tion potential and do not consider detailed economic and technical constraints.)

In addition to these water-use and wastewater production statistics, there are cost considerations. Through the Clean Water Grant Program, billions of dollars will be spent over the next decade to meet state and federal water quality standards. In fact, a State Board survey shows that California needs to build $5 billion worth of sewage treatment facilities just to meet the needs of its projected population in 1990. With this much money going into secondary treatment facilities, and with the urgent need for additional water supplies, it makes little sense to treat and waste.

Using reclaimed water

Against this background, the State Board determined that good water management policy dictates that reclaimed water be considered as an important source of water supply. The Reclamation Policy and Action Plan for California is its response.

Initially, the Board intends to concentrate its efforts to implement wastewater reclamation in water-short coastal areas of the state. There are two reasons for this decision: These are the areas where the highest production of treated wastewater occurs, and these are also areas highly dependent on an imported source of water.

The greatest use potential is expected to be for industrial purposes (primarily cooling), irrigation, and groundwater recharge. There are no plans to include reclaimed water as part of the domestic water supply, because many questions first must be resolved. The research and demonstration program called for by the Policy and Action Plan is aimed at learning more about the health effects and environmental impacts associated with long-term use of reclaimed water. As part of the Action Plan, and following the recommendations of a consulting panel of nationally known experts, the Board is recommending $4.2 million in research and demonstration projects to be conducted over a 5-year period. In addition, it is recommending to the Legislature that additional research funds be made available as part of the next Clean Water Bond issue that the Legislature is expected to submit to the people in 1978.

Water reclamation projects

Today there are about 194 water reuse and reclamation projects throughout California using treated water for agriculture, landscape irrigation, artificial lakes, industrial and power-plant cooling, and ground-water recharge. Approximately 34 more projects are in the planning or construction stage using federal and state monies provided through the Clean Water Grant Fund, and other projects are being built with private funds. For the most part, all of these projects are small, producing from 0.01 to 15 million gallons daily (MGD) of reclaimed water.

Now, with the Policy and Action Plan, we are in a position to move ahead, so that in the competition for funds reclamation projects will be given a higher priority.

We are not asking anyone to drink reclaimed water. We are not asking anyone to degrade their ground-water basins. We are not asking anyone to surrender their water rights. We are asking that reclaimed water be given its rightful recognition as part of the total water resources of the state so that it can be managed in the most comprehensive and intelligent manner possible.

Copies of the plan and other information on reclamation are available upon request by writing the State Water Resources Control Board, P.O. Box 100, Sacramento, California 95801.

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Wildlands and watershed management

Robert H. Burgy ■ Theodore E. Adams, Jr.

California foothill and mountain watershed lands are the primary runoff-producing areas in the state, yielding about 95 percent of the usable water supply. Nearly 65 million acres of forests, brushlands, and mixed woodlands and grass areas comprise the state's wildlands. Of these, the vegetation zones most adaptable for multiple land-use management are the brush (chaparral) and woodland grass cover types. These areas are generally situated in the lower and intermediate elevations on the mountain slopes surrounding the agricultural valleys and are used principally as rangelands. Surveys of vegetation and land use indicate over 30 million acres of such lands could be managed to enhance their productivity for watershed protection and water yield, as well as forage and wildlife habitat.

The potential benefits for water-resource conservation and for rangeland improvement have long been recognized and programs of vegetation control and conversion have been applied to over 2 million acres in California. Results of these programs, executed cooperatively by landowners and managers on both private and public lands, have been highly successful in achieving gains in range production and in modifying hydrologic characteristics to generate additional runoff waters. Studies by water scientists, hydrologists, ecologists, and agronomists have confirmed the water yield increases on pilot tests conducted throughout the state.

Quantitative studies of the hydrologic responses of watersheds where dense vegetative cover has been replaced with range and forage grasses have consistently shown increases up to 50 percent or more (equivalent to 3 to 5 acre-inches per acre) in annual runoff over long periods of measurement. These runoff studies cover the variety of conditions found in northern and central California, and have also been confirmed under similar conditions throughout the world. About half the yield increase occurs in the latter portion of the season, giving usable flow in dry periods. The balance of the increase is produced as increased outflow during the post-storm periods.

The most effective responses in terms of both range production and water-yield augmentation have been gained on sites where annual precipitation is greater than 15 to 20 inches. About 10 to 15 inches of rainfall are generally required to satisfy the moisture storage capacity of watersheds before any effective increases in runoff can be derived.

Well-planned and well-executed treatment programs on watersheds also have demonstrated that: (1) the runoff produced is of good quality and (2) by careful evaluation of site conditions, vegetative conversions may be conducted without environmental degradation.

In addition, wildfire risk is reduced through reduced fuel concentration and greater accessibility to remote sites for control of wildfire, and livestock water supply is better distributed on ranges, both in location and in availability throughout the season. Evaluation of these and other beneficial aspects of vegetation control indicates increasingly favorable economic assessments of the cost-effectiveness of wildland management programs.

In developing multiple land-use

management programs, however, other factors must be considered to provide complete information about direct and indirect impacts—including environmental issues.

Questions about the accrual of useful water yield and its true value need to be resolved. For example, changes in watershed vegetative cover type and reduction in density will result in greater quantities of runoff—but part of it will be delivered during the wet season in regions where no storage capacity is available to hold the additional water until it might be beneficially used. Some have suggested that this is a nonbeneficial result. However, recent constraints on water quality and quantity of flow that must be maintained in major river systems in California tend to favor management policies upstream that will generate more runoff from tributary watersheds. Likewise, during critical drought periods, the prior reduction of nonbeneficial use of water by native trees and shrubs or by riparian plants near streams—and, in some instances, by the phreatophyte types that may develop along water courses—will be invaluable aids in conserving limited supplies of runoff waters.

Water-conservation measures and water-supply schemes should be planned in concert. Programs to increase the yields of watersheds—including precipitation modification programs to gain more input to the watershed and upstream or downstream developments to gain greater efficiency for water production—must recognize the inherent potential of many vegetative types to use up greater amounts of water if it becomes available. Such increased water losses may radically detract from the desired watershed response.

Site selection and management plans need to be carefully devised to incorporate knowledge of soils, geology, and vegetative growth characteristics as well as other watershed factors that could create undesirable or environmentally unacceptable results, such as accelerated soil erosion, degradation of the quality of runoff waters, or increased flood risks.

A reevaluation of management methods to consider current and future needs of total watersheds, including the downstream components, is needed.

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Ground-water management

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If adequate water supplies are to be continually available, and if periods of drought are to be dealt with effectively, management of ground water is essential on every farm and in every city, county, water district, and region using ground-water resources.

Ground-water management means having short- and long-range plans for efficient use of that resource. Traditionally, there has been concern that ground-water management has involved formal agreements, regulations, pump taxes, controls, or other forms of legal constraints. This need not be the case. Successful management involves a clear understanding of the needs, a concise definition of the goals, and a realistic implementation scheme that can be achieved by cooperation and coordination.

In California, ground water is a significant resource that must be developed and wisely used and conserved. The gross storage capacity of the ground-water basins of California is estimated to be more than $1{,}000 \times 10^6$ acre-feet, whereas the gross storage capacity of surface reservoirs in the state, under planned development, will be only 77×10^6 acre-feet. Only part of the ground-water storage capacity is usable from a physical or economic point of view, but estimates place the usable storage at well over 250×10^6 acre-feet. This will be more than five times the total available active storage of all surface reservoirs that are planned for construction in California.

Management of this large ground-water resource is essential if it is to meet the supply and storage needs of the future. Management is also required if undesirable effects such as land subsidence, salt-water intrusion, deteriorating water quality, and higher pumping costs are to be minimized.

Management by individuals

What can the individual well owner do to manage ground water? He can:

- Carefully assess his water requirements, including alternative supplies, seasonal requirements, quality considerations, and maximum short-term needs.
- Locate, design, construct, and develop new wells in accordance with modern design criteria to meet specific needs.
- Operate new and old wells, individually or in groups, to achieve maximum efficiency.
- Monitor well and pump performance and maintain operating records.
- Rehabilitate wells as required.

Design of wells should consider localized effects, such as mutual interference among wells, geologic boundaries, and presence of surface streams for recharge purposes. Also, a well owner who has both surface and ground-water supplies should, in general, make use of the surface supply during wet periods and rely on ground water during dry years. This will make better use of the ground-water storage.

Regional management

How can effective ground-water management be accomplished on a regional scale? The geologic and hydrologic boundaries of a ground-water basin do not normally coincide with the boundaries of those political entities that might need to manage ground water. The regional management area usually includes various jurisdictions—cities, counties, water districts, and possibly others.

Traditionally, ground-water management on a regional basis has been in response to crisis situations—such as drastic lowering of water levels, unacceptable deterioration of quality, notable land subsidence, or critical shortage of surface supplies. These problems have been dealt with largely via lengthy and costly litigation or negotiation. Design and implementation of a ground-water plan in advance of a major crisis could minimize such litigation, as well as inefficient use of water and supply shortages during dry periods.

Effective ground-water management within a region consists of setting policy and developing and implementing a plan. The policy should establish long-range goals that consider economic principles, social values, environmental considerations, and institutional constraints. The plan should include specific objectives, such as determining the quantity and quality of the ground-water resource, developing technically feasible management alternatives, evaluating those alternatives, and implementing appropriate action. The plan also should provide for regular monitoring of ground-water conditions and for periodic updating.

Creating ground-water management policies is extremely difficult in light of existing ground-water law and the relatively unregulated approach to the ownership and use of ground water. Nevertheless, policies must be established based upon two factors: (1) current quantity and distribution of ground water in the region and (2) its quality.

Policies on quantity may vary