally 1,000 yards from mean high tide line, but with important exceptions. Thus in "significant estuarine, habitat, and recreational areas" it goes inland to the first major ridgeline, or five miles from mean high tide, whichever is less. In developed urban areas, the zone generally extends inland less than 1,000 yards. The specific boundary lines of the zone are detailed on maps identified by the enacting legislation.

[2] If a local government's coastal plans have not been certified and zoning and implementing devices made effective by January 1, 1981, the coastal commission may prohibit or restrict the local government from granting permits to develop, or may require state commission permits in the case of developments that would be contrary to the coastal act. *Public Resources Code*, sec. 30518.

[3] The enactment of the Jarvis-Gann Initiative, or any other restrictive measure limiting the traditional funding sources of cities and counties, will impinge sharply on their already heavily taxed ability to respond to any new demand.

[4] One group of researchers examining the record of the South Coast and San Diego regional coastal commissions found evidence suggesting that "whether a commissioner is a public member or an elected official appears to be a significant factor in explaining voting behavior." (p. 47) They found that "Public commissioners vote pro-environment twice as often as elected commissioners...." (p. 51) and also noted that commissioners who were city councilmembers were particularly likely to vote pro-development, as compared with other commissioners. They concluded: "there is now some empirical evidence to suggest that city council members, because of the 'pull' of local control, may not be the best suited to serve on commissions where they have to make land use decisions which are in conflict with the decisions of local authorities." Judy B. Rosener, with Sallie C. Russell and Dennis Brehm, *Environmental vs Local Control: A Study of the Voting Behavior of Some California Coastal Commissioners* (Claremont Graduate School, Claremont, Calif., April 1977).

[5] Quoted material from M. B. Lane letter of December 1, 1975 to Governor Edmund G. Brown, Jr., transmitting the *California Coastal Plan*.

Coastal Planning

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COASTAL PLANNING IN CALIFORNIA: A PROGRESS REPORT*

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Introduction

California's state coastal planning program was enacted in response to certain shortcomings seen in the performance of local government. Critics believed that local governments were often not effective with respect to the environmental aspects of land-use regulation on the coast, were incapable of dealing with big projects, usually proved unwilling to consider the needs of their neighboring communities, and tended to give developers too free a rein. After several years of trying to gain satisfaction from the state Legislature, conservationists went directly to the people with a coastal initiative (Proposition 20). It was approved by a 55 percent vote at the November 1972 general election.

Proposition 20 gave California a temporary four-year mechanism for coastal planning and regulation; the system was then made permanent, although with significant modifications, by a 1976 law. The 1976 legislation sought to resolve some serious controversies by formulating a sort of uneasy compromise between local government supporters and conservationists.

While real disputes and a certain lack of trust underlie the coastal act, it represents major opportunities for resolving conflicts and arriving at workable compromises on coastal issues. The conflicts help emphasize the difficulty of preparing plans concrete enough to meet the requirements of the coastal act, while allowing enough flexibility to take into account future uncertainties and leaving ample room for future creative action in matters that cannot now be foreseen.

California is thus a year and a half into the exceedingly difficult process of implementing the 1976 law. Obviously the end result cannot now be foretold, but there is already enough evidence, some of it impressionistic, to assess problems and accomplishments so far. This "coast-watch" may help Californians judge whether and how well the legal mandate is being carried out, and what the next steps in coastal planning should be.

After a brief look at the federal coastal program, California's experience under Proposition 20 and the 1976 coastal law will be explored.

The Federal Program

California's coastal planning has received a big push under the federal Coastal Zone Management Act, passed in 1972. This act in turn was stimulated largely by the example of the San Francisco Bay Conservation and Development Commission and its successful experiment in Bay fill control and shoreline regulation.[1] Passage of the federal law was part of a larger environmental movement that—beginning with the National Environmental Policy Act in 1969—brought about wide-ranging federal legislation. Examples include the Environmental Protection Agency, requirements for environmental impact reporting, and encouragement of comprehensive planning, particularly the "208" environmental planning efforts now in progress in most metropolitan areas.

The federal program under the Coastal Zone Management Act offered funding for state coastal planning and held out the promise of additional money to help carry out approved state plans. Further incentive was offered the states in the law's "consistency" provisions requiring that federally related activities on the coast be consistent with (federally approved) state coastal plans, in the absence of a cabinet-level decision otherwise. The state work is monitored by the federal Office of Coastal Zone Management under general criteria outlined in the act:

> . . . [a state] must have a management program . . .sufficient to implement its coastal plan. Although states are given maximum flexibility . . . each state management program is expected to provide clarity, unity, and definite assignments of responsibility . . . . [with] a single state agency or entity . . . in charge of the overall program, at least for administrative and policy purposes.[2]

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In qualifying for the federal program, states may exercise direct controls over land and water uses; they may collaborate with their local governments by setting statewide standards for local implementation; or they may provide for administrative review of coastal plans and regulations proposed by state and local agencies and the private sector. The coastal states are trying to comply with the federal programs; California is one of the front-runners, largely because its own coastal program was initiated in 1973 under Proposition 20.

California's Program

Proposition 20 established a four-year coastal planning process backed by a state commission and six regional commissions to oversee planning and regulate coastal development in the interim.[3] Meanwhile the state coastal plan, including recommendations on how to carry out the plan, was delivered to the Legislature at the end of 1975.[4] The Legislature had a year to pass a new coastal statute, or the entire system would have ceased to exist January 1, 1977. At the end of the 1976 session and after a hectic struggle, a coastal bill was approved continuing the system established by Proposition 20, but with important modifications.

The 1976 law continued the state commission; the regional commissions are to be continued only until mid-1979 unless the Legislature passes a bill in the current session to extend them, as seems likely. Local governments were given a key role in coastal planning, under policies in the 1976 act and guidelines set by the state commission. They are to prepare local plans and implement ordinances for their portions of the coastal zone, subject to review by the regional commissions and certification by the state commission.

The local planning effort is being funded largely with federal money available through the Office of Coastal Zone Management, with an additional 20 percent matching share provided by state funds. A major part of the planning process is supposed to be finished by 1981. After the state commission certifies that a local plan complies with the 1976 coastal act, the local government will make the principal decisions on land use and development in the coastal zone, subject to appeals in carefully limited situations.[5] In addition, of course, the state commission must approve any amendments to a state-certified local plan.

A forthcoming shift in the membership formula of the state commission should also be noted here because of the increase in local representation. This is how it works. Presently the Governor, the Senate Rules Committee, and the Speaker of the Assembly each select two state commissioners. The other six state commissioners are appointed by and from the regional commissions, one from each region. The regional commissions in turn are composed equally of public members chosen by the Governor, Senate Rules Committee and Assembly Speaker, and by local councilmen and supervisors chosen by their city and county governing bodies or by regional councils of governments.

As of summer 1978, only two state coastal commissioners were locally elected officials. When the regional commissions go out of existence, however, former regional commissioners will be replaced on the state commission by persons selected by the state appointing authorities, who will choose from lists of county supervisors and city council members sent up by the coastal cities and counties. This change would therefore cause "a significant shift in the composition of the state coastal commission. . . ."[6] At least six of the 12 voting members will be locally elected officials, and perhaps more.

An "Impossible" Job?

To sum up, California's coastal law initiated a new set of collaborative planning processes, while continuing most of the old ones—especially coastal regulation—at least temporarily. The basic planning job was assigned to coastal cities and counties, under guidelines and policies outlined by the state commission, subject to review and certification by the state commission, and with a tight set of deadlines. Some have called the assignment an impossible job, given the limitations on human and information resources and the time constraints.

Guidelines and Other Documents

Local coastal programs (LCPs) will comprise each local jurisdiction's plans for its portion of the coastal zone, with implementing ordinances. First, local governments were asked to identify coastal issues in their areas, and then to develop work programs—including proposed budgets—for completing the LCPs.

The state commission prepared guidelines and other documents giving local governments advice and instructions. The written materials drew a mixed response. Their volume seemed to overwhelm many local planners, although some documents were called "invaluable," and "very helpful." But the LCP regulations were characterized as "too vague" and "hard to interpret." Use of excessive legalese was a major source of criticism:

> Whoever wrote the LCP Regulations was a prisoner of his own jargon. For example, the first sentence in paragraph (b) on page 10 contains 75 words, and if you read it carefully is almost meaningless, or at least open to wide and varying interpretation . . . [and there are many similar examples].[7]

Early Phases of Local Planning: Some Initial Difficulties

While a few local governments had conducted pilot projects in 1976 and 1977, almost all the coastal cities began issue identification in 1977 and started developing their work programs. Most are being submitted to the state commission around mid-year 1978. (In 1977 a very few front-runners also began work on their land use plans as such.)

In most cases, new local staff had to be hired, or consultants employed for the planning work. Some local staff appeared to develop good working relations with regional

or state coastal staff, while others voiced a variety of complaints. These complaints included difficulties in inter-level staff relationships, inadequacy of communication and understanding between levels and agencies, and an appearance of conflicting goals and interpretations between state and regional commissions.[8] Some local people and other observers believe that with better guidance from the state commission and more authority to make decisions, the regional commissions and staffs could play stronger roles in coastal planning, working more closely with local governments.

There was also some local unhappiness with funds made available for coastal planning. By urging local governments to include a wide range of topics in their early identification of issues, the state commission may inadvertently have encouraged local overshooting of the mark by sketching ambitious planning efforts, including studies of numerous topics. In any event, as localities proposed work programs and budgets for approval by the coastal commissions, the latter found many too elaborate and expensive for available time and funds, and called for cut-backs. Subsequent budget reductions led to uneasiness on the part of some local governments who feared that the preparation of acceptable plans would force them to spend much larger sums than would be available through the state commission.

At this point in mid-1978, it is unclear to what extent local governments will have to go back to the drawing board to produce local plans to comply with the coastal law as interpreted by the state commission. It seems certain, however, that virtually all local governments will have to do appreciable additional work to bring their plans into conformance.

Implications of Professional Styles: Some Conflicts

Some recurring problems relate to the professional styles of staff members and questions about the most productive enforcement methods. Many observers have suggested that controversy over approaches to the LCPs has resulted partly from differences that stem from staff background, training, and experience, as well as the professional "tools" they are accustomed to use. For example some coastal policies and procedures may have been too heavily influenced by a legalistic cast of thought and a permit-review style of decisionmaking. One observer of the reception of early local plans suggested that LCP submissions were being treated as "giant permit appeals."

Joseph E. Petrillo, Executive Officer, State Coastal Conservancy, and a former state coastal staff member who was one of the principal drafters of the coastal bill, responded as follows to the "giant permit appeal" comment (letter of August 3, 1978):

> . . . in drafting the final Government, Powers and Funding section of the Coastal Plan, I intended the Local Coastal Programs to be very much . . . [a giant permit process]. The permit staff . . . realized that a project-by-project review of proposals did not get at the "cumulative impact" problem. . . . Although the regions, environmental groups and others . . . wanted a simple adjustment of the current permit process, the permit staff prevailed upon them the wisdom of handling the "cumulative impact" issue through one giant permit, the LCP. . . . I think the fact that . . . the coastal bill . . . retained the specific coastal policies . . . indicates the Coastal Act was meant to concentrate on implementation of the policies and not further planning. . . .

In any event, lawyers and planners obviously sometimes do not see eye-to-eye, and in many situations misunderstandings can arise between them, especially when they must work together in controversial, high-pressure enterprises like coastal governance. To some degree this is probably inevitable:

> . . . lawyers tend to see planners as fuzzy-minded, imprecise people with grand schemes but no ability to put down the fine print that really determines whether the plans will work or not. Planners, on the other hand, tend to see lawyers as narrow minded, prissy people who have no vision and can't understand people who do, and who are always trying to shoot down things by insisting on more detail than can reasonably be provided. . . . In an operation such as ours, you obviously need both kinds of people, but you also need to arrive at a balanced planning approach.[9]

Planners increasingly emphasize the need for new skills, capabilities and sensitivities, as planning shifts from a "product to process orientation" and as negotiation and mediation are recognized as crucial planning tools:

> Open, complex, collaborative planning processes such as [are] required to carry out the Coastal Act need people that can facilitate a "diplomatic" rather than an "authoritative" resolution to the problem.[10]

A New Mission

Many saw the principal success of the *first* commission (under Proposition 20) as based on enforcement, used to reduce damaging impacts by guiding coastal development, and also employing the permit system as a learning process to facilitate completing a comprehensive coastal plan on time. The *second* commission, created by the 1976 law, continues vital enforcement by permit hearings until local coastal plans are completed and certified. Meanwhile, however, its principal new mission in 1977-1981 is to see that local governments develop good local plans and implementing ordinances that comply with state goals and policies for the coast, and that they are accepted and supported at the local level.

In this effort, success may depend on persuasion, explanation, and negotiation as much as it does on state enforcement of detailed regulations, or "strong arm" methods.

The Specificity Controversy

Some other big questions are: What major policy changes in local plans will be required, if any, and how detailed will the coastal plans have to be? Which state coastal policies will apply, how stringently, and in what areas?

Which policies must give way in certain circumstances? Local governments sought clarification and guidance on these questions as they prepared their work programs. In the spring of 1978, a basic controversy emerged over the degree of specificity and amount of detail to be required of local plans before certification.

In drafting coastal plans, many decisions must be made regarding which options are to be kept open, and which "closed down." Making plans more specific means giving up more future options. It is often difficult for a local government to decide finally what ought to be done with individual parcels on a "crash" basis, unless it already has reached a consensus on policies or until it receives and responds to specific developmental proposals. In a continuing *process* of planning, things are presumably never really finished. Although some final decisions can be made, others must be held over for further consideration and to await future developments. On the other hand, an approved plan presumably means approved development, and the approving body needs to have a reasonably good idea of what they are authorizing.

Much of the coastal commission's present power to enforce and implement coastal policy is to be delegated to local government when local plans and zoning ordinances are certified. Local plans as interpreted by local governments will then govern the coastal zone except in carefully limited situations, noted earlier. Thus it can be argued that detailed plans written in specific terms will increase the assurance that current commission policies for the coast will determine its long-term future. This view, drawing on past experience, led to concern that failure to require detail might limit the commission's (and the state's) future ability to be sure that local plans conform to state policy. Accordingly early this year, a state staff member proposed highly specific criteria for local plans. He emphasized "decisions at the first major fork in the road–the land use plan . . . " arguing that ". . . the [local] plan must be 'sufficiently detailed' . . . to leave no major questions unresolved. . . . "[11] The memo continued:

> . . . precise, well-defined land use designations and precisely drafted policies are essential. . . . Thus the [local] Land Use Plan must designate *the* principal *permitted* use(s), *the* specific *conditional* uses, the specific policy (i.e. performance) standards applicable to the *types* of permitted and conditional uses, and the precise policy standards that will be applied in reviewing uses for *specific* geographical uses. [emphasis in original]

In early April 1978 the League of California Cities responded by arguing that the state commission should concentrate on major policy issues rather than on details of local plans:

> The specificity needed in the land use plan should be obtained through the inclusion of policies rather than site specific plans or designs. The land use plan should not contain specific easements and setbacks on a lot by lot basis. . . .There needs to be flexibility in the plans to assure that projects can be made economically viable. [12]

Shortly afterwards a workshop of local coastal planners echoed these sentiments, ranking "degree of specificity" highest among pressing coastal issues causing great concern:

> The coastal commissions may intend to require greater specificity than is prevailing practice in land-use planning. This may make the planning process more difficult and rigid, force decisions prematurely, and close off future options too soon.[13]

The Agua Hedionda Case

The first land use plan submitted for state commission approval related to Agua Hedionda Lagoon and adjoining areas in the City of Carlsbad (San Diego County). At the outset the plan seemed likely to be judged by the detail-emphasizing criteria. Coming before the commission in February 1978, the initial staff comments on the Agua Hedionda proposal were lengthy, calling for many changes and much detail. Statewide attention focused on the issue, with many local governments expressing concern because it was widely believed that decisions on Agua Hedionda were likely to be precedent setting.

Meanwhile there was a top-level change in state staffing, and the new Executive Director Michael Fischer took office in mid-March, replacing the retiring Executive Director Joseph E. Bodovitz, who had served with distinction for five years since the inception of California's coastal planning under Proposition 20. Prior to his appointment Fischer had spent two years carrying primary responsibility for preparing Governor Brown's urban strategy for California, working closely with business, labor, environmental interests, planners, and local governments. In announcing Fischer's selection, state coastal commission Chairman Bradford Lundborg emphasized his view that the commission's most important task was developing "a strong, cooperative relationship with local governments up and down the coast," and noted that Fischer's earlier experience in local government and as a planner should help.

Recognizing the significance of the specificity issue and the precedent-setting nature of imminent decisions, Fischer gave priority to Agua Hedionda and relations with local governments as demanding his close and continuing attention. He worked with coastal staff to prepare a new set of recommendations and conditions for the Agua Hedionda proposal, focussing on principal objectives rather than on design detail. The state commission also asked the City of Carlsbad for its view.

Seeking to permit flexibility in local plans along with reasonable assurance that state policies will be complied with, Fischer asked the League of California Cities to prepare a second memorandum, issued in late May. They suggested several alternatives for conditional or partial certification of local plans that would retain the state commission's basic jurisdiction over unresolved issues while permitting coastal planning and zoning to proceed in an orderly manner with respect to areas and issues where agreement can be reached.[14] Partial certification could apply either to a geographic portion of a local government or to certain portions or policies of its land use plan. This proposal would allow local governments to begin implementing ordinances for approved areas and policies while the state commission and the local government continue to address policies or areas not certified.

New Criteria: Priority Issues

Focussing on high priority issues and giving further guidance to local governments in LCP preparation, coastal staff prepared new criteria (adopted by the state commission on June 20, 1978).[15] The new criteria are summarized as follows: Undeveloped land that would be affected by coastal act policies should be given highest priority, especially if it is under developmental pressures, and natural resource protection (e.g. lagoons and agriculture) should be given high priority. In areas already highly urbanized, LCPs should focus on beach access, parking and traffic congestion, visitor-serving uses, and low-to-moderate cost housing, usually in that order. Development design, bulk, height and setback requirements should be dealt with only in very general terms, except on scenic routes, shore areas or other specially significant areas. Where the potential impact of new development would be comparatively small, the LCP should not try to resolve the issues.

In all cases, original research or new data collection should be minimized. Moreover, "low cost" solutions to problems should be used where possible. For example, review procedures could be established for future determination of geologic stability of proposed developments, rather than actually conducting costly geologic studies in preparing an LCP. To give local governments further guidance, the new criteria were accompanied by one-paragraph summaries for each local coastal jurisdiction, highlighting the principal issues to be resolved in LCP preparation.

State, Local and Regional Tensions

Presumably local governments will welcome the new criteria, which should provide some degree of the desired flexibility. Nevertheless some of the tensions between the state and local levels are likely to remain. After studying coastal planning in nine states, Jens Sorensen likened the shifting relationship to a tennis match, "with the burden of responsibility and work bouncing back and forth between state and local government."[16]

The state must be realistic in its expectations. If its demands exceed local planning capabilities, the locals may see this as demonstrating state staff's failure to recognize local limitations or understand local goals. But Sorensen also emphasizes that state guidelines need to be "demanding enough, [otherwise] local programs may not even come close to achieving the objectives" of the coastal legislation.[17] For their part, the principal question of most local governments will be: "*What is the minimum amount of effort needed to modify the way we are now doing business in order to receive state approval?*" [emphasis in original][18]

In other words, with some significant exceptions, most local governments will try to get by with only marginal adjustments in their existing local plans, whereas the state coastal authority will push for more searching review, and overhaul where needed to comply with state objectives.[19]

Previously, local governing bodies had been accustomed to dealing with their own local constituencies. Each local unit planned and zoned to meet the interests and concerns of those who could effectively make their influence and preferences felt in the local halls of government. As Lenard Grote observes:

> This is the very essence of local home rule. Until the coastal law came into effect, state government had never established regulatory agencies or other machinery to monitor the contents of local general plans.[20]

In short, some basic ground rules of the planning process were changed rather abruptly. Local governments and the coastal commissions are both feeling their way in new relationships that are inevitably somewhat strained, and will surely be characterized by much maneuvering and bargaining. It will not be easy to reduce tensions because they are built into the process, which was established in large part to deal with "real world" conflicts between those who want special protection for the coast, and developers and their presumed allies in local government. Further, as Sorensen notes:

> . . . in states that are beleaguered by rapid growth and threatened with an avalanche of development activity, such as California, Florida and Oregon, the first round of program approvals may be the only good shot the administrative agency will have to assert state interests; the state might not get a "second chance."
>
> [Presumably] . . . the California Coastal Commission will attempt to tie down local government plans with as much specificity as possible to protect against avalanche losses.[21]

A Stronger Role for Regional Commissions?

As noted earlier, some local staff believed that the regional commissions could play better-defined and more important roles in the negotiating process, but to do this would need more guidance from the state commission. Moves in this direction seem imminent. Thus Executive Director Fischer has said that he intends to schedule workshops in each of the coastal regions, where he and each respective regional executive director would meet jointly with city and county planning directors to review policy differences and try to negotiate their resolution. Subsequently regional workshops could also be held with mayors and supervisors, at their request.

As the review of draft LCPs by the regional and state staff proceeds, another device could help insure state-regional coordination and give local governments the policy guidance many have been asking for. State and regional executive directors would send a joint letter indicating their views of the LCP to each local government before the council or board of supervisors reviewed it.

A stronger role for the regions would also clearly be furthered if Assembly Bill 3478 should pass. The measure would extend the life of each regional commission until it has certified all local plans, or until mid-1981, whichever is earlier, instead of dissolving it by mid-1979.

In 1976 the Legislature virtually ignored the regional commissions partly because there was strong opposition to their continuation on the part of labor and builders. This opposition was apparently based on "gut reactions" and may have been stimulated by what appeared to be

arrogant behavior by a single regional commissioner. Moreover the conservationists, who might have been expected to support the regional commissions, did not do so actively, but concentrated instead on the hard-fought struggle to continue the state commission. As an astute observer then on the staff of the League of California Cities observed:

> The decision to abolish the regional commissions was not made after a thorough analysis . . . of the need to continue them, rather they were in a sense sacrificed so that the State Commission could continue.[22]

In addition, state coastal staff may well have harbored some ambivalence toward the regional commissions. The former chairman of the state commission, Mel Lane, had these perceptive comments:

> The planning process could have been organized better. The way it was set up . . . begged for civil war between the regional commissions and the state commission. A tremendous amount of energy and time was spent trying to prevent that civil war. . . .
>
> . . . the state commission and staff just kept pushing. Furthermore the regional commissions and staffs had a sense of responsibility. They had to go along with "our" schedules for the overall good. This meant they went along even when they strongly disagreed.[23]

Lane attributed the tension to distance, the size of the 1,000-mile coastal zone, time pressures, and the difficulty of getting state and regional commissioners together regularly, since state and regional commissioners rarely met, except for the six regional members who also sat on the state body. On the other hand, the relationship improved markedly over time. Lane believed that all the regional commissions were cordial to him personally, noting no animosity but a feeling that he "was on a different wave length than the regional commissioners due to a lack of communication."

Of course, the tensions also were partly due to genuine regional differences of opinion with respect to coastal planning goals. For example, the North Central Coast regional commission (San Francisco, Marin and Sonoma counties) was seen as strongly in favor of coastal conservation, while the North Coast regional commission (Mendocino, Humboldt and Del Norte counties) was considered lukewarm if not down-right negative to coastal conservation. The commissions tended to reflect attitudes believed to be widely held in their respective regions.

Negotiation and Consensus Building

In addition to reflecting regional opinion, however, regional commissions can provide certain important services, especially playing intermediary, consensus-building roles in coastal planning. AB 3478 now has virtually universal support, including that of labor, realtors, developers and contractors, suggesting that opinions have changed drastically on the usefulness of the regional commissions:

> There is general agreement that allowing the regional commissions to go out of business just as local plans are coming together would, at a minimum, cause intolerable delays . . . and might lead to enough confusion to make it impossible to finish some of the plans.[24]

Despite severe work pressures the regional bodies and staffs have handled a heavy permit-hearing load and made other significant contributions to the coastal planning process by reviewing and commenting on draft plans. When asked if the regional commissions would be missed, a strong proponent answered

> . . . indeed they will be. The state commission cannot give the necessary perspective. . . . [with the regional commission] there are few parts of my region where if a person felt he was asking for something consistent with a plan, he could not get to the commission meeting to discuss it. . . . it is possible for [regional] commissioners to look at the problems on the lands themselves. The regional commissions will be sorely missed.[25]

In fact, the shift to local coastal planning under the 1976 law "may have opened a stronger *potential* role [for the regional commissions] in monitoring and reviewing local performance, as well as in helping negotiate future issue conflicts."[26] Such negotiations, involving local officials as well as state and regional staff and commissions, may be one of the most effective ways of seeking local cooperation and accommodation to state objectives.

> Ultimately the entire . . . effort . . . boils down to whether local government will eventually take the attitude that implementation of the certified program is in their best interest.[27]

Additional Responsibilities of the State Commission

In addition to collaborative state-local planning and permit appeals, the state commission also has other responsibilities. Substantial work has already been done on most of the following: serving as lead agency for the coastal energy impact program (financed under the federal act); ranking possible coastal sites for liquified natural gas (LNG) terminals; designating portions of the coast where power plant development would be inconsistent with the coastal act; identifying coastal zone forest land where special logging procedures are needed (advisory to the state Board of Forestry); considering relationships between coastal management and controls of San Francisco Bay (jointly with BCDC); and certifying port master plans for California's four major commercial ports.

Earlier, other Sacramento-based state agency staff may have resented the coastal commission, sitting in San Francisco, with its good publicity and strong permit review powers. "Turf" problems with several state agencies came to a head during the 1976 legislative session when the coastal bill's early version would have given the coast commission some control over the actions of other agencies affecting the coastal zone. Opposition from the agencies caused an entire chapter of the bill to be painstakingly

drafted, reducing duplication of authority and interagency conflict, while giving the coastal commission a clearly acknowledged though largely advisory role with respect to such agency policies and actions. This removed the active opposition, although some coolness persisted in certain quarters.

In any event, the state coastal commission has recently been mending fences with the state agencies, especially since January 1977 when Peter Douglas joined the state commission as deputy director, with agency relationships as one of his principal assignments. Interagency agreements are being concluded to facilitate state agency involvement in the coastal planning process in a meaningful way. This is important, because without increases in manpower the state agencies nevertheless have a good deal of coastal planning to do. The agencies need to participate in LCP preparation in order to be sure that appropriate provisions for future state projects are included in local coastal plans, otherwise later on there will be problems in obtaining permits.

A Stimulus to Local Planning

The infusion of federal and state funding and the demands for coastal planning staff work at the local level have brought in some capable new planners and given preexisting planning staff exciting new challenges. Of course, the local revenue cuts under Proposition 13 could have a severe negative impact on this promising start. Only time will tell, plus the extent of continued state and federal financial support. Meanwhile, in a variety of ways coastal planning is helping shake up and alter the environment many planners have worked in. This paraphrase of comments at a recent conference suggests one view of the status quo that the coastal program is helping to change:

> Most . . . planners have been in their positions for perhaps 15 years. The job many of them have been doing is itself "negative," consisting of saying "no" to developments that do not conform to zoning and other requirements. Added to this, they have been working with out-dated ordinances. Finally, the staff in time comes to mirror the outlook of the board of supervisors or city council, which can sometimes be downright anti-planning.[28]

Some local jurisdictions that were already doing a comparatively sophisticated job of planning have had their attention directed more forcefully toward the coast, and are being required to consider state coastal goals. Other local jurisdictions that were lagging are having to gear up. The following comment (by a coastal workshop participant and experienced local planner) may overstate the case a little, but probably not much:

> We should acknowledge that the coastal law got local government out of the dark ages in planning. Most or all of us were doing sloppy planning, but have stopped fooling around. Despite complaints about some of the details, I am very pro-coastal act over the longer sweep.[29]

This optimistic view of improved local performance relates principally to the work of professional staff planners and consultants. It remains to be seen how local governing bodies and community political leaders will respond to the coastal planning program. So far, city councils and boards of supervisors have scarcely been involved. Before long, of course, they will have to enter the action and necessarily play a crucial role in determining the outcome.

Retrospect: Permit Review and Other Accomplishments

From the California program's start-up in 1973, coastal planning has been back-stopped by permit power, with the regional and state commissions hearing appeals from city and county decisions with respect to development or land-use change within the area of permit control.[30]

Many thousands of permit appeals have gone through the coastal mill since early 1973. In 1977 alone, for example, more than 7,700 applications were processed by the six regional commissions, and over 95 percent of them were approved. Such widely quoted figures on the high approval rates may have led some observers to the mistaken conclusion that the coastal process has made little difference, except in a handful of cases.

Admittedly, in the words of Paul Sabatier, "the vast majority of permits involved essentially routine decisions by the regional commissions."[31] On the other hand, substantial numbers of the permits counted as "approved" by regional commissions were actually approved *with conditions or modifications.*[32] Robert Healy comments:

> Our own observation from attending many permit sessions of the South Coast Commission is that the conditions imposed . . . were frequently quite significant, often involving major changes in design or reductions in density.[33]

Moreover the state commission generally took a stricter approach to permissible development than the regional commissions. Thus many applications approved by the regional bodies were later denied by the state commission, or had other conditions attached to the approval. In fact, when the state commission on reviewing an appeal found a substantial issue and therefore heard the case, "it was virtually certain to either impose conditions or deny the application altogether."[34]

Conditions often related to bulk, height and design of structures, landscaping, provision of public access, transportation and parking, reduction of the density of multi-unit developments, erosion, or water quality controls. The commissions were "very tough on residential projects of five or more units considered significant . . . enough to be appealed to the State Commission."[35] A major nuclear reactor addition—San Onofre—was allowed to proceed after some redesign and other conditions were met. Urban redevelopment projects were required to be scaled down, and other decisions attempted to prevent urban encroachment onto agricultural or forest land.

In addition, another elusive but important factor was at work. When builders and developers saw how the coastal law was being enforced, many voluntarily began anticipa-

tory planning, "upgrading" their proposals before submitting them.

> Developers, local government, and state agencies are all showing a lot more environmental awareness than they used to. And . . . they are acting on this awareness. Not as much or as fast as most environmentalists might want, but not badly either.[36]

Healy sums up his view of California's recent coastal development under commission regulation:

> In general, we find modest growth, mainly in the form of infilling of semi-developed areas or slow increases in intensity of land use in older, built-up areas. No new large-scale subdivisions were allowed in the near-coast area. Owners of lots in existing residential or recreational subdivisions were generally allowed to build, provided they built structures no larger than those on nearby lots.[37]

Drawing on his study of controversial permit decisions, Paul Sabatier concludes that "the coastal commissions substantially altered the developmental outcomes that would have existed in their absence."[38] In short, California's coastal program clearly has effectuated higher standards in coastal development and environmental protection.

Complaints About Permit Processes

Despite Proposition 20's "vested right" protection, California's coastal regulation and the permit process caught some projects in mid-stream, creating awkward policy questions such as : Which projects should be permitted to "build out" and which should not, and why?[39] Some owners of small lots have been unhappy when building plans were slowed, modified or denied. Larger development proposals have also gone through the regulatory mill, and the coastal commissions took a rather strict line with some of them.

Coastal property owners have lodged a number of complaints about the permit decision process, and recent legislative hearings catalog many such grievances. Appellants have alleged that

(1) actions were sometimes arbitrary, discriminatory or capricious;

(2) the process was much too rigid, and tight time limits during hearings precluded adequate presentations;

(3) staff documents were sometimes received by appellants only a short time before hearings, preventing adequate study and response;

(4) last-minute conditions were imposed without adequate study or time for appellant to respond;

(5) staff recommendations were based on inadequate or inaccurate information, and appellant had little or no opportunity for rebuttal;

(6) some owners have been forced into costly long-term holding actions until completion of local coastal plans;

(7) limits on building size and height were unrealistic or architecturally infeasible;

(8) required conditions made projects too costly or economically infeasible;

(9) staff or commissioners were not available for preliminary negotiating sessions;

(10) staff were too young and inexperienced for the difficult tasks;

(11) staff were seen socializing with "Sierra Club types," contributing to appellants' fear of possible unfairness; and

(12) insuffient allowances were made for owners of single family lots who got caught by the coastal act unexpectedly.

While the merits of such complaints are unevaluated, those relating to procedure and due process ought to stimulate improvement of the regulatory machinery's functioning so as to insure equitable treatment for all.[40]

Private Sector Cooperation and Acceptance

Despite complaints from the private sector, however, there are many bases for constructive cooperation between private-sector interests and coastal management. Admittedly there is widespread sentiment that private persons owning individual small parcels or lots (on which they perhaps hoped to build retirement homes but got "caught" by the coastal law) are probably the most deserving group for some form of relief or compensation.[41]

On the other hand there is persuasive evidence that larger developers are learning to live with coastal planning, and in fact look forward to completion of its current phase, which should remove many ambiguities and much uncertainty.[42] In short, a good deal of understanding and even acceptance of the coastal planning process seems to be emerging.

After reviewing grounds for agreement between environmentalists and developers, and noting the learning process the environmental movement has spurred, Robert Healy commented:

> . . . beyond heightened interest and concern, some builders have developed a remarkable sophistication about how their constructions interact with natural systems. They have had to do so in order to stay in business in an era of impact assessment, environmental planning, and stringent land-use controls. [In this regulatory environment] . . . the developer himself receives and digests the reports of his soils engineers, and revises his projects to meet the public's demands. Having gone through this process again and again, the developer is increasingly likely to understand the technical basis of environmental control.[43]

Of course a host of other interests and conflicts also confront communities as they move into coastal planning. Recent interviews with local recreation and park administrators disclosed a wide range of concerns with future coastal policies and the ways these will affect coastal communities. For example, the concept of "coastal access" generated many relevant definitions and interpretations as well as numerous examples of the consequences of access, and conflicts over access policies.[44]

Public Participation

The 1976 coastal law and state commission guidelines

strongly support "public participation" in coastal planning, prompting the publicizing of agendas and announcements of meetings, and the availability of planning drafts and documents. To alert citizens about coastal issues, local governments are mailing notices in larger numbers, encouraging media coverage, and contacting a variety of special interest groups. But local government observers point out that "all of these methods cost money, and . . . [we] will need substantial financial help." Furthermore they complain that, despite such efforts and expenditure of additional funds, "for the most part, regular public meetings and hearings do not get good results" in the form of public participation.[45]

If these methods of encouraging wide public participation have not appeared sufficient, what further measures may be more realistic? One approach is to make opportunities for participation available through as many channels as feasible but to expect only a relatively few well-informed and highly motived citizens actually to come forward. Some of the most effective "public participation" is provided by individual citizens who have the time and inclination to become familiar with coastal issues in their communities. Most of these participants will probably be affiliated with organizations like the Planning and Conservation League, the Sierra Club, the League of Women Voters, or local community groups, who have banded together out of mutual interest in public policies, and who rely on their organizations to provide informational services reaching their fellow members and other citizens.

Sierra Club observers, for example, emphasize the importance of working with a relatively few active citizens and knowledgeable people, focusing on concrete, pragmatic coastal planning issues, rather than on *general* policies or concepts.[46] Experience with other public interest organizations also underlines the important roles a comparatively small number of citizens can play when allied with appropriate community groups, if they are able to become well informed on issues, attend meetings, and communicate their findings and recommendations to others.

Capitalizing on this potential, governmental mailing lists should include–but of course not be limited to–a wide variety of organizations known to be interested in planning concerns. Foreign observers have frequently remarked on the American "genius" for organizing around shared goals and interests through networks of citizen groups. Information provided to such networks–from the coastal commissions and other appropriate sources–will be most likely to reach citizens who have already indicated their willingness and ability to participate in planning discussions. Finally, since such groups play an essential role in public participation, outright subsidies from public funds have been suggested as a way of helping give them continuity and staying power.[47]

Acquisition and Implementation

Even proponents of strong regulation acknowledge that it cannot protect all of the coast that needs preservation, hence "there is a need for a substantial acquisition program, as well as for an expanded watchdog role [over local governments and the coast] on the part of the commission."[48] Because fee-simple acquisition of coastal property can quickly become prohibitive in cost, it is essential to explore measures short of full acquisition. Coastal researcher Jens Sorensen concludes:

> Many state and local planners do not see a bright future for collaborative planning until it can move beyond mere permit regulation toward such positive activities as the acquisition of development rights, low interest loans for promoting socially desirable projects, and tax incentives for retention of lands in open space uses. . . .[49]

State bond issues and other actions in 1976 provided substantial funds for urban and coastal parks and other properties. About $150 million could be applied to coastal acquisition and related activities, with $110 million of this slated for coastal parks and beaches to be acquired by the Department of Parks and Recreation. These sums are clearly modest when compared with the magnitude of the coastal resources needing protection in some way. Further, a coastal observer disputes the frequent assumption that coastal property will necessarily be properly managed and afforded better protection if publicly acquired:

> State Parks with its 10 to 12 years lag time from acquisition to development and staffing will pose some serious problems in the area of resource protection. . . . hence it is mandatory that this limitation be recognized early in the planning process.[50]

Another alternative device is offered by the State Coastal Conservancy, set up as part of the 1976 package of coastal legislation. The agency has important powers to acquire coastal lands, or assist in their acquisition by other state or local agencies for purposes of preservation, restoration or redevelopment. Lacking major funds, however, and necessarily feeling its way, the new agency has so far kept a rather low profile.

Even before Proposition 13 passed, Lenard Grote, city council member, regional coastal commissioner and President of the Association of Bay Area Governments, argued for substantial state funding to help local governments implement the state's coastal goals. He complained that cities and counties have not received new funding sources for achieving such objectives, and thought it unlikely that local governments or voters would willingly use local property or sales tax revenues for such purposes. Grote emphasized the pressures on local governments that would demand more positive state measures:

> The pressures of the old planning game still operate on each coastal city and county. . . . Each must still view every parcel of land in its jurisdiction, and existing or potential development on it, in light of the government's financial position. Each is still in competition with its neighbor for potential beneficial development. Each act of a local official is still accountable to the local voters. Few, if any, could gain political strength locally by championing the rights of a statewide constituency in the development of an LCP, if it runs counter to important local-constituency interests. . . .[51]

Federal Funding

A critical future issue is the need for continued and substantial federal funding of coastal planning. The federal government often encourages state and local governments to start up new programs with "seed money," and then eliminates or reduces federal support when the programs are in progress. Such reductions are usually urged by the money-conscious Office of Management and Budget (OMB) seeking to economize. Failure to provide sustained federal support for the coastal program is likely to have serious adverse effects on the now-promising effort:

> The state and local governments won't pick . . . up [coastal costs] because they can't. They are not going to shut down schools and libraries and discharge firemen so they can hire coastal planners; therefore without the incentive of federal money and federal support, these programs aren't going anywhere.
>
> [Moreover] federal leadership creates the impression that this is an important matter . . . so for the feds to pull away is by contrast to say it is no longer very important.[52]
>
> . . .
>
> . . . without renewed Congressional efforts the program might peter out after current funding expires in September 1980.[53]

These remarks were made before passage of California's Proposition 13 on June 6, 1978. Approval of the tax-cutting constitutional amendment, withdrawing massive funds from local governments, further emphasizes the importance of continued federal funding to the success of coastal planning in California.

A "Stretched-Out" Process

The period of greater public fiscal austerity that seems to lie ahead makes even more attractive a suggestion by Jens Sorensen who calls for phased funding and a "stretched-out" process. Under his proposal, selected localities would be chosen by the state commission, presumably with local governments on the coast having some say in the matter. Resources would be focused on these chosen communities, enabling them to push ahead with their programs, while those of other localities would be deferred or pursued at a slower pace. When the selected initial programs were reasonably complete and further funding becomes available, the other programs could be pursued. Meanwhile the permit system would continue to apply in the "deferred areas," affording them protection in the interim.

Coastal Waters and Seaward-Side Issues

Coastal planning has so far dealt almost exclusively with land-use issues, involving that area from the water's edge inland to the coastal zone boundary. The great immediate pressures are on the land, and the fledgling coastal processes are hard put to deal with them effectively.

On the other hand, a wide range of important issues involving management of the coastal waters is already present and promises to become more pressing. There are extraordinary difficulties in dealing with seaward-side issues, partly because states have only limited experience with matters significantly beyond the shoreline, and partly because of the intricate intermingling of state and federal authority, jurisdictions and interests in the seaward side.[54]

These seaward-side issues may soon become an important testing ground for new organizations and intergovernmental relationships needed to reconcile and achieve federal and state objectives. We have begun experimenting with federal-state regional councils authorized to formulate fishery management plans under the federal Fishery Conservation Act of 1976. That law established the 200-mile zone within which foreign vessels can fish only with a federal permit, and otherwise strengthened offshore fishery management.

It is also important for the coastal states to establish comprehensive coastal water management programs. In their new book, coastal researchers Armstrong and Ryner urge that the need is far greater than many states realize. Moreover they acknowledge the states' comparative inexperience with coastal water management, and recognize the difficulties that must be overcome. But they also point out that the federal Coastal Zone Management Act provides the states with several useful tools, including national recognition of the states as appropriate vehicles, and of the right of the states to review federal activities that may affect coastal waters.

They conclude by urging the states to build on existing estuary, river and coastal land management programs in developing comprehensive coastal water management capabilities:

> . . . a creative use of the Coastal Zone Management Act, along with the other local, state and federal programs, should allow the establishment of a basic integrated management program that can protect, enhance and allocate the submerged lands, water column and surface waters of the coastal zone, as part of an overall state resource management effort.[55]

A Look to the Future: Clarifying Coastal Issues

Coastal planning in California has so far been a success story of some magnitude: initiative petitions for Proposition 20 were circulated in the summer of 1972 and a coastal regulatory and planning process has been in place since early 1973. Virtually all of many tight deadlines have been met, and a hard-fought legislative struggle in 1976 established state-local coastal planning on a permanent basis.

State and local bodies are in the early phases of the collaborative effort to make the process work. Proposed local programs are being reviewed by the state coastal commission, which will later examine and certify acceptable local plans and implementing ordinances.

The state and regional commissions need to focus attention on the major issues that local plans must deal with in order to protect the coast and achieve state goals. In providing needed guidance, the state commission ought

to decide which policies are more important and in what circumstances, and identify those that may require further interpretation.

With such state leadership, the regional commissions and staff can, in turn, play a stronger role in coastal planning, working with local governments more closely in the bargaining and negotiation that lie ahead. Such state-local collaboration will be a central need during the next three years, when a host of issues must be resolved both within coastal communities and between the state and regional commissions and local governments.

Coastal decisionmakers must strike a balance between proposals that may be too lenient to provide coastal protection and others that may be so strict or detailed as to be unworkable, unenforceable or otherwise unacceptable. Clarifying state coastal priorities will give the state and regional commissions additional yardsticks to guide future judgments on local plans.

While refining its policy priorities for the coast, the state commission needs to work closely with other state agencies having major coastal zone responsibilities. Those agencies, in turn, need to develop coastal priorities and plans in cooperation with the coastal commissions and local governments. The concept of collaborative state-local planning includes accommodating the goals and objectives of both local communities and state agencies in the local governments' LCPs, which, when certified, will govern future state activity on the coast.

Other Important Considerations

As suggested earlier, a number of additional considerations must be addressed as coastal planning develops.

First, the 1981 deadline for completing the current phase of coastal planning may be unrealistic. A "stretched-out" planning process permitted under the 1976 law might be useful. Resources could thus be funnelled into selected local governments, and the deadlines for the others postponed. The lessons learned in approving the first round of local plans would probably facilitate the second round.

Second, regardless of the deadline, substantial state and federal funding will continue to be essential to effective coastal planning, probably for a long time to come. The tasks looked formidable even before passage of Proposition 13 in June 1978. The massive diversion of property tax revenue away from local government seems almost certain to affect coastal planning adversely. On the other hand, if major federal funding continues to be available for California and the other coastal states, the initial momentum may be continued.

Third, implementing coastal plans is a big job that must be addressed soon. It is not clear how effective regulation alone can be in preserving the coast. On the other hand, large-scale acquisition of coastal property could be prohibitively expensive, especially if not accompanied by measures to restrain speculative market forces and land price inflation.

Fourth, while difficult problems remain in resolving conflicts between the public's interest in coastal resource preservation and the interests of property owners, regulation will nevertheless continue to be the heart of the coastal protection program. Critics have complained that coastal regulation has sometimes been arbitrary or otherwise faulty. Environmentalists have expressed concern that new regulatory agencies may fall into the same traps as the old-line state and federal agencies, i.e., cumbersome, legalistic and costly court-like procedures that discourage public participation and help pave the way for "client capture" of the agencies. Accordingly the rich experience of California's coastal permit appeals ought to be mined for evidence of what has worked well, and what changes might improve regulatory processes.

Finally, interested private citizens should also monitor coastal planning in their communities, especially since public participation is encouraged and solicited under the law. While widespread participation is hard to achieve in practice, coastal planning nevertheless offers excellent opportunities to citizens having the time and energy to study and understand coastal issues. Even a relatively few active, well-informed persons can have significant influence, especially if allied with one or more organized community groups.

In a National Perspective

It is appropriate to conclude by viewing coastal planning in national perspective, emphasizing its accomplishments and promise. In California and elsewhere the new processes signal an attempt to break with the history of uneven and often poor results of using unassisted local land use powers to protect the environment. Local governments have been required to yield some of their control over land use decisions. Technical planning processes in local governments are being improved, or being installed where to all intents they may have been virtually lacking.

Federal policy is also providing guidance for future state coastal land use decisions. The states will review local efforts to implement the coastal law for compliance with state and federal objectives. The forums created by coastal planning have helped involve new community-minded clientele groups, in addition to those with special interests in the profits that could be made under lenient regulation.

The emerging processes of coastal decisionmaking will force all governments with coastal interests—federal, state and local—to plan more carefully. Long-term commitments will have to be made as coastal plans emerge. These changes will be of major significance to the private sector. While some investors and developers may object to the more stringent regulations, others may find well-defined coastal plans to their liking, and much preferable to uncertainty and delay.

Finally, the federal-state coastal programs may be setting precedents for new experiments in federalism. Federal policy seems aimed at a federal-state partnership, with most of the planning and policy decisions delegated to the state level. The states in turn are free to shift important responsibilities downward, and in most states, local governments will play a major role. So far California's experiment has been one of the nation's foremost successes in coastal planning. With much luck and hard work, it may be possible to keep the momentum.

NOTES

[1] The importance of the Bay Conservation and Development Commission model was emphasized by Robert Knecht, Administrator of the federal Office of Coastal Zone Management, speaking before BCDC on March 17, 1977:

> . . . all thirty coastal states . . . are at work developing or implementing a coastal management program to involve the entire . . . United States shoreline. . . . The BCDC concept . . . started the national movement . . . . The background reports for the Federal Coastal Zone Management Act cite BCDC and its accomplishments, which began in 1965, as an indication of the feasibility of the program. . . . (BCDC Minutes, March 17, 1977, p. 20).

[2] Stanley Scott, *Governing California's Coast* (Berkeley: Institute of Governmental Studies, University of California, 1975), p. 234.

[3] The coastal zone was defined as reaching from the state's three-mile seaward limit to the nearest coastal ridge or up to five miles in flat areas. Regulations and-the permit process had effect from the three-mile limit to 1,000 yards inland.

[4] California Coastal Zone Conservation Commission, *California Coastal Plan* (Sacramento: December, 1975).

[5] After certification, proposals may be appealed if they (1) affect the area between the sea and the first public road parallel to the shore, or within 300 feet of the inland extent of the beach; (2) affect an area within 100 feet of a wetland, stream or estuary, or within 300 feet of a coastal bluff; (3) are in a sensitive coastal resource area and are alleged not to conform with the implementing actions of the LCP; (4) call for developments not designated as the principal permitted use under county zoning; or (5) constitute major public works or energy facilities.

[6] Lenard Grote, "Coastal Conservation and Development: Balancing Local and Statewide Interests," *Public Affairs Report*, 19 (1): 1-7 (February 1978, Institute of Governmental Studies, University of California, Berkeley), see p. 5. Grote included this footnote:

> One group of researchers examining the record of the South Coast and San Diego regional coastal commissions found evidence suggesting that "whether a commissioner is a public member or an elected official appears to be a significant factor in explaining voting behavior." (p. 47) They found that "Public commissioners vote pro-environment twice as often as elected commissioners. . . . " (p. 51) and also noted that commissioners who were city councilmembers were particularly likely to vote pro-development, as compared with other commissioners. They concluded: "there is now some empirical evidence to suggest that city councilmembers, because of the 'pull' of local control, may not be the best suited to serve on commissions where they have to make land use decisions which are in conflict with the decisions of local authorities." Judy B. Rosener, with Sallie C. Russell and Dennis Brehm, *Environmental vs. Local Control: A Study of the Voting Behavior of Some California Coastal Commissioners* (Claremont, Calif.: Claremont Graduate School, April 1977).

[7] Letter from urban planner Rudolph Platzek, of Williams, Platzek and Mocine, May 26, 1978. The paragraph in question (California Coastal Commission Regulations, ch. 8, subchapter 1, art. 4, sec. 00040(b)) reads:

> The policies of Chapter 3 of the California Coastal Act of 1976 that apply to specific coastal resources, hazard areas, coastal access concerns, and use priorities, including consideration of public access and recommended uses of more than local importance, relating to the area covered by the local coastal program shall be applied to determine the kinds, location and intensity of land and water uses that would be in conformity with the policies of the Act. This determination shall include an analysis of the potential signficant adverse cumulative impacts on coastal resources and access of existing and potentially allowable development proposed in the local coastal program.

[8] *Coastal Planning Issues: A Consensus Report* (June 7, 1978). (Based on a workshop sponsored by the Sea Grant programs of the University of Southern California and the University of California April 24-25, 1978, Los Angeles, California. Copies available on request from the Institute of Governmental Studies, University of California, Berkeley.)

[9] Interview with Joseph E. Bodovitz, former Executive Director, California Coastal Commission, April 27, 1978.

[10] Letter from Rudolph Platzek, see note 7 above.

[11] California Coastal Commission, "Legal Requirements for LCP Land Use Plans and Zoning Ordinances," memo from Bill Boyd, Staff Counsel, to Regional Executive Directors and Regional Commission LCP Staffs, January 13, 1978, pp. 1-5.

[12] Memo from League of California Cities to State Coastal Commission, April 5, 1978, p. 2.

[13] *Coastal Planning Issues* . . . , note 8 above, p. 3.

[14] League of California Cities, "Local Coastal Program Certification Program," memo from David F. Beatty to State Coastal Commission, May 25, 1978.

[15] California Coastal Commission, "Statewide LCP Budgets—Revised," memo from E. Jack Schoop, Chief Planner, to state commissioners, regional commissioners and local governments, June 9, 1978.

[16] Jens Sorensen, "State-Local Collaborative Planning: A Growing Trend in Coastal Zone Management," Ph.D. dissertation, University of California, Berkeley, June, 1978, p. 8-1. (Prepublication draft available from U.S. Office of Coastal Zone Management, Washington, D.C.).

[17] Ibid., p. 8-2.

[18] Loc. cit.

[19] Sorensen notes two exceptions to the local strategy of "marginal adjustment." (1) If a local government's planners are already dissatisfied with existing plans, they may welcome the coastal effort as an opportunity to "clean shop and revitalize the entire . . . program. . . . " Santa Barbara County is given as a good example. (2) If the state coastal standards and resulting critiques of local plans reveal major inadequacies, either a local government or active community groups may seize the opportunity to press for stricter local measures. Sorensen, note 16 above, pp. 8-2, 8-3.

[20] Lenard Grote, note 6 above, p. 2.

[21] Sorensen, note 16 above, p. 8-8.

[22] Letter from David F. Beatty, League of California Cities, August 31, 1977.

[23] Interview, February 8, 1977.

[24] "Extending the Coastal Commission," editorial comment, Los Angeles *Times*, July 18, 1978, part II, p. 6.

[25] Interview with Ilene Weinreb, Mayor, City of Hayward, and ABAG appointee to the Central Coast Regional Commission, March 23, 1977.

[26] Stanley Scott, "Notes on California's Coastal Governance: A Reply to Peter Douglas," *Coastal Zone Management Journal*, 5 (1), 1978 (forthcoming).

[27] Sorensen, note 16 above, p. 8-10.

[28] Comments during discussion session, "The Challenges of Land Use Development," joint conference of California chapters of the American Society for Public Administration and the Western Governmental Research Association, San Diego, California, March 2-4, 1978.

[29] From the author's notes on the local coastal planning workshop, Los Angeles, California, April 24-25, 1978. (See also note 8 above.)

[30] Under Proposition 20 state permit controls applied to an area from the seaward boundary of state jurisdiction to 1,000 yards inland. The 1976 law changed this substantially, as permit controls now apply in a zone of varied width intended to include important recreational and environmental resources, and extending inland as much as five miles in some places, but in urban areas reaching inland generally less than 1,000 yards.

[31] Paul Sabatier, "State Review of Local Land-Use Decisions: The California Coastal Commission," *Coastal Zone Management Journal*, 3 (3): 255-290 (1977). See p. 259.

[32] Sample data from three regional commissions (1973-75) for permits large or controversial enough to appear on the hearing calendar show conditional approvals of 23 percent of the permits by the North Coast regional commission, 72 percent by the North Central Coast commission, and 36 percent by the South Coast body. (Robert G. Healy, *The Role of the Permit System in the California Coastal Strategy* (Conservation Foundation, Draft Working Paper no. 4 of California Coastal Management Study, 1977), p. 17.) Speaking from more recent although impressionistic observations, coastal researcher James Fawcett of the University of Southern California said in a private communication dated July 20, 1978: "In the South Coast region alone, at least 40 percent (by my casual observation) of all applications have conditions placed on them, some so onerous that the project becomes no longer economically viable, and yet the application is tabulated as an approval."

[33] Healy, loc. cit.

[34] Sabatier, note 31 above, p. 269.

[35] Sabatier, note 31 above, p. 276.

[36] Letter from Frank Popper, June 28, 1978. Popper is the author of *The Politics of Land-Use Reform* (forthcoming).

[37] Healy, note 32 above, p. 18.

[38] Sabatier, note 31 above, p. 280.

[39] The vested right provision, sec. 27404 of the Public Resources Code, exempted projects for which local building permits had been issued before November 8, 1972, if the person having the vested right had begun "diligent" and "good faith" work, and had incurred "substantial liabilities" before that date.

[40] A landmark study of permit and appeals processes in Britain (the Dobry report) may have some useful guidelines for adaptation in this country. The Dobry report recommended ways of sorting out applications in order to concentrate attention on the difficult ones, bringing planmakers, developers and regulators together, hewing to strict deadline requirements, and consulting with other interested governments expeditiously. It also had additional recommendations for streamlining processes. See discussion in John H. Noble, John S. Banta and John S. Rosenberg, eds., *Groping Through The Maze: Foreign Experience Applied to the U.S. Problem of Coordinating Development Controls* (Washington, D.C.: The Conservation Foundation, 1977), pp. 39-53.

[41] The appropriate extent of such relief and the forms it might take remain unclear. Some observers warn that if relief meant permission to "build out," the cumulative effect might defeat important objectives of the coastal legislation.

[42] During a special seminar of representatives of large developers at the recent Coastal Zone '78 symposium, comments on coastal planning included: "we are working together"; "we have come a long way"; "we are all learning and it is an evolving process"; and "we used to look at the coastal processes as requiring a public relations job and sent PR people to do it . . . we've since learned our lesson." Emphasizing the need for certainty, one developer said: "It is important to know what the answer is, even if it is 'negative.'"

[43] Robert G. Healy, *Environmentalists and Developers: Can They Agree on Anything?* (Washington, D.C.: The Conservation Foundation, 1977) p. 8.

[44] Definitions and forms of access noted in interviews include (1) getting to the water's edge: basic shoreline access; (2) forms of community and urban coastal access; (3) new provisions for access; (4) access to the sea; and (5) visual access.

Some consequences and needs related to access include: (1) the need to facilitate appropriate forms of access, while preventing destructive kinds of access; (2) dealing with pressures on sensitive environments; (3) possible hazards arising from easy access to dangerous areas; (4) conflicts between coastal residents and coastal recreationists; (5) transportation and parking dilemmas.

[45] *Coastal Planning Issues . . .* , note 8 above, p. 6.

[46] Interview with Norbert Dahl, Coastal Land Use Coordinator, Sierra Club, May 22, 1978.

[47] For example, see Scott, *Governing California's Coast*, note 2 above, pp. 63, 73, 107-112.

[48] Dahl, note 46 above.

[49] Sorensen, note 16 above, p. 8-12.

[50] Letter from Andy Manus, Area Marine Advisor, Marine Advisory Programs, University of California, June 29, 1978.

[51] Grote, note 6 above, p. 4.

[52] Interview with Joseph E. Bodovitz, former Executive Director, California Coastal Commission, May 16, 1978.

[53] Gladwin Hill, "Effort to Preserve U.S. Coastline Lagging," New York *Times*, April 25, 1978, p. 66.

[54] Eugene C. Lee and Stanley Scott, "Issues of Coastal Governance, with Special Reference to the Seaward Side," in *Sea Grant, University of California, Annual Report, 1975-1976* (University of California Sea Grant College Program) IMR Reference 77-104. Sea Grant Publication 57, pp. 19-22.

[55] John M. Armstrong and Peter C. Ryner, *Coastal Waters: A Management Analysis* (Ann Arbor, Mich.: Ann Arbor Science Publishers, Inc., 1978), p. 15.

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RECLAMATION POLICY AT A CROSSROADS

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Introduction

This report analyzes a major issue in the current congressional debate over the future of Reclamation policy—the water subsidy. It will be argued that there is little justification for its continuation under either (1) the present policies of the U.S. Bureau of Reclamation (USBR) or (2) those contemplated by most of the proposed Reclamation Act amendments currently before Congress.

The subsidy no longer meets the original objectives of the Reclamation Act. Its elimination would restore fiscal stability to the Reclamation program, provide a measure of equity in the distribution of project benefits, and change the incentives that now encourage wasteful development and use of water, an increasingly scarce natural resource. The only justifiable way to continue the subsidy would involve a major revision of Reclamation policy to bring it into line with its original objectives. Few if any of the legislative proposals before Congress would effectively do this. (See Table, pp. 6-7.)

These arguments will be illustrated with examples drawn from the recent experience of the Westlands Water District, which contains the newest and most expensive of all Reclamation irrigation projects, and which demonstrates, in the extreme, many of the irrationalities of current Reclamation administration policy.

Brief Background to the Current Situation

In 1902 Congress established the Reclamation program to achieve two different policy goals. On one hand, it wished to encourage greater development of water resources and to bring apparently useless western land under cultivation and produce more food and fiber. On the other hand, Congress wanted to promote broad social and economic development, with widespread land ownership and a family farm system of production.[1] To insure achievement of these broad social goals, Congress further stipulated that in order for a family to be eligible for project water, it must not own more than 160 acres within federal water projects, and must reside on or near its land. Congress also provided a small additional benefit to stimulate such economic development by permitting water users to repay the full cost of irrigation construction over a ten-year period, interest-free.

In the intervening 76 years, Congress has not amended the acreage or the residency requirements. It has, however, extended the original ten-year, interest-free repayment period to 40 years, and has changed the repayment criteria so that water users are no longer liable for full repayment of all project costs. Since 1939, water users repay only the portion of irrigation costs they can "afford" to repay (measured by an ability-to-pay formula) and the remaining costs are paid from other project revenues, mainly from sales of hydroelectric power. The effect of these amendments has been to increase the water subsidy dramatically, although this was presumably not the intention of Congress. Instead, Congress amended the law to provide relief to hard-pressed farmers who could not pay the high costs of federal water during a period of extreme agricultural depression, and to stimulate the Reclamation program during the New Deal in order to provide massive public employment. In sum, with these amendments Congress did *not* intend to create a system of subsidies that would, in more prosperous times, give huge windfalls to those fortunate owners of land in Reclamation projects.

The current crisis in Reclamation policy arises from a growing discrepancy between the stated goals of the Reclamation Act and the actual implementation of the program by the USBR. Through a variety of questionable administrative interpretations of the law, USBR has all

but eliminated the effectiveness of the residency and acreage requirements, and has thereby disregarded the broad social and distributional goals that remain part of its legal mandate. These administrative procedures, in combination with the growing magnitude of the water subsidy, have led to the construction of increasingly expensive water projects that impose considerable costs on the taxpayer, misallocate water resources, and give highly concentrated benefits to a few landowners.

The discrepancy between the Reclamation program's stated goals and its actual implementation has received considerable attention from public interest groups, who have forced the issue on Congress and the courts in recent years. Congressional hearings and reports by public agencies have documented the abuses of the current administration of the program and have led to the introduction of legislation to enforce more strict compliance with the intention of the existing law. Moreover, recent court decisions require the enforcement of acreage restrictions in the previously exempted Imperial Valley and Army Corps of Engineers' districts in the Kings River Basin. Consequently landowners in these regions face divestment of about 750,000 acres (which are held in excess of the 160-acre requirement).[2] In response, these landowners, through sympathetic legislators, have introduced legislation to repeal the offending requirements.

Another court order (National Land for People *vs.* the Bureau of Reclamation) required the Department of the Interior to issue a set of written regulations on the administration of its Reclamation program in order to achieve greater congruence between the practices of the USBR and the law's stated objectives. In August 1977, the department issued a set of regulations that would have ended many of the procedures now used by the USBR to avoid enforcing residency and acreage restrictions. Predictably, these regulations stirred bitter debate. Landowners obtained an injunction against the implementation of the new regulations until completion of an environmental impact report. Meanwhile, legislation has been submitted on their behalf to legalize the status quo. For its part, the Department of the Interior has modified its original proposed regulations and had its own bill placed before Congress. Thus at present about 30 pieces of legislation are before Congress, containing at least six major alternative approaches to modernization of the 1902 Reclamation law.

The Issues in the Congressional Debate

Much of the debate over the future administration of Reclamation projects centers on questions of efficiency and fairness. Large landowners have argued that a stricter interpretation of the Reclamation law, forcing a reduction in farm size, would be out of step with modern agricultural technology and would therefore increase production costs, reduce farmer welfare, and raise food prices.[3] They further contend that any reversal of current administrative procedures constitutes an unfair use of public power since most project participants based their decisions to accept federal water on past practices and interpretations of the law.

Proponents of a stricter interpretation respond that smaller 160- to 320-acre farms are economically viable and efficient enough to produce food at current prices. This position has considerable academic support.[4] They also contend that the broad social and economic development goals encouraged by the original Reclamation Act of 1902—widespread land ownership and family farms—remain important and relevant policy objectives today, and can be implemented only by returning to the strict enforcement of existing acreage and residency requirements.

Neither side of the debate has given the subsidy issue much attention, mainly because neither side wants the subsidy eliminated. In the final analysis, however, the most important question confronting Congress is whether or not to continue subsidizing water.

The Magnitude of the Water Subsidy

As noted above, the major subsidy to Reclamation water users is the exemption from paying interest on the costs of irrigation facilities. Most house buyers are aware that interest costs account for the major portion of total mortgage payments. Thus over 40 years, at the modest interest rate of 7 percent, the interest on a project amounts to about 75 percent of total project costs. If water users had to finance their irrigation development privately, assuming the same interest rate and cost of development, they would have to pay roughly four times as much for their water as under the federal system.

This is an additional subsidy to water users, for they are not required to repay the full construction costs, less interest. For example, on those projects completed between 1903 and 1976, the total irrigation construction costs (excluding costs of flood control, recreation, and wildlife refuges) amounted to $3.62 billion. However, water users were originally liable for only 60 percent of the $3.62 billion, or $2.09 billion, with the rest to be paid out of revenues from hydroelectricity sales.

But water users have not even been repaying the $2.09 billion because of the impact of inflation on project operation and maintenance costs. On most projects, it has been the practice to sign a 40-year repayment contract with the irrigation district; during this time the price of water is fixed. The price is initially established to provide sufficient revenues to meet the costs of operating and maintaining (O&M costs) the project as well as the repayment liability for construction costs. As inflation increases the O&M costs, fewer and fewer project revenues are available to meet the repayment liability for construction costs. Thus if total O&M costs accruing between 1903 and 1976 are subtracted from total payments made by water users during the same period, it is found that only about $0.07 billion of the $2.09 billion of construc-

tion costs for which water users are liable have actually been repaid, or 3.3 percent. Moreover, at current collection rates and costs (even assuming no further inflation) it would take 432 years for water users to repay their share of construction costs. This means that of the irrigation construction costs of $3.62 billion, roughly 56.7 percent will be paid from electricity sales, 40 percent from general tax revenues, and the modest remainder by farmers. It might be added that since inflation also increases farm prices and incomes, water users could afford to pay the inflated O&M costs as well as their share of construction costs with no significant loss.[5]

In summary, an explicit subsidy in the form of the interest exemption and the use of hydroelectric revenues is granted to water users, which reduces their share of total construction costs to about 15 percent. Inflation adds an unintentional subsidy by further reducing this share to about 5 percent. Using conservative assumptions, these figures imply that the present value (1976 dollars) of the water subsidy throughout the Reclamation program averaged at least $500 per acre and was probably twice that figure. A more definite estimate for this subsidy is available for the Westlands, the newest of the irrigation projects, where water users repay *all* irrigation construction costs and receive no explicit subsidy from electricity revenues. Nevertheless, the estimated present value of the subsidy is between $1,800 and $2,200 per acre, depending on the outcome of water price negotiations between the government and the water district. This means that the total public cost of irrigating 160 acres averages $77,000 throughout the program and about $353,000 in the Westlands.

The Rationale for Water Subsidies

Public-sector involvement in water resource development is frequently rationalized with the justification that a variety of institutional reasons—e.g., the right of eminent domain, access to cheap financial capital, and the ability to spread risk—enable the government to build large-scale projects more cheaply than the private sector. Therefore, it is argued, governmental involvement increases overall economic efficiency. But this efficiency argument only justifies government intervention, it does not justify the provision of water at below its cost of production. Under this rationale, government should undertake only those projects that the private sector would produce, were it not impeded by the above restrictions. If efficiency is to be maximized, the government would develop only those projects capable of producing a profit, and it should charge the user the full cost of water.

The originators of the Reclamation Act believed that irrigation would create so much productivity that the Reclamation program would easily repay itself and still provide additional economic benefits, hence the program was originally set up to be self-financing. In imposing the acreage and residency requirements, Congress wanted to distribute the extra economic benefits remaining, *after* full repayment of irrigation costs, to as many family farmers as possible in order to stimulate western rural economic development.

As the high costs of western water development became more apparent, Congress was forced to recognize that irrigation in the West could not expand rapidly if development was restricted to only those projects capable of paying their own way. Therefore, in amending the law to increase the irrigation subsidy and permit the more rapid development of western water resources, Congress made a decision to sacrifice some efficiency in order to create more important nonefficiency benefits. The justification for expanding the subsidy has generally been the promotion of widespread land ownership and rural economic development based on small family farms. Congress may, of course, have had other less noble reasons for sacrificing efficiency. For example, the greater subsidy permitted an expansion of the pork barrel. In summary, *non*-efficiency goals may outweigh efficiency goals in the formulation of public policy and provide a legitimate rationale for the water subsidy.

Policy-makers today need to ask whether the sacrifice of efficiency in water resource development is still justified, given different social and economic conditions. Does the subsidy create enough nonefficiency benefits to warrant its existence? Those who would repeal or modify the acreage and residency requirements argue that these provisions must be changed to meet the needs of modern agriculture. In other words, these requirements are alleged no longer to provide sufficient social or economic benefits to justify their existence. But if this is true, similarly, there would also be little justification for a subsidy or for continued inefficient resource development. Yet the proponents of reform would retain existing water pricing practices and hence the subsidy.

The Nature and Magnitude of Project Benefits

As indicated earlier, there is no necessary relationship between the economic benefits created by irrigation and the overall costs of irrigation projects. Efficient resource development consists of funding only projects whose total economic benefits are greater than their costs. These were the kinds of projects that Congress originally envisioned in 1902 and that modern resource development policy guidelines are intended to foster. Under such conditions, water users would experience benefits from project development, even if they were required to repay full project costs. If such projects are subsidized, the water user simply earns an even greater benefit at someone else's expense.

As already implied, many Reclamation projects do not meet these efficiency criteria. Inefficient projects would not be built if water users were forced to repay their full costs (including interest) because the benefits received

through increased land productivity would not compensate for the higher repayment obligations. But when water users are not required to repay a very significant portion of project costs, this means that highly inefficient projects will nevertheless provide landowners with substantial benefits. For example, as noted above, the Westlands subsidy amounts to $2,200 per acre. The writer's research shows that this expenditure creates benefits equal to about $1,000 (or less) per acre. If landowners were required to pay the full costs of irrigating this region, they would not have supported the project, since they would have been worse off with the project and better off without it, even though contending with declining ground water supplies.

The Westlands example does not appear to be an anomaly in the Reclamation program. As pointed out above, the early projects did not support themselves. Moreover, most recent economic analyses of the Reclamation program also conclude that water resources have been prematurely and inefficiently developed, and have been misallocated between agriculture and the rest of the economy.[6]

Subsidized irrigation has encouraged expanded crop production in the arid West, and has thereby imposed increasing costs on the taxpayer through the effects of expansion on the creation of surpluses, and on farmers in competing rain-fed agricultural regions who have lost their competitive position in some crops. For example, after the cotton quotas were eliminated in 1972, cotton production expanded rapidly in California, especially in the Westlands, to the detriment of smaller southern farmers and the related rural economies that lost a profitable market. This shift in location would have been much less pronounced without the public subsidy. Also, since 40 percent of Reclamation cropland is planted in crops subject to government commodity programs, the irrigation of the West has encouraged greater production of crops already in surplus supply. This in turn has helped force the government to impose price supports and supply controls throughout the nation (at considerable taxpayer expense) in order to maintain farm prices at politically acceptable levels.[7] In short, the expansion of irrigation in the West has several invisible but nevertheless costly side-effects. If these were accurately estimated and incorporated into our cost-benefit analyses, the overall inefficiency of Reclamation would be seen as even greater than is generally understood. Briefly, subsidized water permits lands of lesser quality ("scrub lands") that would otherwise not be cultivated, to be put into production. But once they are in production with subsidized water, they have a "heritage" and as time goes by it is difficult if not impossible to stop the subsidy. Yet it is a wasteful use of good water, which is increasingly in short supply. Thus, the subsidy encourages putting good water on bad land, and on a long-term basis.

Supporters of Reclamation, including the USBR itself, attempt to justify the subsidy by arguing that even inefficient projects can create sufficient benefits to justify their existence.[8] It is contended that irrigation projects produce substantial indirect benefits in terms of additional employment, secondary development, and higher taxes, and that these are more than enough to justify the large subsidy.

But this is a fallacious line of reasoning. That is, when the choice is made to irrigate a region such as the Westlands, a choice is implicitly made *not* to irrigate some other area, *not* to commit the tax revenues to some other government project, or *not* to allow the private sector to use the funds by lowering taxes. In other words, if the project were not built, the funds released would be used for other investment or consumption. This would have increased income, raised taxes, and added to employment, thus producing the same kind of alleged indirect benefits elsewhere in the economy. Consequently unless a case can be made that the indirect benefits of the Westlands were greater than those which might have accrued in some other project, these cannot be taken as a measure of project effectiveness.

In summary, the subsidy favors the selection and development of inefficient projects. It helps the USBR to maintain an ever-expanding program, although the efficient irrigation sites have long since been exhausted and the nation continues to face agricultural surpluses. It also encourages the inefficient use of water, which is in short supply. Moreover, since the inefficiencies are often substantial, once projects are in being any attempt to eliminate the water subsidy would lead to economic hardship and possible bankruptcy for many producers. In a sense, we are trapped by our past mistakes.

The Distribution of Project Benefits Under the Current Regulations

It could be argued that, despite the project inefficiencies noted earlier, Reclamation subsidies might still be justified if they facilitate achievement of the *nonefficiency* goals described by the Reclamation Act. This leads to the questions of whether these goals have been fulfilled in the past, and whether they can best be achieved through the use of water development policies. Before attempting to answer these questions, it is first necessary to discuss the nature of project benefits in more detail.

Benefits to Initial Owners

Providing irrigation water increases arid lands productivity and value. The capitalized value of the annual increment to income, equivalent to the rise in overall land values within a project produced by water deliveries, is generally taken as the measure of project benefits. These benefits accrue to owners who had purchased land before its price rose to reflect the increased productivity made possible by project water. These owners who have acquired land within the projects before authorization or

construction are the primary beneficiaries of project water. As long as these individuals are able to sell their land at the increased market price, they will be able to capture the entire windfall benefit associated with the project.

New Buyers

Anyone purchasing land after the authorization of a project will take the increased earnings potential into account and will pay a price for the land such that the expected profit on the investment will approximate that on other investments of comparable risk. The water project does not provide a windfall for such an investor, as it does for the original landowner. Of course, if water prices were unexpectedly raised, or if future regulations were to prohibit the new landowner from using the land in some way, he would experience a net loss of his income or wealth, not compensated by a prior windfall benefit.

One of the critical issues in the Reclamation debate hinges on whether benefits conferred by past administrative practice can be recaptured by new public policies and made available to a different set of beneficiaries. In fact, once the land has changed hands, recapture of benefits is virtually impossible. Policies intended to achieve recapture would redistribute income, but only at the expense of owners who purchased the land at higher prices that reflect its new productivity made possible by subsidized irrigation. In short, bygones must be bygones.

Westlands' Benefits

The writer has investigated the distribution of project benefits in the Westlands Water District, finding that under the current administrative practices of the USBR, virtually all project benefits accrued to the original landowners of record at the time of water deliveries in 1968. This accrual of benefits to original owners has been facilitated by the USBR's administrative interpretation of the Reclamation law, which has led to several questionable practices.

The most important of these practices is the agency's failure to impose the residency requirement, allowing absentee owners to keep their land and lease it out. These actions have all but eliminated the incentives for owners of excess land to place their holdings on the market for new family farmers. Instead, owners can redistribute their holdings under new titles, using the names of family members, relatives, or corporations, in order to conform to the 160-acre restriction on ownership. Next they can lease the land to large agricultural management firms that farm the land in major tracts, using hired managers and laborers. If residency were required, most of this reorganization of titles would be pointless, since the new "owners" do not live on the land, and could not qualify for water.

The second most important practice that allows the original owners to capture project benefits is the ten-year grace period for the sale of excess land, during which time the original owner is allowed to purchase subsidized project water for his entire holdings. In the Westlands, the total value of access to subsidized water and the additional income created over a ten-year period was estimated to be $950 per acre. In addition, when a landowner sells during the grace period, the USBR has permitted selling prices well in excess of the true "non-project" land price, thereby allowing the seller to capture additional project benefits. In the Westlands this has amounted to an additional benefit of about $400 per acre. Finally, the USBR has permitted land sales whereby all price controls were effectively avoided and the original owner captured the entire capitalized value of the subsidy.

In 1968, when water deliveries began, there were approximately 2,500 individuals and corporate landowners in the 545,000 acre Westlands Water District. About 84 percent of this land was held by 280 individuals or corporations, with an average holding of 1,650 acres. The average benefit received by this group was therefore about $1.6 million per owner. On the other hand, the 2,200 other owners, with holdings averaging about 40 acres, received about $40,000 each in benefits from the subsidy.

In 1968 the Westlands was organized into 97 farms (with "farms" defined in terms of production units). Absentee landowners leased their holdings in these farms, which are generally run by hired management and labor. Today, with only half of the land classified as "excess" and possibly available for subdivision into smaller farms, there are only about 216 farms (also mostly leased) averaging about 2,200 acres each.[9] Even if the remaining excess land were subdivided in a similar manner the district would not have more than 350 to 400 farms when the last of the excess land had eventually been sold.

In short, under the current administration of the Reclamation Act, a project has been built whose costs exceed benefits by a ratio of two to one. The public will have spent over $1 billion to irrigate 545,000 acres and create about 300 new farms ($3.3 million per farm). Moreover these farms will be run mainly by hired managers and workers. The benefits of this project will have been captured by a small number of individuals and corporations, many of whom have little interest in or contact with farming, and certainly could not be called "family farmers."

The Westlands experience, though perhaps the most extreme of all Reclamation projects, helps demonstrate the irrationality of the way the Reclamation program has been administered. The large subsidy, never intended by Congress, is used to make an inefficient project politically desirable. USBR administrative practices give a major share of project benefits to the original landowners, helping insure their active support for the program. This arrangement allows the expansion of the Reclamation program, thereby satisfying the agency and select members of

TABLE

Proposed Reclamation Legislation (1978)

Key Provisions	S. 2925 National Land for People	S. 1812 Nelson-Haskell	H.R. 13473 Administration
Maximum land ownership for water eligibility	20-640 acres; average of 200 acres overall; lower average in productive regions	160 acres per adult and 160 acres per one dependent	320 acres per adult involved in significant farming activities
Maximum size of farm (owned and leased land)	unlimited	320 acres	960 acres
Leasing	not allowed	not allowed	maximum 160 acres per owner
Residency	farmer must reside within 15 miles of farm	farmer must reside on or near the land	farmer must reside within 50 miles of farm
Method of establishing price of excess land; duration of price controls	sale price of excess land equals market value less project benefits for duration of project life	sale price of excess land equals seller's cost plus consumer price indexing for 10 years after initial sale; then no price controls	Secretary sets excess land price to reflect market value less project benefits, for 15 years after initial sale; then no price controls
Compliance period[1]	3 years	1 year	5 years
Selection of buyer	lottery[2]	seller selects buyer	lottery[2]
Exclusions and exemptions from acreage and residency	none; requirements apply to all users receiving water by or through federal facilities	none; requirements apply to all users receiving water by or through federal facilities	certain districts when contract payout is complete and others when payout is completed if family farms are established
Other provisions	government land purchase equal to 20% of excess land sold each year for lease to new farmers	government land purchase and lease program and loan guarantees; water prices reviewed every five years	accepts the concept of "commingling" and thus implies regulations apply to any joint state-federal projects

1. Refers to excess landowners. Leased land, foreclosed or inherited land may have different terms.
2. Lottery arrangements grant preferences to certain groups such as family members, neighbors, and employees who otherwise meet remaining criteria.

	S. 2606; H.R. 11638 Church; Baucus	H.R. 13404 Krebs	S. 2818; H.R. 13350, 13480 FARM/WATER Alliance	S. 2867; H.R. 11944, 12187, 12552, 12708 Goldwater; Stump
	1,280 acres owned or leased per family	640 acres owned per family; owner(s) involved in day-to-day farming with 50% of income from farming	320 acres per owner	no limit
	1,280 acres	1,920 acres	unlimited	unlimited
	only within the 1,280 acre limit	only within the 1,920 acre limit	no maximum	no maximum
	not required	not required	not required	not required
	no controls mentioned	Secretary sets excess land price to reflect market value less project benefits, for 15 years after initial sale; then no control	sale price of excess land equals seller's cost plus consumer price indexing for 10 years after initial sale; then no controls	no controls
	10 years	5 years	not given	not applicable
	seller selects buyer	seller selects buyer	seller selects buyer	seller selects buyer
	no controls after repayment of project costs with termination of contract	Kings River districts exempted; no other provisions for relief	district repayment of project interest costs (lump sum or annual); restrictions do not apply to underground water beneficiaries	not applicable
		water prices reviewed every five years		

Congress, while giving large windfall benefits to those who are fortunate enough to own land in the right places at the right time.

On the other hand, the would-be family farmer in whose name this large expenditure is justified receives few benefits. The general public pays much of the bill, both through taxes and through the less visible costs of mal-allocated resources.

The Effects of Pending Legislation

A number of bills have been introduced in Congress dealing with Reclamation policy (see Table). None of the proposals would remove the water subsidy. With one possible exception, none of them would increase the social or "nonefficiency" benefits of water resource development—e.g., widespread ownership and family farms—enough to justify the continued subsidy of water. Several of the bills would, however, reduce the incentives that encouraged inefficient water resource development. To illustrate these points, the pending legislation is discussed in three categories, each analyzed with reference to its possible impact on the development of a hypothetical project like the Westlands.

Removing Acreage and Residency Requirements

The first set of bills comprises those that would repeal the acreage and residency requirements outright, thereby in effect legislatively approving the current administrative procedures described above. These bills include those of the FARM-WATER alliance, Goldwater, and Stump. Obviously if acreage and residency requirements were dropped, but the subsidy continued, projects like the Westlands would become even more attractive to those in a position to benefit, and the benefits would be as concentrated as the initial concentration of ownership.

In short, while the water subsidy remains, such bills will simply assure continuation of the irrationalities of water resource development. They would also allow large landowners to consolidate their existing project benefits and prevent any further dispersal of these benefits to new farmers. In older projects, this legislation might insure a measure of fairness to landowners who never benefitted from the original project windfalls. But this policy would be inappropriate for new projects such as the Westlands, where the original owners are still in possession of much of the land, as well as for future projects where it would encourage inefficient development.

The problem of older, established projects and fairness of administrative treatment could be handled more effectively through exemptions. That is, each of the projects could be examined and exempted from new legislation where conditions warrant.

Tightening Current Interpretations

The second set of bills includes those that would enforce a stricter interpretation of the spirit of the existing law than is currently observed by the USBR. These bills would place a ceiling on land ownership (ranging from 160 to 1,280 acres) and also on farm size (ranging from 320 to 1,920 acres). They would require most benefits to go to landowners who were also farmers (by restricting leasing and in some cases requiring residency). They would control the price of land to prevent speculative purchases. Several would also provide for periodic review and adjustment of water prices. These bills include those of Nelson-Haskell, the Administration, Krebs, and Church and Baucus.

Although there are major differences among these bills, all would have two effects of varying impact. They would (1) reduce incentives for construction of projects like the Westlands, and (2) force a wider distribution of project benefits than has occurred in the Westlands. The first effect is the more important of the two.

All the proposals except the Administration bill would reduce the time period for compliance with excess land provisions. The Nelson-Haskell and Church bills would require landowners to sell their excess holdings within one year, while the Krebs bill requires sale in five years. The current ten-year period would thus be shortened, and the benefits made available to excess landowners reduced by varying degrees, depending on the ownership maximum established (Nelson-Haskell would be the most restrictive).

All of these bills would require the project beneficiary to be an active farmer, thereby eliminating the current practice of conferring benefits on absentee owners who otherwise meet the acreage restrictions. In short these bills would reduce the incentives for the original owners to support a large program, because many would be forced to give up most of their holdings, in return for which they would receive relatively small benefits. This would be particularly true for potential projects wherein landholding is highly concentrated, as in the Westlands.

The establishment of a maximum on farm size and ownership would force a broader distribution of project benefits. The Nelson-Haskell measure would produce the most progressive distribution of benefits, but even under this bill, the distribution of project benefits would not be adequate to justify continued subsidy of water. This can be illustrated by the impact of the Nelson Haskell bill on a project like the Westlands. If farm size were restricted to 320 acres, there could have been at least 1,700 farms in the Westlands, instead of the projected 400 farms that will eventually be formed under the current administrative practices. The increase in number of farms would appear to imply a major change in the nature of the region's farming.

Upon closer inspection, however, the actual impact of

imposing the 320-acre limit on a region such as the Westlands appears less profound than may be thought. For example, on a 320-acre farm the family could provide the management as well as perhaps some of the field labor for certain crops, but the farm would continue to be dependent on hired, seasonal labor. Thus at least 40 percent of the labor required by a 320-acre farm would be supplied by low-wage, temporary farmworkers, the same proportion as under the current system.[10]

In other words, the structure of the rural economy will not be fundamentally changed. Resident family farmers would displace hired managers and permanent farmworkers, but the reliance on seasonal farmworkers, the chief source of rural poverty, would continue. Moreover, such a change in farm management does not imply a new increase in the number of families associated with the agricultural system, so there is little reason to believe that the Nelson-Haskell bill would encourage rural economic development.

Equally important, under the Nelson-Haskell bill the subsidy will remain highly concentrated. It is estimated that a 320-acre farm in the Westlands would derive about $320,000 in windfall benefits under existing water prices. This benefit amounts to about $20,000 per year, in addition to the normal return on management and labor, estimated at between $15,000 and $50,000, depending on prices and crops grown. In short, the subsidy would create a new wealthy landowner class, but would leave the sources of rural poverty untouched. Given these considerations, it seems clear that the water subsidy cannot be justified under even such a strict interpretation of the existing Reclamation Act.

Encouraging Widespread Rural Development

The third category of bills includes only one—that of National Land for People (NLP)—which would attempt to restructure the Reclamation Act to make the most beneficial use of the subsidy in supporting widespread rural development. The NLP bill proposes an average parcel size of between 150 and 200 acres, with minimum parcels of 20 acres and maximums of 640 acres. It would require a lottery to distribute excess land, and include a 15-mile residency requirement to force farmers to live near their land. The bill would also provide for a perpetual subsidy through indefinite control over land prices in the district. Finally, the bill apparently would require compliance with the acreage and residency provisions within three years.

It seems certain this bill would render a project like the Westlands politically infeasible, because it would require landowners to give up most of their land with little in return. Such a bill would therefore likely rule out much of the additional planned water resource development in California, whether the resource development were efficient or inefficient. This might be preferable to the current situation, but obviously might also restrict useful development.

If this bill were imposed on the Westlands, it would distribute the subsidy benefits to a relatively larger number of households and stimulate more overall rural development than any of the other bills. For example, a study of the impact of enforcing a 200-acre average maximum on farm size concluded that population and employment would roughly double in the Westlands, and household income would rise by about 75 percent and be much more concentrated in the middle income groups than under the existing system. The average farm family income would be about $30,000 per year, and with this greater purchasing power there would be more retail purchases and hence new jobs, more community development, and a doubling of nonagricultural employment.[11]

If one can accept the Bass/Kirshner analysis of the impact of the 200-acre restriction and its implications for the Westlands, the NLP bill appears to offer Congress an alternative that would help to re-establish the original purpose of the Reclamation Act, i.e., stimulating rural development. The author has reservations concerning the economic feasibility of this bill in its present form, but does not doubt that an agricultural system of interdependent production units could be devised to support even more families than estimated by Bass and Kirshner.[12]

Admittedly, if enacted the measure would probably restrict water resource development, especially in regions of high concentration of land ownership. If, however, the law were enforced in such projects as the Westlands, it could help to make the best of a bad investment by helping transform the agrarian system and providing new economic opportunities for individuals who have not shared in the past benefits of agricultural and water resource development.

Conclusion

Large water subsidies are the source of most of the problems in the current Reclamation program. Unfortunately, these effects are not well understood, and have been lost in the current congressional debate over acreage and residency requirements. The subsidy has created political incentives encouraging the construction of "pork-barrel" projects which, in turn, require the overdevelopment of rivers and streams and the overconsumption of water by agriculture at a very high public cost.

The subsidy was originated to facilitate the rural development goals of the Reclamation Act. But in fact the record shows that under the program's current administration the subsidy has increased the economic and political power of the original landowners. It has not promoted small family farms or rural development. Instead, the subsidy has contributed to inefficient water resource development and regressive social development.

What is to be done? The previous analysis suggests the following approaches.

First, the subsidy should be withdrawn from all *future* projects. Rural development no longer is the most press-

ing issue. Instead, the main concern is efficient resource development. No matter how widely distributed the subsidy might be, its benefits cannot justify the continued inefficient overdevelopment of irrigation facilities. Where rural development is desirable, other kinds of public policy can achieve these goals more efficiently. If the subsidy for new projects is withdrawn, it is unlikely that there will be any large-scale water development projects in the future, at least until agricultural prices have risen to much higher levels than now prevail.

Second, with respect to projects already completed or under construction, the minimum appropriate reform would reduce the subsidy by requiring water users to repay their share of construction costs, plus operation and maintenance costs, within a reasonable time.[13]

Third, with respect to restrictions on acreage and residency, appropriate reforms would depend on the extent of the subsidy and the age of the program.

(1) Future projects are considered first. If the subsidy were eliminated from future projects, the case for such restrictions would be weakened. Moreover strict acreage and residency requirements might prevent efficient projects from being built, because of landowner reluctance.

Even if the subsidy should be continued for future projects, however, strict requirements would still inhibit construction of water projects, both efficient and inefficient. Accordingly, removal of the subsidy seems clearly preferable to acreage and residency restraints, although the latter would be better than continuation of present practices.

(2) With respect to projects under construction or completed in the comparatively recent past, if participants are willing and able to make full repayment of costs plus interest, an exemption from acreage and residency requirements would seem appropriate. But the situation is different if a substantial subsidy continues indefinitely and the land remains in the hands of the original owners—as is true of Westlands. In these cases strict acreage and residency requirements—like those in the NLP bill—can appropriately be imposed without unduly penalizing such owners, who would already have benefitted from land-value appreciation.

(3) Finally, in older projects like those in the Imperial Valley, we must acknowledge that to impose acreage and residency restrictions would inflict large uncompensated losses on existing owners, who are not the original owners and beneficiaries from the initial land-value appreciation. Accordingly, such old projects should either be exempted, or if restrictions are imposed they should be accompanied by some form of compensation.

To sum up, the greatest opportunity for experimentation is with future projects yet unbuilt, where elimination of the subsidy seems the most appropriate policy. Substantial experimentation is also possible with projects under construction or recently completed—such as the Westlands—where strict acreage and residency requirements are appropriate policies, along with other measures to encourage rural development.

NOTES

[1]See Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement 1890-1920* (New York: Atheneum, 1969); see also U.S., Congress, Senate, *Joint Hearings, Select Committee on Small Business and the Committee on Interior and Insular Affairs: Will the family Farm Survive in America?* 94th Cong., 1st sess., July 17 and 22, 1975, Part 1A-Appendices. See especially Joseph L. Sax, "Federal Reclamation Law."

[2]U.S., Economics, Statistics, and Cooperative Service, *The U.S. Department of the Interior's Proposed Rules for Enforcement of the Reclamation Act of 1902: An Economic Impact Analysis*, Staff Report (Washington, D.C.: 1978), p. 8.

[3]A.D. Reed, "Federal Reclamation Law—160 Acre Limitation." Paper presented to the State Board of Food and Agriculture, Sacramento, California, January, 1976 (Davis: Department of Agricultural Economics, University of California, 1976); see also W.R. Sheesley and E.A. Yeary, *So You Want To Buy a Farm in Westlands Water District!* (Fresno County: University of California, Cooperative Extension, August 1976).

[4]See U.S.E.S.C.S., note 2 above; George Goldman, Daryl L. McLead, Anthony T. Nakazawa, David H. Strong, *Economic Effect of Excess Land Sales in the Westlands Water District* (Berkeley: Division of Agricultural Sciences, University of California, Special Publication No. 3214, 1977); see also Bruce Hall and E. Phillip LeVeen, "Farm Size and Economic Efficiency: The Case of California," forthcoming in *American Journal of Agricultural Economics* (November 1978).

[5]In the past year the repayment provisions of new contracts have been changed. The new contracts call for adjustment of rates every five years, to allow for the effects of inflation. This change will reduce the impact of inflation on new projects, but will have no effect on existing contracts or their repayment.

[6]See, for example, Jack Hirshleifer, James C. DeHaven, and Jerome W. Milliman, *Water Supply: Economics, Technology, and Policy* (Chicago: University of Chicago Press, 1960); see also Joe S. Bain, Richard E. Caves, and Julius Margolis, *Northern California's Water Industry: The Comparative Efficiency of Public Enterprise in Developing a Scarce Resource*, published for Resources for the Future Inc. (Baltimore: The Johns Hopkins Press, 1966); see also Steve H. Hanke and Richard A. Walker, "Benefit-Cost Analysis Reconsidered: An Evaluation of the Mid-State Project," in Robert H. Haveman and Julius Margolis, eds., *Public Expenditures and Policy Analysis*, 2nd. ed. (Chicago: Rand McNally Publishing Company, 1977).

[7]The Sacramento office of the Bureau of Reclamation points out that 60 percent of the federally irrigated land is planted in crops *not* subject to federal commodity programs, and argues that the benefits of irrigation of those crops are directly translated into lower food prices, especially of fruit and vegetables. Moreover, since the poor pay proportionately less for the Reclamation program by virtue of their proportionately lower taxes, the effect of irrigation is to redistribute income toward lower income groups. (Letter to Stanley Scott from M.A. Catino, Acting Regional Director, Mid-Pacific Regional Office, November 17, 1978.) While both of these arguments may be valid, they do not change the analysis presented here. Thus lower food prices are already incorporated into the analysis of efficiency, and the income distribution effect, although not included in the efficiency calculations, must be regarded as extremely marginal.

[8]See, e.g., U.S., Department of the Interior, Bureau of Reclamation, *Federal Reclamation Projects Water and Land Resource Accomplishments: 1976 Summary Report* (Washington, D.C.: 1978), pp. 53-58.

[9]U.S., Department of the Interior, Bureau of Reclamation, *Special Task Force Report on San Luis Unit, Central Valley Project, California* (Washington, D.C.: 1978), p. 196.

[10]E. Phillip LeVeen, *Enforcing the Reclamation Act and Rural Development in California* (Berkeley: Department of Agricultural and Resource Economics, University of California, Working Paper No. 55, September 1978), p. 19.

[11]See Peter L. Bass and Edward M. Kirshner, "Demographic and Fiscal Impacts of Alternative Westlands Reclamation Act Enforcement Scenarios" forthcoming in *American Journal of Agricultural Economics*, proceedings paper from the American Economics Association Summer Meetings, Blacksburg, Virginia, August 6-9, 1978. See pp. 5 and 7, Scenario No. 3.

[12]See LeVeen, note 10 above, pp. 22 and 23.

[13]Appropriate repayment requirements would remove the "inflation" subsidy, but retain the interest and power subsidies. If full repayment of construction costs occurs within the next 30 years, for example, water prices will rise to at least 3.5 times their current levels and will continue to rise with inflation in the future. These higher prices would promote conservation, reduce water consumption by agriculture, and help to offset the fiscal burden on the taxpayer imposed by the Reclamation program. If prices are thus increased gradually, users can absorb them without great hardship.

For additional references, see the following: Note 1 above, *Will the Family Farm Survive in America?* see Part 2B-Appendices, and Parts 1 through 3B, 1975 and 1976 (Washington, D.C.: 1976); U.S. General Accounting Office, *Report to Congress: Congress Should Reevaluate the 160-Acre Limitation on Land Eligible to Receive Water from Federal Water Resources Projects*, by the Comptroller General of the United States, November 30, 1972 (Washington, D.C.: 1976).

Water Conservation

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RESIDENTIAL WATER CONSERVATION: POLICY LESSONS FROM THE CALIFORNIA DROUGHT*

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Introduction

How do residential water users respond to severe water shortages? Are they willing and able to conserve, and if so, to what extent? What are the implications of water users' behavior for long-term conservation in California, a state with a permanent water deficit? Some answers are found in a study of actual experiences during the recent California drought.

In the winter of 1976-77 Central California got far less than average precipitation.[1] Thus a very dry year followed the relatively dry winter of 1975-76. In the San Francisco Bay Area these two successive years of short supply meant that, to get through the summer of 1977 and prepare for the possibility of a third dry season in the winter of 1977-78, water districts had to adopt emergency conservation programs involving their residential users. Fortunately the rain and snow returned in abundance during the winter of 1977-78. Accordingly conservation and rationing programs were removed early in 1978.

Experience with the water districts' different kinds of residential conservation measures during 1977 represented a "natural experiment," whereby the equity and effectiveness of these various programs could be evaluated and compared. Research on water conservation programs in the Bay Area has revealed a remarkable reduction in residential consumption. People actually saved more water than they were requested to, even in areas like Marin County where a critical shortage forced the imposition of stringent rationing programs. These results are encouraging, especially as the Pacific Southwest and many other areas suffer permanent water shortages or deficits, accentuated from time to time by periodic droughts. If people can thus dramatically cut down the use of residential water, conservation as a strategy for dealing with chronic shortages can be much more effective than previously believed.

The research was done in nine selected San Francisco Bay Area water districts shown in Table 1, chosen as follows.[2] Three districts were selected from those having rigorous conservation programs (a conservation goal of 30 percent or more below previous use, coupled with stringent regulations and penalties). Three districts were selected from those having moderate conservation programs (a conservation goal of 25 to 30 percent below previous use, and less stringent regulations and penalties). And finally three districts were selected from those with mild conservation programs (a conservation goal of 25 percent or less below previous use, and with few if any penalties or regulations).

The investigation had four major objectives: (1) to determine how consumers rated the equity and effectiveness of the water conservation program they had experienced, (2) to evaluate the effectiveness of each conservation program in terms of water actually consumed, (3) to investigate relationships between consumer beliefs and behavior, and (4) to assess opinions about regionalization of the San Francisco Bay Area water supply. The findings are presented in full in a report for the National Science Foundation;[3] highlights and policy implications are offered here.

Ratings

In rating the programs, respondents focused on equity or fairness, as well as effectiveness and overall performance of the water districts' conservation measures. In general, all ratings were quite positive. The three rigorous programs were rated as fair, effective, and quite satisfactory overall. Exceptions to the generally positive evaluations were (1) the fairness ratings of the three moderate programs and (2) the effectiveness ratings of the three mild programs.

Respondents rating the moderate program districts recommended improving fairness by basing rationing allotments on numbers of people served, rather than on past

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Table 1

Major Residential Surveys

City or area surveyed	Water service agency	County	Conservation program rating	Percent reduction sought	Basis of allotment
San Rafael and Southeast Marin County	Marin Municipal Water District	Marin	Rigorous	57	Per capita
San Leandro, San Lorenzo, Castro Valley	East Bay Municipal Utility District	Alameda	Rigorous	35	Per capita
Concord	Contra Costa County Water District	Contra Costa	Rigorous	30	Prior use
Palo Alto	Palo Alto	Santa Clara	Moderate	25	Prior use
San Francisco	San Francisco	San Francisco	Moderate	25	Prior use
San Mateo	California Water Service Company	San Mateo	Moderate	25	Prior use
Southeast San Jose	Great Oaks Water Company	Santa Clara	Mild	25	Prior use
Napa	Napa	Napa	Mild	20	Prior use
Vallejo	Vallejo	Solano	Mild	10	Prior use

use, size of lawn, or ability to pay. This recommendation on fairness is a major finding of the study. Thus the per capita allotment system adopted by the rigorous programs probably accounts for their positive fairness ratings, because they were seen as equitable despite their stringency.

Respondents rating the three districts with mild programs emphasized improving effectiveness by making rationing mandatory rather than voluntary. They seemed to be saying "Something worth doing is worth doing well." Respondents from all nine water districts also recommended (1) improved communication between the district and its customers, (2) stricter enforcement of rationing rules and prohibitions, and (3) avoidance of ambiguous "double messages" that actually promote greater use while ostensibly encouraging conservation. Points one and three are discussed more fully below in the section on communication.

Effectiveness

The evaluation of program effectiveness requires a statement of program goals or objectives, and comparisons to determine whether desired changes were obtained.[4] For these water conservation efforts, program goals were expressed in percent reduction of water consumed residentially. (See Table 2.) The results of rigorous and moderate programs were even better than those sought, while the mild programs did not quite reach their stated goals. In short, this ability of residential consumers to reduce daily water consumption exceeded stated conservation goals, and in fact caused the water districts financial problems when revenues declined more than anticipated.[5]

Beliefs, Behavior and Use

Beliefs measured in the survey included views of the seriousness of the drought crisis and the need for long-term conservation. The analyses of self-reported conservation behavior produced an "overall weighted conservation behavior score," based upon number of conservation actions undertaken from the onset of the drought, e.g., installing a shower flow restrictor, use of "grey water," installing toilet tank dams, and so on. The actual number of gallons of water used per person per day during the summer of 1977 was figured directly from respondents' water bills. When measures of belief were correlated with the weighted conservation score, and then with water use, it was found that socio-demographic variables of income bracket and education level did not materially affect the correlations. Further, beliefs about the seriousness of the crisis correlated with the weighted conservation behavior score, but not with per capita daily use. Beliefs about the need for long-term (non-crisis) conservation correlated with

Table 2

Effectiveness of Water Conservation Programs

City surveyed	Daily per capita water use in gallons		Percent reduction	
	Summer 1976	Summer 1977	Sought	Obtained
Rigorous Program				
San Rafael	86	35	57	59
San Leandro	151	61	37	60
Concord	220	100	30	55
Moderate Program				
Palo Alto	213	112	25	47
San Francisco	109	59	25	46
San Mateo	156	92	25	41
Mild Program				
San Jose	172	144	25	16
Napa	160	129	20	19
Vallejo	128	120	10	6

per capita daily use, but not with the overall weighted conservation behavior score noted above.[6]

These results are quite provocative and do not fit in a simple way with the notion that response to a crisis situation produced the low consumption figures of the summer of 1977. The people who believed in a continuing *long-term* need to conserve water actually used less water per person per day than the others. Those who believed the drought to be only a serious *short-term* crisis, even though they changed many behaviors after the drought began and did conserve, nevertheless used as much water as those who doubted that the drought was a crisis.

Regionalism

Regional organization for a variety of purposes in the San Francisco Bay Area is a persistent issue that was raised again by the 1977 drought.[7] Wide differences in conservation programs mounted by the many water districts around the Bay raised questions of inter-district fairness. Would it be better to share water among districts and adopt one overall rationing and conservation plan? The worsening drought made the conflicts apparent during preliminary interviewing in the spring of 1977.

Accordingly a question on regionalization of the Bay Area water supply and related rationing programs was included in the major survey during the summer of 1977. The data in Table 3 show that all areas surveyed, except one of those with a rigorous conservation program (San Leandro), favored local rather than regional water supply systems and conservation plans. Respondents from the other two districts with rigorous conservation plans, while giving a modest edge to local plans, nevertheless also voted for regional approaches in higher percents than in districts with moderate or mild programs. Apparently the respondents residing in the districts having more stringent rationing programs, even though they judged their own programs to be fair, may have desired greater equity between districts in rationing programs, since they were under the most pressure to conserve.

Recommendation: Policy for Acute Drought Rationing Programs

The major finding on equity provides the first policy recommendation for rationing programs in acute droughts: *Water allotments should be based upon number of people served, not last year's use, size of lot, square feet in the house, or any other similar criteria.*

It would be administratively easier for water districts to ask for a percentage reduction based on prior use, but as many respondents pointed out, this penalizes prior conservation and rewards prior excessive use. Also, it causes other problems because all consumers must know their prior use level in order to comply with such a program.[8] Additionally, both consumer comments and our evaluation of program effectiveness strongly support a per capita allotment. In an acute drought, priority must be given to people and their ingestive, culinary, sanitary and cleaning needs. During a real emergency all other uses of water, e.g., agricultural or industrial, become secondary compared to the health and safety of individuals.

Recommendation: Mandatory Rationing

A second important policy recommendation: *Rationing programs for acute droughts should be mandatory, even if restrictions and penalties are not severe.* Major support for this assertion comes from the consumer ratings

Table 3

Attitudes Toward Regionalization of the San Francisco Bay Area Water Supply System by Percentage

	Clearly favors regional plan	Leans toward regional plan	Can't decide	Leans toward local plan	Clearly favors local plan	No data	Percent Total
Rigorous Program							
San Rafael	38	6	1	7	47	1	100
San Leandro	52	5	2	2	38	1	100
Concord	46	0	3	4	45	2	100
Moderate Program							
Palo Alto	25	14	4	5	51	1	100
San Francisco	36	3	9	6	42	4	100
San Mateo	29	4	8	2	55	2	100
Mild Program							
San Jose	27	2	2	4	65	0	100
Napa	26	1	3	5	62	3	100
Vallejo	21	9	3	13	54	0	100

and comments upon effectiveness. People living under the voluntary programs were particularly vocal, finding it incongruous to hear continually about the seriousness of the acute drought afflicting the San Francisco Bay Area, while only being asked to try to reduce their own use, in effect, "if this were not too much of a personal hardship." Also, the data on amounts actually conserved shown in Table 2 demonstrate the mandatory programs' much greater effectiveness. Mandatory rationing by the stringent and moderate programs seemed to reinforce media information that the drought was indeed serious, and that people *must* cut back water use in order to avoid potentially severe future problems and shortages.

Further, if rationing programs employ rules and prohibitions, these should be enforceable, and in fact enforced. When flagrant rule breakers are not punished, this lowers the morale of consumers who carefully follow the rules and abide by the prohibitions. Water district staff may find the idea of enforcement repugnant, since they see their mission as providing services. Nevertheless, if rules and prohibitions are needed to deal with acute drought, these should be vigorously and widely enforced.

If, however, a water district does not wish to become involved in policing door-to-door to ensure compliance, it should adopt rationing rules and regulations that do not require close surveillance. Perhaps pricing penalties or fines, along with a clearly stated quota for each residence, followed by regular feedback to customers on consumption, will suffice in all but the most extreme drought conditions. Even though an individualized system of feedback and penalty for each residence would be difficult to implement, it might nevertheless involve less effort than widespread surveillance programs.

Recommendation: Communication

A third policy recommendation for rationing programs in acute droughts: *Clear and consistent communication between a water district and its residential consumers is essential.* Many comments urged that the communication process be improved, and the survey results suggested that districts were not accustomed to communicating with their customers on an individualized basis. Also, some consumers did not understand their district's overall program, partly because it was put together quickly, and was subject to change as the drought worsened.

In short, information on the water situation and on rationing programs needs to be communicated as clearly, simply, accurately and consistently as possible, with individual feedback to customers on amounts used compared to allotments. Of course, it helps if the rationing plans are as simple as possible—consistent with equity and effectiveness—and it should again be noted that water districts' informational feedback on use may be more acceptable as an aid to "self-enforcement" than vigorous door-to-door enforcement programs, which would cast water district personnel in the role of special police.

"Double messages" should be avoided. The data show that many residential consumers used less than their stated allotments, especially in the three moderate rationing program districts, thus causing financial problems for the water districts when revenues began to decline sharply.[9] Presumably the unanticipated success of conservation presented the districts with an unexpected financial problem, causing some of them to issue messages that seemed to imply that conservation, while desirable, "could be carried too far."

These double messages and lack of vigorous enforcement apparently disturbed respondents who were convinced that the drought was acutely serious, and were trying to follow conservation measures at considerable personal expense and inconvenience. Following are some suggested ways for water districts to avoid the unanticipated double bind that prompted the double messages.

Principles and Policies for Long-Term Conservation

Four major principles should be kept in mind when considering policies for long-term conservation. First, residential water conservation will probably have to be stepped up rather than decreased in California and the western United States over the coming decades. No longer does it seem sufficient to plan in terms of 200 to 300 gallons usage per person per day. Rather, as this research shows, the figures could drop to 100 gallons per person per day or even less. (See Table 2 for per capita water use in the summers of 1976 and 1977.)

There is plenty of evidence of the need to conserve water.[10] California's population continues to increase (though more slowly than many had projected earlier); energy costs for treating and transporting water are rising; the new large-scale inter-basin water transfers are becoming less desirable or feasible; and there is strong support for conserving environmental quality by maintaining wild rivers rather than damming them. Moreover both Californians and immigrants from wetter regions need to be made to recognize the impact of heavy water use in semiarid regions like California.

Second, under the typical district fiscal formula, with most funds coming from water sales, we have seen how conservation places districts in a double bind. Thus conservation reduces water district revenues, and when people conserve dramatically, revenues also fall dramatically.[11] Something must be done to deal with this problem equitably, if necessary conservation measures are not to cause water districts severe financial distress.

Third, residential consumers can and will conserve water. The many individual conservation efforts, going beyond the goals set by the districts, were unanticipated. The results suggest a different basis for future planning of residential water use. Many people found that living on 100 gallons per person per day was not too difficult.[12] Changes required in watering outside plants, as well as in use of indoor plumbing, and in related conservation behavior, were usually not unduly vexing or expensive. In fact, despite the emergency's end when heavy precipitation came in the winter of 1977-78, conservation practices developed during the summer of 1977 appear to have been carried over into the summer of 1978. In any event daily per capita use has remained lower than it was during the summer of 1976.[13]

Fourth, the people with the lowest per capita daily use of water were those who saw the drought as a harbinger of a *longer-term* need to live with less water in the future. People who believed only in a serious *short-term* crisis reported adopting many new conservation behaviors but, surprisingly, their belief in the seriousness of the crisis did not correlate with per capita daily use figures. This implies that the best and most effective approach to reduced residential use may come from steady, long-range, methodical programs carried out in a non-emergency atmosphere. This idea augurs well for long-term residential conservation of water. Probably a crisis is not needed to get people to follow substantial conservation practices. In fact, an approach that focuses on a short-term crisis may not be as effective as preparing for long-run reductions.

Recommendations: Specific Steps

What are the implications of these findings for long-range residential water conservation programs? What specific steps should be taken? First, a *water meter* of some sort should eventually be provided for every separate dwelling unit. A responsible person in each unit should be informed regularly on actual consumption in relation to targeted allotments based on the number of people per dwelling unit. Thus, each responsible person for each residential meter ought to know his or her targeted allotment in understandable terms, and get monthly information on how well he or she has performed in relation to that allotment. A landlord or apartment manager could act as the responsible person for multiple-family dwellings.

Admittedly such a program would require changes and additional operating expenses, as well as costs for installing and monitoring more meters. There is also the problem of determining the number of people served by each meter. One simple way would be to assume that the number of people per meter is three, unless demonstrated otherwise, and using standard procedures for adjusting this number when necessary. Once additional meters have been installed and the basic allotments established, modern computer technology could ease the burden of issuing individualized reports regularly with the water bill. In fact, such reporting might not cost much more than the modern computerized billing procedures already established.

With respect to enforcement, *pricing* should be the major regulatory mechanism employed to encourage conservation, penalize over-allotment use, and provide the water utility with a reliable income. A good method would be a flat rate or minimum monthly service fee for consumption below and up to the basic allotment. Ideally the minimum charge would provide a reasonable income for the water district without imposing a burden on any consumer, for example $10 per month for water use up to but not exceeding 10,000 gallons for the "standard" family of three. While a minimum monthly service charge for consumption that is less than the basic allotment probably would not encourage extremely low levels of conservation, it would promote reasonably frugal use while guaranteeing financial support for the water district.

A *steeply inclining block rate structure* would apply to amounts used above the basic allotment, to discourage such consumption.[14] For the "standard" family example, the second-block rate ($5.00/1,000 gal.) for use over the basic allotment, up to double the allotment, might be five times the rate for the first or basic allotment block ($1.00/1,000 gal.). The third block rate ($10.00/1,000 gal.) might be ten times the rate for the basic allotment (for use from two to three times the allotment) and so on. Excess use would thus automatically be penalized regularly, without

involving water district personnel in door-to-door enforcement.

Admittedly, many details of a conservation plan would need to be worked out, such as: (1) the number of gallons in the first block basic allotment and the flat rate associated with it, (2) providing for reasonable exceptions and appeal procedures, and (3) the steepness of the inclining rate structure. Also, people should be instructed on types of landscaping suitable to California's semiarid Mediterranean climate. Fortunately, the drought of 1977 may already have demonstrated to many residents the need for less exotic and more water-conserving landscaping.

In any event, the inclining block-rate structure has the following merits:

1. recognizes the need for long-term residential conservation of water;
2. can provide a fair financial return to water districts, even when people conscientiously conserve and reduce use substantially;
3. considers the number of people within each dwelling unit when establishing basic allotments;
4. provides for water districts' communication with each residential consuming unit on a regular basis;
5. involves no restrictive regulations or direct enforcement, thus taking advantage of the users' willingness and ability to conserve; and
6. emphasizes the more effective, long-run planning approaches to conservation.

Other advantages include ease of adjustment: The rate structure could be tightened for drier periods and relaxed for wet cycles, simply by modifying the basic allotment. For example, during extended dry periods, the basic allotment of 100 gallons per person per day for the "standard" three-person family could be lowered to 75 gallons per person per day. During extended wet periods, it could be raised to perhaps 125 gallons per person per day. Adjustments could also be made for climatic differences in sub-areas like those around San Francisco Bay. Allowing for such differences could help make regional planning for water conservation more acceptable to the public, while still maintaining a single basic type of conservation program.

Implications for Long-Term Energy Conservation

Now that the drought has abated, contemporary events place residential energy conservation in the forefront of our thinking, even more than residential water conservation. Some of the ideas developed here for the long-term residential conservation of water appear to be adaptable to other scarce resources, e.g., electricity, natural gas, and other energy sources. The goal of a meter for every dwelling unit and basic allotments on the monthly gas and electricity bills, indicating each consumer's use over or under a basic allotment, appear quite feasible. An inclining block rate could be instituted, and already has some precedent in the so-called "lifeline" rates for certain utility customers. High penalty costs for heating in the winter and for cooling in the summer might convince energy bill payers of the value of insulation. Also, penalty costs for electricity usage could help persuade consumers of the value of efficient appliances, and also make solar heating of water and rooms more attractive financially.

As with water conservation, such programs would require a change in the utilities' marketing approaches. Instead of trying to sell more services, they would have to promote conservation. In fact, electricity and natural gas suppliers may already be closer to accepting this idea than are the water utilities. There is much to recommend the concept of allotment quotas noted on bills, along with information on amounts used during the previous month or billing period, with penalty costs clearly stipulated.[15] The initial costs for beginning such programs could be lower for electricity and natural gas suppliers than for the water utilities, as many dwelling units already have gas and electricity meters and monthly billing is computerized on a regional basis. Highlighting information on amounts of energy used, in the context of a clearly stated conservation goal, and using an inclining block pricing structure, with penalty costs for uses over the allotments, might be more effective than rolling black- or brown- outs.

Conclusion

In conclusion, research on water conservation in the recent California drought demonstrates that people can and will save a scarce resource—water—a good deal more effectively than may have previously been believed. These encouraging results suggest that conservation of water and other scarce resources, such as electricity, natural gas, gasoline, heating oil, and coal, will be enhanced if consumers receive convincing evidence of the need for conservation over the long run. Further, the study indicates that conservation programs will be more effective if (1) they are viewed as equitable by those so governed, (2) the need for the programs, including their details, are clearly and consistently communicated, (3) individuals receive regular, periodic information regarding their consumption in relation to their allotments, and (4) there are economic penalties for amounts used over the allotment.

Finally, the research indicates that conservation would be encouraged if current marketing practices were restructured to reward—or at least not penalize—efforts by the consuming public to use less. The "lifeline-inclining block" structure suggested here might also work well for other resources such as electricity, natural gas, heating oil and coal. In any case, economic penalties for excessive use, and rewards for conservation (or at least non-punishment), should apply to the suppliers and consumers of our scarce natural resources.

NOTES

[1]Mark Hoffman, "Urban Drought in the San Francisco Bay Area: A Study of Institutional and Social Resiliency" (Berkeley: Teknekron Incorporated, October 1978), Fig. 1-3, p. 22. Prepublication draft.

[2]During the spring of 1977, and while the selection of water conservation programs for study was underway, a five-part schedule was developed, covering respondent identification, beliefs about the drought, conservation behavior, equity and effectiveness, water consumed, and socio-demographic data. After pre-testing, it was

administered as a person-to-person interview to 100 randomly selected voting age respondents from each of the nine districts surveyed, yielding a total of 900 respondents for the overall study.

[3]William H. Bruvold, "Consumer Response to Urban Drought in Central California," Final Report to the National Science Foundation, NSF Grant Number ENV77-16171, June 1978. Prepared for the Division of Advanced Environmental Research and Technology, NSF-RANN.

[4]See Edward A. Suchman, *Evaluative Research: Principles and Practice in Public Service and Social Action Programs* (New York: Russell Sage Foundation, 1967).

[5]Donald G. Larkin, "The Economics of Water Conservation," *American Water Works Association Journal*, 70(9):470-474 (September 1978), see p. 471.

[6]Richard B. Darlington, "Multiple Regression in Psychological Research and Practice," *Psychological Bulletin*, 69(3):161-182 (March 1968). Advanced statistical analyses, stepwise multiple regressions, were used to analyze the relation between beliefs and conservation behaviors.

[7]See John T. Knox, "Regionalism in the Bay Area," in Paul W. Gates, Ronald B. Robie, John T. Knox and Norman Y. Mineta, *Four Persistent Issues: Essays on California's Land Ownership Concentration, Water Deficits, Sub-State Regionalism, and Congressional Leadership* (Berkeley: Institute of Governmental Studies, University of California, 1978), pp. 53-63.

[8]We found that requiring a percent reduction from last year's use may seem simple and logical, but it is not really a good approach because: (1) last year's use is usually unknown to consumers, (2) usages vary widely during the year due to differing vacation schedules and seasonal demands, and (3) consumption may be expressed in units of 100 cubic feet, a term not familiar to most people.

[9]See Larkin, note 5 above.

[10]Ronald B. Robie, "Water Issues Facing California," in *Four Persistent Issues*, see note 7 above, pp. 31-52.

[11]See Larkin, note 5 above.

[12]See Bruvold, note 3 above.

[13]See Hoffman, note 1 above, Fig. 7-2, p. 291.

[14]See Steve H. Hanke, "A Method for Integrating Engineering and Economic Planning," *American Water Works Association Journal*, 70(9):487-491 (September 1978).

[15]For example, P.G. and E. has begun to show both usage for the month (in terms of therms billed) and usage for the same time period in the preceding year.

Water Policy

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THE CALIFORNIA WATER SYSTEM: ANOTHER ROUND OF EXPANSION?

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INTRODUCTION

After two years of bitter wrangling, the California Legislature adjourned in September 1978 without authorizing "Phase II" of the State Water Project.[1] This monumental $7 billion undertaking[2] would almost double the size of the present California water storage and transportation system, already the largest in the world. Its central and most controversial feature is a Peripheral Canal, which would cross the Delta formed by the Sacramento and San Joaquin rivers at the head of San Francisco Bay. Although strongly backed by the Brown administration, which tried to satisfy project opponents by including certain environmental safeguards and water conservation measures, the project bill (SB 346) died when it returned to the Senate in August, 1978, for concurrence with Assembly amendments. But the idea of expanding the state water system is far from dead. Pressure for a cross-Delta transfer facility and increased movement of water to the south has been building for over a decade, and proponents of Phase II believe its time is overdue. A new project authorization bill (SB 200) was submitted to the Legislature this year, and complex political maneuvering is now taking place.[3]

Since Phase II would be perhaps the largest new capital commitment by state government at a time when the need for fiscal austerity is being widely proclaimed, it is important for the people of California to be apprised of the issues surrounding the proposal.[4] To this end, this report will provide an introduction to: (1) the political alignments and arguments pro and con regarding expansion of the California Water System; (2) the principal features of Phase II; (3) the central issue dividing opinion, i.e., whether water quality in the San Francisco Bay and Delta can be safeguarded; (4) the more basic question whether additional water transfers are needed, or economically rational; and (5) suggested policy alternatives to Phase II, which follow from our conclusion as to the economic and environmental unsoundness of further water supply expansion at this time.

The writers wish to acknowledge the help of several readers, particularly that of Ronald B. Robie, Director of California's Department of Water Resources. While we are not in agreement on a number of points, his knowledgeable comments and queries helped clarify a number of questions, and are appreciated. We, of course, are solely responsible for the information, interpretations and conclusions presented in this paper.

ISSUES AND ALIGNMENTS

The main support for Phase II of the State Water Project (SWP) comes from the water-short areas of Southern California: urban users represented chiefly by the Metropolitan Water District of Southern California (MWD) and San Joaquin Valley growers and their local irrigation districts. These areas receive massive transfers of water from Northern California's Sacramento River system by means of the SWP, Phase I, operated by the Department of Water Resources (DWR), and the Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation (USBR). Over the years the water users to the south have been persistent and successful in securing new supplies. They won authorization of the CVP in the mid-1930s, the SWP in the late 1950s, and are now fighting for the third generation expansion of the state water system.

Supporters of Phase II make four basic arguments. First, they claim that the SWP was never completed as authorized, since a cross-Delta transfer facility was included in the California Water Plan (1957). Second, the MWD fears that Arizona will begin to divert its full legal entitlement from the Colorado River in 1985, cutting into MWD's draft.[5] Third, many growers in the Valley are faced with a falling water table, which makes drilling and pumping increasingly expensive and causes ground subsidence in some places. Finally, both MWD and Valley irrigation districts point to contractual obligations incurred by the state and USBR that cannot be met with existing storage and delivery capabilities. Behind all these arguments, of course, lies a claim of "need" for more water, which rests on an assumption of the invariability of present day use and pricing practices.

Arrayed against the water industry is a loose coalition in Northern California opposed to further water development. The principal opponents are the farmers of the rich agricultural Delta region. They presently draw water directly from the Delta channels to irrigate their crops, and fear that further diversions south will jeopardize water quality, when salt water from the Bay penetrates the Delta in the summer because of low runoff from the Sacramento and San Joaquin rivers.[6]

Additional opposition comes from Bay Area municipalities concerned about the detrimental effects on the Bay of reduced freshwater outflow from the Delta. They worry about the loss of Bay "flushing" and possible neutralization of gains in water quality achieved through large investments in pollution control.

Environmentalists echo the fears of others regarding Bay and Delta water quality, more from an ecological point of view than a financial one. Particular concern attends the possible degradation of Suisun Marsh, with its considerable birdlife, and reduction of large migratory and in-Delta fish populations. In addition, environmentalists question the long-range plans of the water industry to develop the last remaining wild rivers in California, North Coast rivers such as the Eel, Trinity and Klamath.[7] Environmental arguments in this case coincide with the regional interests of the northern third of the state, for which the rivers are the main natural amenity and basis for any further local development.

The environmentalist camp has developed an important schism. In 1978 the Sierra Club supported the Brown administration strategy of incorporating legal protections for Delta water quality *within* the Phase II package. The club's leadership argued that unless the compromise legislation were accepted, a worse bill with no environmental safeguards whatsoever might be enacted in years to come.

On the other hand, Delta farmers and other environmental groups, such as Friends of the Earth, put little faith in government promises about water quality protection *after* the Peripheral Canal is completed, removing the principal obstacle to greater water withdrawal. Indeed, opposition within the ranks of the Sierra Club itself has subsequently forced the leadership to retreat to a neutral position.[8]

At the same time a split also emerged among forces normally pro-development. Many Valley water districts, the California Farm Bureau Federation, and several Republican Senators representing Southern California, refused to support the Phase II package in 1978 because they felt that Delta environmental protections were too strong and could prevent delivery of water. Thus, the governor's attempt to satisfy interests on both sides of the controversy—by enlarging the California network while providing legal safeguards for Delta water quality—was not successful. The interests in conflict were not resolved.

PRINCIPAL FEATURES OF PHASE II

The Peripheral Canal

Some kind of facility to transfer water across the Delta has been envisioned since the drawing up of the California Water Plan in 1957.[9] In 1966 DWR officially designated the Peripheral Canal as the desired transfer mechanism, and it has been embroiled in controversy ever since. Reaction was so strong against the Environmental Impact Report issued in 1974 by the Reagan administration that the incoming Brown administration undertook a new "Delta Alternatives" study, which went through several drafts between 1975 and 1977. In the end, the Peripheral Canal emerged once more as the official favorite.[10]

Water planners face a basic geographic discrepancy in water supply and demand: the area of greatest rainfall and the largest rivers is the northern third of California, where the main storage dams of the State Water Project and Central Valley Project are located—CVP's Shasta, Trinity and Folsom, and SWP's Oroville.[11] To the south lie the arid regions, with much of the state's arable land and the majority of its population. In the middle of the state, however, lies a major obstacle to water transport: 1,100 miles of meandering channels and 738,000 acres of islands, comprising the largest inland delta in the United States, outside Alaska. Some 5-6 million acre-feet (MAF)[12] of water per year are pumped out of SWP's Clifton Court Forebay and the nearby CVP Tracy pumping station (both on the south edge of the Delta) into two man-made rivers, the California Aqueduct (SWP) and the Delta-Mendota Canal (CVP), for delivery to 76 contracting agencies. The purpose of the Peripheral Canal, then, is to span the Sacramento-San Joaquin Delta with an efficient, large-scale conduit to move more water from the northern part of the state to the south.

When the giant project pumps are operating at capacity, water does not so much move across the Delta as around it, traveling down the main channel of the Sacramento River and then being pulled back around the westernmost island. This "reverse flow" drags salt water back with it from the tidal zone where the Delta's fresh water mixes with the San Francisco Bay's salt water. In summer, lower river flow and maximum water demands coincide to make the problem worse.

Saline intrusion into the Delta has four major impacts:

(1) Water users to the south do not want salty water, so the agencies are limited in the amount of water they can pump.[13]

(2) Delta farmers are directly affected by saline conditions. Very low water during extremely dry years such as 1976-77 already seriously jeopardizes agriculture in the western and southern Delta.[14]

(3) Homes and industries in northern Contra Costa County are serviced with water drawn from the Delta via the Contra Costa Canal. In the spring of 1977, during the drought, water quality was seriously lowered. With the exception of only four days, intake water at Rock Slough daily exceeded health standards of not more than 25 milligrams of chlorides per liter. Thereafter, the state built emergency rock barriers across several channels to keep back the salt water.[15]

(4) The Delta and adjoining Suisun Marsh are, variously, home, breeding ground, and migratory way station for many waterfowl and fish, including King Salmon and Striped Bass. High salt levels affect the success of these species in ways not well understood, but very likely detrimental. In addition, the "reverse flow" confuses migrating fish and the project pumps ingest millions of fry and eggs. Together, these effects have had a negative impact on fish

populations.

The water agencies hope that the Peripheral Canal will solve all the above difficulties, as well as fulfilling their primary purpose of moving the water south. The Canal would be an unlined ditch, 43 miles long, 400 feet wide and 30 feet deep, with a capacity of 16.3 MAF per year—enough to carry over 70 percent of the average flow of the Sacramento River. It would skirt the east side of the Delta, pumping water directly from the Sacramento near Hood and delivering it to Clifton Court Forebay. Along the way it would have 12 gates from which water could be released into the channels of the Delta to create a westward flow.

Remainder of the Phase II Package

By itself the Peripheral Canal cannot solve the problems of the Delta, let alone meet the goals of the water industry for supply expansion to meet an estimated export demand of 7.5 MAF by the year 2000. As a result, a complementary system of storage and conveyance facilities has been proposed by DWR to go along with the Canal. These are:

1. Storage components north of the Delta: Cottonwood Creek project (2 reservoirs) and Glenn Reservoir and diversion complex (or, alternatively, the Colusa Reservoir complex). All three are off-stream storage located on the west side of the Sacramento Valley. Glenn would be the state's largest reservoir at 8.7 MAF (cf. Shasta's 4.5 MAF capacity).
2. Facilities in the Delta: the Peripheral Canal; relocation of the Contra Costa Canal intake to Clifton Court; southern and western Delta water quality improvement structures; and Suisun Marsh protective structures.
3. Components south of the Delta: the Mid-Valley Canal to offset groundwater overdraft in a federal service area; Los Vaqueros unit (2 reservoirs west of Clifton Court); if needed, Los Banos Grandes Reservoir, near San Luis Reservoir; unspecified additional service to the Bay Area; and groundwater storage works and wastewater reclamation projects.

In all, Phase II would cost over $7 billion, of which approximately $1 billion would go to the Peripheral Canal. The federal government would pay for half the Peripheral Canal and provide water for the Mid-Valley area.[16]

The system would augment the delivery and storage capability of the CVP and SWP by about 3 MAF and make it easier to meet commitments during water-short years. Phase II also contains certain innovations its proponents herald as differentiating it from all previous water projects. Most crucial here is the stipulation that, for Phase II to proceed, Congress must order the USBR to operate in accordance with California state Delta water quality standards—although exact standards are not specified by statute. In addition, water conservation and wastewater reclamation are declared to be goals of state water policy and some money has been targeted for agricultural conservation loans and reclamation facilities. Finally, the package includes as goals groundwater restoration and storage, and the state government is pushing for reform of water rights laws to achieve conjunctive use management.[17]

PROTECTING THE BAY-DELTA ENVIRONMENT

The debate over Phase II centers on the ability of certain water management measures and legal safeguards to offset the effects of increased withdrawals from the Sacramento-Bay Delta system. Many backers of the project, including administration officials, see it as an environmentally sound alternative to the present degradation of the Delta.[18] Project opponents claim that these measures are insufficient to protect the Bay and Delta, arguing (1) that the environmental impacts of Phase II are poorly understood and (2) that the formal protections to be erected would be unable to withstand future political pressure for their relaxation or elimination.

Unresolved Environmental Problems

The Peripheral Canal would probably solve the problem of "reverse flow" in the Delta, as planned,[19] but it leaves unanswered questions regarding performance of fish screens, sufficient water releases to protect water quality in the Delta and Bay, and increased agricultural runoff.

The Peripheral Canal will shift the point of intake 40 miles north to the Sacramento River, but will not eliminate one basic problem. As noted, millions of fish eggs and fry are now sucked into the Delta pumps every year, despite attempts to devise a preventive system of screens. In recognition of this, DWR proposes that a secure screen be installed at the head of the canal. Furthermore, the DWR proposes that the canal be constructed in three segments that could not be connected until effective screens were developed and demonstrated. The state Department of Fish and Game, which supported SB 346, claims that development of an effective fish screen is close at hand but the U.S. Fish and Wildlife Service disagrees.[20] Project opponents ask why it is assumed that such screens can be invented if specialists have thus far found it an impossible task. In addition, they point out that it is unlikely that the absence of a suitable fish screen would realistically be expected to hold up a $7 billion project once it is nearly complete.

A second difficulty arises concerning the requirements of the Delta for freshwater flows from the Sacramento. Satisfactory scientific knowledge is lacking as to the long-term impacts on the wildlife and soils of the area of greater saline penetration. Researchers are gradually discovering the serious implications for the Delta environment of progressively larger water diversions. In the last 12 years, estimates of the amount of riverine inflow required to maintain minimum summer water quality in the Delta have risen significantly from 1800 to 4000 cubic feet per second. Further research could raise these estimates—the 4000 cfs figure is currently under challenge by Delta farmers and municipalities unhappy with the latest water quality standards.[21]

The water circulation patterns and flow requirements of San Francisco Bay are even more poorly understood. It is not known how much Sacramento River flows can be diminished and at what times of the year, without degrading Bay water quality. This question is particularly important for the portion of the Bay south of the San

Francisco-Oakland Bay Bridge, an area with little natural runoff and one that experiences only weak tidal action. The South Bay receives significant amounts of fresh water "flushing" only when there are relatively large volume, rapid outflows from the Sacramento River. Otherwise, a threshold apparently exists under which almost all river water bypasses the South Bay and goes directly out the Golden Gate.[22] South Bay water has been seriously polluted by urban wastes and has only begun to improve as the result of large expenditures for municipal sewage treatment systems; but the margin of safety for dissolved oxygen levels in summertime remains narrow. At the same time, the North Bay relies on steady freshwater outflows to clear its heavy load of industrial and municipal wastes, so even the reduction of average flows could lower overall Bay water quality.

The Bay and Delta are further jeopardized by Phase II because as more water goes south to irrigate farmland, more runoff laden with salts and chemical pollutants is generated. A growing dilemma for San Joaquin Valley farmers is what to do with their wastes. The proposed solution is called the San Joaquin Valley Agricultural Drain, already partially completed. The State-Federal Interagency Drainage Program recently recommended that the drain be continued to the Delta, where its load of pollutants would be discharged.[23]

Thus, in spite of the long effort to market Phase II as an environmentally sound alternative to the present situation, serious questions about its ultimate impact upon the unique Bay-Delta environment remain unanswered.

Legal Safeguards

The crux of the Brown administration plan for Phase II is a set of legal safeguards designed to govern operation of the expanded State Water Project and to force the USBR to tailor management of the Central Valley Project to meet state Delta water quality standards. By physically bypassing the Delta, the Peripheral Canal would preserve the quality of water going south, regardless of possible deterioration of Delta water quality. Therefore the Delta is especially vulnerable and needs firm guarantees as part of any compromise package. Project supporters believe in the efficacy and permanence of legal regulations, while opponents hold that—in the words of former California Senator Peter Behr—"A thirsty beast cannot be contained in a paper cage."

The State Water Resources Control Board (SWRCB) presently sets standards for the Delta. These emerged, after years of intense conflict, in the form of Decision 1379 in 1971.[24] The State Water Project attempts to meet SWRCB standards, but the U.S. Bureau of Reclamation does not. The Bureau's Regional Director set CVP policy in 1957 when he informed the state: "I consider that the obligations of the Central Valley Project are satisfied when a satisfactory quality of water is provided at the intakes to the Contra Costa and Tracy pumping plants."[25]

The controversy recently came to a head in the Supreme Court decision in *California v. United States*.[26] The court, however, begged the question by ruling that the state could impose conditions of operation on the CVP when they were not inconsistent with "clear Congressional directive" for operation of the Project. Secretary of the Interior Cecil Andrus recently announced that the Bureau would voluntarily comply with the state Delta standards in years of sufficient water supply, but here again the federal government gave away nothing: the Secretary reserved the right to challenge the consistency of state standards. In any event his decision could be reversed by a subsequent administration.[27]

The SWRCB is also empowered to undertake basin planning for pollution control.[28] Objectives for the Delta are contained in a Water Quality Control Plan for the Sacramento-San Joaquin Basin. In August 1978 SWRCB released a new Basin Plan that replaces Decision 1379[29] and continues the historic trend with upward revision of minimum standards for Delta protection. At the same time, the board now believes that with fine tuning of fresh water releases from upstream dams a higher level of protection can be achieved while another million acre-feet of water are exported. This finding appears to be an attempt to please all concerned, but its feasibility is questionable.[30]

The Basin Plan is supposed to guide operation of the CVP under sections 502 and 313 of the Federal Water Pollution Control Act Amendments of 1972, which say that all federal facilities must comply with state plans. Nonetheless, the Bureau of Reclamation claims that because the CVP has prior water commitments authorized by Congress, it is exempt.[31] Because of the Bureau's intransigence, the Phase II package includes a provision that Congress require the CVP to be operated in accordance with state regulations before Phase II can begin service.

Will this assure compliance? Several unfortunate scenarios can be foreseen, such as: Congress does not agree but state legislation is amended to eliminate this provision; Congress agrees, but fails to provide airtight requirements, so that a court challenge overturns the agreement; Congress agrees and all political pressures are focused on the SWRCB standard-setting process.

What is the security of state standards? We already have evidence of how poorly they hold up under pressure. Twice during the drought year of 1977 Decision 1379 was amended to lower Delta water quality standards on an "emergency" basis in the face of inadequate upstream storage (owing to normal drawdown in 1976 which was not replenished when the drought continued into 1977, the driest year on record).[32] But if standards can be set aside precisely when they come into play—during periods of lowest flow—then their protective powers are an illusion.

If we are to believe proponents of Phase II, laws governing operation of the CVP and establishing Delta water quality minima are expected to work in the future when they have not worked in the past. Unfortunately, powerful political forces, armed with actual dams and canals, can often find ways around seemingly airtight agreements.[33]

WATER NEEDS AND SUPPLY ALTERNATIVES

The debate over expanding the State Water Project has centered on considerations of environmental and regional

interests. Yet the need for additional surface water supplies has never been clearly demonstrated. In this section we answer the major arguments proponents use to justify Phase II, and question the rationality of present water use and pricing practices. By thus showing that water use does not expand inexorably, we point the way to alternatives to Phase II.

Contractual Obligations

DWR claims that it requires Phase II in order to meet the contractual obligations incurred as part of the SWP –4.23 MAF vs. 2.5 MAF now being delivered. This discrepancy says less about the need for water than about the overly optimistic predictions of DWR planners, who promised more than they could feasibly deliver with the system built under the original SWP authorization. In fact, current DWR contracts have clauses that limit delivery and construction obligations to cases where they are "physically and financially feasible," and it can be argued that the contracts are not binding if adequate facilities for delivery do not exist.[34] We consider it to be self-fulfilling prophecy for the state to promise more than it can deliver and then to use those promises to justify further supply expansion.[35]

At the same time, USBR wants the Peripheral Canal so that it can incur *new* contractual obligations.[36] Here again agency optimism overrides wise planning, so that contractual commitments are made and expectations of water supply created, which cannot be met.[37] On one hand, the bureau makes promises of "firm" water, based on predictions of supply that underestimate climatic variability and overestimate the ability of its storage dams to serve as a hedge against drought. On the other hand, the bureau delivers "interim" water, which cannot be assured in dry years, yet which the bureau always hopes to convert to firm contracts, and which creates economic dependence on outside water in the contracting areas. So long as these practices continue, there can *never* be a water supply system big enough to meet demand, and there will always be a built-in lever for supply expansion in the form of unfulfilled contractual "obligations."

Groundwater Overdraft

Presently over half of water withdrawals in California come from the ground. Supporters of Phase II argue that groundwater overdrafts threaten the future of irrigated agriculture in portions of the San Joaquin Valley unless the project is undertaken.[38] The problem is undoubtedly serious, but the question is whether further water imports will actually solve the problem. History suggests they will not.

When the Central Valley Project was proposed in the 1930s, one major rationale was to replace the use of groundwater in the San Joaquin. Nonetheless, after the CVP was constructed, the groundwater problem remained because excessive pumping now extended to the West and South Valley, as irrigated agriculture expanded into these areas. The State Water Project was then promoted to help alleviate *this* overdraft; but it was not intended for the promotion of further irrigated agriculture. In developing the SWP, however, DWR contracted more than 1 MAF to the Kern County Water Agency (KCWA). Unfortunately, groundwater proved cheaper for Kern County farmers than project water, despite falling water tables, so KCWA had to seek out buyers in previously unirrigated areas. As a result, much of the agricultural supply of the SWP went to *expand* irrigated agriculture.[39]

We conclude that such divergences between intent and result are likely to be repeated as long as groundwater pumping remains unregulated. Nor will the demand for genuine water-table rescue operations end as long as the future implications of competitive pumping are ignored in favor of short-run gain.

Despite extensive evidence of the need for and possibility of successful groundwater management,[40] the agricultural lobby remains officially opposed to even the moderate program proposed by the recent governor's commission to review water rights law. One of the principal water industry lobbyists argued before a recent hearing of the Senate Agriculture and Water Resources Committee that: "there is no groundwater overdraft . . . [but] simply a shortage of imported surface water." In short, the water users have not been interested in conserving and managing California's water resources rationally because so far it has been more profitable for them to secure imported water[41] (see below, regarding subsidies).

Colorado River Water

The Metropolitan Water District of Southern California (MWD) currently draws much of its water from the Colorado River aqueduct.[42] But MWD could lose several hundred thousand acre feet per year, because Arizona won a Supreme Court decision in 1963 entitling it to a larger share of the Colorado River, and the USBR is now constructing the Central Arizona Project (CAP). MWD has a projected demand of 2.1 MAF for the year 2000, and a minimum supply of 1.2 MAF at that time. Present use is about 1.3 MAF per year. Does this mean, as the district argues, that additional Northern California water must be imported?

Perhaps not. First, MWD has consistently overestimated water demands.[43] In fact, MWD has never yet taken its full firm entitlement from the SWP. As a consequence, large quantities of water earmarked for the Los Angeles basin have actually been sold as "surplus," at bargain prices, to landowners in the San Joaquin Valley. Now it looks as if the same mistake will be made again. If we look at MWD's predicted demand and supply for the year 2000, it *appears* that additional SWP water will not be needed. MWD predicts a demand of 2.1 MAF per year. On the supply side it will have a guaranteed 1.0 MAF from the SWP, even in dry years; between 0.4 and 0.55 MAF from the Colorado River, even after CAP diversions; and 0.3 MAF from wastewater reclamation. This means a firm supply of 1.7 to 1.85 MAF per year. With 15 percent conservation–a figure DWR itself thinks reasonable (see below)–MWD will be able to eliminate the difference between demand and supply.[44]

In addition, the SWP is an expensive source, because the water must be pumped over 3,000-foot-plus elevations

through the Tehachapi range. MWD must therefore pay a power cost of over $60 per acre-foot. As economists Bain, Caves and Margolis[45] suggested more than ten years ago, a cheaper alternative supply lies near at hand: Colorado River water currently allocated to irrigators in the Imperial–Palo Verde–Coachella valleys. Since the latter pay the federal government only $7.50 per acre-foot, MWD could compensate the farmers handsomely and still come out ahead. Less than a 20 percent diversion of their roughly 4.4 MAF entitlement would make up the shortfall in water rights lost to Arizona, as estimated by MWD.

A further consideration of cost that weighs against expanding water imports from the north is the demand for energy. The SWP is the largest single user of electrical power in California, owing to the tremendous pump-lift over the mountains. The planned increase in water shipments to the southern coastal basin will very likely double present energy consumption, which already equals the electricity used by the entire City of Los Angeles in 1965. DWR will have to construct several new power plants to provide this power. Where will these be sited?[46]

Pricing and Subsidies

Must all new demands for water be met? Water *demands* are not water *requirements* dictated by nature.[47] Nor are all demands economically rational, since water is costly to supply and is no more to be dispensed carelessly than any other economic commodity. This is particularly true where water is used in an industrial process, as it is in California agriculture, the state's biggest business. Agricultural water demands derive from the demand for food, fibre and forage crops, and the potential for growth in such markets.

Yet agricultural water is heavily subsidized in California, making it appear very cheap to growers. The low price of water artificially inflates demand and offers little incentive to make wise use of existing water supplies.[48] Among other things, water subsidy promotes the irrigation of low-value crops: e.g., forage crops such as alfalfa account for fully 63 percent of all agricultural water used in the state. Far from being naturally given, water demand is flexible and responds to price changes: Economic studies have repeatedly shown acreages of low-value, water-intensive crops being reduced as water prices rise.[49]

In granting subsidies, the federal reclamation program is the worst offender. Average prices to irrigators are $3.50 to $8 per acre-foot for USBR water, compared with $18.50 to $30 for SWP water; prices to cities are considerably higher. Actually, the state system only nominally charges its posted prices. "Surplus" water is priced with capital costs removed; and since up to 50 percent of this "surplus" water is mixed in, the average cost paid by agricultural customers drops much closer to USBR rates.[50]

The pricing and repayment policies of the USBR are so generous that irrigators pay less than 5 percent of total costs of supplying the water they use.[51] They pay so little, in fact, that the CVP could not even cover its operating costs recently. In comparison, the state's water program is a model of fiscal responsibility, and at least is financially solvent, but it also gives subsidies. The principal sources of subsidy are: local water district property taxes on urban nonusers; hydro-power revenues; revenues transferred from Tidelands oil leases; and capital provided at below market rate.[52] In short, despite apparent fiscal soundness, Bain, Caves and Margolis judged the benefit-cost ratio of the SWP to be below 1:1.[53] At the same time, as noted above, water demand is artificially inflated because the amount users pay does not reflect the costs of the water they use.[54]

Water Use Efficiency and the Potential for Conservation

There is an alternative "source" of water–other than supply augmentation– i.e., conservation through reduced and rationalized use.[55] But given current policies and practices–such as excess contractual obligations, groundwater mismanagement, and government willingness to supply low cost water to meet all demands–users have little incentive to conserve. Under these circumstances, substantial water conservation without significant dislocation would be made possible by: (1) cutting unnecessary losses in storage and transfer, (2) investing in improved equipment, and (3) paying closer attention to efficiency of use, not to mention eliminating low-value uses.

The potential for *urban* residential water conservation was demonstrated in the great drought of 1976-77, where unprecedented cutbacks of 50-75 percent were achieved with water rationing, and 10-25 percent on a voluntary basis in less hard-hit communities.[56] While one need not advocate such extreme reductions, 25-33 percent no longer seems unrealistic, and can be secured by a few basic technical modifications, without significant changes in habits. Indeed, the permanent efficiencies in urban water use realized as a result of efforts during the drought have put demand well below previous estimates of growth, forcing local water agencies to raise prices to meet their fixed costs. A Lawrence Berkeley Laboratory study has concluded that 1.8 MAF per year could be obtained from urban conservation, while DWR itself sees 1.2-2.4 MAF of potential urban water savings statewide.[57]

The potential importance of agricultural water saving is much greater, of course, since 85 percent of California's water withdrawals go to irrigation. Although blanket condemnation of agricultural practices is not justified, there is considerable room for improvement by cutting delivery and application losses (through seepage and evaporation) and reducing excessive consumption by the crops themselves (plants can actually consume more water than needed for optimum growth). For example, many canals are unlined and uncovered; the Coachella Canal alone loses some 300,000 acre-feet of the 1.2 MAF sent down it each year. (Ironically, the Peripheral Canal would also be unlined.) Some 82 percent of California's irrigation is by gravity methods, chiefly open-ditch, which use much more water than other techniques. For example, sprinkler irrigation uses only 18 percent as much water as open-ditch (gravity) and drip irrigation only one percent as much.[58] Although the latter are not applicable to all situations, no one–including DWR–believes that their

potential has been fully tapped. Similarly, possibilities have scarcely been touched with respect to scientific management of irrigation, especially careful scheduling related to soil moisture and crop growth patterns. The USBR began an advisory irrigation management service for this purpose within the last five years, and it has shown good results.[59]

DWR's rather conservative estimate of potential water saving in agriculture is 1.2 MAF.[60] Of course, water conservation measures are not without cost, but they may cost society less than massive water supply projects. The problem is that under current arrangements—particularly government subsidies for water supply but not for water conservation—the rational solution for the whole populace is not presently rational *for the farmers*.[61]

SUGGESTIONS FOR REFORM

Proponents of Phase II have promised conservation, water quality agreements for the Delta, and now a series of expensive water conservation policy studies originally proposed by the environmentalist opposition. Nevertheless, the preceding discussion should make it clear that a high priority for conservation is not part of the California water industry's prevailing philosophy. We believe basic reforms are needed in the state's water law, policies and practices before further authorizations for expansion of supply. Otherwise, the process of building more water transfer systems to slake the thirst of the agricultural and urban water industries seems likely to continue.

Reforms should include: (1) a firm acre-foot limit on Delta exports; (2) congressional reauthorization of the Central Valley Project to make it conform to state water quality objectives in the Delta; (3) further research on the Bay-Delta system's water requirements before building the Peripheral Canal; (4) federal Wild and Scenic River protection for the North Coast rivers; (5) reform of state and federal repayment practices so that water users contribute their fair share of project costs; (6) following the suggestion of the General Accounting Office, authorizing no further projects in areas with groundwater overdrafts, unless management programs are in force; (7) well-financed research and funding programs for diffusion of water conserving techniques; (8) changes in agency contracting practices to eliminate overcommitment of supplies; and (9) making all water use rights contingent on demonstration of good management practices.

The real answer to the need for environmental protection, economic efficiency, and safeguards for water supply lies in wise use of the water resources already at hand. But forceful and effective conservation policies will not be adopted and implemented as long as the alternative of government subsidies and rescue operations are available. If Phase II of the State Water Project is approved without the reforms we have suggested, the water industry will continue to operate in the future as it has in the past. Demand will once again outrun supply, and even larger projects will be proposed to meet the inevitable "need" for more water. We argue that Phase II will not solve California's water problems, but will simply recreate them again on a larger scale.

NOTES

[1] We choose to call the proposals "Phase II" rather than merely "completion of the State Water Project," as proponents of the proposals would have it, for several reasons, amplified in the rest of the paper. For example, (1) the cost is over three times the original SWP bond issue; (2) the authorization of the Peripheral Canal in the Burns-Porter Act is questionable; (3) the addition of many new features besides the Canal would double or triple SWP storage capacity; and (4) much time has lapsed since the SWP was authorized. Perhaps a better name for the project would be "Stage III of the California Water System."

[2] $3.4 billion in capital costs plus $3.8 billion in interest charges, with a 5.84 percent weighted average interest rate over a 30-year repayment period. Sources of capital are: California Water Fund, 60 percent; Tidelands oil reserves, 5 percent; State Central Valley Project Construction Fund, revenue bonds, 20 percent; miscellaneous receipts, 10 percent; unexpended Burns-Porter bonds (general obligation), 5 percent.

[3] As of this writing (5/7/79) several bills are under consideration:

–SB 200 (Ayala). Introduced as a duplicate of Brown's SB 346 (77-78), it is now significantly amended and allows the state to construct the Peripheral Canal without federal participation; it has also removed appropriations, enabling the bill to pass with only a majority vote, rather than the normal 2/3 required for appropriation acts. Presumably, DWR will issue revenue bonds, thereby avoiding the need for a 2/3 vote in the Legislature or the need to consult the electorate.

DWR Director Ron Robie has pledged DWR's support for the bill, so long as it requires state protection of, and a federal commitment to, Delta water quality before any federal water is allowed through the state-constructed Peripheral Canal. If the federal government refuses to meet Delta standards, Section 11460 of SB 200 (as amended in Senate, 4/30/79) allows the state to meet standards alone, but requires the standards to be reconsidered when appropriate permits for the Peripheral Canal have been issued by the SWRCB.

The push for a state-only canal comes primarily from the Metropolitan Water District, which had earlier proposed its own legislation (Resolution 7768 and accompanying draft legislation, MWD, 2/13/79). MWD accurately perceived that federal approval of a facility would take years, if it occurred at all, given Washington's current unfavorable view of expensive water projects. Senator Ayala apparently acceded to MWD's strategy in amending his bill.

–AB 442 (Kapiloff). Introduced by the Chair of the Assembly Committee on Water, Parks and Wildlife, AB 442 is a general policy bill. Kapiloff held a series of hearings to reexamine the basic questions of California water management, including subsidies and groundwater management. The committee staff is preparing an extensive bill to include both management reforms and construction of Phase II. This language will be amended into AB 442.

–Several minor bills to authorize the Peripheral Canal have also been introduced, e.g., AB 303 (Lehman).

–Several water management bills, including: SB 47 (Nejedly) to establish a groundwater management procedure, following the recommendations of the Governor's Commission to Review California Water Rights Law. AB 1147 (Filante) would authorize water transfers and establish tighter fiscal controls. AB 1209 (Gage) would set up a task force to establish the potential for agricultural water conservation in the state.

Politically, the battle will be between the Senate-sponsored bill, which most closely reflects the priorities of the water industry, and the more reform-minded Assembly bill(s).

[4] Under SB 346, the capital costs of the project would have been borne by the State Water Project and the Federal Central Valley Project, but may be carried by the state alone under current legislative proposals (see note 3, above).

[5] MWD's contract was amended in 1964 to add .5 MAF from the SWP to substitute for losses anticipated from CAP diversions.

[6] It should be noted that the Delta experienced very high saline penetration prior to the construction of the water projects. The upstream storage reservoirs of the SWP and CVP allow releases of fresh water in summertime that keep salt water at bay. This is necessary both for Delta agriculture, which has been established since the Delta islands were reclaimed by levees around the turn of the century, and because the water quality at the SWP and CVP pumping stations in the south Delta must be maintained.

[7] Plans for North Coast development have long been on the books of the water agencies (see Sidney Twichell Harding, *Water in California*, Palo Alto: N-P Publications, 1960; and Johannes Humlum, *Water Development and Water Planning in the Southwest United States*, [Denmark], Aarhus Universitet, Kulturgeografisk Institut, 1969). The state Wild and Scenic Rivers Act of 1972 currently restricts development in the Eel, Trinity and Klamath watersheds. But it should be noted that Sen. Ayala introduced a companion bill to SB 346 in 1977-78 which would have repealed the Scenic Rivers law. Ayala dropped the bill to push SB 346. Nonetheless, many water agency officials are frank about their eventual plans to repeal the protection law and dam the Eel. In any case, the status of the Eel River must be reconsidered in 1983. The storage and conveyance facilities of Phase II, it should be said, only make the next step of tapping the North Coast much easier, physically and financially.

[8] A similar reversal occurred within the Planning and Conservation League, another Sacramento environmental lobby. The PCL Board of Directors narrowly voted to endorse SB 346 in 1977, at the urging of their executive director, who had helped to draft the bill. In 1979, PCL reversed its position, with the appointment of a new executive director and shifting sentiments on the part of board members.

[9] California, DWR, Div. of Resources Planning, Bulletin No. 3, *The California Water Plan*, May 1957. The Burns-Porter Act of 1959, submitting the bond authorization for the SWP to state voters, is the key legal document. It mentioned "channel improvements and appurtenant facilities in the Sacramento-San Joaquin Delta for water conservation, water supply in the Delta, transfer of water across the Delta. . .and related functions." (Chapter 1762, Cal. Statutes, 1959). During the 20 years since, three major questions of interpretation have arisen: (1) does Burns-Porter specifically indicate the Peripheral Canal as the Delta Facility? (2) does Burns-Porter constitute an authorization for the whole Phase II project? (3) Is any action required by the Legislature to construct Phase II? Whatever the legality, however, it would be politically impossible to proceed without legislative approval.

[10] The EIR drew 836 negative public comments. When Gov. Brown was elected, he promised to reconsider the whole proposal, in order better to include environmental considerations. He appointed two strongly pro-environmental protection people to be Director and Deputy Director of DWR. Nonetheless, the only "Delta Alternative" ever seriously considered in the DWR study was the Peripheral Canal. See Kelly Robinson, "Project Report: Delta Alternatives Study," Department of Geography, U.C. Berkeley, June 10, 1977. The main change produced by the study was to include, along with the canal, the whole package of storage, transfer and mitigation features that comprises Phase II.

[11] The Sacramento River carries an average flow of 23 million acre-feet per year, but the San Joaquin only 6.3 million acre-feet. Together they carry roughly 40 percent of total runoff in the state. The North Coast rivers, on which only one major dam (Trinity) has been constructed, carry another 40 percent of the runoff. Less than 15 percent of California's river outflow occurs south of San Francisco.

[12] An acre-foot is the amount of water necessary to cover one acre of land one foot deep, or about 325,000 gallons. The average water used in irrigated agriculture in California is three acre-feet per year, though the amount varies widely according to crop, climate, soil and method of irrigation.

[13] The USBR's operating standard is 750 parts per million dissolved solids.

[14] Another threat to Delta agriculture is the scouring of protective levees by project-induced currents. This would very likely *not* be solved, but merely shifted to a new location by the Peripheral Canal.

[15] In 1977 water quality at Emmaton, near the middle of Sherman Island in the west Delta, regularly exceeded the 10-day mean salinity standards of 1000 milligrams per litre chlorides.

[16] There is maneuvering underway to have the state assume the entire cost of the Canal, so that federal approval would no longer be required. See note 3, above.

[17] See California, Governor's Commission to Review California Water Rights Law, *Final Report* issued in December 1978.

[18] The ostensible purpose of the Peripheral Canal has been changed over the years from merely a water conduit to an environmental protection measure. We believe that the basic impetus for the Canal is the same as ever, but that backers have been forced into trying to mollify opponents on environmental grounds.

[19] SB 346 required federal participation in the construction and operation of the Peripheral Canal. This year's bill, SB 200, authorizes the state to construct the Peripheral Canal without federal participation in financing or use of the Canal. It would allow the federal government to wheel water through the Canal under specified conditions. This is important because under the SB 346 plan, the federal government and the state would have drawn all their water from the lower end of the Canal, at Clifton Court Forebay. However, should the federal government not use the state-only Canal, a situation could conceivably develop where the state is pumping its water from the Canal at Clifton Court Forebay, and the CVP is pumping its water directly out of the Delta through its Tracy Pumping Plant. With this even more complex pumping situation, it is not known whether the Canal would correct the existing reverse flow patterns in the Delta. Thus, a state-only canal might not satisfy even the most obvious environmental requirements.

[20] William D. Sweeney, Area Manager, U.S. Fish and Wildlife Service in a statement to Assembly Committee on Water, Parks and Wildlife, 4/4/79: "the present state of the art in fish screening does not allow us to endorse the project as being of overall benefit to a total fish management program for the Delta. . . ."

[21] On the historical evolution of standards, see John MacLeod MacDiarmid, "The California State Water Project: Development, Description, Current Conflicts," speech presented to the 62nd Annual Conference of the National Council for Geographic Education, San Francisco, November 27, 1976. DWR maintains that up to 5,000 cfs are built into its current plans. Our point here is that this is an area where knowledge is not sufficient and thus estimates are subject to significant change. In light of water commitments now being planned, there is serious risk to the Delta. As we have attempted to illustrate, we believe it unlikely that, once these commitments have been made, new scientific knowledge of outflow requirements would be reason enough to curtail use of the expensive new facilities.

[22] Hugo B. Fisher Associates, "A Preliminary Report on the Effects of Density Stratification in San Francisco Bay," Report to the Association of Bay Area Governments, Oakland, California, June 1977. See also D.S. McCulloch et al., "A Preliminary Study of the Effects of Water Circulation in the San Francisco Bay Estuary–Some Effects of Freshwater Inflow in the Flushing of South San Francisco Bay." U.S. Geological Survey Circular No. 637A (Washington, D.C.: 1970).

[23] San Joaquin Valley Interagency Drainage Program. "Agricultural Drainage and Salt Management in the San Joaquin Valley," January 1979.

This has given rise to several criticisms and concerns: (1) Some observers question whether it is possible to meet salt standards safely while discharging 300 cfs of drain water into Suisun Bay, when total Delta outflows are sometimes less than 10 times that amount. (2) Discharges of chemicals such as DDT, dieldrin and toxaphene are predicted, but no specific mitigation or control measures are suggested, and no discussion is offered as to whether federal and state water quality standards would be violated. (3) The Environmental Impact Report on the drain makes assumptions of adequate knowledge about the impacts of wastewater discharge on the stimulation in growth of algae and other organisms (owing to high nutrient levels). But as the EPA pointed out, there is a "paucity" of information on the subject.

[24] Negotiations between project sponsors and Delta growers produced the first water quality standards for the Delta in 1965. These standards called for a Delta outflow of 1,800 cfs. This meant that at least part of the Delta would have had to find an alternative water supply, due to salt incursion. But Congress passed the Federal Water Pollution Control Act in the same year, instructing the state to establish water quality standards. The standards proposed by the state in 1967 (Res. 68-17 of the SWRCB) were rejected by the Secretary of the Interior. The SWRCB then held hearings and eventually produced the first comprehensive water quality standards for the Delta, embodied in Decision 1379. The water quality under this decision would be maintained at roughly twice the level of the 1965 standards.

[25] There is a long history of conflicting purposes for Delta salinity control. The CVP was originally a state project that included salt water repulsion as a function, but it could not be financed on account of the Great Depression. When the federal government assumed responsibility for the project, salinity control did not appear in the congressional authorization. Nonetheless, the building of Shasta Dam markedly improved conditions in the Delta, so the Bureau of Reclamation continued to publicize its success in this regard, especially in its annual appropriations hearings before Congress. Over 125 references to Delta salinity control by the USBR have been documented, despite their official refusal to meet standards. See MacDiarmid, note 21 above.

[26] *California v. United States*, 46 LW 4997, July 3, 1978 (Docket No. 77-285).

[27] Andrus' decision memo, dated December 29, 1978, reads in part:

> . . .Interior would reserve, and the state would recognize, our right to challenge the consistency of the state standards, whenever meeting those standards impairs Interior's ability to fulfill other project purposes.

Andrus also proposed to have legislation introduced in Congress amending CVP authorization to include Delta protection as a project purpose, but the fate of such legislation and its ultimate impact remain to be seen. Hearings are now underway to determine the new scope of CVP authorizations.

[28] Under Section 303 of the Federal Water Pollution Control Act Amendments of 1972 and the state Porter-Cologne Water Quality Control Act of 1969.

[29] When combined with Decision 1485 (1978) to coordinate the plan with water rights.

[30] Criticisms of the SWRCB Basin Plan and Decision 1485 are too numerous and complex to be explained here. A number of water districts in the Delta, environmental groups, and the EPA have all raised serious questions about the board's plan. The EPA has not yet approved the SWRCB plan and has asked for several revisions. One important area of dispute is the "relaxation provision," which operates as follows: the Plan sets water quality standards for the Delta. The standards vary according to the hydrological year, i.e., in a wet year, water quality is maintained at a standard higher than in a dry year. The quantity of project deficiencies in firm water supplies is used to determine the quality of water that will remain to protect Delta water quality. As current USBR surplus water is converted into firm supplies, once the Peripheral Canal is built, and as DWR contract entitlements increase, potential project deficiencies in firm supplies will be larger for the same water year type. This means lowered water quality. For instance, if a drought in 1979 had caused 2 MAF in firm water deficiencies to project users, sufficient water would have had to be released between April 1 and May 5 to meet an electrical conductivity standard of 4.4 millimhos at Antioch, in the Delta. Based on the board's proposed relaxation provision, if the *exact same* conditions occurred in 1988, when commitments may be 2 MAF higher than 1979, there would be a 4 MAF deficiency, but only the Delta would suffer. See "Petition of Friends of the Earth appealing SWRCB's approval of Water Quality Control Plan and EIR and Decision 1483," September 11, 1978.

[31] Section 502 of the Federal Water Pollution Control Act identifies those pollutants subject to cleanup. Salinity incursions were included in discussions on the Senate floor–particularly those between Sen. Muskie, author of the act, and Sen. Bayh. Section 313 requires federal facilities to meet the effluent limitations. In addition, Pres. Carter has issued an executive order (No. 12088, 10/18/1978) that requires all federal facilities to comply with section 313.

[32] But the recent drought years of 1976 and 1977 were not the driest years in the long-run record taken from tree-ring data. In fact, the 1976-77 drought was by no means extraordinary climatologically. Such periods in the future must be anticipated and planned for–not, however, by expanding supplies under *present* institutional arrangements, which assure that climatic variability will *not* be sufficiently taken into account (see notes 34-35 below).

[33] Phase II also calls for a Four-Agency Fish and Wildlife Administrative agreement. This compact between USBR, DWR, California Department of Fish and Game and the U.S. Fish and Wildlife Service, would specify that fish and wildlife populations be maintained at "average historical levels" in the Delta. Quite apart from the impossibility of objectively determining the meaning of "average historical levels" in an ecosystem that has been drastically altered by human beings (including the introduction of the Striped Bass from the East Coast), the same basic argument about the inherent malleability of such standards under political pressure holds here as well.

[34] It has been argued that constructing Phase II could create the obligations to deliver all 4.23 MAF of contracted water, but that, in the absence of facilities, the contracts are not binding. The contracts have not been tested in the courts, however—so the argument at this point is one lawyer's opinion against another's. SWP contracts are made in accordance with the "Governor's Contracting Principles," which are guidelines only, not statutory requirements.

[35] In the October 1972 update of its Delta Alternatives study, DWR even proposed expanding its contractual obligations further, but this has been dropped from current plans.

[36] USBR currently delivers 0.9 MAF on an "interim" basis which it proposes to convert into a permanent or "firm" commitment. At the same time, it proposes firm new contractual commitments of 0.25 MAF to the Westlands Water District, and 0.115 MAF to the Tehama-Colusa service area. The bureau may be unable to make these commitments and conform to Delta water quality standards, without new facilities. But there is more. If USBR makes commitments to the Delta, as proposed by Secretary Andrus, and the Westlands and Tehama-Colusa contracts are executed, it will not have sufficient water to supply the proposed West Sacramento Valley Canal (0.148 MAF), the Folsom South service area (0.7 MAF), and the Mid-Valley Canal (0.550 MAF). New storage and conveyance facilities would have to be constructed to meet this significant new build-up in commitments.

[37] Even with existing commitments, USBR had to make delivery cutbacks of up to 75 percent of contract entitlements in 1977. California, Resources Agency, DWR, *The Continuing California Drought* (August 1977) p. 24.

[38] The Mid-Valley portion is openly acknowledged to be a "rescue" operation. California, Resources Agency, DWR, *Phase II: Alternative Courses of Action, to Provide Delta Protection and Adequate Water Supplies for California* (March 1976) p. 14. DWR admits, moreover, that groundwater levels will still fall an average of 140 feet *with* the project. Ronald B. Robie, Director of DWR, letter to Assemblyman Gualco, dated August 11, 1977.

[39] MacDiarmid, note 21 above.

[40] The big success story in this regard is in Orange County, where conjunctive use management has been in effect since 1933, and a previously declining water table has stabilized. See Stephen C. Birdlebough and Alfred Wilkins, "Legal Aspects of Conjunctive Use in California," in David Seckler (ed.), *California Water: A Study in Resource Management* (Berkeley: University of California Press, 1971), pp. 263-270.

[41] For example, the San Joaquin Valley Agricultural Water Committee, an organization of valley water districts, recently issued a formal report saying that the best solution to groundwater depletion is surface imports, not controlling groundwater use. "Report Urges Importing Water. . ." San Francisco *Chronicle*, March 14, 1979, p. 5, col. 1.

[42] The MWD includes the City of Los Angeles, but the latter does not use its share of Colorado River water because it has a better source in Owens Valley. MWD serves the suburban areas.

[43] The original Colorado Aqueduct was built at least 10 years too soon. See Jack Hirshleifer, James C. De Haven and Jerome W. Milliman, *Water Supply: Economics, Technology, and Policy* (Chicago: University of Chicago Press, 1960).

[44] Sources: 1.3 MAF (memo from MWD General Manager to Board of Directors, 4/4/79); year 2000 demand (same memo); supply, year 2000 (letter from DWR Director Robie to Planning and Conservation League, 4/3/79); conservation, 15 percent (same letter); reclamation (Orange and Los Angeles Counties Water Reuse Study, October 17, 1978); Colorado River supply (memo, MWD General Manager to Board, 4/4/79).

[45] Joe S. Bain, Richard E. Caves and Julius Margolis, *Northern California's Water Industry: The Comparative Efficiency of Public Enterprise in Developing a Scarce Natural Resource* (Baltimore: Johns Hopkins Press for Resources for the Future, 1966), p. 721. Cf. Hirshleifer et al. (note 43) who originally suggested the idea.

[46] As the recent conflicts over power plant siting in California—e.g., Sun Valley and P. G. & E.'s plans for a coal-fired plant in the Central Valley—attest, finding sites will not be easy. Nuclear plants are opposed by the Brown administration, while coal plants almost invariably violate air quality standards.

[47] See Steve H. Hanke and John J. Boland, "Water Requirements or Water Demands?" *Journal of the American Water Works Association* (November 1971), 677-681.

[48] This holds for groundwater, too, since it is replenished by surface imports—which are regularly brought in to "rescue" irrigators from their own poor groundwater management practices. See above, note 38.

[49] See e.g., Siegfried Berle, *Irrigation Agriculture in the Southwest United States*, Marburg University Geographic Institute, 1976, Figure 5, p. 68. In fact, a 1978 DWR report indicated a rapidly falling demand for water used to irrigate forage land in California. See Kenneth Turner, "Feed and Forage Crop Projections: Review and Analysis," California, Resources Agency, DWR, *Office Report*, May 19, 1977, revised October 1977.

[50] Many users even have built into their contracts a commitment for continued surplus water at low prices.

"Surplus" water is so designated because each year the total yield of the SWP is allotted to the various contractors in accordance with a formula contained in the contracts. When a contractor does not take the entire share of that year's firm yield, that water becomes part of the surplus. The contractor, however, still pays the capital costs on the water, as set forth in the contract. Hence MWD actually subsidizes San Joaquin Valley growers, primarily in the Kern County Water Agency service area, where many of the largest agricultural corporations have their holdings.

We believe this indicates that the SWP already has built-in overcapacity.

[51] E. Phillip LeVeen, "Reclamation Policy at a Crossroads," *Public Affairs Report*, 19:5, October 1978, p. 3.

[52] See the essentially correct, but now outdated, treatment of the problem in Robert C. Fellmeth et al., *Politics of Land: Ralph Nader's Study Group Report on Land Use in California* (Grossman: New York, 1973).

Property taxes are levied on all land in a water district, regardless of whether the owner actually purchases water. Urban land has a disproportionately high value, but accounts for relatively little water use, so "captive" cities pay more than their share of the costs, e.g., Bakersfield in the Kern County Water Agency service area. A similar situation obtains in Los Angeles, where the city of L.A. uses only 2 percent of MWD's water but pays 21 percent (1978) of the total taxes; hence the city subsidizes the suburban purchasers of MWD water.

[53] Bain, Caves and Margolis, note 45 above, p. 570.

[54] Cf. Willey, "Financial Impacts on the State Water Project of New Supply Projects Compared to Water Conservation, Reclamation, and Management." Testimony before the California Assembly Committee on Water, Parks, and Wildlife, March 28, 1979.

[55] DWR recognizes this and maintains that conservation is an important part of Phase II. But we do not believe this can be sustained. No conservation is actually required in DWR's plan and the comparatively small $50 million loan fund for water conservation equipment contained in SB 346 has been eliminated in the new bill, SB 200. In any case, if one contrasts a proposed $50 million for conservation with $7 billion for supply expansion, with subsidies intact, Phase II seems to embody major disincentives to water conservation.

[56] See William H. Bruvold, "Residential Water Conservation: Policy Lessons from the California Drought," *Public Affairs Report*, 19:6, December 1978. Of course, where water restrictions were severe, some real hardship resulted but the achievements were far greater than anyone had previously predicted. Economists advocating as little as 10 percent demand reductions through metered pricing had previously been viewed as unrealistic dreamers.

[57] California, Resources Agency, DWR, *Water Conservation in California*, Bulletin 198, May 1976, p. 38, Table 8; see also Peter Benenson, *A Water Conservation Scenario for the Residential and Industrial Sectors in California: Potential Savings of Water and Related Energy*, Lawrence Berkeley Laboratory Report No. 6817, August 1977.

[58] DWR Bulletin 198, pp. 42-45.

[59] Ronald L. Ritschard and Karen Tsao, *Energy and Water Use in Irrigated Agriculture During Drought Conditions*, Lawrence Berkeley Laboratory Report No. 7866, June 1978, Appendix A, pp. 57-59.

[60] DWR Bulletin 198, p. 3.

[61] Willey, note 54 above, argues that conservation options are economically viable, but that evaluations of "conservation hardware" as an alternative to water supply projects are distorted by using current market costs for the one but undervalued, historical costs for the other. He points out that water could be conserved at a cost of $23-43 per acre-foot (using a discount rate varying from 5-10 percent) while on Phase II yield, customers would pay an average capital cost of $89.11 per acre-foot plus a $74.55 electric power cost. Adding about 10 percent operations and maintenance costs, this totals about $180 per acre-foot. Thus, if conservation options are compared to the costs of *new* water development—which is the relevant comparison—conservation would be more attractive.

Subsidies in the SWP distort this choice. For example, artificially low interest rates undervalue the total cost of borrowing. Capital costs at 5.84 percent interest, as in SB 346, make water worth $90 per acre-foot. At a market rate of interest, say 10 percent, water would cost $132/AF. Second, financing of electric generation for the SWP is done at low interest rates (approximately 6 percent), which Willey estimates to add another $7.50 subsidy per acre-foot. The two subsidies together amount to nearly $50/acre-foot.

Readers' Window

A copy error on p. 6 of the April 1979 *PAR* produced an erroneous statement suggesting that sprinkler and drip irrigation methods are much more efficient in using water when compared with gravity methods, than is actually the case. The authors had intended to compare the *numbers* of each system in use, not their relative *efficiency* in conserving water.

The error was called to the attention of authors Richard Walker and Michael Storper by Ray Coppock, Communications Specialist, Agricultural Information, Cooperative Extension, U.C. Davis. They responded by submitting the following correct version of the statement: "Gravity methods make up some 82 percent of California's irrigation systems, sprinklers 18 percent, and drip 1 percent." Walker also commented: "Although sprinkler and drip methods *are* more efficient than gravity methods (chiefly open ditch and flooding), their efficiency and appropriateness vary by crop, so general averages are not very helpful. The more water-saving methods could be more widely adopted, but they are expensive and the incentive is lacking where water is cheap."

The authors and editors regret this error.

A Reader's Response

. . . I wish to thank you for publishing a most interesting and informative article on the California Water System and situation, the April 1979 *Report* on "The California Water System: Another Round of Expansion?" by R. Walker and M. Storper. It is the clearest and most to the point article I have read in many years on this problem. The authors are to be commended highly for so clear and understandable a presentation.

Future subjects in the PAR could include (1) the actual value of busing and its influence on the quality of education and (2) the question or problem of voter turnout, reasons for the low response, relation to age, economic status, and influence of any of the multilingual ballots, etc., in California.

—Lionel Farber, Mill Valley, California

Seismic Safety

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CALIFORNIA'S EARTHQUAKE HAZARD: A REASSESSMENT

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Introduction

In trying to reduce seismic hazard in vulnerable regions like California, it is essential to understand the kinds of damage and other consequences that earthquakes can produce. Of course, detailed projections of future casualties and allied losses cannot be made without accurate, reliable, and rather specific forecasts of the size, location, and timing of major earthquakes. At present we lack the capability for such forecasting, even though a few successful predictions have been made in recent years. Moreover we must expect that specific predictions of very large earthquakes will be especially difficult to achieve. For now, therefore, we must continue to judge future earthquakes on the basis of the historic earthquake record, geodetic measurement of crustal strain, and evidences of geologic activity along earthquake-generating faults during the past few thousands of years.

As might be expected, smaller earthquakes are much more frequent than the larger events:

Worldwide Average Annual Earthquake Frequency[1]

Richter Magnitude	Number of Earthquakes
8	2
7	20
6	100
5	3,000
4	15,000

California has small earthquakes every day. These minor events are recorded, located and cataloged by seismographic stations, but are rarely felt and cause little or no damage. Every two or three years, however, California has a magnitude 5 or 6 earthquake that can cause appreciable local damage, especially if its epicenter is in or very near an urbanized area, with poor construction or with soil conditions or underlying geologic formations that make it unusually susceptible to strong shaking. In the San Francisco Bay region, for example, the most recent earthquakes in the 5 to 6 range were the magnitude 5.3 Daly City earthquake in 1957, the 5.6 and 5.7 magnitude Santa Rosa earthquake in 1969 (two jolts close together), and the 5.9 magnitude Coyote Lake earthquake in the vicinity of Hollister in August 1979.

All these shocks were widely felt and resulted in damage. The smaller Daly City and Santa Rosa quakes, however, caused a good deal more damage than the higher-magnitude Hollister event, principally because the epicenters were more centrally located within urbanized territory. Partly because the affected area's underlying formations tend to magnify shaking, the Santa Rosa earthquake caused by far the greatest amount of destruction (estimated at $10 million).

Magnitude 6 to 7 earthquakes are much less frequent but much more damaging than the 5 to 6 events. Indeed, earthquakes of 6 to 7 magnitude can be about as damaging locally, in the affected areas, as the really big ones—i.e., large or "great" earthquakes of 7.0 magnitude and higher—that are the central focus of this article. The principal difference lies in the total amounts of energy released and hence the size of the areas affected by severe or violent shaking.

Editors' Note: Seismologist Bruce A. Bolt and geologist Richard H. Jahns, recognized authorities in their respective fields, and both members of the California Seismic Safety Commission, have long been active in advising on public policy needs for earthquake safety. We are gratified that they have collaborated in this essay, pooling their resources to make up-to-date estimates of the seismic hazard in California, and to reassess the implications of future earthquakes. Their conclusions are based on interpretations of present knowledge and recent findings about fault displacement, seismicity and earthquake phenomena, as well as judgments on the significance of available information about past casualties and earthquake damage.

Thus earthquakes of 7 to 8 and greater magnitudes may seriously affect regions 50 to 100 kilometers long (roughly 30 to 60 miles) and many kilometers wide. If their epicenters are anywhere near urbanized territory they can cause significant casualties and economic losses, and when they occur in or near large metropolitan areas, damage and casualties can be greatly increased.

When Can We Expect a Large Earthquake?

In anticipating the next big California earthquake of magnitude 7 or higher, we must conclude that time is running out. The evidence strongly suggests that such an event must now be considered imminent. Until recently there has been a tendency to think of such an occurrence in terms of "the next 10 or 20 years." But now, for several reasons, we can no longer keep pushing this "time window" into the future. In short, present evidence that a large earthquake is imminent in California is much stronger now than 30 years ago—or even 10 years ago.

Historical Events

What is the basis for this conclusion? The first line of evidence comes from the historical record that, for California, goes back to about 1800. In the period since 1800 there have been ten very large earthquakes in this state of magnitude 7 or greater (see Table, "Large Historic Earthquakes..."). Looking first at northern California, the record shows a major earthquake in 1836; it was centered on the Hayward fault, which extends along the foothills east of San Francisco Bay. From what we know now, the 1836 event probably should be classed as "great," with an estimated magnitude of 7+. Two years later, in 1838, another large earthquake also with a magnitude estimated at 7+ was felt strongly in San Francisco and was accompanied by rupturing along many kilometers of the San Andreas fault.

In 1868 another big (7+) earthquake occurred on the Hayward fault with surface rupture reaching at least from Berkeley to San Jose. This earthquake caused destruction in San Jose, Hayward, and downtown San Francisco, and until 1906 was referred to locally as "the great earthquake." A group of laymen wrote a report on the 1868 event, but this report seems to have been suppressed; no copy of it has been seen in the present century. In 1906, however, some people who had experienced the 1868 earthquake were asked to give their recollections (these will be referred to later).

In the great 8.3 magnitude San Francisco earthquake of 1906 the San Andreas fault broke from San Juan Bautista to Humboldt County, a distance of 450 kilometers (280 miles). The attendant life loss and damage (estimated at $1 billion) in the San Francisco Bay region are matters of record for this catastrophic event, which still ranks as the only great earthquake to occur in a thickly settled part of the United States.[2] Since then, no major land-based earthquake of magnitude 7 or greater has occurred in northern California, although several smaller ones have caused considerable damage, and an earthquake estimated at 7.5 magnitude occurred offshore about 80 miles west of Eureka in 1922.

In southern California, the great Ft. Tejon earthquake (estimated magnitude 8.3+) occurred in 1857 on the San Andreas fault, which appears to have ruptured from points north of the Carrizo Plain to San Bernardino, a distance of at least 400 kilometers (250 miles).[3] Extensive surface displacements near the easterly base of the Sierra Nevada, along a quite different zone of faults, attended the 1872 Owens Valley earthquake. Although judged by some investigators to have been the greatest among all recorded shocks in the state's history (estimated magnitude 8.3+), this earthquake was in a remote region and hence did not affect urbanized areas significantly.[4] In 1940 a 7.1 magnitude earthquake in the Imperial Valley caused $8 million in damage. The shaking in this earthquake was long used as the basis for seismically resistant design standards, until later evidence proved the standards to be inadequate. In 1952 the severe 7.2 magnitude earthquake in Kern County, on still another fault system, caused major damage in Bakersfield. At this writing, the 1952 Kern County earthquake is the most recent one in southern California of magnitude 7 or greater.

It may also be appropriate to note such smaller damaging southern California events as the 1925 offshore earthquake of 6.3 magnitude that caused $8 million loss mostly in the Santa Barbara business district, and the 1933 earthquake of 6.3 magnitude that caused $60 million loss in the Long Beach area and severely damaged or destroyed many public school buildings. The 1971 San Fernando earthquake, with a magnitude of 6.5 or less, was accompanied by fault rupture approximately 15 kilometers long (about nine miles) and was destructive in relatively small parts of the San Fernando Valley and Los Angeles.[5]

Despite these and other damaging shocks, no major (7+ magnitude) southern California earthquake has occurred in or near present metropolitan areas for more than a century, i.e., since the Ft. Tejon earthquake of 1857. In fact, because southern California was then only sparsely settled, it is justifiable to say there has *never* been a major earthquake (magnitude 7 or greater) in or near heavily urbanized territory in the southern California region. This fortunate accident of fate does not, however, mean that there is no serious threat in that region. To the contrary, the evidence shows that major earthquakes have severely shaken parts of southern California that have subsequently become heavily settled. In time, this kind of earthquake activity is sure to recur.

Historic Record Too Short

Historic records like those just summarized provide some of the most helpful data we have for judging the seismicity of California. But the historic record is all too short for fine-grained estimates of when and where the next major earthquakes are likely to occur, especially when some recurrence intervals are as long as or longer than the entire historic record itself. For example, knowing that a single great earthquake occurred along a portion of the San An-

Large Historic Earthquakes in California Since 1800
(Magnitude 7 or greater)

Year	Region	Magnitude	Causative Fault
1836	San Francisco Bay	7.0+ (?)	Hayward
1838	San Francisco Bay	7.0+ (?)	San Andreas
1857	Carrizo Plain-Ft. Tejon-Palmdale	8.3+ (?)	San Andreas
1868	San Francisco Bay	7.0+ (?)	Hayward
1872	Owens Valley	8.3+ (?)	Sierra Nevada
1906	San Francisco Bay	8.3	San Andreas
1922	Cape Mendocino	7.5+ (?)	Mendocino Escarpment (offshore)
1927	Pt. Conception	7.3	Offshore fault
1940	Imperial Valley	7.1	Imperial
1952	Kern County	7.2[a]	White Wolf

a. As revised, based on new analyses of the 1952 seismograms and accelerograms. See B. Bolt, "The Local Magnitude, M_L, of the Kern County Earthquake of July 21, 1952," *Bulletin of the Seismological Society of America*, 68(2): 513-515 (1978); Hiroo Kanamori and Paul Jennings, "Determination of Local Magnitude, M_L, from Strong Motion Accelerograms," *Bulletin of the Seismological Society of America*, 68(2): 471-485 (1978).

Source: Adapted with minor modifications from Charles F. Richter, *Elementary Seismology* (San Francisco: W.H. Freeman, California Institute of Technology, 1958), pp. 466-537; H.O. Wood and N. Heck, "Stronger Earthquakes of California and Western Nevada," in *Earthquake History of the United States: Part II* (Washington, D.C.: Environmental Science Services Administration, 1966). Several of the magnitudes given here differ from those appearing in other recent sources. Some of the "new" magnitudes have been reckoned differently from the classic Richter magnitudes. The authors preferred to use the latter—except where otherwise indicated—reasoning that it would not be appropriate to make further changes unless *all* the events were reappraised according to the newer means of analysis.

dreas fault, if it is the *only* big one historic records show for that area, tells us little about when the next great earthquake will occur there. For some large active faults, like the Garlock in southern California, the entire historic record is no more than a portion of the gap between the most recent earthquake, which presumably happened in very young prehistoric times, and the next event that has not taken place yet. Small wonder that scientists are actively seeking evidence of datable *prehistoric* earthquakes, to round out the past record and help us understand better what to expect in the future.

Going Back in Geologic Time

One method of extending our information back into prehistoric time is to make highly detailed geological studies of earthquake-related features along individual faults. In the past two decades, such work has led to important breakthroughs. Thus in some parts of California the studies have revealed and dated features ascribable to specific large earthquakes that appear to have occurred during past millenia. Interpretation of the findings indicates that, for the San Andreas and some other large faults, the average recurrence intervals of major earthquakes are measured in hundreds rather than thousands of years.

Trenches recently excavated across the San Andreas fault in southern California have extended the historical record back significantly to include an impressive series of past great earthquakes. Displacement and liquefaction effects of such paleoearthquakes have been preserved in beds of sand and peat. Important measurements of this kind recently were made by Kerry Sieh of Stanford University (now a professor at the California Institute of Technology).[6] One site was at Pallett Creek, which crosses the San Andreas fault 50 kilometers northeast of Los Angeles. Sieh found evidence of at least nine paleoearthquakes extending back more than 1400 years to A.D. 545. The dates, all but one of them approximate, are as follows:

1857 1745 1470 1245 1190 965 860 665 545

(1857 is the date of the historically documented Ft. Tejon earthquake noted earlier; the 1745 event was probably from a rupture of the San Andreas fault southeastward from San Bernardino.)

Two conclusions follow from this work. First, large earthquakes along the southern reach of the San Andreas may break different segments of the fault at different times. Second, the average recurrence interval for these past earthquakes is approximately 165 years, but there is a good deal of variation from one pair of events to another. The greatest interval was nearly 300 years and the smallest perhaps as short as 55 years. (It should be noted that the Pallett Creek site gives information on earthquakes caused by rupture along only one large segment of the San Andreas fault in southern California—and not its whole extent even there.)

Geodetic Measurements and the Buildup of Crustal Strain

In addition to historic and prehistoric earthquake information, there is an important third source of data. Successive surveys measure horizontal and vertical displacements between points on the earth's surface, and those made in California since the middle of the 19th Century give us important clues as to what is happening underground and what to expect in the future.

In the San Francisco Bay region, for example, the surveys show a northwestward movement of the Farallon Islands, about 30 kilometers (20 miles) offshore, with respect to "fixed" points on the mainland, i.e., Mt. Diablo, Mt. Sonoma and Mt. Ross.[7] This movement was going on before the 1906 San Francisco earthquake, and has continued since, at an estimated average annual rate of between 2 and 3 inches per year, leaving no doubt that strain is building up in the intervening crustal rocks, somewhat like the tightening of a watch spring when a watch is wound. The level of strain that had been reached prior to the 1906 San Andreas fault rupture is known from geodetic measurements made in the 19th Century. A comparison suggests that a sudden slip will again have to occur along one of the main faults in the Bay region in order to relieve the growing strain.

One or More Major California Earthquakes Due

In California, more than a dozen faults are known to be capable of generating major earthquakes. Recurrence intervals for such events probably range from about a century to many centuries, depending upon the fault in question. But an estimated or calculated *average* interval has limited meaning in terms of the probable elapsed time between *two successive events on a given fault*, which can be considerably shorter than the long-term average. Geologic studies provide a reasonable basis for suggesting that some of California's faults are "due" or "nearly due" for major earthquake ruptures, although this must be expressed as a probability rather than a certainty. Several of these faults traverse areas of dense urban populations, or are within moderate distances of such areas. In fact, of California's principal urban concentrations, all except the Sacramento and San Diego areas appear to be exposed to fairly high levels of seismic risk.

For further illustration, let us consider four parts of the San Andreas fault system that could produce great earthquakes: (1) central California, (2) the Hayward fault, (3) Ft. Tejon-Palmdale, and (4) San Bernardino and southeastward. On the latter two sections, the average time between great earthquakes may well be about 160 years. In central California, the geodetic surveys show that it took about 100 years for the rocks to strain enough to produce the 1906 San Francisco earthquake and fault displacement, and there is no reason to suppose that this rate of strain accumulation is not about the same in the other sections. It has been 122 years since the last great earthquake on the San Andreas fault in southern California, and 73 years in central and northern California. Moreover it has been 27 years since the last major earthquake on *any* fault in the state.

Probability and Timing

What does this evidence tell us about the imminence of damaging earthquakes of magnitude 7 or greater? When all sections of major earthquake-producing faults are considered jointly, a rough estimate of the odds finds them now about even—50-50—that an earthquake with a magnitude greater than 7 will occur in California during the next decade. With every passing year, these odds will steadily increase. In any event, present knowledge supports as a reasonable working hypothesis that we should anticipate a great earthquake somewhere in California during the next ten years. (See "Explanatory Note . . . ." at the end of this article.)

Earthquake Prediction?

What about more precise earthquake forecasts? Obviously more specific earthquake predictions would help prevent loss of life from collapsing structures, but seismology has not yet advanced to the stage of practical and precise earthquake prediction. In some countries that experience earthquakes, among them Japan, China, the United States, New Zealand, the USSR, and Italy, efforts have been made to forecast precisely the time and place of damaging shocks. No more than limited and partial success thus far has attended these efforts. The Chinese, for example, did not predict the devastating 1976 Tangshan earthquake, near Beijing (Peking) that is estimated to have caused 650,000 deaths. In short, earthquake prediction may have a long way to go before it becomes a practical means for trying to deal with many large earthquakes. Moreover, we should not forget that even if valid and relatively precise earthquake prediction were feasible, making it possible to get people into positions of relative safety prior to an event, the hazard to unsafe *structures* would continue and therefore the threat of physical damage and economic loss would not be mitigated.

Earthquake Casualties and Damage: Worldwide

What is known about earthquake losses? It is believed that there have been approximately 13 million deaths from earthquakes, worldwide, during the past 4,000 years. Some 3.5 million of these deaths occurred in the past 400 years, and nearly 2 million of them in the last 100 years.[8] The sharp increase observed in the *rate* of earthquake-related life loss is due partly to world population growth *per se*, and partly to increasing concentrations of people in some of the world's vulnerable seismic areas. It should be recognized, however, that there have been many departures from the broad trend, and that the occurrence of a single great earthquake in or near a metropolitan area can cause the statistics on casualties and economic losses to change dramatically.

The recent year 1976, with less than the average annual number of large earthquakes worldwide, nevertheless saw about 700,000 people killed, most of them in China's Tangshan event. In fact the heavy losses from the Tangshan earthquake, which drastically affected the global statistics

for the present century, provide a special lesson for residents of the United States and other urbanized nations that may experience major earthquakes. This lesson is that statistical data on earthquake losses are themselves vulnerable and can undergo drastic upward revision after a single great earthquake in a heavily populated area.

Earthquake Casualties and Damage: California and the U.S.

Since the beginning of the 19th Century, only about 1,700 lives have been lost in the United States because of earthquakes. But let us look closer at the distribution of casualties in space and time. Approximately two-thirds of the total can be assigned to California, and nearly one-half is attributed to a single California event, the San Francisco earthquake of 1906.[9]

Although more than 100 damaging events have occurred in California since 1800, essentially all of the related death toll has derived from only 17 of these earthquakes, with an average life loss of about 65 persons per event, and with the events occurring at an average rate of once every ten years.[10]

Admittedly these averages are of limited meaning, partly because the life loss has been unevenly distributed among the earthquakes, and also because the earthquakes have been unevenly spaced in time. For example, if the San Francisco earthquake is excluded from the reckoning, the average death rate from the other pertinent California earthquakes drops from 65 per event to less than 20. The skewing effects related to concentrations of people are further emphasized by a drop to 4 deaths per event by the exclusion of only four additional earthquakes: 1812 Capistrano, 1868 Hayward, 1933 Long Beach, and 1971 San Fernando.

Looking at more recent times, we see that in the United States during the period 1925-1975, 590 deaths were attributed to earthquakes.[11] This is only about 3 percent of the combined life loss from floods, hurricanes, tornadoes, and earthquakes during that half-century period,[12] and little more than 1 percent of the loss from all natural hazards in that same period. The corresponding worldwide percentage for earthquake deaths is four times as high as that of the U.S.,[13] owing to differences in seismicity, topographic and climatic conditions, concentrations of population, styles of living, construction practices, and other factors. Earthquake-related deaths in the United States have amounted to about 15 percent of the death toll from hurricanes, and to less than 10 percent of that from floods and tornadoes.[14] They have been at about the same level as losses of life from snow avalanches, but only 7 percent of those from lightning strikes. As a sobering comparison, it can also be pointed out that life loss from *all* natural hazards in the United States during recent decades has amounted to only about 2 percent of the deaths from vehicular traffic.

Cumulative physical damage from United States earthquakes has been reckoned at approximately $2 billion since 1800.[15] This total seems small when compared with the $4 billion price tag for a single recent non-seismic event, Hurricane Agnes in 1972. The average cost of 10 cents per person for earthquake damage during the past century (or less than 55 cents per person as reckoned in 1971 dollars) also seems small when compared with the average of nearly $25 per person for all damage from natural hazards in the United States during the same period.[16] But, as we shall see, these data are not satisfactory for long-term predictions of future costs.

The Future: Higher Losses Must Be Anticipated

It should be emphasized that four-fifths of the U.S. earthquake costs noted above were associated with only three events: San Francisco (1906), Alaska (1964), and San Fernando (1971). As a hint for the future, we should heed the significance of the $1 billion in direct damage and indirect costs resulting from the San Fernando event, a moderate earthquake located in a metropolitan area. Both physical and demographic factors were considered by the California Division of Mines and Geology in projecting for this state a startling $21 billion in earthquake shaking damage during the period 1970-2000, assuming a continuation of present kinds of responses to earthquake hazards.[17]

The record of earthquakes and their effects in the United States leads thoughtful, responsible people to conflicting views. Some, using the comparative data noted above, regard seismic hazards as relatively modest threats when contrasted with other physical hazards. To be sure, major earthquakes in this country are infrequent, and the costs associated with historic events have been relatively low. Reasoning from past history, some have argued that earthquake risks should have relatively low priority in the allocation of our attention and resources.

Admittedly the historical statistics, taken alone, can be interpreted to support this notion. *But the data also contain another and quite different message.* Life loss and property damage are influenced not only by the magnitude and duration of a strong earthquake, but also by the numbers of people involved and the nature of the buildings and other structures affected. The only major earthquake in the United States to occur in a heavily populated region with modern structures was the San Francisco event of 1906. Consequently this single earthquake has dominated the nation's statistical record of seismic losses. But substantially higher losses must be anticipated when another great earthquake occurs in a U.S. metropolitan area.[18] Moreover, there is a high probability of just such an occurrence. Indeed, metropolitan areas in both northern and southern California are certain to be hit by major earthquakes in the future.

How Well Prepared . . . ?

To sum up, future earthquakes are inevitable in California, and the damage potential is high in the likely event that a big one strikes an urban region fairly soon. Earthquake preparedness therefore should be prominent on the public agenda for attention. So what is the present state of earthquake preparedness?

Until recently at least, California has not been very

consistent or methodical in its approach to seismic safety. The style has been one of reaction rather than action, with responses that have tended to focus on single specific problems highlighted by the results of actual earthquakes. Perhaps the best example of such ad hoc response was enactment of the Field Act in 1933, immediately after the Long Beach earthquake heavily damaged or destroyed many public schools, in order to enforce safety standards for all public schools built thereafter. Over time this ad hoc process has brought some important improvements in earthquake safety, but it has left other significant hazards relatively unattended.

Earthquake safety began to get appreciably more attention after the great Alaskan earthquake in 1964. This prompted renewed interest in California, and led in 1969 to creation of a joint legislative committee on seismic safety, headed by State Senator Alfred E. Alquist, and in 1972 to establishment by Governor Ronald Reagan of the Governor's Earthquake Council. The 1971 San Fernando earthquake provided further strong stimulus that eventuated in several elements of earthquake-related legislation and, perhaps even more important, establishment of the California Seismic Safety Commission in 1975.

The commission has brought together different kinds of interests and expertise, and has stimulated more effective efforts toward seismic hazard mitigation. It has broad independent advisory powers to formulate earthquake safety policy, including proposals for needed legislation. In our view, establishment of the commission represents the greatest single public accomplishment on earthquake hazard mitigation in California since the landmark study of the 1906 earthquake by the State Earthquake Investigation Commission, a temporary body set up specifically to study that one event.

Meanwhile some help is also coming from the federal government, stimulated in part by the 1964 and 1971 earthquakes, and also due to the efforts of key individuals such as California's U.S. Senator Alan Cranston. This resulted in the Earthquake Hazard Reduction Act of 1977, a law designed to encourage efforts to reduce risk to life and property in future earthquakes.

Progress . . . But We Are Still Vulnerable

Despite advances in seismic studies, earthquake policy formulation, and pertinent legislation, California continues to be seismically vulnerable in many ways. Even in the absence of great recent earthquakes, this vulnerability has been periodically reemphasized by relatively modest but damaging earthquakes. An excellent example is the Santa Barbara shock of August 1978, which was comparatively small, with a magnitude of only 5.6. The strong ground motion in this earthquake lasted 2 to 3 seconds and shook only a limited area, yet it caused approximately $9 million in public property damage, and another $2.3 million to the private sector.[19] By comparison, the strong ground motion in the great 1906 San Francisco earthquake lasted about 40 seconds. The released energy, spread over most of central and northern California, was perhaps 10,000 times greater than that released in the Santa Barbara shock.

Sixty-five people were injured by falling objects and glass in the Santa Barbara earthquake. The most serious residential damage occurred in mobile home parks, with 263 units affected.[20] The earthquake also damaged a number of buildings built *after* 1952, thus refuting any idea that *only* old buildings from another era should be considered in assessing earthquake dangers in California. Reports from the University of California, Santa Barbara, note evidence that the building code and building designs were not invariably followed, and that errors seemed to have been made in construction. These findings raise questions about the need for improved inspection, during construction, of both publicly and privately owned buildings in California.

Preparing for a Great Earthquake in California

If a magnitude 5.6 earthquake is able to produce significant destruction in a limited area, what is the likely damage from a great earthquake and what preparations are needed? First, we need a careful reexamination of earthquake hazards and risks in California. We need a broader framework than in the past, a framework that considers earthquakes in relation to the whole economic system. We should find out how building codes are being applied, how communities are responding to suggestions that they prepare for earthquakes, and how we can best assess the costs and benefits from properly carrying out earthquake mitigation plans.

While elements of a comprehensive hazard mitigation program already exist at the state and local levels and in the private sector, little has yet been done to link them in mutually supportive ways or to insure comprehensive attention to seismic hazard. Increasing efforts should be made to involve and activate the private sector more effectively.

Because the private sector owns most of our buildings and other structures where future damage and casualties will occur, and because the economy may be drastically affected by a great earthquake, this sector cannot escape the social and economic consequences of a great earthquake. Thus it is good policy as well as practical self-interest for the private sector to be concerned.

We obviously must become more deeply involved with earthquake preparation and emergency preparedness in the future than we have been in the past. Although the fear of added expense is often an excuse for inaction, much can be done at a very reasonable cost if proper forethought is given to the problem.

Today more people in California are concerned about earthquakes than ever before. Local community groups are beginning to ask: What can we do in this particular neighborhood if a big earthquake occurs? What can we do to see that hazards are reduced before the next earthquake strikes? Will adequate fire-fighting facilities be available? What other responses should we consider? What is government doing?

What is Likely to Happen?

The Seismic Safety Commission and other groups should encourage this grassroots activity throughout the state. On April 18, 1979, the University of California, Berkeley, observed an "Earthquake Awareness Day." Planning for this program involved many meetings of administrative officers, clerical staff, laboratory managers, officials and representatives from student groups, all concerned with environment, health, and safety. The organizing committee met frequently with no lag in interest. In short there is clear evidence of a desire for concrete, reliable information about *just what is likely to happen* during and after another earthquake.

California has extensive experience with earthquake effects, including eyewitness accounts and reports based on direct observation. Reviewing some of this past experience can give a feel for "what it is like to be there," and may help prepare people on what to expect in the future. The following accounts, for example, are based on experience with two large earthquakes, the 7+ earthquake on the Hayward fault in 1868, and the 8.3 earthquake on the San Andreas fault in 1906:

1868, near San Leandro.

> I managed to get out of the building . . . when the shaking started. The house was thrown from its foundation, the chimney was torn from the roof, and the porch was wrenched away, dishes were broken and everything was in confusion. I found that most of the houses were in the same condition as my own—thrown from their foundations, with chimneys down, porches knocked sideways, etc. All the while the ground was shaking and continued to shake for days, even weeks.[21]

1868, near Irvington.

> I was then about 15 years of age and my home was near Irvington. When the shock came I was alone in the house with my baby brother and my mother called to me to get the baby. I managed to get the child over my arm, face down with a pillow on top, then falling and crawling I worked my way to the kitchen door. My mother was on the ground, and every time she tried to get up she was thrown again. As I sat there I could see the ground in waves like the ocean. After the main shock I think we had a hundred shocks during the first 24 hours, not a house was left with a chimney on it.[22]

1906, San Francisco.

> To some extent the earthquake caused damage to buildings and other structures in all parts of the city and county of San Francisco . . . . Almost everywhere chimneys were thrown down or badly broken, but in a few small localities most of the chimneys withstood the shock . . . . Plaster on walls and ceilings was very generally damaged. So, probably, were frail partition walls and chandeliers, crockery and fragile household furnishings. Such effects were typical of large sections of the city. There were relatively small districts, however, in which brick and frame buildings of ordinary construction were badly wrecked or quite destroyed. Pavements were fissured, buckled, and arched. Sewers and watermains were broken. In places, portions of streets were moved laterally several feet out of place. Well-ballasted street-car tracks, equipped with 8, 10, or 11 inch rails, were arched and flexed or thrown into shallow wave forms . . . . Effects of this degree of violence were pretty closely confined . . . to areas of "filled" or "made" land.[23]
>
> . . . . .
>
> About the Ferry Building, at the foot of the Market Street, is a district of "made" land . . . in which high intensity was manifested . . . . Wooden buildings, 1 story to 3 stories high, with brick or stonework fronts, were interspersed among ordinary brick buildings from 2 to 6 or 8 stories in height. Mingled with these was a considerable number of modern, class A, office buildings. Here the fire burned fiercely and caused great havoc . . . . After the fire had past, standing walls revealed ugly, sinuous cracks, in rudely parallel systems, which were not due to fire nor to dynamite. Masonry blocks in the walls of excellent modern buildings were broken as by a blow. Rivets were sheared off in parts of the framework of steel structures, and tension rods in such frames were badly stretched. Tubular cast-iron columns, supporting floor girders, were broken off near their bases in cellars where they rested upon piling. The concrete casing[s] of piles were frequently broken. Wherever the intensity was high, the tendency to crack or crush near the base, as tho a sharp blow had been struck there, [was] notably conspicuous. In spots the streets sank bodily, certainly as much as 2 feet, probably more . . . . The surface of the ground was deformed into waves and small open fissures were formed, especially close to the wharves. Buildings on the water side, along East Street, generally slumped seaward in some cases as much as 2 feet. The damage was greatest close to the water's edge . . . .[24]
>
> . . . . .
>
> In the neighborhood of the crossing of Steiner and Sutter Streets, there is an irregularly bounded district a little larger than a city block in which several buildings not conspicuously weak were totally destroyed. St. Dominic's Church, at the corner of Steiner and Bush streets, was a complete ruin . . . . Its steeple towers were ruined, its roof fell in, and all its walls were so badly cracked that it became a menace to the neighborhood. If the shock had occurred during the hours of religious service, few would have escaped from the building alive. Probably it was not a building of the most excellent construction; but, on the other hand, it did not appear to be built flimsily. It certainly suffered a

most violent shaking.[25]

1906, Stanford University.

> I came suddenly awake, as if someone had given me a very strong shove. Nothing happened for a moment, and then I found myself clutching at the blankets to keep from being tossed out of my wildly shaking bed. Between the big pulses of movement, I struggled upright and into my slippers, and then groped my way to the door in the faint morning light. The building was rocking in a most violent way, and I fell more than once as I moved down the hallways. What I remember best, though, was the frightful noise—an overall dull roar, with the groaning of timbers and the cracking and falling of masonry. I made it to the end of the hall in spite of the pulsating motions, and looked out the window to see other buildings swaying like so many trees in a high wind. Then the big stone chimney of the power plant collapsed with an awful roar.[26]

Need for Earthquake Education

Such first-hand accounts give people a chance to reassess their thinking about what to do when the next great earthquake occurs. Some now make highly unrealistic assumptions that they can put through emergency calls on the telephone, or, if at work, get in their cars and go home to join their families!

In short, there is a wide gap between what many people think they are going to do, and what will actually be possible during and immediately after heavy earthquake shaking. Such unrealistic perceptions are one of the uncertainties involved in reassessing the possible consequences of the next great earthquake.

Obviously more effective earthquake education will be very important in trying to achieve an adequate defense. We must get the attention of a large portion of the population in describing the kinds of earthquake experiences to be expected, so that individuals are prepared to respond in sensible ways. While the public appears presently to lack knowledge about earthquake safety measures, a recent survey of public attitudes toward earthquake prediction in southern California, as made by Professor Ralph Turner of UCLA, found that people would like to know more about earthquake preparedness.

It seems extremely unfortunate that most California public schools no longer provide disaster education programs for students, because over the years imaginative programs could contribute significantly and improve basic public awareness of the nature of earthquake disasters and what to do about them. The Department of Education did conduct a federally funded disaster program a few years ago, but it was discontinued when the federal funding ceased.

No Cause for Complacency

Clearly there is no cause for complacency about earthquake risk in California. Many widespread dangers persist. Many old hazardous buildings, for example, should be strengthened or removed, even though such actions will take major commitments of time and effort to achieve long-term solutions. Meanwhile, short-term efforts must be increased, because present state and local ability to respond to major disasters appears highly questionable compared with the magnitude of resources that a large earthquake will call for. In weighing both short- and long-term needs, a Seismic Safety Commission report comments on existing hazards and disaster preparedness:

> Given the great number of hazardous structures in use today . . . built prior to any consideration of lateral force requirements [to resist sideways shaking], any program of rehabilitation and strengthening . . . must be directed toward . . . long-term solution[s]. There is a general consensus, however, that in the short term (within the next ten or fifteen years), disaster preparedness can provide the greatest degree of hazard mitigation in terms of lives saved . . . .[27]

Despite this, less than 2.0 percent of the state's expenditure for seismic safety is going into disaster preparedness. In short, we clearly need to be thinking and doing more to understand and prepare for what will happen in another great earthquake. During the next few years we should try to reduce the hazard to an acceptable or minimal level of risk statewide, for time is no longer on our side.

Conclusion

In assessing preparedness, we have argued that in the not-distant future California must expect major earthquakes in thickly settled areas, causing large losses. Moreover, without being over-pessimistic, it seems sensible that our precautions should anticipate what has not yet happened in California: (1) highly unfavorable timing of earthquake occurrence with respect to the activities of people, (2) periods of heavy rainfall prior to an earthquake in the affected area, and (3) other factors known to increase losses. With a combination of adverse circumstances, the death toll could become heavy, and in a single earthquake property damage caused by ground shaking, landslides, soil liquefaction, and other kinds of ground failure could exceed by an *order of magnitude* the total of all earthquake damage recorded in the United States so far.

In sum, we cannot simply extrapolate the historic earthquake record into the future if we wish to make realistic estimates of future losses. Instead we must take into account the several unfavorable physical and demographic factors of the present social and economic situation, i.e., we must plan for events that will drastically change the actuarial base for appraising seismic hazard and risk. This is a crucial justification for devoting special, wide-ranging efforts to the reduction of seismic hazards. The situation causes increasing concern to scientists and engineers, and fortunately also to key prime-movers of seismic legislation such as the Alfred Alquists in Sacramento and the Alan Cranstons in Washington. All these

efforts are helping to raise seismic safety issues to the level of attention they deserve in the eyes of California's citizenry.

Explanatory Note on Probability Estimates for a Major Earthquake in California

The record of recurrence for major quakes in California is too short for any detailed or definitive analysis of probability. So let us look at the record of earthquakes of Richter magnitude 7 or greater (M 7+) in a simple way.

As shown in the Table, "Large Historic Earthquakes...," ten M 7+ events have occurred in California during the past 150 years (in 1836, 1838, 1857, 1868, 1872, 1906, 1922, 1927, 1940 and 1952). This means that the average recurrence interval from 1820 to 1979 has been 15 years—if we include the time since the latest event, in 1952, plus adding an arbitrary seven years prior to the 1836 event to make a 150-year period. (The average recurrence interval would drop to less than 13 years if we considered all ten earthquakes and used the shorter 116-year period, 1836-1952, between the earliest and latest events.)

Let us now turn to recurrence intervals between successive M 7+ earthquakes. Since 1836 these have been 2, 19, 11, 4, 34, 16, 5, 13, 12 years—a minimum of 2 years and a maximum of 34 years. It has been 27 years since the latest big one (1952 in Kern County), a length of time exceeded only *once* since 1836. And 27 years is almost twice as long as the estimated *average* of 15 years (or less than 13 years). We conclude that California is "due" or even "overdue," unless we assume some sort of long-term fluctuation in the intervals between California earthquakes. But there is little or no justification for assuming such fluctuation: the crustal plates that meet in California are moving steadily with respect to each other, and most of the large earthquakes discussed here are associated with major rupturing along the boundary zone between the plates (i.e., the San Andreas fault system).

In any event, data available from the historic record suggest that odds of 50-50 for a major earthquake in the next 10 years are by no means too great. One might argue that the likelihood is even greater. If by 1989 no M 7+ quake has occurred in California, it would then have been 37 years since the 1952 event—and that would be an historic record-breaker for length of a quiet interval. Such a continuation of the current quiet period for another 10 years is possible, of course, but unlikely.

Now let us go back in time beyond the historic record for evidence from a longer-term period, and use that to extrapolate. We can examine a single reach of the San Andreas fault—from Paso Robles to the Coachella Valley—and consider Kerry Sieh's findings, which go back nearly 1500 years.[28] As noted earlier, there have been at least nine major earthquakes from about 545 A.D. to 1859. The average recurrence interval has thus been approximately 165 years, with intervals between successive events of about 120, 195, 105, 225, 55, 225, 275, and 110 years.[29] It has been 122 years since the most recent event, in 1857.

These time intervals estimated by Sieh apply to only *one* reach of one quake fault. Naturally they are considerably longer than would be the case for California *as a whole*, with a record involving major events on several faults. Accordingly let us now begin extrapolating by adding the more northerly section of the San Andreas fault—while still leaving out other segments in the Imperial Valley-Gulf of California region. Inclusion of the northerly San Andreas roughly cuts the estimated time interval in half, and doubles the estimate of earthquake frequency for the San Andreas fault. On this basis the estimated average recurrence interval since 545 A.D. drops to about 80 years.

In addition, other faults of the San Andreas system (Hayward, Calaveras, San Jacinto, Elsinore, Imperial) also must be reckoned with, as some of them have contributed to the record of M 7+ historic earthquakes (see Table). So we can argue that extending Sieh's findings to the other parts of the San Andreas system justifies further reducing our estimate of the average recurrence interval to the order of 70 years, and to even less if we include two major events that have occurred in the Colorado River delta region of Mexico.

The estimate is reduced still further, to about 25 years, by including the faults of the Transverse Ranges, the Sierra Nevada, and adjacent Basin Ranges, along with other faults that have shown a capability for M 7+ earthquakes. Moreover, this does not exhaust the list of major faults that are likely to produce M 7+ earthquakes felt in populated areas (e.g., the Garlock fault).

In short, the *historic record* with its 15-year average interval is in fairly good agreement with the *probable longer-term record*, with an average interval of 25 years or less, as extrapolated from information about one reach of the San Andreas fault. In this light, 50-50 odds can be viewed as a modest, perhaps even conservative appraisal of the likelihood that California will experience an earthquake of magnitude 7 or greater during the next 10 years.

NOTES

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Water Conservation

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PUBLIC PARTICIPATION IN ENVIRONMENTAL DECISIONS: WATER REUSE

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Introduction

Water reclaimed from municipal wastewater can be a significant source of supply in California and elsewhere in the semiarid western United States.[1] But public opinion about such uses is, of course, a controlling determinant, as was recognized several years ago in a number of studies that attempted to assess attitudes.[2]

Unfortunately all of the previous research on wastewater reclamation dealt with *hypothetical* uses of reclaimed water that might occur at some unspecified time in the future. There is a lack of studies assessing attitudes toward specified uses of reclaimed water proposed for the actual communities under investigation. Such research is needed to give policymakers more reliable guides to public responses; it is based on citizens' personal attitudes to concrete proposals, rather than only impersonal projections or speculations.

The major purpose of the work discussed here was to study voters' evaluations of several wastewater reclamation and reuse options that were actually proposed for selected California communities. Uses assessed ranged all the way from (1) minimal treatment followed by ocean disposal, to (2) advanced treatment and subsequent reuse for drinking, and were evaluated by people immediately affected by the options under consideration. The rather surprising results found that respondents did not favor either (1) minimal treatment followed by discharge, or (2) very high levels of treatment followed by domestic use. Instead they preferred relatively high levels of treatment, followed by a "middle" level of use, e.g., for park and greenspace irrigation. The research findings also further suggest ways to involve the public more fully in wastewater reuse and related environmental decisions.

The Study

The study used face-to-face interviews, including full presentations of real wastewater treatment and reuse options for the community under study, intended to obtain thoughtful evaluations of these options by the respondents. This approach—presenting specific options to residents of communities in which such options had actually been proposed—changed the frame of reference of "somewhere" to one's own community, and from "sometime" to one's own immediate future.

The interview schedule was deliberately made different from those employed in most survey research, each respondent receiving an individualized educational presentation describing and comparing three wastewater treatment and reuse options tailor-made to the community under study. At the end of the presentation, respondents were asked to rate each treatment option with respect to environmental impact, health impact and economic impact. Respondents were also asked for statements of the option liked best and why. Perhaps most important, respondents were asked if they would vote for each option if it were later offered to the local community in the form of a bond issue. The option statements in the educational presentation were carefully developed for each of the ten communities surveyed. The cities and towns were chosen to cover as wide a range as possible. A complete and detailed description of all research procedures used is available in a technical report.[3]

Principal Findings: Water Use—Contact Combination Preferred

The major findings are summarized in Table 1.

None of the ocean discharge options received a favorable vote, nor did any of the proposals for using reclaimed water for drinking. Each of the options proposing conventional waste treatment and disposal by a bay or ocean

TABLE 1

Voter Preferences for Reuse Options Analyzed by Level of Treatment, Type of Reuse and Degree of Human Contact

Level of Treatment: Type of use: Degree of Contact:	CWT Discharge None	CWT Reuse Low	AWT Discharge High	AWT Reuse Low	AWT Reuse Moderate	AWT Reuse High	AWT Reuse Very High
Community							
Livermore	Bay outfall No contact (21-77)				Irrigation reservoir Food crops (71-24)		Groundwater recharge Drinking (31-66)
Watsonville	Bay outfall No contact (30-67)				Irrigation Food crops (84-13)	Recreational lake Swimming (30-66)	
San Luis Obispo	Bay outfall No contact (14-81)				Irrigation Food crops (76-17)	Recreational lake Swimming (62-31)	
San Diego				Irrigation Urban greenbelts (65-27)	Aqua culture Food production (41-49)		Reservoir Drinking (28-64)
Santa Rosa		Irrigation Fodder crops (45-46)	Stream discharge Swimming (56-36)		Irrigation Food crops (49-40)		
Oxnard	Ocean outfall No contact (36-59)				Irrigation Food crops (40-57)	Groundwater recharge Food crop irrigation (56-41)	
Modesto		Irrigation Fodder crops (61-33)	River discharge Swimming (41-55)		Irrigation Food crops (33-63)		
Fairfield		Irrigation Turf nursery (40-55)		Irrigation Turf nursery (54-40)	Irrigation Food crops (51-41)		
Pomona			Stream discharge Swimming (36-54)	Industrial use Paper mills (59-34)	Irrigation Food crops (27-66)		
Fountain Valley	Ocean outfall No contact (22-70)			Irrigation Golf courses (73-21)			Groundwater recharge Drinking (26-64)
Overall Success Ratio	0/5	1/3	1/3	4/4	4/9	2/3	0/3
Overall Success Percentage	.00	.33	.33	1.00	.44	.67	.00

Source: William H. Bruvold, *Public Attitudes toward Community Wastewater Reclamation and Reuse Options* (Davis: University of California, Water Resources Center, August, 1979), Contribution no. 19.

Notes:

CWT = conventional waste treatment (secondary treatment concluded by disinfection).

AWT = advanced waste treatment (secondary treatment followed by some form of advanced waste treatment and concluded by disinfection).

Discharge = discharge to a stream, river, bay or ocean without further planned reuse.

Reuse = some planned beneficial reuse for reclaimed water.

Degree of human contact categories are defined as follows: *very high* for ingestive use such as drinking and cooking; *high* for body contact uses such as swimming and laundry; *moderate* for secondary contact uses such as food crop production and dairy pasture irrigation; *low* for uses where human contact is incidental or remote, such as fodder crop production or golf course hazard lakes; and *none* where the possibility of human contact is extremely remote as in a deep bay or ocean outfall.

Figures in parentheses under each option are results from the straw vote on that option. The percentage of favorable responses is given first and undecided responses are omitted.

Overall success ratios given at the bottom of the table represent the number of successful straw votes obtained for each of the seven general options represented by the columns of Table 1.

outfall was voted down decisively. Equally significant was the negative response to the three options proposing reuse for drinking, each also being voted down decisively. In short, the respondents strongly opposed conventional treatment with disposal by discharge, and also strongly opposed advanced treatment with reuse for drinking.

The most favored option involved advanced waste treatment and beneficial reuse for low-contact purposes, such as golf course and greenbelt irrigation. Respondents consistently favored advanced waste treatment when *coupled with beneficial reuse for purposes involving a low degree of human contact.* Approval ratios also generally declined as proposed treatment and use levels decreased from the most favored option.

Why did the results turn out this way? Earlier findings had suggested only a simple linear relation between the degree of proposed contact and extent of opposition, and had not forecast the U-shaped opposition pattern reported here. The reasons for preferences (see Table 2) provide useful insights into respondents' motivation.

Respondents were asked to give reasons for liking and not liking the 20 options given, ten of which were liked best and ten liked least. The reasons given most often concerned the extent to which the option provided environmental protection, public health protection, and water resource conservation. Together these three considerations comprise respondents' principal explanation for both their positive and negative preferences. Level of treatment, cost of treatment and control of development were cited infrequently.

Apparently respondents favor wastewater treatment and reuse options that (1) safeguard public health, (2) protect the environment, and (3) conserve water. Conventional treatment followed by disposal met the public health requirement, but failed the environmental protection and conservation requirements, and thus were consistently voted down. Advanced waste treatment followed by ingestive use met the conservation and environmental protection requirements, but failed the public health requirement, and thus were also consistently voted down. The option that seemed to meet all three requirements best—public health, environmental protection, and conservation—involved advanced waste treatment followed by beneficial reuse, but only for purposes that entail low levels of human contact.

Facilitating Community Approval of Reuse Projects

What are the implications of these findings for ways of facilitating actual community adoption of water reuse projects? A major impact of the present research may lie in what it suggests about community adoption procedures, in addition to the light it sheds on community preferences for reuse options.

The State Water Resources Control Board (SWRCB) distributes federal and state funds to California communities for construction of wastewater treatment facilities, and has produced a large, detailed compendium of guidelines for communities applying for grants to construct wastewater systems.[4] Table 3 outlines the three principal steps in the process of planning and constructing such a system as (1) option development and selection; (2) development and approval of construction plans; and (3) actual construction and operational testing of the wastewater treatment facility. The following discussion focuses on step one, *option development and selection.*

In a useful monograph on a community adoption of water reuse systems, Kasperson, McCauley, and others[5] report that step one is usually divided into three sequential phases. In the first phase, the technical planning sector, comprised of city employees and consulting engineers, selects a single wastewater treatment option they consider best to meet the perceived goals and preferences of significant components of the community decisionmaking structure.

The option selected is then submitted to the local political decisionmakers, who test it against their understanding of the local water resources situation, public opinion goals, local political goals, and the views of the state agency. If the option survives this local political review, it is then ready for presentation to the local voting public, through public hearings, city council votes, and most important, local bond issue elections.

Kasperson and McCauley said little about the public ratification phase, because their report was prepared before many major reclamation and reuse projects had actually been adopted in the United States. This prompts several questions about the ratification phase. How can the public best be included in the adoption process? What can be learned from the present study that would extend the Kasperson and McCauley model of the adoption process, and its facilitation?

Public Involvement in Wastewater Reclamation Planning

Three principal approaches to public involvement in wastewater reclamation planning are considered here: (1) involve the public heavily from the earliest stages of planning all the way through to adoption; (2) seek public involvement, but only after planning has been completed, and at the point when approval of a bond issue is needed to fund the project; and (3) a "middle ground" that would involve the public after initial planning has identified the major options, but well before the time to ratify funding by a public vote. The pros and cons of each approach are reviewed below.

1. On behalf of the first approach it can be argued that the best time for public contribution to decisionmaking is early in the process (stage one of the Kasperson and McCauley model) to help ensure that planning proceeds

TABLE 2

Considerations Most Frequently Cited in Each Community Survey for Options Liked Best and Least

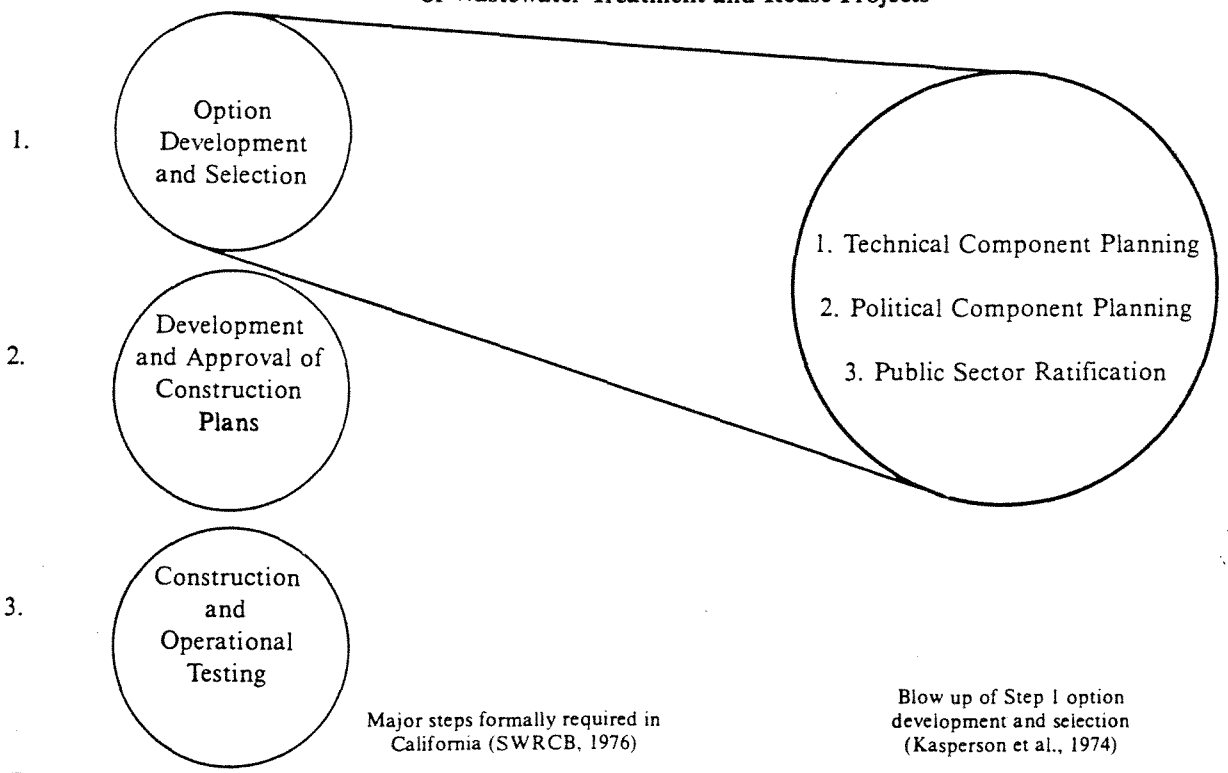
Consideration	Most Cited Reason for Preferring the Best-Liked Option	Most Cited Reason for Opposing the Least-Liked Option	Overall Best & Least
Treatment	Adequate treatment 0	Inadequate treatment 0	0
Environment	Protects the environment 2	Does not protect the environment 2	4
Health	Protects public health 3	Does not protect public health 3	6
Cost	Economic advantage 2	Economic disadvantage 0	2
Conservation	Conserves water 2	Does not conserve water 5	7
Development	Controls development 1	Stimulates development 0	1
Totals	10	10	20

Source: Bruvold, *Public Attitudes . . . .*

Note: Numbers in the body of the table refer to the reasons most often cited by respondents for preferring the best-liked option and for opposing the least-liked. For example, in Livermore, the local irrigation option was best liked because it controlled urban development and the discharge option was liked least because it did not conserve water.

TABLE 3

Schematic Outline Showing Community Adoption of Wastewater Treatment and Reuse Projects



Source: Bruvold, *Public Attitudes . . . .*

on a course that is acceptable to a majority. Democracy is based in part on an assumption that governance is better when there is active involvement of an informed populace. If this is true in principle, it would be improper to put off or delay the community's participation.

The opposing argument is that the ordinary voter lacks the technical expertise necessary to formulate options for wastewater management or to judge which is best. In this view, lack of technological expertise on the part of the voting population poses very serious impediments to the early involvement of voters in the planning process. Further, it may be argued that most people, even if capable of understanding the basics of the technology, are neither interested in nor have the time for systematic analysis and assessment of options.

2. On behalf of the second approach—public involvement *after* planning is complete—such participation can best come much later in the decisionmaking process, when the option selected by technological experts is to be ratified (e.g., a vote on a local bond issue). This allows technological and professional experts to do the kinds of planning and analysis that require their expertise. These individuals select and develop options, decide which of several possibilities is best, and then present the one selected to the voting public for ratification. With only one choice, the voters must simply approve or reject the single option the technological experts and politicians have selected. It may be argued that this approach preserves democratic principles, while allowing technological personnel to do technological work.

One major problem with this approach, however, is that it frequently results in conflict and failure. Most local bond issues are at best hard to pass in an era of fiscal stress and double-digit inflation. Moreover local bond elections and attempts to finance advanced wastewater treatment by other means can also lead to serious difficulties.[6] Thus when the technical experts and professional planners choose wastewater treatment and reuse projects they must be extremely careful to select those that have substantial public approval. Otherwise the support needed to finance construction and operation may not be forthcoming. It can also be argued that a yes-or-no vote on a single option chosen by experts weighs too heavily in favor of technocratic expertise, and gives too limited a role to democratic processes and participation. While most voters admittedly are not expert enough to analyze options, they may be quite able to understand the options and the option analyses developed by the technical experts, when this information is presented using clear, non-jargon language.

3. A number of arguments can be advanced to support the third approach, which attempts to balance technical and democratic imperatives, while also helping ensure greater success in the polling booths. Under this approach the technical and political participants are to select a small number of options for wastewater treatment and reuse that (1) seem feasible for the area, and (2) deliberately represent divergent or different combinations of reclamation and reuse. Careful comparative analyses of the options by the technical experts and planning professionals would be translated into lay language, and presented to voters for their reaction and input, *before* either deciding on the chosen option or going on to a formal public ratification. While this procedure would not require each voter to become expert in wastewater reclamation and reuse, it would also not postpone public involvement until the very last.

Arguments against this approach center on its practicality. Can it actually be done, and if so, how? Will it be successful? The present study suggests two ways of implementing this approach, permitting the technology sector to assess risks and efficiency, while the public sector evaluates safety and community benefits, as recommended by Lowrance.[7]

Conclusions and Recommendations

The methodology underlying the present study is a workable procedure for obtaining public reaction to several options developed by technical experts. Thus a carefully drawn sample of respondents can test the opinion of the affected voting population, and can give results that are reasonably accurate. The brief educational effort required by such a survey would not be extensive, and care can be taken to make it factual, fair, complete and systematic. The results of carefully done polls would be useful to the political decisionmakers (shown on the right of Table 3) and could surely reach more of the public than the present minimal involvement in reviewing environmental impact reports.[8]

Another way of using this methodology would involve all voters in the decisionmaking process, after they had been exposed to an informational campaign and debate covering the several options developed by the professionals. Information on several wastewater treatment and reuse options would be widely disseminated, followed by an advisory referendum, perhaps conducted in connection with a local or county election. Each voter could be sent information that carefully and systematically describes the treatment and use for three or four viable options. Informed comments on environmental, health, and economic impacts associated with each option would be included. All of this would be done in lay language, supported by simple maps and charts as needed. Position statements on various options by interested groups could also be included. The mailing could be followed by public meetings, TV and radio coverage of debates, newspaper articles, and the like, to arouse interest and supplement the written information.

The advisory referendum could appear, possibly at the end of the regular election ballot, asking each voter to indicate "yes" or "no" to each option. The results should be highly indicative of voter sentiment, being an expres-

sion of voters actually participating in local elections. This could then be considered by the local political leadership in choosing the option to be presented for a formal ratification. While either the poll or the advisory referendum would cost money and complicate the planning process, they could be much less costly in money and confidence than failed bond elections, or recall campaigns brought against elected public officials by disgruntled citizens.

The present study indicated that a majority of respondents would like to be involved in water-reuse option selection in meaningful ways. Public participation through public hearings is limited, because such hearings are usually not well attended by citizens, and may be dominated by various interest groups that do not necessarily represent the voting public. In short, public hearings, while essential, do not seem to provide an effective vehicle for public participation in choosing options. Accordingly either the special poll or the advisory referendum are recommended as better ways of implementing the recommended planning approach.

Results of these participatory procedures should be: (1) marked increase of chances of success in local bond elections; (2) increased confidence in public officials and their technical planning consultants; and (3) increased citizen participation in local political decisions. The processes could possibly serve as models for citizen participation in school bond issues, planning and zoning decisions, public works improvements, and other similar matters requiring voter ratification at a local or county election.

In summary, a two-step political review and ratification process is recommended. The first would assess public opinion regarding several viable options, either by a special poll or an advisory referendum. The second step would involve final formal public ratification of the single plan selected as best for the community by a decision process that has already involved the technical and planning sectors, local political leaders and the voting public.

NOTES

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8. It is important to note that an effective polling approach must involve competent surveys conducted specifically for the community and issues at hand. Local political conditions can render general findings—e.g. those shown in Table 1—but they may be inapplicable to a specific local community and situation.

Water Policy

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CALIFORNIA'S WATER: QUALITY, QUANTITY, AND THE DELTA

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INTRODUCTION

This article is intended to give readers perspective on Proposition 9 – the June 1982 referendum on the Peripheral Canal and associated facilities – and help place the discussion in the broader context of the Delta and the state's water system. Most of California's high-quality water that is available for shipment flows into the Delta through the Sacramento and San Joaquin rivers and their tributaries, and the amounts of water exported are inextricably linked to Delta water quality. That is, water quality (salinity) in the Delta and southward depends on the quantity of freshwater in the Delta. The interdependence of the two prompts public concern about both. There are no panaceas, no simple solutions to the complex problems involving water quantity and quality. Satisfactory management of the state's water depends on the outcome of a series of policy decisions reached over time, each influenced by considerations of politics, technology, and economics. The vote on Proposition 9 will be a crucial decision in the series.

The following discussion first presents necessary background on the Delta and its role in the state's water system. The article then considers the effect of three sets of state policy options on Delta water quality and quantity: (1) the first set of options involves flood protection and levee enhancement in the Delta; (2) the second, ways of moving water through or around the Delta; and (3) the third, legal and institutional changes affecting water management and distribution.

THE DELTA: CHARACTER AND USES

Geography

As defined by statute, the Delta comprises almost 740,000 acres, and includes parts of Contra Costa, San Joaquin, Sacramento, Solano, and Yolo counties.[1] The natural flow of freshwater is from Central Valley rivers through Delta channels and canals into San Francisco Bay. At high tide, however, the incoming saltwater holds the freshwater in the Delta. Moreover, if the flow of fresh river water into the Delta is low, saltwater enters the Delta, reducing its water quality.

The Delta occupies a crucial site: 70 percent of the state's water originates to its north, while 80 percent of the demand is from south of the Delta.[2] The situation is further complicated because water supply and demand are seasonally out of phase, and even more severely mismatched in dry years. Supply is greatest in winter, when demand is lowest, and may fluctuate substantially from year to year. When free-flowing supplies are lowest, demand is highest for summer irrigation, although this seasonal need is reasonably constant from year to year.

CALIFORNIA POLICY SEMINAR

The California Policy Seminar, administered by the Institute of Governmental Studies on the Berkeley campus, is a Universitywide program that supports research on future policy problems the state may face. The Seminar is chaired by the University President. Its members include the Governor, the President Pro Tempore of the Senate, and the Speaker of the Assembly, plus appointees from the faculty, the associated students, and the Assembly, Senate, and executive branches of government. The commissioned research represents the latest in academic thought about major state policy questions. This issue of the *Public Affairs Report* summarizes and interprets other work by the authors.

PROPOSITION 9

California's June 1982 ballot will include Proposition 9, entitled "Water Facilities Including the Peripheral Canal," asking voters to approve or reject Senate Bill 200 (SB 200). SB 200 was passed in the summer of 1980, and would have taken effect on January 1, 1981, had it not been delayed by a voters' petition requiring it to be placed on the ballot. Proposition 8 (ACA 90), approved by voters in November 1980, will have no force or effect unless the voters approve SB 200 in the forthcoming referendum.

SB 200 would authorize (1) construction of the Peripheral Canal around the Delta, (2) relocation of the Contra Costa Canal, (3) construction of the Glenn or Colusa Reservoir, and the Los Vaqueros Reservoir, for offstream storage, and (4) enlargement of the East Branch Aqueduct in southern California (see Figure 1 and Figure 2).

In addition to these authorizations, SB 200 also:

> requires agreements to ensure protection of Delta water quality and fish and wildlife within the Delta; agreements to ensure implementation of additional surface and ground water storage (San Joaquin Valley and Los Angeles Basin); and water conservation and reclamation programs to meet the water needs of the SWP through year 2000. It also authorizes, separate from the SWP: (1) the Mid-Valley Canal to help stop falling ground water levels on the east side of the San Joaquin Valley, and (2) undefined facilities to transport water to Alameda, Contra Costa, San Joaquin, San Francisco, and San Mateo counties. (California, Department of Water Resources, *The California State Water Project – Current Activities and Future Management Plans.* Bulletin 132-81, November 1981, p. 4.)

If ACA 90 takes effect, it will place into the State Constitution procedural barriers designed to forestall any legislative efforts to reduce the Delta water quality or fish and wildlife protections set forth in SB 200. Specifically, the article requires:

> (1) that the State Water Project (SWP) must meet State Water Resources Control Board water quality standards to protect the beneficial uses of water in the Delta, Suisun Marsh, and San Francisco Bay; (2) that the SWP must provide water releases in case the Federal Government fails to operate the Central Valley Project in compliance with such standards; (3) that the Department of Water Resources, before constructing the Peripheral Canal, must enter into a permanent agreement with the Department of Fish and Game to restore and maintain Delta fish and wildlife resources to their historic levels (1922-1967). (California, Department of Water Resources, *The California State Water Project – Current Activities and Future Management Plans,* Bulletin 132-80, October 1980, p. 10.)

Thus, if and when it becomes effective, ACA 90 is designed to preserve water quality rights of users within the Delta from legislative intervention. The article does not affect administrative modifications – e.g., the definition of "historic fish levels" – already allowed under SB 200. However, it does give protection to the wild and scenic rivers of northern California. A later vote of the people could change any of these stipulations, and protection of North Coast rivers could also be changed by a two-thirds vote of the Legislature.

Agriculture

Two-thirds of the statutory Delta, known as the "Delta lowlands," is at elevations from five feet above sea level to 20 feet below. Eighty percent of this reclaimed marsh is in agriculture, 9 percent is in open waterways, 10 percent is in native vegetation, and 1 percent is residential. It includes 61 islands currently surrounded by 1,100 miles of flood protection levees. The lowlands have been zoned for agriculture by the five counties having jurisdiction, with minimum parcel size varying from five acres in Contra Costa County to 80 acres in Sacramento and Solano counties. Agriculture is the only industry in the Delta lowlands, agricultural produce being packed in small sheds scattered throughout the Delta and then shipped out by truck.

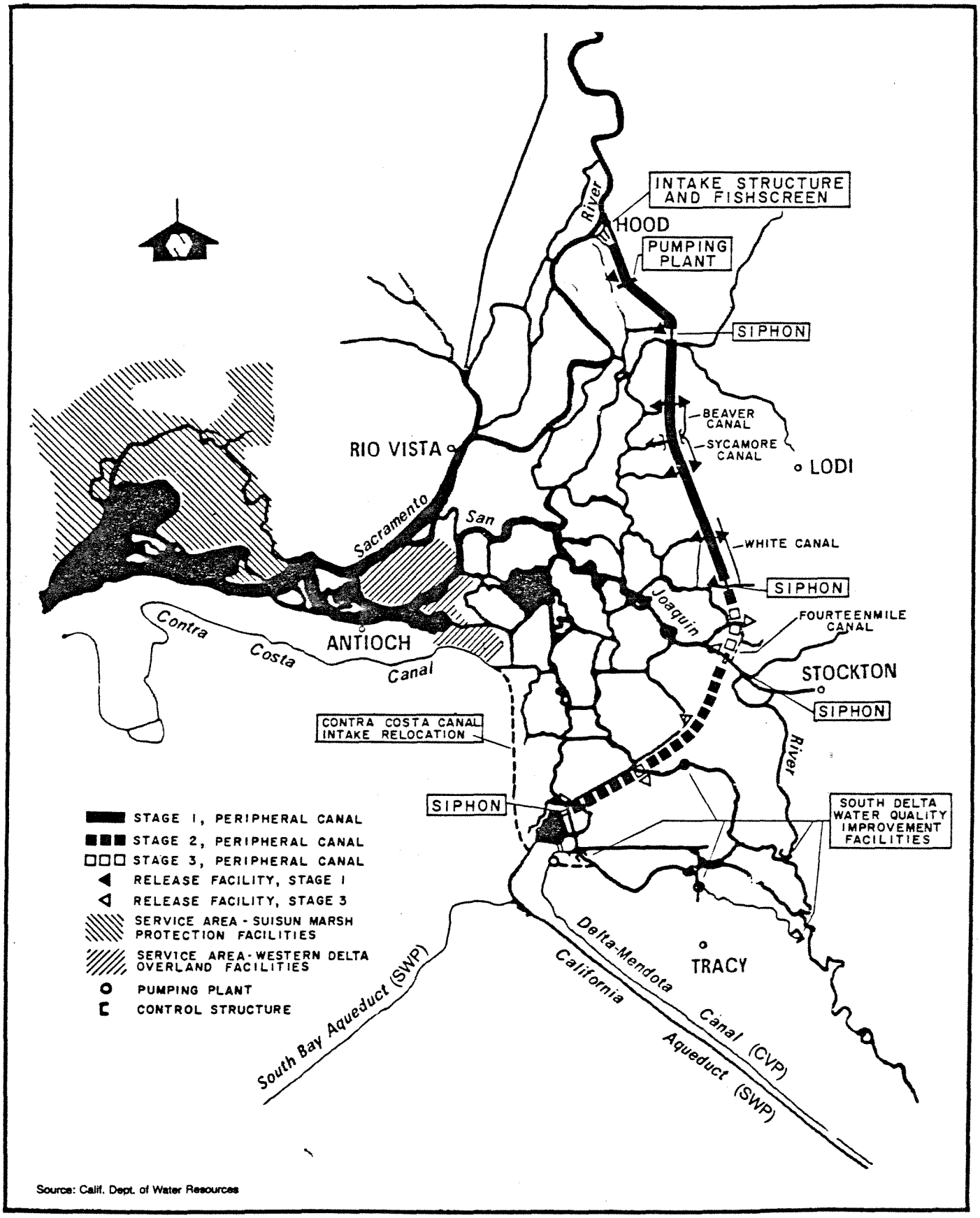
Population and Recreational Use

There are four incorporated cities (total population 98,560 in 1980) in the "Delta uplands": Antioch, Pittsburg, Brentwood, and Tracy. The lowlands have only one incorporated town (Isleton, population 930) and about 10 villages. A 1975 Department of Commerce special census reported about 11,000 people living in the lowlands.[3]

The Delta has more than 700 miles of navigable waterways, with small resorts on 24 of the islands, and

FIGURE 1

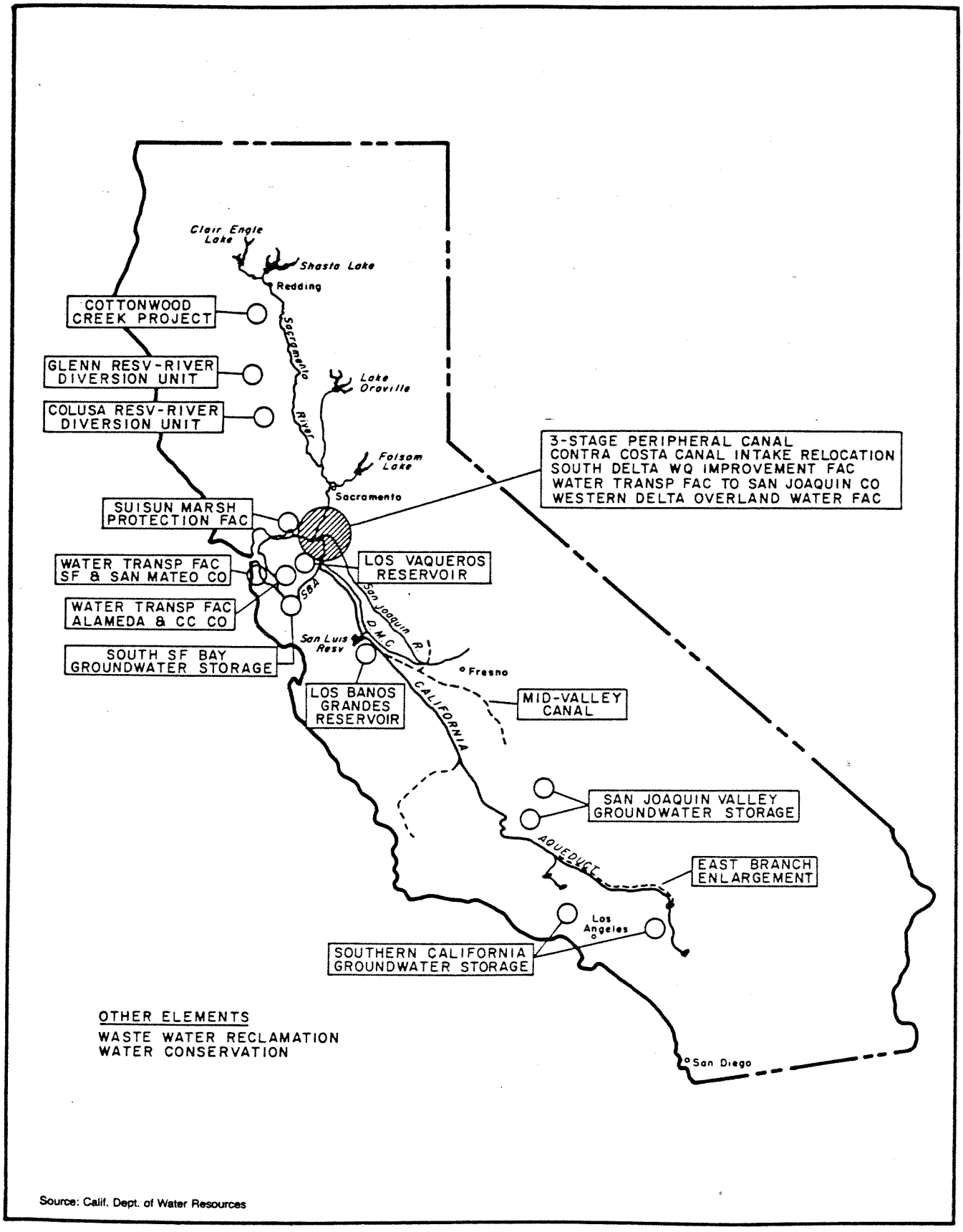
Proposed Delta Facilities



Source: Calif. Dept. of Water Resources

FIGURE 2

Key Elements of the Plan



Source: Calif. Dept. of Water Resources

two islands have recreational housing (Bethel Island and Discovery Bay). A 1978 survey by the California Department of Water Resources (DWR) estimated that over 7 million people use the Delta area, boating and fishing being the prime attractions for two-thirds of them. In 1978 approximately $70 million was spent in the area for recreation.[4] That same year the five Delta counties had 82,282 registered pleasure boats served by 150 marinas inside the Delta, and additional pleasure craft also used the Delta waterways.[5]

Transportation and Utilities

While parts of the Delta seem remote, it has vital transportation and utility uses. A 1975 inventory of 56 islands protected by "non-project levees," i.e., levees maintained by local interests only, found 37 to have public roads, including major state highways (routes 4, 12, and 160). Sixteen islands are crossed by aqueducts or pipelines, 18 by power transmission lines, and 11 by railroads. Fifteen islands have gas wells, and McDonald Tract provides underground storage for both domestic and Canadian gas.[6]

Fish and Wildlife

The Department of Water Resources characterizes the Delta as a unique and varied environment that is important to the survival of a large segment of California's fishery. Migratory fish, including salmon, steelhead, shad, sturgeon, and striped bass, move through the Delta on their upstream spawning runs. About half of the striped bass spawn in the Delta itself, and young fish of all species use Delta channels as a nursery before moving through San Francisco Bay to the ocean.[7] In the process, the Delta's small young fish suffer high mortality from pumping at water intakes used by water agencies, utilities, and industries. Pumping also kills some larger fish and causes "normal" water flows to reverse, confusing fish that are trying to reach the ocean. Fish that survive the pumps now provide significant opportunities for sports fishing in canals and reservoirs south of the Delta.

The Delta also provides an ideal environment for over 200 species of birds, including five major species (ducks, geese, and pheasants, which are hunted as game, as well as sandhill cranes and swans, which are protected). There are 39 species of mammals, 19 of reptiles, and 8 of amphibians [8] Preservation of this habitat for fish and wildlife depends on adequate water quality and continued plant growth on the Delta's levees and farmlands.

Agencies Involved

Numerous governmental agencies make decisions affecting the Delta, including 6 local water districts, 50 levee districts, 5 county governments, the DWR, the State Water Project (SWP), the State Water Resources Control Board (SWRCB), the United States Bureau of Reclamation (Central Valley Project – CVP), the US Army Corps of Engineers, the State Reclamation Board, and the Sacramento-Central Valley Regional Water Quality Control Board.[9] The Contra Costa County Water District currently uses Delta water from the Contra Costa Canal, whose intake is in the western Delta at Rock Slough.

SWAMPLAND RECLAMATION AND THE LEVEES

History of Delta Development

Before 1850, the swampy Delta islands were mostly used to graze cattle. Swampland reclamation was legalized and encouraged by the federal "Arkansas Act" of 1850, granting title of swamp and overflow lands to certain states, on condition that proceeds from their sale would be used to assist in reclamation. California's 1861 "Swampland Act" allowed the state to offer patents to those who would drain and reclaim river-bottom lands.[10] By 1930 the Delta had been fully reclaimed for intensive agriculture, the shallow natural channels having been dredged to build levees on the natural ridges and create new islands.

Many of today's levee problems are a result of this early construction by private initiative, about half of the old levees being built on peat soils, and most without adequate stable foundations. While they hold, these levees protect the islands and low-lying tracts from flooding caused by heavy river runoff, high tides from the ocean, and waves driven by strong winds. In the 1920s, federal flood control projects rehabilitated levees (known as "project levees") along the Sacramento and San Joaquin rivers, using appropriate engineering design standards.

The Delta Levees

The levees were originally constructed for flood protection only, whereas today they are necessary not only to protect reclaimed agricultural land, and transportation and utility facilities, but also to maintain high water quality, provide a desirable fish habitat, offer recreational amenities, and serve as channels for water transfer. Levees are necessary for high-quality water because each additional flooded island means that the SWP must release more freshwater from northern reservoirs to keep saltwater out of the Delta and compensate for increased evaporation. When Andrus-Brannan islands flooded in 1972, 300,000 acre feet of water was released from Shasta and Oroville reservoirs to compensate for the freshwater covering the island. This release was necessary to maintain the water quality for export.[11]

Levee maintenance is in a variety of hands. Maintenance for the Sacramento Deep Water Ship Channel and

certain river levees is a federal responsibility. The Port of Stockton has an agreement with the federal government for the latter to repair and restore levees along the Stockton Deep Water Ship Channel and San Joaquin River – this represents about 10 percent of Delta levees. In addition, districts controlling 15 percent of the private levees have agreements with the federal government to maintain their levees to US specifications. These are called "project levees."

The remaining 75 percent of the Delta island levees are called "non-project levees," which are maintained by the landowners or by special districts created for that purpose. The utilities and railroads that cross the Delta pay a local district tax for levee maintenance, and in addition the three railroad companies maintain their own rights-of-way. The state has no jurisdiction or responsibility for these non-project levees, although the districts can ask for state assistance during emergencies, and in case of a disaster they are usually eligible for state and federal financial assistance.[12]

In 1980, the estimated value of land and improvements within these districts was over $1 billion. The districts could levy "approximately $4 million per year for levee maintenance... we believe that in many years, expenditures have been substantially less... [and] there appears to be an inadequate level of local commitment for (non-project) levee maintenance."[13] A 1980 inspection of non-project levees by the DWR rated levees of 4 islands very poor, 28 as poor, and 20 as fair.[14]

Delta Island Flooding

Flooding of Delta islands is mainly attributable to increased hydrostatic pressure on already weak levees. Many of the islands' interiors are below water level, as a result of land subsidence due to soil erosion and compaction. In order for crops to grow, the islands' groundwater levels must be lowered further. Ditches are dug to collect the ground water, and pumps lift the drainage water up into the canals, causing an increase in water pressure on the canal side of the levees. The levees are also undermined and punctured by burrowing rodents, wave action in the wake of boats, and, in certain channels, scouring caused by the increased water velocities due to the SWP and CVP pumping.

All six islands and tracts that flooded in 1980 had non-project levees. These six total 30,956 acres of land, valued at $45,849,000.[15] Four of the islands flooded during winter high-water stages, and two flooded under normal summer conditions. State and federal aid of over $40 million has been spent repairing the levees, pumping out the water, and repairing the flood damage.[16] This work is expensive; pumping costs on one island alone were three times the land's appraised value.[17] On the other hand, a failure to reclaim flooded islands could also be costly, as many engineers fear that if one island is left flooded, the resulting wind and wave action could hasten the flooding of neighboring islands with poor levees.

Since Delta levees are necessary to the continued availability of high-quality water, levee protection becomes a crucial issue. In 1969, the Legislature asked the DWR to formulate a plan for improved Delta flood protection. The May 1975 DWR report proposed specific levee improvements to provide 100-year flood protection (i.e., a flood recurrence interval on the average of about once in 100 years) for 8 islands with urban development, and 50-year flood protection elsewhere.[18] A 1976 act (Chapter 1302, Statutes of 1976) directed the DWR to review and complete feasibility plans for the improvements, including recommendations on: construction, cost-sharing, land use, zoning, flood control, recreation, fish and wildlife habitat, and aesthetic values. The DWR final report is expected in the summer of 1982. The US Army Corps of Engineers joined the DWR in this study. In 1980 the DWR estimated the cost of complete rehabilitation of the Delta levees on 55 islands at between $800 million and $1 billion.[19]

THE STATEWIDE WATER EXCHANGE AND DELTA WATER QUALITY

The Water Exchange

Whereas the Delta was once only a drainage estuary and a natural conduit to the sea for California's two major rivers, increased statewide demand for water has converted the Delta from a largely seasonal freshwater source for local use, into the center of an immense water exchange. In other words, the Delta currently operates as a year-round "river" for water being shipped from northern to southern California.

The SWP and federal CVP currently use the existing channels and rivers to transport water through the Delta to facilities near Tracy, where it is pumped into the two canals that take it to the San Joaquin, Livermore, and Santa Clara valleys, southern Alameda County, and southern California. The SWP moves about two-fifths – 2.2 million acre feet (MAF) per year – and the CVP moves about three-fifths – 3.1 MAF – of the water exported from the Delta.[20]

> When the CVP was built, a short "Delta Cross Channel" was installed to connect the Sacramento River to the Mokelumne River delta channels. (This allows a certain amount of Sacramento River water to flow into the central Delta.) The CVP export pumps (near Tracy) then sucked down southern Delta water levels and thereby provided a gradient to draw water through that channel and across the central Delta to the pumps. When the SWP added its pumps it further reduced southern Delta water levels, but the capacity of the Cross Channel was

not augmented, so water is now sucked down the Sacramento River around Sherman Island bringing salt from the bay.[21]

Thus part of the water moving south toward the pumps flows through the western Delta in a direction counter to normal flow.

Withdrawals of Delta water by the CVP and SWP have tended to exceed the amounts originally planned for the state water facilities.[22] This is a source of serious concern, because the quality of the water pumped depends entirely on the quality of the water in the Delta. Increased pumping has caused severe water-quality problems due to salinity intrusion from San Francisco Bay, as well as scouring of the channels, and reduced tidal flushing of the southern Delta. It has also contributed to drastic depletion of the estuary's fish resources. The problems caused by the recent three-year drought underscored the Delta ecosystem's fragility and the need for careful water quality management.

Delta Water Quality

In August 1978, the SWRCB adopted (1) the Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (called the Delta Plan), and (2) the Water Right Decision 1485 (D-1485).[23] In effect, decision D-1485 states that the criterion for Delta water quality should be "pre-project" conditions, i.e., as if neither the CVP nor SWP existed. The Delta Plan included water-quality control and use of water rights in a single set of water-quality standards to be reviewed in 1988. The plan is intended to protect beneficial uses of Delta and Suisun Marsh water, and deals primarily with water flows as they relate to salinity intrusion.

The beneficial uses noted in the plan include: agriculture on both peat and mineral soils (recognizing differences between the Delta's northern interior and western and southern portions); municipal and industrial uses, including water exported to the San Francisco Bay Area, to the San Joaquin Valley, and to the Los Angeles basin; and fish and wildlife. The standards are set and can be changed by the SWRCB. As noted above, SB 200 also sets forth certain guarantees designed to protect Delta water quality, requirements which – resulting from the adoption of ACA 90 in 1980 – cannot be altered by the Legislature. These guarantees will come into force only if Proposition 9 is approved and SB 200 takes effect.

The US Bureau of Reclamation, the SWRCB, and the DWR are now engaged in negotiation, discussion, and litigation over (1) the extent to which federal water projects are subject to state water-quality regulations; (2) how much levee work the Army Corps of Engineers is responsible for – this depends on whether Delta levees are primarily for flood protection or for reclamation; and (3) the proper allocation of levee and water-quality control costs among state and local Delta water agencies.

ISSUES AND CONCERNS: WATER QUALITY, QUANTITY, FISH PROTECTION, AND COST

All the current water issues cannot be treated here, nor are all possible solutions presented. Furthermore, each suggested solution implies sets of trade-offs among agricultural, municipal, industrial, environmental, and wildlife water needs. Each solution also involves different combinations of physical and political risks, costs, financing methods, benefits, and beneficiaries. California's water concerns are much too diverse and its water industry too complex to deal with adequately in the space available here. Nevertheless, we believe that the discussion provides a way to analyze and compare solutions proposed for some of the major water issues confronting the state.

The solutions discussed below deal with the main issues of water quality, water quantity, fish protection, and cost. Currently, the SWP and CVP water contract deliveries for the year 2000 indicate a 50 percent increase in volume over 1980.[24] Delivery of this increased amount of water would reduce Delta water quality unless compensating measures are initiated, e.g., developing additional water supplies or adopting selected institutional options. On the other hand, if additional water supplies are limited, some institutional and technological changes could encourage better use and stretch existing supplies. A reduction of water export would allow the maintenance of relatively high water quality in the Delta.

Californians are concerned about how the vote on Proposition 9 will affect the future distribution of water, and what the implications will be for additional water development. For example, agriculture now uses 85 percent of the state's developed water, whereas municipal uses take only 9 percent, and industrial uses about 6 percent. Will it be possible for agriculture to maintain or increase its already large share of the state's water, or will urban needs for more water cut into farm allocations?

There is real concern about who will ultimately control California's water. Farmers north of the Delta speculate that their access to local surface water for irrigation may be curtailed as increasing amounts of water are shipped south, or are impounded in new reservoirs. Many Delta farmers fear that the demands of southern California users will control Delta water quality, especially in times when freshwater is in short supply. Further, since various state agencies have conflicting priorities, and the federal government also has its own criteria for the water it controls, many people believe legally established Delta water-quality standards are politically vulnerable to administrative changes.

The need to protect the fish that use the Delta is a major influence on the quality and quantity of water shipped south. Many recreationists worry, however, that the present laws are not strict enough, and that under drought conditions fish protection and Delta water quality

standards would get a low priority. On the other hand, agriculturalists fear that in water-short years environmental protection laws will give the maintenance of good water quality for fish a higher priority than supplying high-quality irrigation water for farmland.

Increasing competition for public funds and growing resistance to tax-supported water development have raised equity questions about who pays for and who benefits from protecting water quality, and developing more water. The public pays a large portion of the cost, and we are all beneficiaries. Landowners protecting their levees in the Delta also provide some of the benefits we all share. In short, determining appropriate, equitable roles for public and private contributions to water-project financing is complex, and made even more so by the increasing number of interests that share in decision-making about water development and use.

The fiscal pressures and issue-conflicts are aggravated by the fact that future water development will be more and more expensive. The era of cheap water is over. Not only are construction and energy costs rising, but so are the costs of simply maintaining current Delta water-quality standards. Deteriorating levees, increasing risk of flooding, and ineffective drainage add to the escalating costs. For instance, over $40 million in public funds was required to repair Delta flood damage in 1980, not counting funds from individuals, utilities, and the railroad.[25]

The discussion now turns to several policy options that have been suggested to help California resolve some of these complicated and difficult water issues.

THREE SETS OF POLICY OPTIONS

Three sets of policy options are outlined, all relating to Delta water quality and use. The first set of options would protect the islands and levees from flooding. The second relates to the movement of water around and through the Delta en route to the San Francisco Bay Area, the San Joaquin Valley, and southern California. The third involves institutional and legal changes in the State Water Project. Some options are mutually exclusive, while others could be combined.

First Set of Options: Alternatives for Flood Protection and Levee Maintenance

These options concern decisions on Delta levee maintenance, and on who pays. Research indicates that the formation of lakes by flooding of Delta islands would call for larger freshwater releases than are now required to maintain the SWP and Delta water quality levels. Complying with these demands would reduce the supplies of water available for the entire system, and increase the need for costly water releases to maintain quality standards. The following options contemplate different levels of landowner responsibility for protecting their property from flooding, and corresponding roles in land protection for state and/or federal aid.

(1) The *status quo* is one alternative. Delta landowners would continue to bear most of the protection costs, with little state participation, no major new protection facilities built, and no changes in institutional rules. Local districts would continue the current low level of funding for levee maintenance and repair. Federal agencies would deal mostly with navigation and channel maintenance, and provide monetary help only after catastrophic floods. The state would help coordinate emergency relief.[26] Finally, rates of pumping by the CVP and the SWP would attempt to keep pace with the growing commitments to water contractors.

While this option has worked in the past, its continuation in the face of limitations on future supplies means further degradation of levee structures and water quality. Certain kinds of fish will decrease and perhaps disappear, particularly the striped bass. Delta agriculture will either literally "farm itself into flooding" through further soil subsidence and levee erosion, convert to less remunerative crops (this has already happened on many islands), or shift from agriculture to other forms of business, e.g., seasonal recreation. Recreational boating will increase, and boat wakes will hasten the breach of some weaker levees. Loss of some islands will enlarge the open water areas, perhaps leading to further levee damage from wind and waves.

The status quo option will lead to increased public costs. Sooner or later urban users of Delta water – from Contra Costa County to the Metropolitan Water District of Southern California – would have to install expensive new water treatment facilities to safeguard public health. Utility companies using the islands would have to shore up their structures, or develop alternative routes in which to relocate severely threatened facilities. Local governments would suffer tax-revenue declines if flood-threatened property were reassessed downward or removed from the tax rolls. Further, costs to state and federal governments would rise if flooding forced releases of additional freshwater from limited upstream facilities to dilute the resulting intrusion of saltwater from the ocean. Finally, the status quo could also cost taxpayers more than $1 billion, if it were later decided to "save" the Delta by rehabilitating levees and pumping drowned islands dry.[27]

(2) This option differs from the previous one only in that the *federal government would severely reduce the amount of aid* provided for flood relief. Thus, relief would be available only if benefits greatly exceeded costs.

Governmental responsibility for channel maintenance and navigation facilities would continue. Under this option, each landowner or district would be solely responsible for their own flood-prevention programs and protection standards.

Most of the consequences noted for the first alternative would also apply to this one. In addition, the strict limitations on public relief funds would increase the probability of flooded islands being left as unreclaimed lakes. Clearly, if reclamation costs exceed the value of the flooded land, as has been the case recently, individual landowners would have little incentive to rehabilitate their flooded islands.

Moreover, further water degradation could mean that society's loss would greatly exceed the sum of individual landowner's losses. Examples of such losses from pumping low-quality water include increased repairs of water distribution facilities, reduced yields from irrigation, and greater expenditures required to protect public health. Finally, as under the first alternative, a later decision to salvage the Delta could easily cost $1 billion or more.[28]

(3) The final alternative under this set of options would *mandate public and private cost sharing* of land protection, including levee operation, maintenance, and emergency relief. This would require agreement on levee protection standards, on who would do the work, and on how costs would be shared. Once an emergency was declared, flood recovery help would come from federal and state sources, without considering the program's costs and benefits. Maintenance of channel and navigation aids would continue as a federal responsibility.

This alternative would minimize or eliminate most of the previously mentioned losses of freshwater, agricultural land, and water quality. On the other hand, it could increase individual levee assessments, and even increase the Delta's share of funds taken from the state's general tax fund. Total federal Delta expenses could be reduced from what they are today, however, if improved levees reduced the incidence of flooding.

With more public dollars invested in levee protection, increased access and augmented recreational facilities will be required throughout the Delta.[29] An improved levee system could have a positive influence on fish protection. Total costs of levee rehabilitation would remain the same, i.e., about $1 billion.[30]

This alternative would do nothing to inhibit land subsidence, nor would it guarantee minimum water quality levels, in the face of increased pumping by the CVP and/or SWP. Finally, it would not protect water quality from possible degradation during periods of low flow or drought.

Second Set of Options:
Ways of Transporting Water South

The second set of policy options involves ways of moving CVP and SWP water around or through the Delta, including (1) the status quo, (2) a "non-isolated" Through-Delta facility, and (3) an "isolated" facility, e.g., the Peripheral Canal. These options involve differences in quantities of water moved, and the impacts on the quality of both Delta water and transported water. But all of them would require upstream storage facilities to meet SWP and CVP projected demand. None of the options would deal with land subsidence.

(1) The *status quo* alternative has already been discussed, and the problems of continuing water transport considered. CVP and SWP pumping near Tracy moves almost 6 MAF of water out of the Delta annually, creating reverse flows and causing stagnation and high salinity in the South Delta, confusing many migratory fish, and threatening to force water systems drawing from the Delta to use more expensive purification methods.[31]

(2) The next alternative in this group is a *"non-isolated" Through-Delta facility,* i.e., the one currently proposed by the Central Delta Water Agency.[32] Water would be taken from the Sacramento River near Walnut Grove and transported into the Delta interior, through improved channels of the Mokelumne River system. A pump located near Clifton Court Forebay would draw the water south, through improved and widened channels in the Central Delta, and around Victoria Island. Pumps would send some of this water east into the southeastern Delta, and move some north toward the Contra Costa Canal intake.

Fish screens would be needed at the intake from the Sacramento River, and before Clifton Court Forebay. Since this would be a non-isolated facility, fish and water could circulate into the branch canals, because the pumps would create a southward-flowing current. This option would require upgrading of some levees adjacent to selected channels. Total cost estimates for the facility range from $330 to $545 million in 1981 dollars.[33] (The cost of fish screens is difficult to predict because appropriate techniques and designs are still being developed, but cost estimates range from $100 to $150 million.)

Supporters claim this option would reduce flood potential (because some levees would be strengthened), while providing for water shipments south. It would also eliminate much political uncertainty about the availability of sufficient freshwater in the Delta because export water contractors are interested in high-quality water. Furthermore, they claim that costly relocation ($17 million in 1979 dollars) of the Contra Costa Canal's present water intake would be unnecessary.[34] On the other hand, opponents say the Through-Delta facility would cost more than the Peripheral Canal, continue degradation of the fisheries, jeopardize water exports, and harm the scenic qualities of the lower Mokelumne River.[35] They also suggest that operation and maintenance costs would be much higher than those for the Peripheral Canal. Finally, they argue that this type of option was fully reviewed and rejected in previous studies that led to the selection of the Peripheral Canal alternative.

The Delta's levees and islands comprise part of a large saltwater barrier that protects the quality of the

exported water. Accordingly, the non-isolated canal would focus state attention on the levees, whose preservation would be essential to the maintenance of high water quality. Fish losses due to stream-flow reversals around Sherman Island would decline. Recreationists would continue to enjoy a Delta with many channels and protected sloughs.

This facility could be completed within four years of approval. Although the environmental safeguards of Proposition 8 would not apply, D-1485 water-quality standards would prevail, since they do not depend on any water transport alternative.

(3) The final alternative under this set of options is an *"isolated" water transfer facility,* e.g., the Peripheral Canal, as provided for in SB 200. This option differs from the previous one in that the canal would bypass the Delta. Its key feature would be a large ditch through which up to 80 percent of the upstream storage released into the Sacramento River could be shunted around the Delta, for shipment south. This percentage would vary with actual stream-flow and time of year.

The shunted water could be available for pumping by both the CVP and the SWP. The CVP would, however, be restricted from using the canal unless it agrees to Delta water-quality standards set by the SWRCB. (It has also been suggested that the SWRCB might *order* the Department of Water Resources to permit federal use of the canal so as to protect fish in the Delta from the reverse-flow phenomenon discussed above.) The DWR states that the Peripheral Canal could provide between 500,000 and 700,000 acre feet of extra water for transportation south without degrading Delta water quality. This would really be "saved water," because the canal would render unnecessary releases into the Sacramento River to offset saltwater intrusion due to reverse stream flows in its western portion. To increase water delivery above these amounts – 500,000 to 700,000 acre feet – additional upstream reservoirs would be needed (e.g., those authorized by SB 200), regardless of the alternative chosen to transport water in or around the Delta.

Planning for the Peripheral Canal was based on the assumption that the SWP and the CVP would both use it, and would also coordinate their efforts to control Delta water quality. Currently, while there is no formal agreement about water-quality standards, there is tacit coordination between the CVP and the SWP about pumping from the Delta. In the absence of a formal future agreement, however, SB 200 would require the SWP water releases to compensate for any failure by the CVP to meet SWRCB standards for the Delta.

The canal would be 42 miles long, approximately 10 feet above ground, 400 to 500 feet wide, and 20 to 30 feet deep. It would require 94 miles of road, 6,500 acres of right-of-way, siphons to bypass 4 rivers, large fish screens and 6 pumping units at the intake, and 14 release facilities.[36] It would take approximately ten years to complete if all SB 200 environmental requirements are met. Completion could be postponed if these requirements are not met. The cost for the canal alone has been estimated at $680 million in 1981 dollars.[37]

The Peripheral Canal as designed by the DWR and described in SB 200 could handle about twice as much water as the present arrangements deliver. Readers should note, however, that this additional water would be available only if the rest of the upstream facilities in SB 200 were built. Estimates of the cost of these facilities vary, but would certainly be several billions of dollars.

Proponents of the canal claim that many years and millions of dollars have been spent on studies for the State Water Plan, leading to the selection of the Peripheral Canal alternative. They say that rejection of the canal alternative would waste the time and dollars already spent and cause additional costly delays to completion of the plan. They add that the canal alternative provides an achievable balance between environmental concerns in the Delta and long-run commitments to ship water south.

Opponents claim that in spite of all the efforts and studies, the Peripheral Canal is not a good choice, given the present package of environmental safeguards. Some critics claim either that the canal might not be completed, or that all the available extra water would be used to meet the environmental requirements. Critics also maintain that the canal is too large and expensive as presently designed. They argue that if the supporting facilities of SB 200 are not built, there will be no reason for the canal to be so large. Other critics maintain that no matter what the entitlement arrangements are, southern California does not need all the water that the Peripheral Canal could deliver.

If the Peripheral Canal were built, the quality of water transferred south would be high. It would no longer depend on the quality of water in the Delta, because the canal would draw high-quality water from the Sacramento River at Hood. During periods of low flow, the canal could be used to increase water-quality levels in the Delta by releasing water from any of its 14 valves. This should alleviate problems that fish have with low-quality water and reverse flows, and could lead to an increase in their survival rate, despite some deaths from the diversion pumps drawing water from the Sacramento River. The released water could flush the south Delta, helping remove stagnant water and poor-quality San Joaquin River water.

But recreationists, Delta farmers, and municipal and industrial water users who draw directly from the Delta waterways fear that the SB 200 guarantees to maintain minimum water-quality standards will not be observed. An isolated canal could reduce the state and federal government incentives to improve Delta levees, thus shifting initiative and responsibility for levee operation and maintenance to Delta landowners and local districts. In addition, the isolated canal might reduce federal aid granted in times of flood, because federal CVP water would not be affected.

Third Set of Options: Institutional Change Relating to Water Use

The final set of policy options are institutional and regulatory changes affecting users of SWP water. Similar federal changes could be made for CVP water users. Water demand could be reduced, and/or supplies stretched, by such measures as conservation, water pricing, water rights transferability, reclamation, conjunctive use, and drainage. Reducing the amount of water actually used would enhance the quality of Delta water, and of water transported south.

(1) More positive encouragement of *conservation measures* is one way to reduce the demand for water. Conservation could be mandated in ways that leave water agencies and users free to choose their preferred conservation techniques, e.g., lining ditches, improving irrigation technology, or raising runoff water quality standards.

(2) *A revision in water pricing* is another possible change. Water agencies have traditionally priced water so that it is feasible for users to buy it, instead of pricing it so as to meet costs. Present water pricing gives inadequate incentives for water conservation. Thus an individual who reduces water use does not reap the resulting benefits as economic savings, which instead accrue to the entire system.

If users were charged the total added cost of delivering any "new" water, instead of an averaged cost for both "new" and "old" water, people would probably make decisions on water use more favorable to conservation. Such a pricing system would require identifying uses of new and old water. It would also involve equity considerations between new and old users of water. For example, would it be fair and feasible to charge new water users higher rates than old users?

(3) Free market advocates suggest the *sale of developed water on an open market basis*, with prices covering total costs. Under foreseeable conditions of restricted water supplies and increasing demand, different users could bid up the price for water until they got what they wanted, or were priced out of the market. To establish an open market, California would have to change existing water law and the system of water rights presently in effect.

(4) Water-use efficiency could be increased by *making water rights transferable*. That is, water users would be able to buy water rights from others, and transfer them to new locations. Under a transfer system, those directly involved would be better off economically, or else they would not trade. Nevertheless, these actions may not lead to the best long-run resource use.

(5) *Mandated reclamation* is another option that could increase the supply of usable water in California. Proponents claim that this option could yield hundreds of thousands of acre feet of water at prices competitive with the cost of developing new water supplies. Under present regulations, reclamation would not reduce any entitlement under the State Water Plan, but it could reduce the demand for the SWP-delivered water.

(6) *Conjunctive use*, i.e., the combined management and use of ground and surface water, is another way to reduce surface water use. While this option is now used in many water basins, there are some which do not require it. Individual users currently have little personal incentive to recharge water basins also used by others, or to conserve water in a basin (except in responding to their own pumping costs). If there were different controls on ground water use, the need to transport expensive surface water to recharge basins could be reduced. As things now stand, most ground water users can pump out unlimited amounts of water, paying only the costs of pumping, and not paying any possible costs of recharging the basin.

(7) Drainage has a major effect on Delta water quality. Accordingly, *effluent standards* established for water that drains into the Delta is another possible institutional change. If more water is supplied to the San Joaquin Valley, drainage needs will be increased. This would, in turn, add to the water-quality problems of the Delta and the Bay Area. Freshwater releases are the only way now available to cope with such problems in the Delta. Other proposals that could help solve drainage problems include requiring settling or evaporation ponds, regulating treatment of drain water, or even reversing the Valley Drain so that it flows southward into the Tulare Sink.

SUMMARY

Each person voting on Proposition 9 in June will presumably be strongly influenced by what he or she considers to be the most likely water transport alternative if the proposition loses and the Peripheral Canal is defeated. This article has dealt with alternatives for moving water south, and for coping with Delta environmental problems of water quality, fish and wildlife, as well as meeting existing contracts for state water.

On the other hand, if Proposition 9 passes, the state will be given clear authority to complete the State Water Plan. In either case, the people of California will still have the responsibility of deciding among Delta levee protection alternatives, and on institutional changes which apply to water issues.

The Delta is a key water-transfer facility for CVP and SWP withdrawals. Consequently the state's water users are increasingly concerned about the Delta's dependability as a source of high-quality water, and as a major recreational and environmental resource.

Three sets of policy options that would influence Delta water quality have been reviewed: (1) levee maintenance and repair, (2) water-transport, and (3) selected institutional and regulatory changes. (Some of these options can be combined.)

The existing Delta levees are deteriorating. Effective protection for fish and the environment is also declining. Further loss of islands to flooding will lower water quality. Offsetting these negative effects will require the release of more freshwater into the Delta. There is no easy way out: all the available options – even maintaining the status quo – will be increasingly expensive.

The present system and the proposed Through-Delta facility both rely more heavily on maintaining Delta water quality than does the Peripheral Canal. As a result, the political vulnerability of Delta water quality will increase if voters approve the Peripheral Canal and it is built. Proponents of both the Through-Delta and Peripheral canals claim they will improve fish protection, and enable more water to be handled than is possible now. Official agency opinions conflict, however, on which alternative will be the more expensive way to provide essentially the same amounts of export water.

Institutional changes could help solve the water-quality problems by reducing the amount of water actually used, or "stretching" it to make it go farther. Moreover, any of these institutional changes could be implemented along with options chosen from the other groups: levee maintenance and repair, and water transport.

The June 1982 vote to either affirm or repeal SB 200 cannot begin to resolve all the complex and politically sensitive water issues. No matter how the referendum is decided, a crucial question will remain unanswered: Can the Delta's water quality be maintained (or perhaps even enhanced) without prohibitive costs, while still assuring adequate supplies and an equitable distribution of California's water?

NOTES

Principal Agency Acronyms

CVP = Central Valley Project (federal)
DWR = Department of Water Resources (state)
SWP = State Water Project
SWRCB = State Water Resources Control Board

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ACID RAIN AND ECOLOGICAL DAMAGE: IMPLICATIONS OF SIERRA NEVADA LAKE STUDIES

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Introduction

"Acid rain" is a popular term describing precipitation—rain, snow, fog, mist, dew, dust—whose acid content has been increased by human activity. It is generally attributed to the burning of fossil fuels such as coal, oil, and natural gas, in power plants, industrial facilities, and automobiles, producing emissions of sulfur oxides and nitrogen oxides. These oxides then undergo acid-forming chemical transformations in the atmosphere, and are transported—often substantial distances from the emission sources—and deposited as "acid rain."

Acid rain was first recognized as a serious problem in the Scandinavian countries. As early as 1955, increasing acidity was being noted in southern Norway and Sweden.[1] The problem was soon widely acknowledged as fish populations in many Scandinavian lakes and streams were reduced or eradicated. Concern over acid rain in the United States began mounting in the 1960s with the loss of trout populations from sensitive Adirondack lakes of northern New York state.[2] The effect of acid rain on forests, grasslands, and croplands is now also a real concern, with the possibility of significant economic loss due to lowered productivity.[3]

Acid Precipitation in California

California was long assumed to be relatively free of acid rain. Winds blowing across the state from the Pacific Ocean are free of the industrial pollutants that blow across the northeast; there are no large, coal-fired power plants in the state; and the Central Valley and desert areas contain alkaline soils, which are a source of dust particles that could neutralize acid rain.

But two projects sponsored by the California Air Resources Board (CARB) studied the chemical composition of the state's rain, using samples collected in 1978 and 1979, demonstrating that precipitation was acidic in both northern and southern California.[4] A network of eight stations in northern California, from urban areas to the Tahoe Basin, was set up to record seasonal variations in the acidity of rain and snow. The pooled data showed an average pH of 4.9—measured on the pH scale that defines unpolluted rain as pH 5.6.[5] (On the pH scale each decrease of 1.0 represents a ten-fold increase in acidity, with the neutral point at 7.0.) Rainfall in urban areas such as Los Angeles and the Bay Area was found to be particularly acidic, the pH of some storms being as low as 2.89, about the same pH as vinegar. These results concerned CARB officials, who, in January, 1981, convened a symposium on the effects of acid precipitation.[6] It was agreed that California faces potential ecosystem damage from acid rain, including forest, fish, and agricultural crop loss. The principal sources of the acids were not positively identified, but likely candidates are the urban population centers with their automobiles, refineries, and oil-fired power plants.

The High Sierra Watersheds

Fortunately, California recognized the potential problem before its natural resources were damaged. So far,

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scientists are unsure how acid rain may affect the state's ecosystems. From observations in other parts of the world, however, we know that the small headwater lakes of the Sierra Nevada—being relatively unable to neutralize acids—are good systems to study in looking for early signs of deterioration.

Subalpine lakes on the western slope are especially susceptible because their small volumes, limited watershed areas, location in granitic basins, and thin watershed soils all contribute to a lack of buffering capacity, or ability to neutralize acid.[7] These sensitive lakes constitute an early warning system that may reflect the effects of increasing California air pollution.

A large volume of California's precipitation falls as snow on the western slope of the Sierra, as east-moving weather systems pass over California's population centers and then drop much of their precipitation. Studies of acid snowfall in Canada and Norway have noted that pollutants were concentrated in the part of the snow that melts first in the spring.[8] If that also happens in California, then the acid and associated ions may flow out in a concentrated pulse, harming the lakes and streams that receive the meltwater. The biological activity of these especially vulnerable mountain lakes could be seriously damaged by such acid pulses.

Measurement of pH alone is not likely to provide the most useful information for anticipating chemical and biological changes in the lakes. Before a significant pH drop is observed, there is a gradual loss of buffering capacity. Consequently periodic measurements of buffering capacity are particularly important. A drop in a lake's buffering capacity is an early warning of impending change in the pH and the lake's biological character. Buffering capacity can be partially renewed by natural geological and biological processes.[9] It is important to measure the rate of renewal of buffering capacity, as this provides a useful measure of the resistance of the lake and its surrounding watershed to acidification.

Our research project collected data on the sensitivity of these subalpine lakes. A brief summary of our experimental approach and results is given here. (For complete details concerning analytical techniques, sampling methods, and analysis of experimental error, the interested reader is referred to the final research report).[10]

The first step in studying selected aquatic systems of the Sierra Nevada was to record the existing chemical and biological conditions of lakes likely to be most vulnerable, thus providing a baseline estimate of the systems' health. In a controlled laboratory setting, we also studied possible changes caused by increasingly acidic precipitation. These laboratory experiments were conducted with simulated lake systems (called microcosms), to which acid was added. The resulting chemical and biological changes were then compared with the conditions of other lake microcosms used as controls, which received no acid. Observations made elsewhere suggest that lakes affected by acid rain have elevated concentrations of such elements as lead, zinc, cadmium, iron, aluminum, and manganese.[11] Large concentrations of such metals could damage water quality and biological populations. Enhanced metal concentrations may also flow downstream and endanger the health of downstream water users. Accordingly, we watched particularly for changes in levels of toxic metals in the microcosm systems receiving acid treatment.

Water-Quality Studies in the Sierra Nevada

Twenty-six lakes located at elevations of 5000 feet to 9000 feet on the western slope of the Sierra Nevada were sampled during the spring, summer, and fall of 1980 and 1981. Many are located in the subalpine zone (basins with few trees and thin soils), in national parks, national forests, and wilderness areas. As noted earlier, baseline data were obtained on pH, buffering capacity (measured by the amount of material available to neutralize acid), and on concentrations of trace metals such as aluminum, cadmium, copper, iron, lead, manganese, and zinc.[12] Calcium and magnesium, components of some of the most common natural buffering materials in lakes and soils, were also measured. Phytoplankton species (microscopic plant life) were identified and individuals counted to provide an indication of the biological state of the system.

The pH of all lakes sampled between June and October was in the neutral range, pH 6-8. Alkalinity of the Sierra lakes, or the amount of material available to neutralize acid, was very low, measured at 10 μeq/liter (micro-equivalents per liter) to 500 μeq/liter. By comparison, a well-buffered aquatic system has an alkalinity of more than 1,000 μeq/liter. These data are summarized in Figure 1 and Figure 2. Figure 3, plotting pH versus alkalinity, shows low alkalinities in Sierra lakes over a range of pH values. (Note: For comparison, data were also collected on two lower-elevation reservoirs, Briones and Isabella. These showed both high pH and alkalinity, and are represented in Figure 3 by the square symbols.)

Wide regional variations in lakewater metal concentrations were found, with relatively high levels of aluminum (40 to 250 micrograms per liter) being recorded in some Sierra lakes.[13] Aluminum is toxic at high concentrations, and is easily leached by acids into lakewater from watersheds and sediments. In areas plagued by chronic lake acidification, fish kills have been directly attributed to aluminum toxicity.[14]

The combination of near-neutral pH, low alkalinity, and availability of alumina minerals in soils and sediment, indicates that many Sierra lakes are susceptible to acid-rain damage. These characteristics are shared with lakes found to be sensitive in other parts of the world.

Our study provides a limited data base on the chemical and biological characteristics of a group of vulnerable Sierra lakes. In the future, field monitoring of selected lakes needs to be continued regularly, to watch for gradual changes in lakewater chemistry that could warn of ecosystem acidification. Especially important is monitoring of lakewater chemistry during snowmelt, when the lakes may be most vulnerable to acid stress.

Experimental Studies of Lake Acidification

When the field survey found the Sierra Nevada lakes susceptible to acid rain, we then sought to determine how acidification might affect these aquatic systems.

Although field experiments in which lakes and streams were artificially acidified have been performed elsewhere, we concluded that laboratory microcosm research, not involving damage to natural lakes, was more appropriate for studying Sierra lakes' vulnerability to acid precipitation.[15]

The microcosms used to simulate the lakes and test their probable response to acid rain were 18-liter plastic tanks, filled with water and sediment collected in the field, and maintained under controlled light and temperature conditions. By using these small replicas of the lake ecosystems, we were able to study the effect of altering acidity. Controllable variables such as temperature, light, and aeration were matched approximately to the levels observed in the actual lakes. Chemical and biological interactions in the lakewater determined the nutrient and metal concentrations, and changes in the plankton populations.

The lakes simulated included a well-buffered Bay Area reservoir (Briones), and two high-altitude, subalpine Sierra lakes (Mosquito Lake, west of Ebbetts's Pass, and Tenaya Lake in Yosemite National Park). Nitric acid (HNO_3) was added to stress the systems because of the high relative concentration of the nitrate anion in precipitation falling in California. It was assumed that it would be easier to interpret changes in a microcosm that had been subjected to increases in a single acid anion.

In each experiment, microcosms were studied under various conditions. For greater statistical reliability three replicates of each condition were set up for the Sierra lake experiments and two were set up for each condition to be studied in the Briones Reservoir experiment. Because lake sediments are sources of both potentially toxic metals and of buffering agents, microcosms were set up with and without lake sediments. Some of the microcosms were stressed with enough acid to bring the system down to pH 4, an acidified state. Following this one-time acid addition, resembling the acid stress observed in Scandinavia and the Adirondacks during snowmelt, several variables were measured weekly over a seven-weeks experimental period: (1) pH, (2) alkalinity, (3) metal concentrations in the water, and (4) phytoplankton and zooplankton (animal life of the plankton) species and numbers. To demonstrate that inadvertent metal contamination did not occur in the laboratory, distilled water controls were set up in parallel with the lake microcosms, and metal concentrations were measured weekly in these controls.

Chemical and Biological Changes

Due to the comparative lack of buffering materials in the water and sediment, the Sierra lake microcosms recovered slowly or not at all after they were treated with acid (see Figure 4, Mosquito Lake, and Figure 5, Tenaya Lake). The Mosquito Lake systems recovered slightly--the pH increased to about 5. This could be attributed to the buffering capacity of the fine-grained organic sediments. These sediments are characteristic of lower-elevation lakes in forested basins and have a greater buffering capacity than the coarse-grained gravel sediments of high-elevation lakes such as Tenaya.

Over a number of years vulnerable lakes may gradually lose the ability to buffer acid because the buffering capacity may be partially used up during the successive snowmelt acid pulses. These subtle changes in lake chemistry may not become obvious until a lake's alkalinity is exhausted, producing a sudden pH drop. Figure 6 charts the exhaustion of buffering capacity in an experiment using water and sediments from Briones Reservoir. Here, acid was added at weeks 0, 2, and 4, depressing the pH to 4 each time. In each instance the pH begins a recovery towards the baseline, but the alkalinity remains depressed (between 0 and 150 μeq/liter). Moreover, pH and alkalinity recovery is weaker following each successive acid addition.

These pH and alkalinity changes after acidification are only some of the complex chemical reactions caused by such stress. Acid can also cause the release of metals, from sediment and suspended particles. For example, Figures 7-9 summarize the levels of dissolved aluminum, iron and manganese released during the Mosquito Lake microcosm experiment.[16]

Phytoplankton and zooplankton populations responded to acid in various ways. Generally the counts of individuals and numbers of species decreased in the acid-stressed systems, although the magnitude of the effect was more pronounced on zooplankton populations than on phytoplankton populations. In some cases acid did not cause a decrease in the populations, but instead suppressed the population blooms observed in the unacidified controls. (Because nitric acid supplies the nitrate ion, a nutrient for algae, some scientists have speculated that acidification might enhance algal growth. Indeed, for one species—a filamentous green alga—a bloom was encouraged in the acidified microcosms of Tenaya Lake.)[17]

Summary of Experimental Results

In summary, these experiments have identified some of the variables that change significantly during acidification. Large decreases in pH cause significant increases of certain metals that are toxic at high concentrations. The acidified systems also exhibited significant biological effects, with some species being favored over others. By monitoring these variables in real lakes, changes in ecosystems due to acidic deposition can be identified. Admittedly in these experiments the lake microcosms were acidified suddenly, while in the field this process may take years or decades. Nevertheless, the diagnostic variables identified can help in recognizing early signs of lake damage due to acidification.

Acid-induced biological and chemical changes can progressively alter freshwater lake systems. The greatest threats to Sierra lakes are (1) loss of the already small buffering capacity, leading to chronic lake acidification, (2) toxic effects of increased acidity on organisms, and (3) indirect and synergistic toxic effects on organisms, including man, due to metals leached from watershed soils or sediment because of increasingly acid rainfall and snowmelt.

Recommendations: Monitoring, Research, and Regulation

The sensitive Sierra lakes will almost inevitably deteriorate if they are exposed to acid rain. Their chemistry and biology will change as their buffering capacity is depleted.

Changes in these sensitive systems due to acid rain may also serve as a warning of more gradual, imperceptible changes that may be taking place in other ecosystems further downstream. Accordingly, California should not defer policy decisions on acid rain until the Sierra lakes have in fact been damaged and changes have begun to be observed. More research is needed on pollution pathways, deposition, and effects, but there is already enough information to justify formulating environmental regulations to protect all of California's natural resources from acid-rain damage.

The most pressing priority is a network of precipitation sampling stations to detect variations in the pH and chemical composition of rain, snow, fog, mist, and dry deposition. Anions, principally sulfate and nitrate, and other important atmospheric constituents such as ammonium, alkaline agents, and trace metals, should be monitored on a year-round, storm-by-storm (or event) basis to identify sources of air pollutants and seasonal trends.

We can now only guess at possible sources and pathways of pollution affecting acidity of precipitation in California. Without better understanding of the atmospheric pathways of pollutant dispersal, it will be difficult to make informed policy decisions about power plant siting. We know that the mountain lakes are sensitive to acid deposition, but we do not yet know how to predict the amount of acid deposition that will reach the Sierra Nevada from fossil-fuel power plants located at alternative sites within the state. Monitoring the chemistry of precipitation provides insight into the atmospheric pathways for pollutant dispersal from existing sources, but provides little direct information about the consequences of locating new sources in areas where there are now no sources of pollution. Developing the ability to predict these consequences will require the combined research skills of atmospheric chemists and meteorologists. Such an interdisciplinary effort is currently in progress at the Lawrence Berkeley Laboratory.

Another pressing priority for California is a lake-monitoring network in the Sierra Nevada. Water quality is important because these lakes are used for recreation, fishing, and as sources of agricultural and municipal water supplies. Without monitoring, important changes in lakewater chemistry could go undetected until the lakes are damaged.

Large changes in pH, alkalinity and dissolved metals have been observed when snowmelt enters adversely affected Adirondack and Scandinavian lakes. Any monitoring scheme should emphasize the snowmelt period to see if similar changes in water chemistry occur in California. Studying snowpack chemistry may also alert us to changes in the precipitation chemistry in the Sierra Nevada where most of the precipitation falls as snow. Because acidification can cause increased toxic metal concentrations in the water, it is also important to monitor background metal levels, and to identify the major sources of toxic metals in California's waters.

Studies are needed of other biological effects of lake acidification that are likely to extend beyond damage to the plankton populations observed in the experiments described here. Microbe-mediated nutrient cycles, soil building processes, and forest and fish productivity in Sierra watersheds could also be altered and perhaps harmed by acidification.

The California Air Resources Board appears to be taking the lead in studying and regulating precursors of acid rain, such as sulfur dioxide or nitrogen oxide emitted during fossil-fuel combustion. In the future, California agencies responsible for regulating energy production and for protecting aquatic resources should cooperate in studying and regulating potential causes of acid rain. In addition to the California Air Resources Board, other agencies that might participate include the California Energy Commission, the Department of Fish and Game, and the Water Quality Control Board. Federal concern with acid rain in California prompted the National Atmospheric Disposition Program (NADP) to install a number of monitoring stations in the state. Federal and state officials should be encouraged to cooperate in expanding networks to monitor both precipitation and lakewater quality.

Despite uncertainties about acid rain and its effects in California, existing data can be used for informed regulation of fossil-fuel burning processes and for siting fossil-fuel burning facilities. For example, available evidence points to mobile sources—principally automobiles—as a major contributor to acid deposition in California, especially in the urban areas. Although the evidence has not yet been thoroughly analyzed, southern California mobile-source pollution may even be a significant contributor to acid rain in the Rocky Mountains.[18] In light of these findings, and those on the Sierra lakes' susceptibility to acid inputs, we recommend against weakening present automotive nitrogen oxide emission standards. Moreover, stricter future standards may be warranted after we learn more about atmospheric pathways and lake vulnerability.

An improved understanding of the Sierra lakes' vulnerability can help policy makers formulate siting criteria that will avoid, or at least limit, the adverse effects of fossil-fuel combustion on water supplies. The effects of acid rain will probably be most severe in high-altitude lakes with predominantly granitic bedrock and sparse vegetation, in central- and southern-Sierra regions. Accordingly, decisions about where to locate large, fossil-fuel burning facilities should be made in light of what is known about atmospheric transformation of pollutants, and the deposition and effects of acidic compounds in these sensitive regions. Meteorological information on the movement of air masses and pollutants in California can suggest where acid might be deposited, and these areas can be monitored. This information can be used in making decisions about where to build power plants or large industrial facilities. In this way, vulnerable areas could be protected from pollution.

State environmental assessment procedures do not currently require that new facilities be evaluated in terms of their potential contribution to acid rain. There is a

precedent, however, for requiring specific impacts to be evaluated (e.g., impacts of projects on energy consumption). Environmental impact reporting for new refineries, and for petroleum or coal-fired electric generating plants, could thus be required to include full discussion, using the best available scientific information, of the facility's probable contribution to acid deposition, and of the possible impact the acid deposition will have on the state's sensitive ecosystems. The analyses might include information on emissions, meteorological trends, and existence of sensitive ecosystems downwind of proposed new sources. We believe that such environmental impact reporting ought to be required in California.

Conclusion

The California Legislature recognized the importance of the acid-rain problem by creating the Assembly Select Committee on Acid Precipitation to evaluate existing evidence on acid deposition and recommend legislation. In February 1982, Assembly Bill 2752 was introduced, proposing the Kapiloff Acid Deposition Act, designed to finance and implement a coordinated monitoring and research effort administered by the California Air Resources Board. This legislation was passed by the California Legislature, and signed by the Governor in September 1982. This act is a reasonable first step toward controlling acid deposition and limiting its deleterious effects. It authorizes not only monitoring and research to define the extent and nature of the problem in California, but also calls for an analysis of possible control strategies, including emission-control technologies, alternative-energy policies, and air-quality management strategies. This kind of research and analysis can lay the groundwork for effective future regulation.

Delay in regulation, after the extent of the problem is recognized, could mean loss of the valuable goods and services society derives from healthy ecosystems.[19] Many ecological effects are either irreversible or very costly to remedy. Now that we know something about the sensitivity of the Sierra aquatic systems, these data should be used in regulatory decision making. The potential for significant damage should not be ignored until damage has occurred. Even if some of the initial regulations should later prove to be too strict, it would be easier to modify regulations than to restore damaged ecosystems.

Through a reasoned consideration of (1) the best scientific information on the subject, and (2) the economic impact of possible regulations, public policy makers can attempt to formulate regulatory strategies to protect ecosystem quality. Resolution of the scientific and economic uncertainties should result in more effective policies for control of acid-rain damage.

FIGURE 1

Distribution of Sierra Lakes pH's
Measured in 1980-81 (n=26)

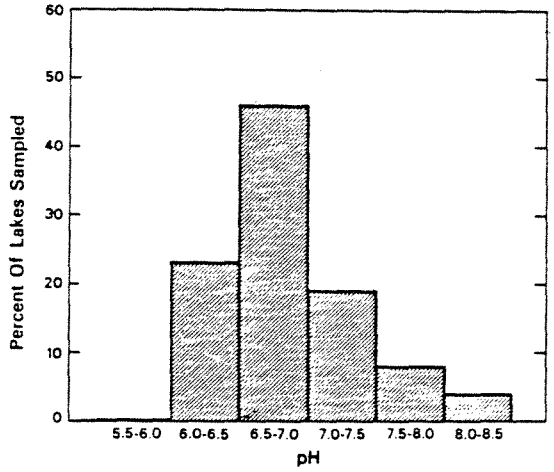


FIGURE 2

Distribution of Sierra Lakes Alkalinities
Measured in 1980-81 (n=26)

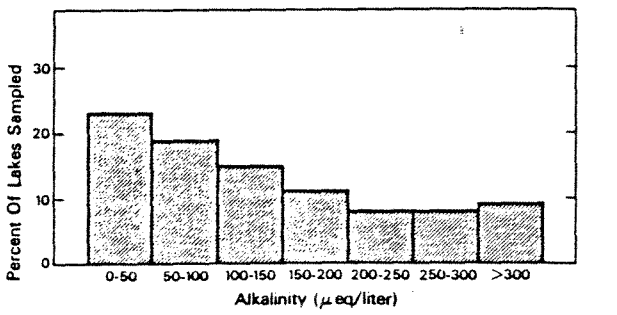
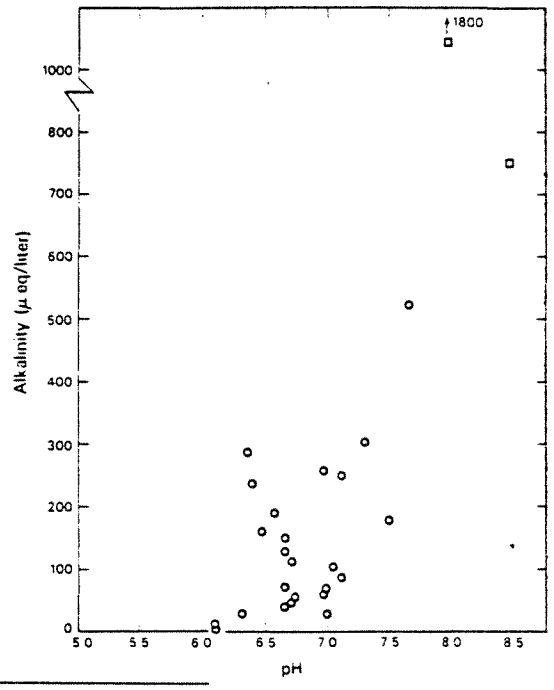


FIGURE 3

pH and Alkalinity for Sierra Lakes
Measured in 1980-81 (n=26)



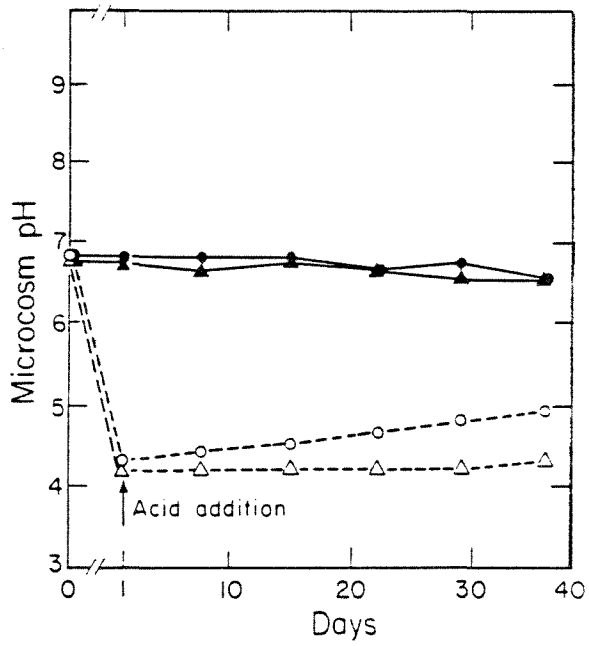
Legend:

o = a high-elevation Sierra lake.

□ = a lower-elevation reservoir.

FIGURE 4

Changes in pH of Microcosms (simulated lake systems), the Mosquito Lake Experiment



Legend:

▲——▲ Controls

●——● Controls with sediment

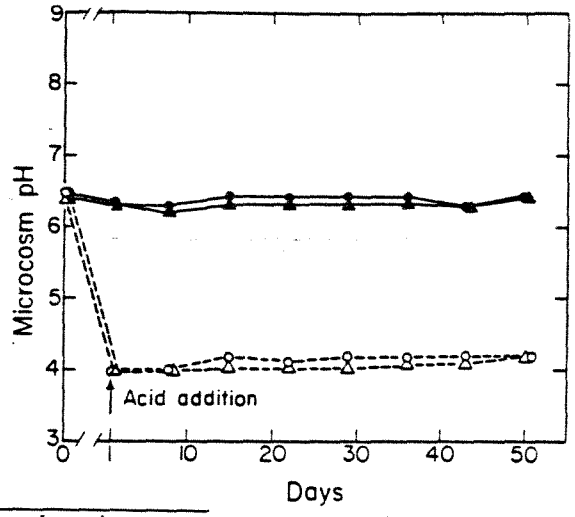
△---△ Treatments

o---o Treatments with sediment

Note: The experiment covered five weeks.

FIGURE 5

Changes in pH of Microcosms (simulated lake systems), the Tenaya Lake Experiment

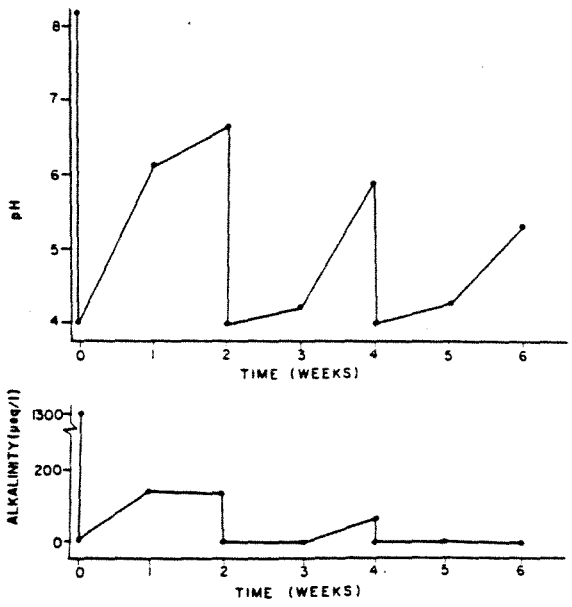


Legend:
- Controls
- Controls with sediment
- Treatments
- Treatments with sediment

Note: The experiment covered seven weeks.

FIGURE 6

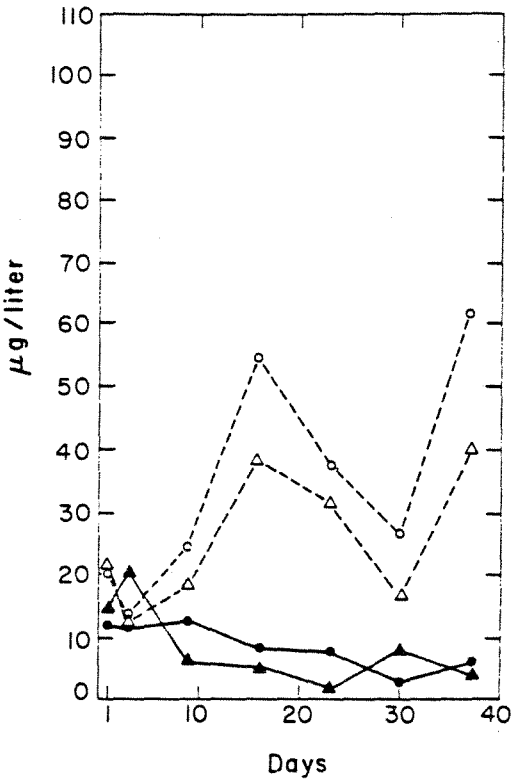
Loss of Buffering Capacity in Briones Reservoir Microcosms (simulated systems)



Notes: Acid was added at weeks 0, 2, and 4.
The experiment covered six weeks.

FIGURE 7

Levels of Dissolved Aluminum Measured During the Mosquito Lake Experiment

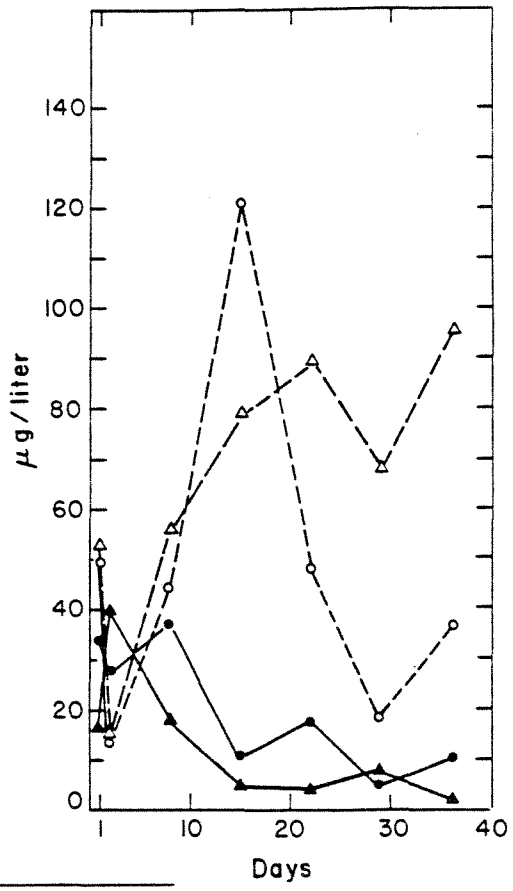


Legend:
- Controls
- Controls with sediment
- Treatments
- Treatments with sediment

Note: The experiment covered five weeks.

FIGURE 8

Levels of Dissolved Iron Measured During the Mosquito Lake Experiment



Legend:

▲——▲ Controls

●——● Controls with sediment

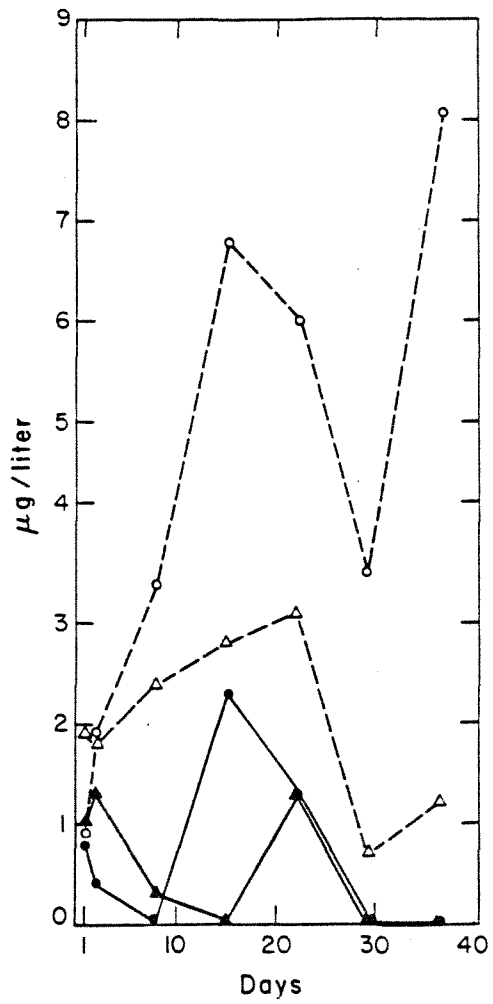
△---△ Treatments

o---o Treatments with sediment

Note: The experiment covered five weeks.

FIGURE 9

Levels of Dissolved Manganese Measured During the Mosquito Lake Experiment



Legend:

▲——▲ Controls

●——● Controls with sediment

△---△ Treatments

o---o Treatments with sediment

Note: The experiment covered five weeks.

NOTES

Kathy Tonnessen is a Research Associate and John Harte is a Professor in the Energy and Resources Program, University of California, Berkeley.

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1. See the report by E. Barret and G. Brodin, "The Acidity of Scandinavian Precipitation," *Tellus*, 7: 251-257 (1955), for a discussion of some of the early data collected on acid rain occurrence in Scandinavia.

2. See, for example, U S Department of Interior, Office of Water Research Technology, C.L. Schofield, *Acid Snowmelt Effects on Water Quality and Fish Survival in the Adirondack Mountains of New York State*, Research Programs Technical Comprehensive Report No. A-072-NY. (1977).

3. For a complete discussion of possible effects of acid rain on forests, crops, and soils, see the symposium volume *Effects of Acid Precipitation on Terrestrial Ecosystems*, T.C. Hutchinson and M. Havas, eds. (New York: Plenum Press, 1980).

4. See, for example, J. McColl, *A Survey of Acid Precipitation in Northern California*, Final Report #A7-149-30 to the California Air Resources Board (February 19, 1980); and J.J. Morgan and H.M. Liljestrand, *Measurement and Interpretation of Acid Rainfall in the Los Angeles Basin*, Final Report to the California Air Resources Board (February 29, 1980).

5. The pH scale measures the acidity or alkalinity of solutions, in a range from 0-14, with decreasing numbers indicating increasing acidity, and larger numbers signifying higher alkalinity. Because the pH scale is logarithmic, each unit decrease corresponds to a ten-fold increase in acid content. Distilled water with a pH of 7 is considered neutral. Precipitation is often considered acid if its pH is below 5.6, the normal value for unpolluted precipitation in equilibrium with atmospheric carbon dioxide (CO_2).

6. See the forthcoming report, "Proceedings of the California Symposium on Acid Precipitation" (Sacramento: California Air Resources Board, 1982).

7. Buffering capacity is the ability of a lake to recover by neutralizing acid that enters the lake basin as rain, snowmelt or dry deposition. The normal pH of Sierra lakes is near neutrality, (pH7) but the lakes have a very low buffering capacity (alkalinity) of only 10-500 μeq/liter (micro-equivalents per liter). A lake's alkalinity is defined as the amount of material available to neutralize any added acid. A well-buffered system typically has an alkalinity greater than 1000 μeq/liter. Studies of the alkalinity of Sierra lakes by Professor J. Melack of U.C. Santa Barbara also demonstrate the low alkalinity of these systems. (See the *Proceeding of the American Water Resources Association, International Symposium on Hydrometeorology,* Denver, Colorado (June 13-17, 1982).

8. See, for example, D.S. Jeffries, C.M. Cox, and P.J. Dillon, "Depression of pH in Lakes and Streams in Central Ontario during Snowmelt." *J. Fish. Res. Board Can.* 36:640-646 (1979), for a discussion of this concentration effect in Canada. Similar observations in Norway are described in, M. Johannessen and A. Henriksen, "Chemistry of Snow Meltwater: Changes in Concentration During Melting," *Water Resources Research* 14(4):615-619 (August 1978).

9. These processes include the weathering of rocks and biological production, which can yield acid-neutralizing products.

10. See K. A. Tonnessen, "The Potential Effects of Acid Deposition on Aquatic Ecosystems of the Sierra Nevada, California," Ph.D. dissertation, Energy and Resources Group, U.C. Berkeley, 1983 (in preparation).

11. For a review of data on increases in trace-metal concentrations in acidified lakes, see the report of the National Research Council of Canada, *Acidification in Canadian Aquatic Environment: Scientific Criteria for Assessing the Effects of Acidic Deposition on Aquatic Ecosystems,* NRCC Report No. 18475, pp. 189-192 (1981).

12. Water samples were collected at mid-day at three stations in each lake (the shore, the mid-lake surface, and the maximum depth at which a standard black and white disk, called a secchi disk, can be seen by an observer). Some lakes were sampled in two consecutive years; others were studied once. Standard methods were used for all chemical measurements: the lake pH was measured using a Sargent-Welch pH meter with glass, combination electrode; alkalinity determinations were made by Gran titration with 0.01 $\underline{N}$ HCl. Trace-metal concentrations were measured by atomic-absorption spectrophotometry.

13. A μg/l (microgram per liter) is equal to a part per billion on a weight-of-metal per weight-of-water basis.

14. For a general discussion of the aluminum leaching phenomenon, see C.S. Cronan and C.L. Schofield, "Aluminum Leaching Response to Acid Precipitation: Effects on High-Elevation Watersheds in the Northeast," *Science,* 204:304-306 (April 20, 1979).

15. See two articles in D.S. Shriner, et al., *Atmospheric Sulfur Deposition Environmental Impact and Health Effects* (Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., 1980). In this volume, stream acidification experiments in Hubbard Brook Experimental Forest are described in R.J. Hall and G. Likens, "Ecological Effects of Whole-Stream Acidification." Canadian experiments with lake acidification are described in D.W. Schindler, "Ecological Effects of Experimental Whole-Lake Acidification."

16. Points on the graphs of metal concentrations vs. time represent the mean ($\bar{X}$) of the replicate tanks. These values have standard deviations of 10 to 15 percent in most cases. Differences in the mean concentrations between treatments and controls are significant at the 99 percent confidence level.

17. Data on changes in zooplankton and phytoplankton populations are included in K. A. Tonnessen, "Potential for Aquatic Ecosystem Acidification in the Sierra Nevada, California," in the *Proc. Symp. Acid Precipitation: Aquatic Effects,* G. Hendrey, ed. (Ann Arbor, Michigan: Ann Arbor Science Publishers, 1983).

18. The similarity of precipitation composition on the western slope of the Colorado Rockies and that of the L.A. Basin is discussed in J. Harte, G.P. Lockett, and R.A. Schneider, "Acid Precipitation and Surface-Water Vulnerability on the Western Slope of the High Colorado Rockies" (submitted for publication to *Environ. Sci. Technol.)* Lawrence Berkeley Laboratory, Berkeley, CA.

19. Goods derived from healthy ecosystems include fish, lumber, and agricultural crops. Services include the regulation of air quality; the maintenance of water quality, storage, and flow; the moderation of climate; the maintenance of a genetic "library" for future generations; the cycling of essential nutrients within and between soil and water; and the breakdown of toxic wastes to harmless products. For a full discussion of these goods and services, along with an evaluation of the ways energy technologies can degrade them, see J. Harte and A. Jassby, "Energy Technologies and Natural Environments: the Search for Compatability," *Annual Review of Engergy,* 3: 101-146 (1978).

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