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WATER SALINITY PROBLEMS: APPROACHES TO LEGAL AND ENGINEERING SOLUTIONS*

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The purpose of this article is to acquaint the legal profession with the nature and extent of some of the salinity problems of the arid West today.[1] Although no complete estimates have yet been made, the economic consequences of excessive salinity[2] will probably run into the billions of dollars.[3]

"Salinity"—perhaps more accurately "mineralization"—of fresh water supplies presents a number of difficult problems in water quality controls: To what extent should we seek to prevent or reduce

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1. The technical data and analyses contained in this article (*e.g.*, ways of measuring salinity, effects of salinity on the use of water, and mechanics of saltwater intrusion) are general and sometimes oversimplified. They are presented solely for the purpose of enabling readers of this article to understand the nature of the problems and solutions.

2. *See* FWPC Administration, U.S. Dep't of Interior, Water Quality Criteria: Report of the National Technical Advisory Committee to the Secretary of the Interior 113 (1968): "[O]nly very preliminary assessments have been made of the economic consequences in terms of the cost of reducing salinity."

In this article, "FWPC" means "Federal Water Pollution Control" as in "FWPC Act" and "FWPC Administration."

3. The FWPC Administration, for example, has reported that "excessive salinity in fresh water is another difficult non-point source problem" for which "the eventual remedial costs . . . will be *very high*" (emphasis added). U.S. Dep't of Interior, FWPC Administration, The Cost of Clean Water: Summary Report at 37 (1968). The FWPC Administration has not quantified the term "very high" in dollars; but, for context, one might observe its companion estimate that cash outlays to meet project waste treatment, sanitary sewers, and water cooling requirements for the five fiscal years 1969-1973 would approximate 26 to 29 billion dollars. *Id.* at 9, table 1.

salinity? What practical means are available to control salinity and what new methods can be developed? What institutional tools are available to impose salinity controls and what new tools can be devised?

Our approach here is a pragmatic one—to examine the means by which these salinity problems are being probed and solved. To restrict the scope of the article to reasonably workable limits, we consider only problems associated with mineralization of normally fresh water supplies caused by man's withdrawal and use of water. By way of examples, a case study is utilized in each of these three areas: (1) Seawater intrusion into ground water basins; (2) saltwater tides moving up streams that flow into the ocean; and (3) increased salinity concentrations in a highly developed river basin in an arid area.

I
NATURE OF THE PROBLEM

A. DEFINITION OF SALINITY AND HOW IT OCCURS

"Salinity" is the popular term used to describe minerals in solution in water. Rainwater in the atmosphere has negligible mineral constituents, but water withdrawn from surface and underground sources does contain varying amounts of minerals in solution. These minerals are dissolved from the rocks and soils over or through which the waters have passed.

In humid areas, the heavy rainfall carries soluble salts present in soils into ground water or into surface streams and thereby to the ocean. Saline soils are thus almost nonexistent in humid regions except where soils are subjected to seawater intrusion in river deltas or other low-lying lands near the sea.

Saline soils do occur in hot arid regions. High evaporation rates concentrate salts in the soils and in surface waters, and there is not sufficient natural rainfall to leach out and dispose of soluble salts. Salt springs contribute highly saline water to streams in many parts of the arid western United States.

Man also contributes to salinity problems. He adds mineral constituents to the water, as by an industrial waste discharge. He increases the concentration of the minerals already in solution by his activities that reduce the amount of water, as by evaporation from a reservoir (pure water evaporates, leaving the same amount of salts in the lesser quantity of water remaining in the reservoir).

Return flow from irrigation increases salt concentrations in many ways. Water applied to the soil leaches out soluble salts in the soil and adds them to the stream. Since a substantial portion of applied water is consumptively used by evaporation and plant transpiration, the salt concentration of the drainage water will necessarily be greater (from two to ten times) than the salt concentration of the diverted water.[4] In addition, during the water's journey through the soils, the proportions of the chemical constituents in the water may change in a manner that reduces even further the utility of the water. For example, an increase can occur in the relative chloride content of the salts, thus making the water less fit for chloride-sensitive crops, such as fruit trees.[5]

Just as a bookkeeper must balance his books, an irrigator must be concerned with the "salt balance" on his irrigated lands. He must wash accumulated salts from the soil. He must apply sufficient water to meet the water requirements of his crops and also to provide additional water to leach from his soil the salts deposited there by his irrigation water. Drainage facilities may have to be installed in order to remove water from the soil at a rate necessary to accomplish these purposes.

The concept of "salt balance" is simply this: The amount of soluble materials that should be removed from the soil of an irrigated area is at least equal to the amount entering the area from all sources.[6] If irrigation water is bringing in more salts than are going out, the irrigator is failing to maintain salt balance. His land will gradually become saline, less productive, and ultimately sterile.

Without adequate drainage, the water table may rise to within a few feet of the surface of the ground. Ground water then may move by capillary action upward into the root zone and to the soil surface, evaporating at that point and leaving its salts behind on the soil.

B. WAYS OF EXPRESSING SALINITY LEVELS[7]

Mineral constituents in water are identified and measured in a laboratory by means of quantitative analytical procedures. In work-

4. Bower, *Salinity Control in Irrigation Agriculture and its Effect Upon Stream and Ground Water Quality,* in Agricultural Waste Waters 59, 60 (Water Resources Center, Univ. of Cal., Rep. No. 10, 1966).

5. *Id.* at 59.

6. For example, suppose that irrigation water contains one ton of salts in each acre-foot, and an irrigator applies 1,000 acre-feet of water to his lands each year. He is bringing in 1,000 tons of salts per annum. If the salt outflow is only 600 tons per annum, he is leaving 400 tons of salts each year on and in his soils. The return water must carry out 1,000 tons or more of salts in order to maintain salt balance.

If the irrigator needs to wash accumulated salts from his soil, then his salt outflow must *exceed* salt inflow.

7. For fuller discussion of ways of measuring and expressing salinity levels, see U.S. Dep't of Agriculture, Agric. Info. Bull. No. 283, Salt Tolerance of Plants (1964); U.S. Geological Survey, U.S. Dep't of Interior, Water Supply Paper No. 1473, Study and

ing with salinity problems, it is necessary to consider not only the total amount of solids dissolved in the water, but also the makeup of those solids (*i.e.*, its chemical constituents). Some minerals are more harmful than others, and some are more harmful to one type of use than to another.

Weight measurements, which are the most commonly used methods of expressing salinity levels, are used in this article in explaining salinity problems. However, other expressions of salinity levels are easier to determine or are more useful in solving engineering problems. Since these other expressions of salinity levels will be found in literature on the subject, two of the more common expressions are also briefly described below.

1. In Terms of Weight

The most common method of reporting salinity levels is to express the weight of the total dissolved solids (TDS) in the water. There are several ways of doing this:

In the metric system, TDS is expressed in terms of "milligrams per liter" (mg/1)—that is, there are so many thousandth parts of a gram of TDS per liter (1000 grams) of solution (water plus TDS). In English units, the term "parts per million" (ppm) is used —that is, there are so many pounds of TDS per million pounds of solution. One mg/1 is approximately equal to one ppm.

In talking about irrigation waters, the salt content is often expressed in terms of "tons per acre-foot," that is, there are so many tons of salts in an acre-foot of water.

2. In Terms of Electrical Conductivity

In many instances it is necessary to know only the approximate total amount of salts in solution. This information can be conveniently estimated from the "electrical conductivity" (EC) or, as it is sometimes called, "specific electrical conductance" of the solution.

Salt molecules, in solution, split up to produce electrically charged particles called "ions." Pure water is a very poor conductor of electricity, but the salt ions in a water solution can carry an electrical current. The higher the electrical conductivity of a solution, therefore, the greater is the concentration of salts in the solution.

EC is usually expressed in micromhos per centimeter ("EC x 10^6" being the shorthand expression)—*i.e.*, the conductivity of an elec-

Interpretation of the Chemical Characteristics of Natural Water (1959); U.S. Dep't of Agriculture, Agric. Handbook No. 60, Diagnosis and Improvement of Saline and Alkali Soils (1954).

trical current through a cube of solution one centimeter on a side at 25° centigrade. In a given solution TDS, expressed as ppm or mg/1, increases or decreases in the same proportion as EC increases or decreases.

3. IN TERMS OF CHEMICAL EQUIVALENTS

As noted above, salts dissolved in water dissociate into electrically charged ions. The ionized salts thereupon yield "cations," which are positively charged ions, and "anions," which are negatively charged ions. The principal cations are sodium, potassium, calcium, and magnesium; and the principal anions are sulfate, chloride, bicarbonate, and nitrate.

For some purposes, a useful refinement in expressing salinity levels is to account for mineral concentrations not in terms of weight but rather in terms of the concept of "chemical equivalents." Elements entering into chemical combinations do so in proportion to their combining or equivalent weights. Chemical equivalence is determined by dividing the values of each ion in ppm by the combining weight of that ion (atomic or molecular weight divided by ionic charge). The term "equivalents per million" (epm) has been generally adopted to express these values.

The distinction between cations and anions, expressed in terms of equivalents, also provides a check for the accuracy of measurement. Cations and anions always travel in pairs. Expressed in chemical equivalents, the sum of the cations should equal the sum of the anions. Any substantial discrepancy indicates an error of measurement.[8]

4. INTERRELATIONSHIPS

Each of the foregoing methods of expressing salinity is convertible to any other method if the mineral constituents are known. For example, four and a quarter ounces of table salt (NaCl) dissolved in 50 gallons of pure water would be reported as follows:

a. *Total Dissolved Solids (TDS):*
   640 ppm.
   640 mg/1.
   0.87 tons per acre-foot.

b. *Electrical Conductivity (EC):*
   1000 micromhos per centimeter at 25° C (77° F).

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8. *See, e.g.*, Hill, *Transitory Irrigation Developments*, 35 Civil Eng'r 57 (March 1965); U.S. Dep't of Agriculture, *supra* note 7, at 69 (1954).

c. Chemical Equivalents:

10.95 epm sodium (252 ppm sodium).

10.95 epm chloride (388 ppm chloride).

In the water solution, the chemical equivalents of the sodium cations, which are the positive ions, must equal the chemical equivalents of the chloride anions, which are the negative ions. It should be noted also that although the chemical equivalents of sodium and chloride are (and must be) equal, the former at 252 ppm weighs about one third less than the latter at 388 ppm. (The 252 ppm of sodium plus the 388 ppm of chloride equal the 640 ppm TDS).

C. EFFECTS OF SALINITY ON UTILITY OF WATER

1. IN GENERAL

Salinity cannot be seen, and it has no odor. Hence, unless salinity is extremely high it usually has no detrimental effect upon recreation, water contact sports, or fish and wildlife. (There are exceptions: Certain fish spawn in fresh water. The food chain for some is dependent upon fresh water.) It usually has no effect upon navigation, hydroelectric generation, or esthetic enjoyment. (Again, there may be exceptions: Salinity may cause corrosion in pipes used in some of the older hydroelectric generation plants.)

Biologically and chemically, salts are not subject to degradation nor, except within minor limits, settling out.

High salinity has adverse effects upon most domestic, industrial, and irrigation water uses. At its lower levels, however, salinity, within a wide range, has little or no effect upon health. Its detrimental effect is solely economic.[9]

2. SPECIFIC USES

a. Domestic

The United States Public Health Service has developed standards for the quality of drinking water. The latest edition of these standards[10] states that the TDS of drinking water should not exceed 500 ppm where more suitable supplies are or can be made available.[11] However, many areas utilize supplies for drinking water with a TDS above 500 ppm and even higher than 1000 ppm, although these high

9. *See* A. Kneese, The Economics of Regional Water Quality Management 100 (1964).

10. Public Health Service, U.S. Dep't of Health, Education & Welfare, Drinking Water Standards (1962). These standards have been endorsed by the American Water Works Association and have been widely adopted.

11. *Id.* at 7.

ranges of salinity adversely affect taste. Salinity in excess of 5000 ppm renders water completely unusable for drinking.[12]

The problem of hardness of water is related to salinity. Excessive hardness of water causes increased consumption of soaps and detergents, faster wear of clothing, increased cost of water softening, and formation of scale in pipes and fittings.

b. Industrial

Industrial water is put to a wide variety of uses, some of which are very sensitive to salinity and hardness. Processing water in breweries, textile mills, and chemical plants requires water with less than 300 to 400 ppm. Otherwise, the salinity will contribute an undesirable taste or color to the manufactured product.

Boiler feedwaters must be low in mineral content to avoid frequent and costly maintenance and replacement necessitated by mineral residues deposited in the equipment. Low pressure boilers can tolerate a TDS of 300 ppm, while modern higher pressure boilers should have only a few parts per billion.

Water used for industrial cooling should be low in salinity to minimize the cost of treatment for inhibition of corrosion and scale formation. In addition, water with a low TDS can be reused oftener, thus reducing the amount of makeup water required.

Water used for washing and other general purposes need not be of high quality.

c. Irrigation

Ancient irrigators in arid regions did not recognize that each application of water deposited some salts on their irrigated lands. Unless washed out by natural means as in the Nile Valley, these salts caused the land to become less and less productive and finally sterile. As this happened, irrigation simply ceased on that land and was moved elsewhere. Since man could not then identify the problem, there was nothing he could do about it. Thus, excess salinity undoubtedly contributed to the failure of many early civilizations.[13]

As one of our most perceptive observers has deduced:

> I recall seeing the traces of one irrigation system of almost text book pattern, which must have served at least 200,000 acres, in an area now virtually uninhabited between the Tigris and the Euphrates about half

12. *Id.* at 34.

13. FWPC Administration, U.S. Dep't of Interior, Water Quality Criteria: Report of the National Technical Advisory Committee to the Secretary of the Interior 113 (1968); Bower, *supra* note 4, at 57.

> way between Bagdad and Basra. . . . [I]t was apparent from the lack of vegetation and the color of the soil that this once productive area had been destroyed by too much salt. Of the once great Chaldean Empire only ruins remain. The city of Ur, near the Persian Gulf, is now surrounded by a salt flat. These are not exceptional conditions; they are characteristic of the region. All that remain of most of the city-states of Mesopotamia are a few ruins, a few traces of irrigation works, and an expanse of barren land.
>
> We can only surmise that water logging of the irrigated land near each city took place with concurrent accumulation of salts in the soils, forcing abandonment of these and progressive extension of irrigation into other areas further away from the central city. We can only surmise further, because there was no transportation in the modern sense, that this drain on the economy of each such city continued until it was either conquered and destroyed, or was simply abandoned. We do know, nevertheless, that great areas of irrigated land were permanently abandoned and that the dependent city-states are now only names in history. . . .[14]

Today it is well known that crops are adversely affected by soil salinity that goes above certain limits. Soluble salts in irrigation water will accumulate in the soil unless they are removed. Thus, in good irrigation practice more water is applied than is required for maximum plant growth so that the excess salts can be carried away from the root zone. This procedure is called "leaching." The higher the salinity of the irrigation water, the greater the quantity of water required for leaching.

Increasing salinity in water is a definite economic deterrent in irrigated agriculture. As the salinity increases, the irrigator must purchase, transmit, distribute, and remove more water to obtain the same crop yield. If the water supply is limited, he will have to reduce his acreage or shift to crops more tolerant to salt, although they are not necessarily as profitable. If the natural drainage capacity of the soil is insufficient, he will also have to go to the expense of installing drainage facilities in his fields.

The salinity factor in irrigated agriculture is rather complicated. The type of soil, the salinity of the water applied, the composition of the salts in the water, the type of crop grown, and irrigation procedures all have their effects. All other factors remaining constant, however, increasing salinity of the irrigation water will reduce the crop yield per unit of irrigation water applied.

14. Hill, *supra* note 8, at 56.

II
NATURE OF THE SOLUTIONS

A salinity problem presents three major issues: First, what are the desirable levels for salinity in a given supply of water? Second, what methods are available to achieve improved salinity levels or maintain existing levels? Third, what institutional arrangements are needed to implement the plan?[15] The answers will depend upon economic, legal, and engineering factors, as well as upon political considerations.

A. ESTABLISHING DESIRABLE SALINITY LEVELS

The desirable salinity levels in a given water supply look somewhat different to an economist, a lawyer, a legislator or other government official, various water users, and an engineer.

To an economist, excessive salinity in water presents the classic case of a "technological external diseconomy."[16] In the context of this article, this mouth-filling phrase means that a problem exists because one person degrades the water, and a different person suffers an economic loss as a result.[17] Thus, the former does not take into account the effects of the degradation that he has caused in someone else's supply, whereas the latter must take into account all effects of the degradation caused in his water supply by someone else. As a result, the person degrading the water has no incentive to consider (1) alternative use of greater value that could have been made of the water by others if he had not degraded it, and (2) efforts that he might have made to reduce the effect of his wastes per production unit so that he does not unnecessarily commit water resources to waste disposal.[18]

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15. *See* Kneese, *supra* note 9, at 4:

> Water quality management raises three main issues. How do we determine the quality of water we want to maintain in our streams? How do we devise the best physical systems for achieving that quality? And how do we determine the best institutional arrangements for administering and managing water quality?

16. *Id.* at 36, 40.

17. Translated, "technological" means the transfer of costs from one unit to another independent unit by technical or physical connections between their production processes; "external" means that the effect of the diseconomy is outside of the unit causing it; and "diseconomy" means uneconomical; that is, that cost of production is less valuable than some other alternative. *Id.* at 40-41.

A more descriptive phrase is "spillover effects" or "third-party effects," in which the effects of pollution caused by one unit spill over to damage other independent units. *Id.* at 40.

18. *Id.* at 42-43.

A necessary corollary of the second proposition in the text is, of course, that under

"Technological external diseconomies," if left uncorrected, tend to result in resource misallocations. Suppose that factory *A* discharges a waste that precludes the use of the water by factory *B*, which has no feasible alternative supply. Suppose also that the net profits from factory *B* would greatly exceed the net profits from factory *A*. If the same person owned both factories *A* and *B*, he would take some action to eliminate the pollutant discharged by factory *A*. He could, for example, close factory *A*, or treat the wastes, or discharge the wastes at a location where they would not enter the water supply of *B*. This would produce optimum economic use of the water resource. However, if one person owned factory *A* and another owned factory *B*, then the owner of *A* would have no incentive to go to the trouble and expense of eliminating the degradation.[19] This is the "technological external diseconomy."

The foregoing example suggests a method of "internalizing the externalities" by operating a basin as if it were owned by one person. Thus, pollution would be reduced until the cost of eliminating the next unit of pollution was greater than the consequent reduction in pollution damages. One could say that the net costs of pollution abatement have thereby been minimized, or conversely (but identically as to result) that the net benefits have been maximized.[20]

"Internalizing the externalities" is a method of determining theoretically what are optimum salinity levels in a given water supply. The least costly remedies would be utilized to reduce salinity as long as the cost thereof was less than the benefits derived from the reduction in salinity. The desirable salinity level from the economist's point of view is reached when the cost of removing the next unit of salinity would exceed the benefit to be derived therefrom.[21] Of course, the monetary quantification of both costs and benefits is often quite difficult.

To a lawyer, where increases in salinity levels are caused by the extraction and use of water, vested water rights can have an important effect upon the determination of optimum salinity levels.

certain circumstances it may be most economical to commit water resources to waste disposal to some extent. This approach must be tempered by a policy that the proper course is the conservative one of erring, if at all, on the side of safety to assure water of adequate quality for all beneficial uses to be protected. See Lynch, Gindler & Stanton, *Coordinated Resource Development: Legal Controls of Water Quality in a Marine Environment,* 44 Los Angeles Bar Bull. 154, 183-84 (1969).

19. *Cf. id.* at 40-41.

20. *Id.* at 48-52.

21. *Id.* at 49-52.

Not all effects of mineral degradation are external. A person pumping from a ground water basin adjacent to the ocean may be causing seawater intrusion into that portion of the aquifer underlying his own land as well as into the supply of others.

Suppose that in a ground water basin adjacent to the ocean the pumping by inland user *A* is contributing to a condition that permits seawater to intrude into a part of the basin from which wells of user *B* are pumping. The relative priority of their water rights may determine what private rights, if any, *B* may exercise to prevent the seawater intrusion being caused by *A*.[22] If *B*'s rights are senior to *A*'s rights, *B* can sue to reduce or stop *A*'s extractions.[23] If, on the other hand, *A*'s rights are senior to *B*'s, then *B* has no private legal remedy against *A*.[24]

But private vested rights can be compensated in money as well as by water. Thus, optimum resource development may dictate that *A* be compensated for reducing his pumping under his senior water rights. The costs of such salinity abatement may still be less than the resulting benefits of a basin free from saltwater intrusion.

To a legislator or government official, the problem has still other facets. Suppose that salinity levels have been increasing because of irrigation practices of federal reclamation projects. The executive and legislative branches of the government may hesitate to take the position that a substantial portion of the federal investment should be abandoned to improve salinity levels downstream. Indeed, water users' attitudes are often fiercely and emotionally held, so that restricting or closing of a water project, even with adequate compensation, will be strongly opposed.

Salinity objectives are easier to sell if the remedy proposed is dilution or (perhaps) improvement in irrigation practices, rather than restricting or closing a water project. Building new projects to provide dilution, for example, is one way to get reelected in the area benefited. Closing down projects is not.

Thus, an engineer can conceive a technological solution to a problem; but before a project can be built, it must be determined whether (a) the project is economically feasible, (b) financing and repayment can be arranged, (c) institutional arrangement for construc-

22. Priorities to the use of water from an underground basin may be established in many ways. In California, for example, if the basin has not been overdrawn for five consecutive years overlying users, who have correlative rights, are senior to exporters of water out of the basin, who have only appropriative rights; and those appropriators take among themselves in inverse order of priority of appropriation. When a ground water basin has been overdrawn for five years, persons who have been pumping for five consecutive years have proportionate rights established or retained by prescription that would be senior to the rights (actually nonrights) of persons who have not been pumping for five consecutive years. *See* W. Hutchins, The California Law of Water Rights 431-60, 503-06 (1956).

23. Allen v. California Water & Tel. Co., 29 Cal. 2d 466, 176 P.2d 8 (1946).

24. *See* Gindler, *Water Pollution and Quality Controls,* 3 Waters and Water Rights 60-61, 75, 89, 96-109 (R. Clark ed. 1967), regarding the rights of senior water rights holders to pollute the water supply as against junior water rights.

tion of the project exists or can be established, and (d) the project is politically feasible.

In short, establishment of desirable salinity levels, from a practical view, depends upon whose ox is to be gored, and how badly. Yet all these views must be considered, evaluated, and integrated into any proposed solution.

B. METHODS OF ACHIEVING DESIRABLE SALINITY LEVELS

There is sufficient technical knowledge available to improve salinity levels in a water supply. However, there are not too many ways that are practical and economical. For example, desalination would be an ideal solution to excessive salinity if it could provide a sufficient amount of water at a low enough cost. To date, it cannot.

Analytically, there are five methods for dealing with excessive salinity:

1. REDUCTION IN SALT INCREASES OR CONCENTRATIONS. If water users curtail their extractions and use of water, salinity levels should tend to improve. A cutback in pumping from a ground water basin adjacent to the ocean would tend to limit seawater intrusion into the basin. Similarly, a restriction on diversions from a stream flowing into the ocean will leave more water to stem incoming tides. A reduction in the consumptive use of water by agriculture would reduce the concentrating of salts by irrigation return flows.

The cutback-of-uses approach is very unpopular among the water users who would be restricted. However, a cutback in one source of supply is more acceptable where the cutback, proportionately, is small, and an alternative source is available that is reasonably priced under the circumstances.[25]

Technical improvements can also hold down increases in salinity levels. For example, irrigation can be conducted upon the least saline soils available, where there is a choice of areas to be irrigated. Or salts can be transported to a disposal area where they cannot reach a fresh water supply. For example, the ocean is an ideal dumping area for waste waters whose only fault is that they are too salty.

25. This is the situation that permitted the reasonably speedy settlement of the Central Basin adjudication suit in Los Angeles County. Central & West Basin Water Replenishment Dist. v. Adams, No. 786656 (Cal. Super. Ct., Los Angeles County, Oct. 20, 1965). Each party's pumping right from the ground water basin is restricted to 80% of his adjudicated water right. However, imported water is available for all users from the basin, either directly or by way of exchange, through The Metropolitan Water District of Southern California. Uses in the Central Basin area are almost entirely municipal and industrial, with only a very small percentage of agricultural uses.

In some areas in the West, point sources of salinity, such as salt springs, can be diverted away from a river, thus reducing the salinity problem of that river. However, this may create a new or different problem at another place.

2. REMOVAL OF SALTS. Desalination has been mentioned as a way of treating salty water. It could be applied to the wastes being discharged, the water supply while it is in transit, or the waters being diverted for use. To date, except for unique situations, desalination has not demonstrated economic feasibility for municipal and industrial water supplies. Even if it does become feasible in the future in some areas for those purposes, the cost will be prohibitive to the bulk of agricultural users. And, even where it can be afforded, desalination may simply change the problem. Except where an ocean is handy, what do we do with the concentrated brine that results from desalination?

Consequently, desalination is considered only briefly in this article.

3. DILUTION. New better-quality water can be brought in (such as by transbasin diversion or weather modification) and mixed with the lower-quality native water. Conservation of water (such as by reduction of reservoir evaporation or elimination of phreatophytes) will reduce the concentration of salts because there will be more native water to dilute the same amount of salts.

Reservoirs can be used for low-flow augmentation (discharge of higher flows to dilute the water when salinity levels are rising), and conversely, but equally effective where it can be practiced, the most saline wastes could be discharged during times of higher flows.

4. ADJUSTMENT OF USES. The water user can undertake certain modifications of his practices to offset an increase in the salinity of his water supply. He can change to crops that are more tolerant to salts, and he can apply additional irrigation water to leach out salts from his soils. Of course, he may end up growing less profitable crops and achieving lower crop yields per unit of applied water, but that is better than no crops at all.

Where salt water intrusion into ground or surface water supplies occurs, wells or diversion structures can be moved inland or upstream respectively. However, this solution would be expensive, and it may prove temporary if the intrusion continues to move in.

5. COMBINATION OF METHODS. The foregoing methods of dealing with excessive salinity are not mutually exclusive. Some or all of them may be applied simultaneously or seriatim. For example, where irrigation return flows have greatly concentrated the existing salt

content of a river, the proper remedy may be a combination of irrigating the least saline soils (method 1), bringing in better quality water from another basin to mix with the river water (method 3), and growing salt tolerant crops with applications of the necessary leaching water (method 4).

C. INSTITUTIONAL ARRANGEMENTS

Private solutions would seem to have limited efficacy in handling salinity problems. Where a small number of firms are involved, market solutions are possible. For example, the downstream water user could buy out the upstream water user so that the former could receive water with lower salinity levels. Or, if the equities are with the downstream user, the upstream user could buy him out so that the upstream user could increase salinity levels downstream without restraint. But situations in which the market machinery could operate usefully in this manner are rare in our modern society.[26]

Similarly, private litigation does not often provide an effective means for control of water quality. Suits are brought on a haphazard basis, without regard to developing a comprehensive water quality control program. Damages are difficult to recover because a large number of persons are affected but each has relatively small damages. Prescriptive rights to pollute may be established.[27] Occasionally, however, litigation may provide the incentive and the machinery to shape agreements for controlling salinity.

In the main, therefore, public intervention is necessary to seek optimum utilization of water resources in the handling of salinity problems.[28]

Salinity usually presents complex basin-wide problems. The affected basin, such as a ground water basin, may be located entirely within one state. But some river basins, such as the Colorado River Basin, cross state and even international boundaries. Furthermore, the extraction and use of water is only one cause of increasing salinity levels. As we have seen, there are many other causes, both natural and man-made.

This nature of salinity problems suggests that they can be best resolved on a regional level.[29] A regional agency could be established

26. Kneese, *supra* note 9, at 45-46.

27. *Id.; see also* Gindler, *supra* note 24, at 29-30.

28. Kneese, *supra* note 9, at 53. *See also* Martin, Birkhead, Burkhead & Munger, River Basin Administration and the Delaware 125 (1960).

29. For a more detailed discussion of the reasons for a regional approach, see A. Kneese, Approaches to Regional Water Quality Management 2-3 (RFF Reprint No. 64, 1967).

to deal solely with salinity,[30] but it is more likely that it would be formed to handle a broader range of water quality or water utilization problems. Thus, a regional agency may provide water quality management for the basin,[31] or it may provide river basin management in all respects including water quality.[32]

To do its job, the regional agency would have to produce or be provided with a comprehensive plan showing the desired salinity levels.[33] It would have authority to take action to seek those levels,[34] but in many instances it would look to other governmental instrumentalities to assist in implementing the master plan. It should be able to marshal a complete arsenal of tools to deal with salinity problems.

Sometimes a regional agency that can deal effectively with a salinity problem will already be in existence. At other times, one will have to be created for that purpose. Occasionally the problem will be dealt with by supervening state or federal authorities. Not infrequently differences arise among local, state, and federal officials regarding what should be done about salinity levels. Many times these differences have been worked out through negotiation.

III
ANALYSIS OF SPECIFIC SALINITY PROBLEMS

Three case histories will be used to analyze specific instances of salt water intrusion into ground water basins, salt water tides moving up streams that flow into the ocean, and increased salinity concentrations in highly developed river basins in arid areas.

In addition to involving mineralization of normally freshwater supplies that is caused by man's withdrawal and use of water, these case histories have two further points in common. First, each case history has wholly or partially a California setting. The authors are most familiar with the problems of their state, and California has each type of problem. Second, each case history presents a problem

30. *See* Delta Water Agency Act of 1968, Cal. Water Code App. §§ 108.1.1 et seq. (West Supp. 1968).

31. *See* Kneese, *supra* note 9, at 99-119, for a description of salinity problems on the Ohio River system and methods proposed by the staff of Ohio River Valley Sanitation Compact ch. 581, § 1, 54 Stat. 752 (1940), an interstate compact established to provide water quality controls on the Ohio, and by Dr. Kneese. This analysis is limited to problems of salinity contributed by waste discharges and excludes salinity problems occurring in arid areas caused by natural sources and irrigation return flows.

32. *E.g.*, Delaware River Basin Compact, Pub. L. No. 87-328, 75 Stat. 688 (1961).

33. *See* Kneese, *supra* note 29, for criteria to evaluate regional water quality management organizations.

34. *See* Gindler, *supra* note 24, at §§ 229.1-.4, for a discussion of the administrative power of a water quality and pollution control agency.

not yet completely resolved. Thus, we can speculate upon the procedures now being followed to resolve each problem; and, perhaps at some later date, we can reexamine them to ascertain whether these procedures have been successful or at least useful.

A. SEAWATER INTRUSION INTO GROUNDWATER BASINS: OXNARD BASIN, VENTURA COUNTY, CALIFORNIA

1. BACKGROUND AND HISTORY

a. *Mechanics of seawater intrusion*

The problem of seawater intrusion into ground water basins has had a long and widespread history. During the middle and late 1800's, ground water being pumped in parts of Europe adjacent to the ocean became salty. Two European scientists, W. Badon Ghyben in 1889 and Bairat Herzbert in 1901, independently and correctly postulated that seawater was intruding into the freshwater aquifers.[35] Today seawater intrusion is a problem of international proportions.[36]

Seawater intrusion is a potential problem whenever a freshwater aquifer is in contact with the ocean. This contact may occur at the shoreline or, where confined pressure aquifers are involved, may extend beyond the shoreline and under the ocean floor.

Seawater intrusion can occur only when the pressure head of the seawater exceeds that of the fresh ground water, a condition which usually results when ground water levels are lowered to or below sea level by extractions from wells. When the hydraulic gradient within a coastal ground water basin slopes seaward, ground water is moving toward the ocean. Conversely, when the slope is reversed, seawater is moving landward. Where extremely small seaward gradients of the fresh water exist, both conditions can exist simultaneously with the lighter fresh water floating on the heavier seawater with very little mixing.

The seawater front assumes the shape of an inclined surface, called a seawater wedge because of its shape, which slopes landward and advances or recedes in response to changes in the hydraulic

35. *See* Cal. Dep't of Water Resources, Bull. No. 63, Sea-Water Intrusion in California app. C at 9, 43 (1958).

36. *Id.* at 49-71 for a discussion of seawater intrusion in the United States (Calif., Conn., Fla.. Hawaii, N.J., N.Y., Tex., Va., and Wash.) and internationally (Bahama Islands, Belgium, England, France, Germany, Japan, and the Netherlands).

See also Y. Kahana, *Some Aspects of Ground Water Management,* U.S. Dep't of Agriculture, Fresno Field Station, Proceedings: 1965 Biennial Conference on Ground Water Recharge, Development and Management H-10 (1966) on seawater intrusion in Israel.

gradient. Continued pumping of the fresh water inland lowers the freshwater level of more of the aquifer below sea level, causing the seawater wedge to intrude further inland.[37]

b. Control of seawater intrusion in California

In California, prevention of seawater intrusion has been treated as one aspect of total ground water basin management. In 1961 the California legislature enacted the Porter-Dolwig Ground Water Basin Protection Law.[38] It declares the primary interest of the people of the state in the correction and prevention of irreparable damage to ground water basins or impairment of their use caused by overdraft, depletion, seawater intrusion, and degraded water quality[39]

The Porter-Dolwig Act authorizes California Department of Water Resources, when money has been appropriated for that purpose, to initiate or participate in studies for construction of projects deemed by the department to be practical, feasible, and urgently needed to accomplish the purposes of the act.[40] As used in the act, "project" includes any facilities "to prevent, stem, or repel the intrusion of sea water" into a ground water basin or to improve the quality of its waters.[41]

Before 1960 the Department of Water Resources had conducted six ground water basin studies in cooperation with local agencies at costs ranging from $37,000 to $76,000. Since 1960 and primarily in response to the Porter-Dolwig Act, several major ground water studies have been conducted or initiated in cooperation with local agencies at costs running into the millions of dollars.[42]

37. Cal. Dep't of Water Resources, *supra* note 35, at 15-16, app. C at 11-12. The specific gravity (ratio of weight of substance to weight of water) of saline water is greater than the specific gravity of fresh water. Therefore, under the Ghyben-Herzberg principle, at an interface of fresh and salt water, the saline water will be held stationary when the fresh water table is maintained at an adequate elevation above mean sea level. *Id.* app. C at 11.

The specific gravity of seawater is 1.025 times that of fresh water. Therefore, at an interface of fresh and salt waters, there will be forty feet of fresh water below sea level for every foot of fresh water above sea level. The formula is: $H + T = 1.025\ H$, or $T = 1/40\ H$, where T is the height of the fresh water table above sea level and H is the depth of the fresh water below sea level. *Id.* at 15-16.

38. Cal. Water Code §§ 12920-23 (West Supp. 1968). For resumes of investigations under the act, see Price, *The Porter-Dolwig Law—Four Years Old* and Porter, *The Approach to Groundwater* in U.S. Dep't of Agriculture, Fresno Field Station, Proceedings, *supra* note 36, at A5, B1; Cal. Dep't of Water Resources, Local Participation in Ground Water Basin Management Studies (1967).

39. Cal. Water Code § 12922 (West Supp. 1968).

40. *Id.* at § 12923.

41. *Id.* at § 12921.3.

42. Cal. Dep't of Water Resources, *supra* note 38, at 8-12.

c. Seawater intrusion in the Oxnard Basin

One of the areas being studied pursuant to the Porter-Dolwig Act is the Oxnard Basin in southern Ventura County, California. A progress report on seawater intrusion into that basin was issued in March 1967,[43] and final reports on management of that basin are now scheduled by the Department of Water Resources for 1971. The Oxnard Plain is shown[44] in Fig. 1.

In the 1880's artesian flows were prevalent on the Oxnard plain, and fresh water flowed toward the ocean. A rapid expansion of agriculture resulted in an increasing use of water from the Oxnard aquifer, the major aquifer in the Oxnard plain.[45] The first sign of water quality degradation in the Oxnard Basin was noted during a drought period in the early 1930's, when water levels were reduced to as much as five feet below sea level near the coast. The salinity of several wells near the coast indicated the possibility of seawater intrusion into the Oxnard aquifer. However, the salinity decreased as ground water levels recovered during the wet period of the late 1930's and 1940's, and water levels in the aquifer remained above sea level during that time.[46]

After 1945, the Oxnard aquifer again experienced declining pressure levels. By 1949 the levels had been lowered to more than 30 feet below sea level in some areas of the Oxnard Basin. By 1952 seawater was actively invading the aquifer, and wells near Port Hueneme and Point Mugu were producing waters with increasing amounts of chloride. In 1965 seawater intrusion had advanced 2½ to 3 miles inland in the vicinity of Port Hueneme and at Point Mugu. It is estimated that seawater intrusion is advancing at a rate of approximately 1200 feet per year.[47]

By 1965 approximately 4900 acres in the Port Hueneme area were underlain by waters which contained chloride in concentrations in excess of 100 ppm, and approximately 5700 acres were similarly affected in the vicinity of Point Mugu. This represents the degradation of 255,000 acre-feet of ground water in storage and a loss of

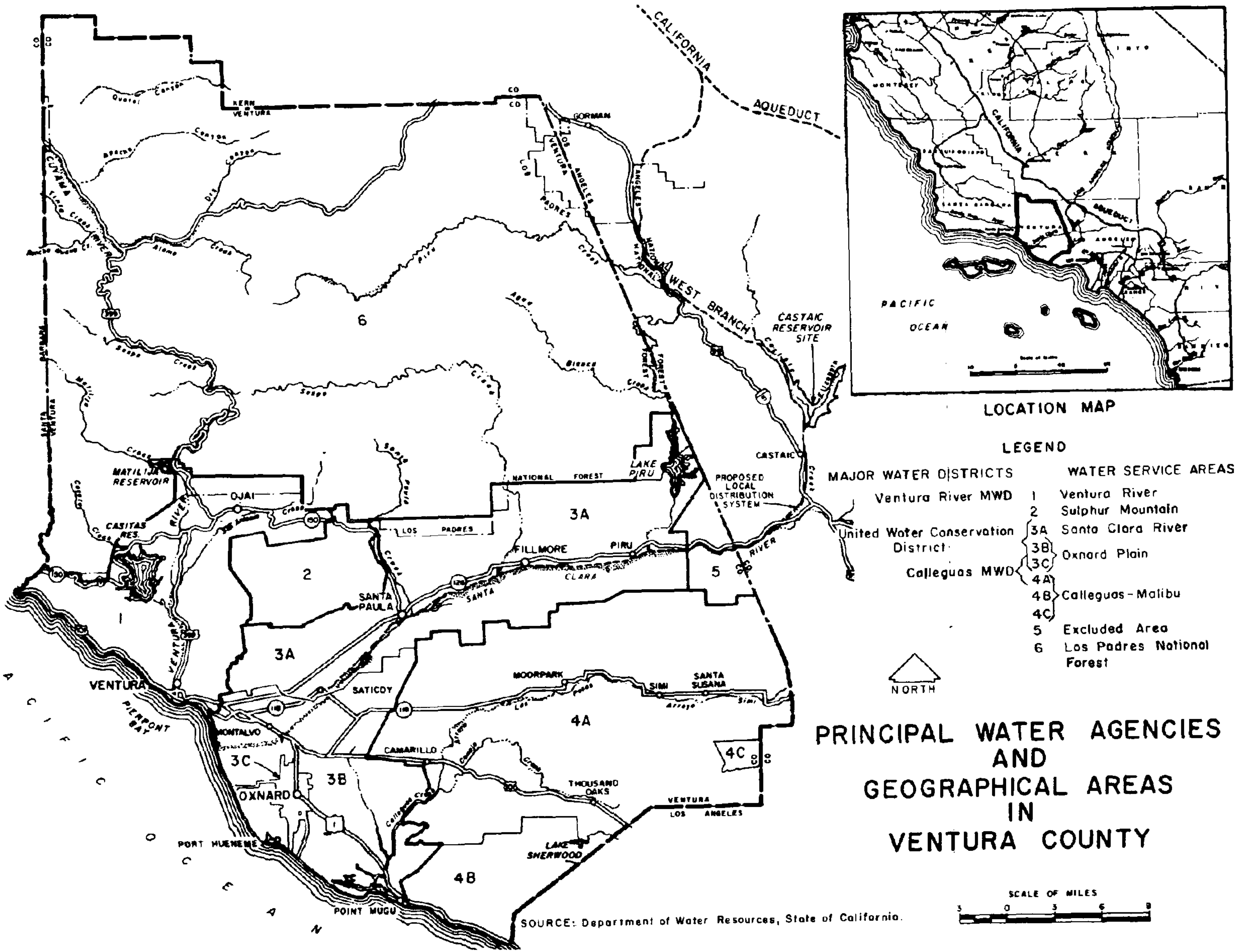
43. Cal. Dep't of Water Resources, Ground Water Basin Protection Projects: Oxnard Basin Salinity Barrier, Ventura County—Progress Report (1967), [hereinafter cited as Oxnard Basin Progress Report]. The discussions herein relating to the Oxnard Basin have been drawn largely from this report. Naturally, the findings or conclusions in this progress report may be changed before the investigations are completed and the final reports issued.

44. The map was obtained from the California Department of Water Resources.

45. Oxnard Basin Progress Report 34.

46. *Id.* at 1.

47. *Id.* at 1, 8, 55.



PRINCIPAL WATER AGENCIES AND GEOGRAPHICAL AREAS IN VENTURA COUNTY

SOURCE: Department of Water Resources, State of California.

usable storage capacity of about 169,000 acre-feet for the Oxnard Basin as a whole.[48]

2. Establishing Desirable Salinity Levels

Ocean water off the Oxnard coast, which has a TDS of about 34,000 ppm,[49] will totally destroy the utility of fresh water in the portion of the aquifers into which it is intruding.[50]

To decide from an economic viewpoint whether further sea-water intrusion should be prevented, the costs of protecting the basin must be compared with the benefits derived from the basin and the water stored in it. Economic justification is determined by comparing benefits with costs. As presented by the Department of Water Resources, the annual benefit to be derived from a barrier to prevent the intrusion of ocean water into the basin is the protection of its four principal beneficial uses.[51]

a. *Value of the annual water supply of the basin*

The department estimated that if the average annual dependable supply of groundwater from the Oxnard Basin of 46,000 acre-feet were totally lost, the economic loss, conservatively valuing water at $15 per acre-foot, would be $690,000 a year. Of course, this loss would occur gradually, but without a barrier, a complete loss seems inevitable.

The figure of $15 per acre-foot as the value of the water in ground water storage seems low. The logical alternative source of supply would be The Metropolitan Water District of Southern California. If the balance of the Oxnard area is brought within Metropolitan (only a part is within Metropolitan now), several million dollars in back taxes would have to be paid to Metropolitan for that portion of the Oxnard area presently outside of Metropolitan. The Oxnard area would also have to pay from $20 to $40 per acre-foot (the cur-

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48. *Id.* at 8, 54-55.

Unfortunately, the ground water supply of the Oxnard Basin is never of better than marginal quality. As the department succinctly reported:

> The usable ground waters of the Oxnard Basin are being threatened from all sides, except possibly from below. While sea water is moving in from the ocean, inflowing waters from inland areas are entering with increasingly greater salt loads, and wastes discharged on the ground surface are degrading the shallow semiperched zones. . . .

49. *Id.* at 55.

50. Water with a TDS in excess of 3000 ppm is considered either unsatisfactory or injurious for domestic, irrigation, and most industrial uses. *See* Cal. Dep't of Water Resources, *supra* note 35, at 13-14.

51. Oxnard Basin Progress Report 60-62.

rent prices for untreated irrigation and for domestic water respectively) for imported water purchased from Metropolitan.

b. Value of the basin as a distribution unit

The expenditure of several million dollars would be required to provide surface distribution facilities to areas now served by pumping ground water. In addition, there would be operation and maintenance costs for any surface distribution system.

c. Value of the basin as a storage unit

Surface water reservoirs with capacity to control the average annual supply of 46,000 acre-feet are estimated to cost in excess of $9 million.

d. Value of water in storage as emergency supply

Although it is difficult to assign a dollar value to it, the ground water basin has value as an emergency water supply and distribution system. When surface supplies become unusable (*e.g.*, by contamination) or imported supplies are temporarily interrupted, ground water remains available, and can reduce economic loss and possibly even assure survival.

Hence, the benefits of protecting the Oxnard Basin seem to be worth several million dollars per year plus substantial other values that are difficult of monetary quantification. Since these benefits are likely to exceed the apparent costs of any seawater barrier plan, the Department of Water Resources has tentatively concluded in part that "because of the potential value of the Oxnard Basin as a storage and distribution unit in planned basin operation, corrective measures should be implemented to protect it from further seawater intrusion."[52]

The California courts have recognized the need for protecting ground water basins from continuing and unrestricted overdraft,[53] including protection from seawater intrusion.[54] In fact, one trial

52. *Id.* at 8.

53. Pasadena v. Alhambra, 33 Cal. 2d 908, 207 P.2d 17 (1949).

54. Allen v. California Water & Tel. Co., 29 Cal. 2d 466, 472, 474, 485-86, 176 P.2d 8, 12, 13, 20 (1946) [Tia Juana Basin in San Diego County]; California Water Service Co. v. Edward Sidebotham & Sons, 224 Cal. App. 2d 715, 721, 722, 724, 37 Cal. Rptr. 1, 4, 5, 6 (1964) [West Basin in Los Angeles County]. *See* Central Basin Water Dist. v. Fossette, 235 Cal. App. 2d 689, 696, 45 Cal. Rptr. 651, 655 (1965) [Central Basin in Los Angeles County].

Seawater intrusion was also alleged to be a basis for irreparable injury in other ground water adjudication suits. *See* Central & West Basin Water Replenishment Dist. v. Adams, No. 786656 (Cal. Super. Ct., Los Angeles County, Oct. 20, 1965) [Central court has concluded, and correctly so it would seem, that an overdraft in a qualitative sense occurs when the level of extractions from the basin threatens seawater intrusion.[55] These holdings would protect both the ground water basin and its water supply, although the methods of protection available to the courts, primarily through reductions in pumping, may not be the most effective or economical.

3. METHODS OF ACHIEVING DESIRABLE SALINITY LEVELS

Of the four basic methods of achieving improved salinity levels,[56] only one seems practical with regard to seawater intrusion. Dilution might be temporarily feasible when intrusion begins and salinity levels begin to go up. Adjustment of uses might also be feasible temporarily when intrusion begins.[57] However, both methods would have to be eventually abandoned as water from intruded areas became poorer in quality. In short, the only practical remedy for seawater intrusion is to prevent it and thereby eliminate salinity increase from that source. The following methods are available either singly or in combination.[58]

a. *Use of artificial surface recharge (spreading basins)*

Large quantities of imported water spread on the ground can raise ground water levels above sea level if total recharge exceeds extractions and if the aquifer transmissibility is high enough to convey the water from the recharge site to extraction site. Seawater intrusion would stop and pumping lifts would be reduced. In the Oxnard Basin, this method has limited use due to (1) the high cost of imported water, (2) low aquifer transmissibility limiting the quantities which can be recharged, and (3) the necessity of leaving ground water storage capacity for natural inflows.

Basin in Los Angeles County]; Orange County Water Dist. v. City of Chino, No. 117628 (Cal. Super. Ct. Orange County, filed Oct. 18, 1963) [Santa Ana Basin in Orange, Riverside, and San Bernardino counties]. The latter adjudication was enlivened by an appellate writ proceeding not related to any salinity issue. Chino v. Superior Court, 255 A.C.A. 873, *modified,* 256 A.C.A. 41, 63 Cal. Rptr. 532 (1967).

55. San Luis Rey Water Conservation Dist. v. Carlsbad Mutual Water Co., No. 184855, at 10 (Cal. Super. Ct., San Diego County, filed Aug. 3, 1959) [Mission Valley Basin in San Diego County].

56. *See* p. 340-41 *supra.*

57. *But see* Allen v. California Water & Tel. Co., 29 Cal. 2d 466, 483, 176 P.2d 8, 19 (1946) [overlying owner not limited to raising crops with high tolerance to salinity, even though salt water intrusion is a claimed danger; "he is entitled to sufficient water for such crops as may normally be raised under conditions of noninfringement of his water supply"].

58. Oxnard Basin Progress Report 65-71, 122-32.

b. Reduction of ground water extractions

If ground water extractions were reduced below the annual basin supply, ground water levels in the basin would slowly begin to rise, eventually above sea level. Seawater intrusion would be ended, and pumping lifts would be reduced. In the Oxnard Basin, the disadvantage of this method is the cost of importing, storing, and distributing large quantities of water for direct surface distribution to replace the ground water that could no longer be pumped.

c. Rearrangement of ground water extraction pattern

This method retards but does not stop seawater intrusion. Major extractions would be moved inland, creating a pumping trough with a steeper gradient on the landward side and a flatter gradient on the seaward side. Thus, the incursion of the ocean water would be slowed while the fresh water inflow from the recharge area would be increased. Legal enforcement to control extractions could present a problem, and a distribution system would be required to provide water to areas where extractions would be reduced.

d. Construction of a static physical barrier

A subsurface physical barrier, such as a puddled clay barrier, would reduce the permeability of water-bearing materials, thereby precluding subsurface inflow of seawater. With a physical barrier, water levels could be drawn down below sea level as a part of planned basin management, thus providing maximum available storage capacity for recharge. On the other hand, since a physical barrier has never before been constructed to the depth required in the Oxnard Basin, many important factors are unknown; *e.g.,* duration, stability, and ability to withstand earthquakes and high differential pressure heads.

e. Construction of an injection ridge

Fresh water could be injected to create a ridge along the coast. The fresh water could be injected so that 80-90 percent would flow landward. The advantages include full utilization of the basin, maximum storage capacity kept available, and recharge of the basin from injected water. The chief disadvantage is that surplus water for injection is not presently available; however, more imported water may become available in the future, and ground water could possibly be used for the barrier.

f. Construction of extraction trough

An extraction or pumping trough consists of a line of extraction wells along the coast that would lower water levels below the basin levels at the coast. In effect, seawater moving inland would flow down into the trough, since the freshwater levels landward of the trough would slope seaward. By continual pumping, the trough is maintained. Among its advantages are full utilization of the basin, maximum storage capacity kept available, and no surface fresh water required for its operation. Its disadvantages include the power demands for continuous pumping, possible dewatering of certain areas, need for maintenance and operation staff, and general lack of information on the operation of an extraction barrier. Furthermore, the pumping trough would lower ground water somewhat below the current levels, thus increasing pumping lifts.[59]

g. Construction of combination injection ridge and extraction trough

An extraction trough could be constructed seaward of an injection ridge. This combination would give the same results as either barrier alone but with only about one third as much pumping and slightly less fresh water for injection. The major advantage of this combination is that possible undesirable side effects of each alone (waterlogging of land from an injection ridge and subsidence from a pumping trough) may be reduced substantially.

Other combinations are possible. The amount of water required to maintain an injection ridge barrier is directly related to the depth of ground water levels. Hence, where an injection ridge has been constructed, pumping from the basin might be controlled and restricted to keep ground water levels from sinking too low.

The department has concluded at this time that "basin management techniques, such as artificial surface spreading, reductions in extraction, or rearrangement of extraction pattern, do not appear to be suitable for complete protection against seawater intrusion. . . ." It has further concluded that "a static physical barrier, an injection ridge barrier, and an extraction trough barrier" or "a combination of the latter two barrier types" could provide "complete protection from continued seawater intrusion."[60]

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59. From 1966 to 1968, an experimental extraction trough barrier constructed by the state near Port Hueneme was operated by United Water Conservation District with technical assistance by the Department. Oxnard Basin Progress Report 72-75. A report from the Department on the results of that operation is anticipated shortly. Counsel for the district advises that the barrier was unsuccessful.

60. Oxnard Basin Progress Report 8-9.

4. INSTITUTIONAL ARRANGEMENTS

a. *Specific problems in the Oxnard Basin*

Within the Oxnard Basin, an experimental extraction-type salinity barrier was constructed near Port Hueneme. By agreement between the Department of Water Resources and the United Water Conservation District, test operation of the barrier was handled by United for fiscal 1966-67 and 1967-68, with technical assistance from the department.[61] California's Water Conservation District law,[62] under which United was formed and operates, contains no express authority for a district organized thereunder to engage in activities to prevent seawater intrusion. However, the district's express power to "conserve" water[63] should imply the authority to do so by preventing seawater intrusion.[64] In addition, the district has express authority to drill, construct, install, and operate wells and other facilities, and may pump water therefrom for sale, delivery, distribution, "or other disposition."[65] The "other disposition" of water should include distribution or injection of water to conserve the basin supply by preventing seawater intrusion.

There are within the Oxnard Basin a number of water districts, including United Water Conservation District, as well as several municipalities. Legitimate differences of opinion may develop on local levels about the need for the expense of providing protection against seawater intrusion, what areas should bear such expenses in what proportions (i.e., issues of areas or zones of benefit) and the proper form of controls to provide such protection. Differences may develop as well between local interests on one hand and the state on the other, and such differences may require some determination by the state of its responsibility in preventing seawater intrusion to protect a basin and its water supply as a part of an integrated water plan for the state.[66]

Current institutional arrangements for prevention of seawater intrusion in the Oxnard Basin have been described as follows:

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61. *Id.* at 72, 74.
62. Cal. Water Code Div. 21 (West 1966).
63. Cal. Water Code § 74521. (West 1966).
64. *Cf.* 25 Op. Cal. Att'y Gen. 164 (1955), stating that irrigation districts, California water districts, and county water districts are empowered to engage in rainmaking under their general powers with respect to water.
65. Cal. Water Code § 74525 (West 1966).
66. *See* Cal. Water Code §§ 12922 (West Supp. 1968) [declaring that "the people of the State" have a "primary interest" in protecting ground water basins from *inter alia*, "sea water intrusion"] and 12922.1 (West Supp. 1968) [declaring that ground water basins are subject to, *inter alia*, "sea water intrusion" to the detriment of the people of the State].

> At present there is no single public agency empowered to accomplish the actions necessary to prevent and control seawater intrusion by all the methods discussed in this report. Effective control of intrusion could involve more than spreading waters or constructing and operating a barrier; it might also entail planned use and management of the entire basin. Management may, in turn, include limiting ground water extractions and rearranging pumping patterns.
>
> The implementation of a complete saline-water intrusion control program may involve legal complexities for which existing laws may prove to be inadequate. For example, no state agency or very few local districts have the authority to enforce a reduction of pumping or rearrangement of pumping patterns, except under a voluntary agreement among the affected parties or after a ground water adjudication. . . . A reduction of pumping may be effected indirectly by the levying of assessments or charges based upon the amount of ground water extracted; some public agencies have the power to levy such assessments or charges. A voluntary agreement among the affected parties or a court order is usually required, however, to substantially reduce pumping and to bring about a rearrangement of pumping patterns.[67]

b. *Property rights and litigation*

Even when sufficient centralized authority exists within a local area for a program to prevent seawater intrusion, certain other legal problems may arise as a byproduct of the particular program adopted because of its effect upon property rights in the area.[68]

Water rights might be affected in a number of ways. Operation of an injection ridge might accelerate the movement of the toe of the saline wedge into a freshwater area. Lowering of ground water levels could withdraw the supply from owners of shallow wells.[69] Holders of water rights should be entitled to compensation for rights taken or damaged by the program to prevent seawater intrusion.[70] Water rights might be used as the basis for distributing the costs of a program to prevent seawater intrusion, for furnishing water to persons entitled to it, and for payment of damages to those whose water rights are adversely affected.

In addition, a salinity barrier might damage real property in the basin. A freshwater ridge could raise water levels so as to waterlog the ground and impede drainage. A pumping trough might lower water levels so as to dewater some soils and cause subsidence. An

67. Oxnard Basin Progress Report 63.

68. *Id.* at 64-65; Krieger & Banks, *Ground Water Basin Management,* 50 Cal. L. Rev. 56, 73 (1962).

69. *See* W. Hutchins, The California Law of Water Rights 481-85 (1956).

70. Krieger & Banks, *supra* note 68, at 56, 73.

agency operating a salinity barrier should be empowered to compensate real property owners for such damages.

Litigation to reduce ground water extractions may be used for a number of purposes, including the need to restrict seawater intrusion into a basin. The leading California case is *Allen v. California Water & Tel. Co.*[71] where plaintiffs, holders of senior overlying rights, sought to enjoin defendant, holder of a subordinate appropriative right,[72] from pumping and transporting underground waters of the Tia Juana Basin (San Diego County) outside the natural watershed. The trial court found, among other things, that defendant's pumping had not caused seawater intrusion but might do so in a drought period.[73] The court held that plaintiffs were entitled to a judgment that would protect their decreed rights and that would protect them, pending a physical solution, against any exportation of water that would "unduly increase their cost of use or lower the underground water level below the danger point."[74]

In *California Water Service Co. v. Edward Sidebotham & Sons,*[75] plaintiffs filed suit to adjudicate water rights in the West Basin (Los Angeles County) and to enjoin the overdraft on that basin to prevent eventual depletion of the supply and "permanent injury by mineralization and salt water intrusion."[76] The trial court found that annual overdrafts since 1932 had resulted in continual lowering of the ground water elevations, "which permitted salt water infiltration"; that the overdrafts, "if allowed to continue unabated would result in a progressively increasing area of salt water infiltration"; and that this situation would lead to "eventual destruction" of the ground water in the basin and "elimination" of the basin as a common source of potable water supply.[77] The appellate court had "no question that the trial court had authority to limit the taking of ground water to protect the supply. . . ."[78]

In *Central & West Basin Water Replenishment District v. Adams*[79] plantiff sought an adjudication of water rights of all pumpers in the Central Basin of Los Angeles County and a restriction on their pumping. The complaint alleged among other things that a continuing overdraft and lowering of water levels resulted in sea-

71. 29 Cal. 2d 466, 176 P.2d 8 (1946).
72. *Id.*
73. *Id.* at 474, 176 P.2d at 13.
74. *Id.* at 485-86, 176 P.2d at 20.
75. 224 Cal. App. 2d 715, 37 Cal. Rptr. 1 (1964).
76. *Id.* at 721, 37 Cal. Rptr. at 4 (1964).
77. *Id.* at 722, 37 Cal. Rptr. at 5 (1964).
78. *Id.* at 724, 37 Cal. Rptr. at 6 (1964).
79. No. 786656 (Cal. Super. Ct., Los Angeles County, filed Jan. 2, 1962).

water intrusion into the Central Basin (Los Angeles County) in the vicinity of Alamitos Bay; that unless defendants' extractions were enjoined, continuing overdrafts would damage and destroy the basin by further seawater intrusion which would constitute an irreparable injury, and that to preserve the utility of the basin, extractions must be reduced to prevent further seawater intrusion.[80] The case was essentially settled by stipulation. The court found that the elevation of the water table in the greater portion of the basin was below sea level, and that seawater intrusion was occurring in the vicinity of Alamitos Gap.[81] It further found that the Los Angeles County Flood Control District planned the construction of an injection barrier in the vicinity of Alamitos Gap, that plaintiff paid for the water required for the barrier, and that the amount of water required for the barrier increased as ground water levels fell farther below sea level.[82] A judgment restricting ground water extractions was duly entered.[83]

Similarly, in *Orange County Water District v. City of Chino*[84] plaintiff alleged as one basis of irreparable injury that an overdraft in the Santa Ana River system (Orange, Riverside, and San Bernardino counties) had lowered ground water levels within the lower area in Orange County to such an extent that salt water from the ocean intruded into the basin, "thereby impairing its utility as a ground water reservoir", and that unless defendants' extractions are limited, "there will be increased intrusion of seawater" in the basin.[85]

San Luis Rey Water Conservation District v. Carlsbad Mutual Water Co.[86] is the only California case found that was brought to enjoin groundwater extractions *solely* to prevent seawater intrusion into the basin (in other cases, plaintiff sought also to preserve the ground water supply from depletion). Plaintiff asked in part that defendant be precluded from extracting and exporting water from Mission Valley Basin (San Diego County) whenever the water table in the wells had fallen below 10 feet above sea level.[87]

The trial court ruled substantially as follows:[88] Questions of

80. *Id.* Complaint paras. 22, 26, 29.

81. *Id.* Findings of Fact filed October 11, 1965, paras. 8-9.

82. *Id.* Findings of Fact filed October 11, 1965, para. 9.

83. *Id.* Judgment entered October 20, 1965.

84. No. 117628 (Cal. Super. Ct., Orange County filed Oct. 18, 1963).

85. *Id.* Complaint para. 26.

For detailed description in this area, see Cal. Dep't of Water Resources, Bull. No. 147-1, Ground Water Basin Protection Projects, Santa Ana Gap Salinity Barrier, Orange County (1966).

86. No. 184855 (Cal. Super. Ct., San Diego County, filed Nov. 3, 1953).

87. *Id.* Complaint, 3d cause of action.

88. *Id.* Mem. Opinion filed Aug. 3, 1959.

quantity cannot be divorced from quality. As ground water levels are lowered, seawater intrusion can occur. An overdraft in a qualitative sense first occurs not when the groundwater becomes saline but when the draft on the basin is such that, if unrestrained, it will in time pull the water levels down to a point where seawater intrusion will occur. This situation is similar to a quantitative overdraft, which occurs not when the ground water is all gone but when the draft exceeds the average annual supply. Since a qualitative overdraft existed for more than five years before the complaint was filed, defendant had acquired prescriptive rights to export basin waters.[89] Subsequently, judgment was entered restricting defendant from exporting more than 2382 acre-feet per annum, its prescriptive right.[90]

Remedies available by way of litigation to protect a ground water basin are injunction, damages, inverse condemnation, and declaratory judgment.[91]

Where actions are brought to adjudicate underground basins in the southern California counties of Santa Barbara, Ventura, Orange, San Diego, and Los Angeles,[92] the State Water Resources Control Board[93] may seek injunctive relief to prevent serious seawater intrusion where it is acting as court referee.[94] After the Board has filed its report as referee,[95] it may conclude that ground water extractions, if not restricted, would result in destruction of or irreparable injury to the waters of the basin due to seawater intrusion before final judgment. If so, the Board may apply for a preliminary injunction to restrict pumping so as to avoid such destruction of or irreparable injury to the basin's waters.[96] However, the final judgment must equitably compensate in quantities of water for variations between

89. *See* Pasadena v. Alhambra, 33 Cal. 2d 908, 207 P.2d 17 (1949).

90. San Luis Rey Water Conservation Dist. v. Carlsbad Mutual Water Co., No. 184855 (Cal. Super. Ct., San Diego County, Oct. 1, 1965).

91. *See* W. Hutchins, The California Law of Water Rights 487-94 (1956).

92. The legislature declared that solution of seawater intrusion problems in groundwater basins in the arid coastal area of the state are unique to that area, and a general law would not be applicable. Cal. Stats. 1953, ch. 1690, § 3.

However, by 1958, five of the areas of *known* seawater intrusion in California—Petaluma Valley, Napa-Sonoma Valley, Santa Clara Valley, Pajaro Valley and Salinas Valley Pressure area—out of nine such areas in the state were located outside of these five counties in the southern coastal area of California. In addition, 29 of the 71 areas of suspected seawater intrusion and areas of over 100 ppm choride were located outside those five counties. Cal. Dep't of Water Resources, Bull. No. 63, Sea-Water Intrusion in California 20-21 (1958).

93. Formerly the State Water Rights Board. In 1967, that Board and the State Water Quality Control Board were combined into the State Water Resources Control Board. Cal. Water Code §§ 175, 179, 186 (West Supp. 1968).

94. Cal. Water Code §§ 2000-48 (West 1956) provide for appointment of the Board to act as referee in water adjudication suits.

95. *Id.* at § 2016 (West Supp. 1968).

96. *Id.* at § 2020 (West 1956).

the rights on which the preliminary injunction is based and such rights as are determined in the final judgment.[97]

An application for injunction filed after the Board has submitted its report might come too late. In the seven references and re-references to the Board from 1939-64, it has taken from three to ten years from the time of reference until the Board filed its report. In that time a significant portion of a basin might be lost to seawater intrusion.[98]

A special panel established to review and recommend changes in California's water quality control laws has considered this problem. In its report, the panel has recommended in part that after the California Department of Water Resources has submitted plans and recommendations for the protection of the quality of groundwater or in reliance upon the investigation of any governmental agency, the State Water Resources Control Board may file an action to protect groundwater quality. However, before commencing any such action, the board must first permit a local agency to initiate such litigation.[99] As of June 1969, the panel's legislative proposals were before the California legislature.

c. *Administrative powers under existing law*

It is clear that the complex nature of seawater intrusion problems calls for administrative arrangements to develop the best combination of solutions. Litigation alone cannot do that job.

The agencies to which one would look first for administrative control of water quality degradation—the Regional Water Quality Control Boards and the State Water Resources Control Board acting under the state's Water Quality Control Act[100]—have no jurisdiction over seawater intrusion. Their authority is presently[101] limited to regulation of discharges of "sewage" or "other waste,"[102] and seawater intrusion is neither.[103]

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97. *Id.* at § 2021 (West 1956).

98. The statistics are summarized from Declaration of Max Bookman, para. 13, at 23, filed May 10, 1968, in Orange County Water Dist. v. City of Chino, No. 117528 (Cal. Super. Ct., Orange County, Oct. 18, 1963).

99. Cal. Resources Agency, Study Project—Water Quality Control Program, Recommended Changes in Water Quality Control: Final Report of the Study Panel to California State Water Resources Control Board, app. A at 15-17 (1969), adding proposed §§ 2101-03 to the Cal. Water Code. *See* note 100 *infra*.

100. Cal. Water Code, Div. 7 (West Supp. 1968).

101. California's water quality laws were under study by a panel, which is reviewing the legislation and administrative practices. The group, known as the "Study Project—Water Quality Control Program," has recommended changes to the California legislature. Mr. Gindler was a member of the panel.

102. Cal. Water Code § 13005 (West Supp. 1968). "'Sewage' means any and all waste substance, liquid or solid, associated with human habitation, or which contains

There are some public agencies authorized to take appropriate action to prevent seawater intrusion. For example, water replenishment districts in California have authority to do any act necessary to replenish ground water of the district, to spread, sink, and inject water into the underground, and to take any action necessary to protect the quality of the waters of the basin.[104] Such a district therefore has authority to spread water or construct a barrier to prevent seawater intrusion. As we have seen,[105] such authority can be implied from the express powers of a water conservation district. The Orange County Water District has authority under its organic act to raise funds by taxes and bonded indebtednes for the purposes of acquiring, constructing, or developing intrusion prevention projects.[106]

Within a single basin a number of local agencies may have authority to take steps to prevent seawater intrusion, but none of them may have sufficiently broad jurisdiction or financial resources to handle the problem single-handedly. These agencies may cooperate with each other in seeking a coordinated solution under the Joint Exercise of Powers Act.[107]

B. SALTWATER TIDES MOVING UP STREAMS: SACRAMENTO-SAN JOAQUIN DELTA; SOLANO, SACRAMENTO, AND CONTRA COSTA COUNTIES, CALIFORNIA

1. BACKGROUND AND HISTORY

Ocean water can move upstream during periods of low stream flows and degrade the lower reaches of coastal rivers and streams.

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or may be contaminated with human or animal excreta or excrement, offal, or any feculent matter."

" 'Other waste' means any and all liquid or solid waste substance, not sewage, from any producing, manufacturing, or processing operation of whatever nature."

The study panel (*supra* note 101) has recommended in its report (*supra* note 99) that the terms "sewage" and "other waste" be combined into the one term "waste" (defined in proposed section 13050 (d)).

103. *See* Moskovitz, *Quality Control and Re-use of Water in California,* 45 Cal. L. Rev. 586, 590 n.24 (1957).

104. Cal. Water Code §§ 60220, 60221(d), 60222 (West 1966).

Use of a multi-purpose water management district has also been considered for prevention of seawater intrusion into ground water basins in Florida. Maloney & Plager, *Florida's Ground Water: Legal Problems in Managing a Precious Resource,* 21 U. of Miami L. Rev. 751, 762 n.28 (1967).

105. Cal. Water Code Div. 21 (West 1966); Cal. Water Code § 74521 (West 1966); Op. Cal. Att'y Gen., *supra* note 64; Cal. Water Code § 74525 (West 1966).

106. Cal. Water Code Uncodified Act No. 5683 (Orange County Water District Act) §§ 17-21.

107. Cal. Gov't Code §§ 6500-78 (West 1966, Supp. 1968).

The low flows may be due to natural phenomena or water diversions by man, or both. Population centers, industrial complexes, and irrigated agriculture are located in tidal areas. Increased salinity of surface water supplies adversely affects those uses. The severity of this salinity problem can range from a nuisance or inconvenience to possible abandonment of the supply because it has become unfit for use.[108]

One area that suffers from this type of problem is the Sacramento-San Joaquin Delta, which is located at the confluence of the Sacramento and San Joaquin rivers in central California, at the head of Suisun and San Francisco bays. The delta area is shown in Fig. 2.[109]

For many years the delta has been a significant part of the California economy. It now contains over 700,000 acres of land with a highly developed agricultural economy. The western part of the delta has a large industrial area, and the delta is also a major recreational area for fishing, boating, and water skiing. Historically, winter flows from the two rivers have caused flood damages, and low flows in the summer and fall months of many years have resulted in the intrusion into the delta of saltwater tides from the bays and the ocean.[110]

Early records show that saltwater tides reached into Suisun Bay in 1775 and as far upstream as the city of Antioch in 1841. In the 1860's and 1870's early settlers were aware of a salinity problem in Suisun Bay and at Antioch.[111] After 1917, increased diversion and use of water from the Sacramento and San Joaquin rivers combined with subnormal runoff in certain years continued to reduce the outflow of fresh water so that saltwater tides moved farther upstream.[112]

The construction of a barrier to hold back the saltwater tides in

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108. *E.g.*, salinity intrusion has been a major problem on the lower reaches of the Delaware River. The matter had been litigated [New Jersey v. New York, 283 U.S. 336 (1931), *modified per curiam,* 347 U.S. 995 (1954)], but the most recent crisis, triggered by a lengthy drought, was handled administratively through the Delaware River Basin Commission. For a discussion of these matters, see Gindler, *supra* note 24 at 330-31, 346-48. The drought was officially declared at an end on May 7, 1968. Letter from J. F. Wright, Executive Director, Delaware River Basin Commission to B. J. Gindler, May 28, 1968.

109. The map was obtained from The California Department of Water Resources.

110. *See* Cal. Dep't of Water Resources, Bull. No. 123, Delta and Suisun Bay Water Quality Investigations 123 (1967) for map showing the extent of salinity intrusion in the delta in various years.

111. Div. of Water Resources, Cal. Dep't of Public Works, Bull. No. 27, Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay 28 (1931).

112. *Id.* at 42.

the delta area was under consideration by the 1860's and was studied by the California State Engineer in 1880.[113]

In 1944 the United States Bureau of Reclamation completed Shasta Dam on the Sacramento River as a major feature of its Central Valley Project. Waters conserved at Shasta are released down the Sacramento River and pumped out of the delta and conveyed through the federal Delta-Mendota and Contra Costa canals southerly to the San Joaquin Valley for use in the Central Valley Project. Both the Project and Shasta Dam are operated to provide sufficient flow at the intakes of the Delta-Mendota and Contra Costa canals to protect their supply from salinity intrusion, so that the federal government's contractual commitments to deliver water through the Project are met. As an incidental but direct result of this operation of the Central Valley Project, however, over 90 percent of the delta has been protected against adverse effects of saltwater intrusion.[114]

The delta has been the subject of intensive study by local, state, and federal interests for the past few years due to problems involved in expansion of the federal government's Central Valley Project and the construction of California's State Water Project. In time, these projects are expected to transport up to 7.8 million acre-feet of surplus northern California water each year to the central and southern portions of the state.

The delta serves as a natural collecting pool for surplus fresh water from the northern part of the state. Waters conserved at Oroville Dam on the Feather River (a tributary of the Sacramento) and at Shasta Dam enter the delta via the Sacramento River and are pumped out at the southern end of the delta for distribution to the south. These dams conserve water that would otherwise waste to the ocean, but the location of the export pumps tends to encourage saltwater intrusion into the delta. For this reason federal, state, and local interests have searched for means to protect against saline degradation of the delta water users' supplies.

Because of the importance of delta water quality problems to fed-

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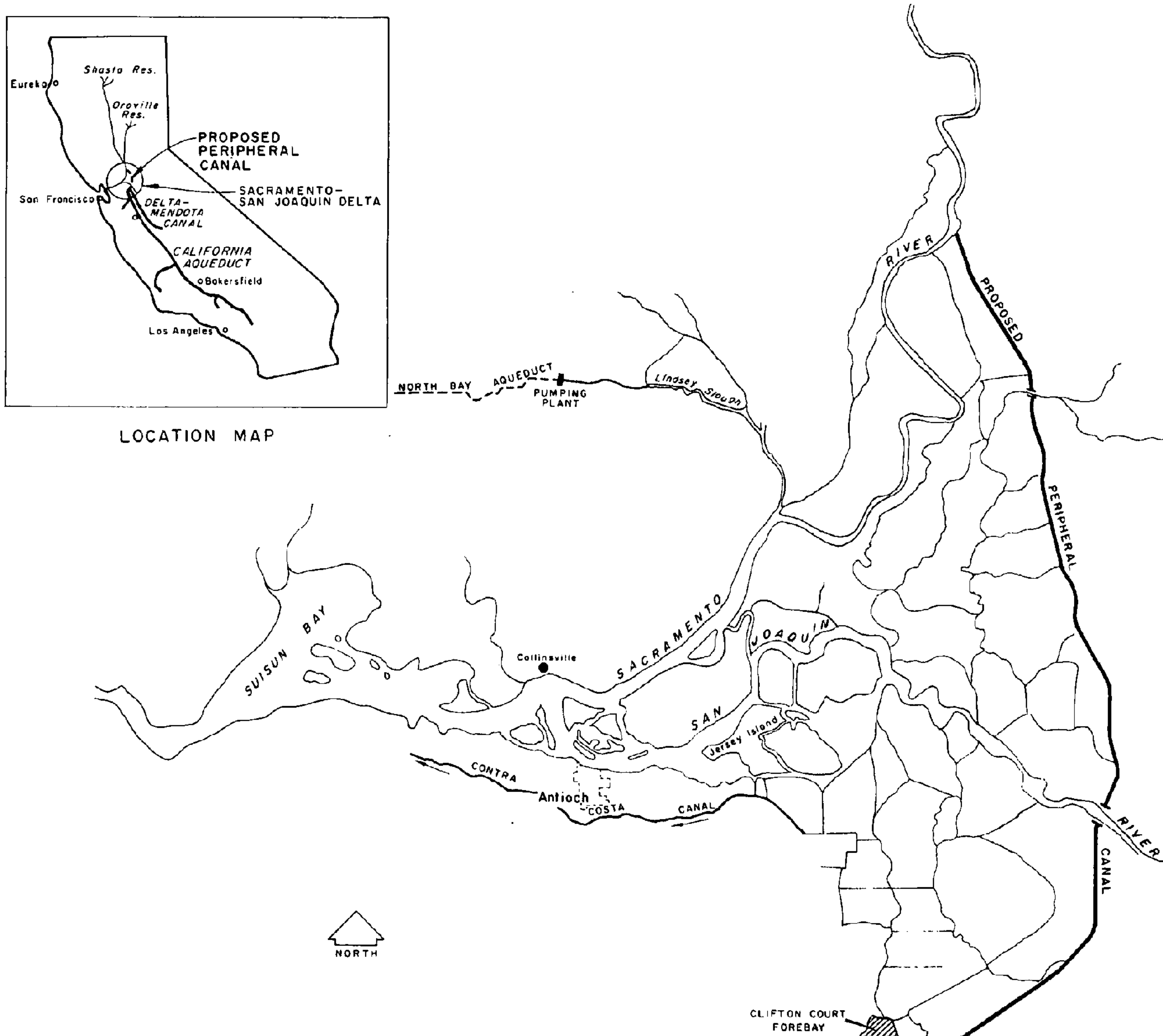
113. Div. of Water Resources, Cal. Dep't of Public Works, Bull. No. 28, Economic Aspects of Salt Water Barrier Below Confluence of Sacramento and San Joaquin Rivers 22 (1931).

114. Statement by E. F. Sullivan, Assistant Regional Director, U.S. Bureau of Reclamation, before Cal. State Water Resources Control Bd., Sacramento, Cal., Oct. 3, 1968, on proposed supplemental delta water quality standards.

Prevention of salinity intrusion in the delta, although not specifically mentioned as a project function in the statutes authorizing the Central Valley Project, is considered to be included within the express irrigation purpose of the project. *See* H. Doc. No. 146, 80th Cong., 1st Sess. (1947), *reprinted in* H. Doc. No. 416, 84th Cong., 2d Sess. 574, 581, 586, 588 (1957).



SELECTED FEATURES IN SACRAMENTO-SAN JOAQUIN DELTA WITH PROPOSED PERIPHERAL CANAL

Figure 2

eral and state water project development in California, studies were jointly undertaken by an interagency committee composed of the California Department of Water Resources, the U.S. Bureau of Reclamation, and the U.S. Corps of Engineers, with the cooperation of local interests. The task of the interagency committee was to examine past proposals and to recommend a comprehensive plan that would satisfy the needs of the federal and state water projects and still provide for the needs in the delta without unnecessary waste of water.[115]

2. ESTABLISHING DESIRABLE SALINITY LEVELS

a. *Economic factors*

The delta presents two water quality problems. These must be considered separately in order that the limits of economic feasibility of each can be validly analyzed.

One problem is to avoid potential degradation of the high quality surplus waters from northern California as they are transferred through or by the delta on their way to the south. The second problem—the only one being considered here—is to protect the delta users' water supply from saline intrusion.[116] This protection could be provided by preventing saltwater intrusion into the delta channels from which those users divert. Alternatively, it could be provided by means of an equivalent substitute supply delivered by overland facilities rather than through the delta channels. Obviously, the protection could be provided in-stream as to part of the delta (the eastern part farthest from the salty bay waters) and by means of a substitute supply for another part (the western part closest to the salty bay waters).

115. *See* Cal. Dep't of Water Resources, The Peripheral Canal of the Sacramento-San Joaquin Delta—A Summary of This Proposed Joint Use Feature of the California State Water Project and the Federal Central Valley Project (1966).

The studies culminated in the following report: Interagency Delta Committee, Plan of Development: Sacramento-San Joaquin Delta (1965) [hereinafter cited as Interagency Delta Report].

116. The Interagency Delta Committee seems to have evaluated the tangible economic advantages and costs of the various plans to carry water by or through the delta without ascribing costs and benefits separately to those two water quality objectives. Both are combined in an item of "Economic Advantages for Planning Objectives" termed "Water Quality Transfer." Interagency Delta Report 6. The Bureau of Reclamation's feasibility study on the problem had not been issued at the time of this writing.

Interestingly enough, the most comprehensive economic analysis at this writing appears to be a report authorized by a local water agency. Metcalf & Eddy, Report to the Contra Costa County Water Agency: An Economic Evaluation of the Water Quality Aspects of Contra Costa County's Offshore Water Supply (1965).

Costs of holding back the saltwater tides involve, first of all, what might generally be called "structure" costs. These are costs attributable to those portions of facilities (such as dams and canals) that are properly allocated to the prevention of saline intrusion. But costs of holding back saltwater tides may also involve what might generally be called "water costs." These are costs attributable to that portion of the fresh water releases properly allocated to holding back saltwater tides.

Where releases of fresh water are involved in preventing salinity intrusion, some of those releases will undoubtedly serve more than one purpose. For example, releases to protect the fishery resource of the delta will also assist the prevention of salinity intrusion for other purposes. This would seem to require an appropriate allocation of the costs and benefits of such releases among complementary uses.

Generally, water over and above that released for other purposes would have to be released solely to prevent salinity intrusion. The benefits from releases of such additional water will vary with the size and timing of the releases. As more and more water is released for salinity control at proper times, saltwater tides are pushed back farther and farther.

At some point, the cost of releasing additional water will exceed the benefits to be derived therefrom. This is the limit of economic feasibility of providing protection against saltwater intrusion by this means. However, the cost of providing an equivalent substitute supply may be less than the cost of providing in-stream protection.

An economic analysis thus presents double difficulties. The first is to segregate in an accurate and meaningful way the costs and benefits properly attributable only to prevention of saltwater intrusion. The second difficulty is to attribute monetary values to the benefits.

b. Water rights

The problem of preventing saltwater intrusion into the delta also involves in a very important way the extent and effects of the water rights of delta water users.

(1) *Appropriative rights in delta*

The water rights feature of the delta salinity problems first came to a head in 1920, when delta water interests were threatened with a serious saline invasion resulting from an impending water shortage that year. A series of meetings and discussions were held between water users in the upstream valleys and delta water users in an attempt to reach agreement on their conflicting claims to water. When these efforts proved unsuccessful, suit was instituted on July 2, 1920, by the town of Antioch against upper irrigators: *Town of Antioch v. Williams Irrigation District*.[117] Although the nominal plaintiff was the city of Antioch, the real forces behind initiation and prosecution of the suit were the delta landowners.[118]

Antioch, asserting both riparian and appropriative rights, alleged that in 1919 and 1920, defendants' diversions from the Sacramento River[119] for irrigation purposes so reduced the flow that saltwater tides reached Antioch's point of diversion, rendering the water salty and unfit for use. At that time, Antioch was diverting less than one cubic foot per second.

The trial court granted an injunction to Antioch, as a prior appropriator,[120] prohibiting defendants from diverting so much water from the Sacramento River system to nonriparian land that the flow at the city of Sacramento would be reduced below 3500 cubic feet per second. This minimum flow at Sacramento would provide sufficient water flowing downstream to keep the saltwater tides below Antioch's point of diversion.[121]

On appeal by defendants, the judgment was reversed.[122] The California supreme court concluded that a prior appropriator at the mouth of a stream does not have any right to insist that junior appropriators upstream leave enough water flowing in the stream to hold the saltwater tides below his point of diversion.[123] Otherwise, upstream users would be prevented from diverting and putting to use large quantities of water; and the water would flow downstream and be wasted into the ocean to protect a minor use at the mouth of

117. 188 Cal. 451, 205 P. 688 (1922).

118. Div. of Water Resources, *supra* note 111, at 23.

119. At two points above Antioch, water from the Sacramento River escapes through sloughs into the San Joaquin River. The combined current of water from the two rivers ordinarily is strong enough to keep saltwater tides below Antioch's point of diversion on the San Joaquin River. 188 Cal. at 455, 205 P. at 690.

120. In its complaint, Antioch asserted rights in the waters of the San Joaquin "both by virtue of its riparian situation and by virtue of a diversion and appropriation of the waters of that river." At the hearing before the trial court, however, Antioch conceded that any water rights that it might have would be appropriative rights. 188 Cal. at 454, 205 P. at 689-90. The supreme court agreed. It held that a city does not become a riparian appropriator because of its political jurisdiction over riparian land. 188 Cal. at 456, 205 P. at 690-91.

Hence, the case was decided with regard to the rights of the city of Antioch as a prior appropriator as against the upstream irrigationists as subsequent appropriators.

121. The early reports on a State Water Plan for California predicated the prevention of salinity intrusion into the upper bay and delta by means of a flow of not less than 3300 cubic feet per second past Antioch. *E.g.*, Cal. Div. of Water Resources, Bull. No. 25, Report to the Legislature of 1931 on State Water Plan 119 (1930).

122. For analysis of the decision, see Gindler, *supra* note 24, at 101-04.

123. 188 Cal. at 465, 205 P. at 694-95.

the river from saltwater tides.[124] The court also suggested that both sides could have avoided the expenses of this litigation by cooperacting to move Antioch's diversion point a few miles upstream.[125]

The court expressly refused to consider the rights of delta landowners who were not parties to the suit.[126] No explanation has been found why delta landowners, who pushed the matter into litigation, did not themselves initiate or join the suit against the upper irrigators. Perhaps the delta landowners thought that the interference with a city water supply would be more appealing to a court than interference with agriculture, or that if Antioch prevailed, either as a riparian or as an appropriator, the decision would inure to their benefit. However, if Antioch lost, as it did, they could argue that the decision does not apply to their different situation. On the other hand, one might speculate that if the delta landowners, with their substantial uses and points of diversion that could not be moved upstream, had been plaintiffs, the court might have reached a different result.

Antioch is the only California case found dealing with the right of a senior lower water user to the hydraulic force of a surface stream to prevent intrusion of saltwater tides. It certainly negates any such right in a prior appropriator with minor uses whose point of diversion can readily be moved upstream above the saltwater tides. It probably negates any such right in any prior appropriator, unless its holding is restricted to the facts.[127] However, it does not deal at all with the rights of delta riparians.[128]

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124. 188 Cal. at 461, 205 P. at 692-93. *Cf.* Houston Transp. Co. v. San Jacinto Rice Co., 163 S.W. 1023 (Tex. Civ. App. 1914) (where sandbar held back saltwater tides from intervenor's diversion point, defendant was enjoined from taking sand from sandbar for building materials).

125. 188 Cal. at 465, 205 P. at 694. This suggestion seems fatuous since, as we have pointed out at note 118 *supra* and accompanying text, the real forces behind the suit were delta landowners, who could not have moved their points of diversions above the saltwater tides. It is possible, but hardly likely, that Chief Justice Shaw, who as the court's water lawyer wrote the opinion, was unaware of the real situation.

126. 188 Cal. at 467, 205 P. at 695: "There were no allegations in the complaint concerning these lands. No owner of such land, by intervention or otherwise, sought relief at the hand of the court below, and that court, so far as appears, did not consider the effect on such land. It did not find any facts relating thereto, the pleadings alleged no facts bearing thereon, and none are presented in the record for our consideration. There is, therefore, nothing for this court to say on the subject. We know of nothing relating to such lands that would require a conclusion different from that which we have stated."

127. The court states as its "conclusion" that such a right does not exist in "an appropriator of fresh water from one of these streams, at a point near its outlet to the sea. . . ." 188 Cal. at 465, 205 P. at 694.

On the other hand, an appropriator with substantial uses whose diversion point cannot be inexpensively moved upstream above the saltwater tides would argue that

(2) *Riparian rights in delta*

Do landowners hold valid and compensable riparian water rights[129] which entitle them, as against junior appropriators upstream, to the hydraulic force of the stream to hold back saltwater tides? Resolution of this issue depends upon the interpretation of California water law before and after November 6, 1928, the date article XIV, section 3, was added to the California Constitution.

Before November 6, 1928, a riparian in California could enjoin the use of water by an upstream appropriator who was junior, so that the full flow of the stream would reach the riparian's land and irrigate it by overflow. In *Herminghaus v. Southern California Edison Co.*,[130] the California court enforced by injunction the release of water to serve this right, although the quantity of water actually overflowing and beneficially irrigating the riparian land was only a very small fraction of the full flow of the stream that had to be released to achieve that result. On November 6, 1928, the California voters amended the state constitution by adding article XIV, section 3, which curbed any water right, including a riparian right, from being exercised thereafter in an unreasonable or wasteful manner.[131]

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the further reasoning in *Antioch* precludes such a right only when it requires the waste of a large quantity of water for a very small benefit.

128. *See* Treadwell, *Modernizing The Water Law,* 17 Cal. L. Rev. 1, 18 n. 28 (1928).

Cf. Div. of Water Resources, *supra* note 111, at 23: "The actual outcome of the suit and the final decision rendered is not of very great importance to this study, although, at the time, it was considered a great victory for the upper irrigationists and equally a great loss to the city of Antioch, and more particularly to the delta land owners who were in fact the real force behind the initiation and prosecution of the suit. Of greatest importance to the State and all of the interests involved and affected by the salinity conditions is the fact that the filing and prosecution of the Antioch suit forcibly called to the attention of the public the seriousness of the salinity problem confronting the upper bay and delta interests. It became evident to all concerned, and especially the State authorities, that it was necessary and essential that a complete investigation be made of the salinity conditions with the objective of finally determining, if possible, remedial measures to control the invasion of salinity. . . ."

129. No consideration is given herein as to how much of the delta lands are riparian lands under California water law. For discussion of the requirements for land to be classified as riparian, see W. Hutchins, The California Law of Water Rights 196-204 (1956). Nor is any consideration given to the acquisition of prescriptive rights by junior upstream interests to render the delta waters unfit for use for delta riparians by upstream diversions that permitted salinity intrusion into the delta in earlier years. *See id.* at 298-343; Gindler, *supra* note 24, at 176-80.

In any event, the factual questions involved in attempting to resolve either of these issues would alone be too complex for investigation and analysis in this article.

130. 200 Cal. 81, 252 P. 607 (1926).

131. Cal. Const. art. 14, § 3, provides:

"It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use

If, before the 1928 amendment, riparian water users in the delta had the right against junior appropriators upstream to the hydraulic force of the stream to prevent salinity intrusion,[132] an important issue today is whether that exercise of riparian rights is an unreasonable and wasteful use barred by the 1928 amendment. If not, holders of such rights should be entitled to water (in-channel or by way of equivalent substitute supply) to satisfy the rights or compensation for their taking. If so, then the holders of such rights may be entitled only to compensation for their taking, if that much.

In *United States v. Gerlach Live Stock Co.*,[133] the United States Supreme Court upheld a compensation award for deprivation of riparian rights along the San Joaquin River caused by the construction of Friant Dam as part of the federal Central Valley Project. As in *Herminghaus*, the riparian rights in *Gerlach* were claimed for irrigation of lands by seasonal overflows of the river at its high stages. The Court noted:

> [C]laimants' benefit comes only from the very crest of this seasonal stage, which crest must be elevated and borne to their lands on the base of a full river, none of which can be utilized for irrigation above and little of it below them. Their claim of rights is, in other words, to enjoy natural, seasonal fluctuation unhindered, which presupposes a peak flow largely unutilized.[134]

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or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. Riparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses; provided, however, that nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which his land is riparian under reasonable methods of diversion and use, or of depriving any appropriator of water to which he is lawfully entitled. This section shall be self-executing, and the Legislature may also enact laws in the furtherance of the policy in this section contained."

132. *Cf.* Peabody v. City of Vallejo, 2 Cal. 2d 351, 369, 40 P.2d 486, 492 (1935), holding that the use of the stream by artificial check dams and levees to wash salts from plaintiff's salt marsh lands was not a proper riparian use under common law. The washing of salts from the soil, which preserves the utility of the land, can probably be distinguished from preventing saltwater intrusion, which preserves the utility of the fresh water. The latter may be a proper part of the riparian right to the use of water although the former is not.

133. 339 U.S. 725 (1950).

134. *Id.* at 730.

The Court held that the federal law required compensation to be paid to holders of riparian rights compensable under state law when they were taken by the United States for the operation of its Central Valley Project. This holding raised the issue of whether the overflow rights involved in *Gerlach* were compensable under California law after the 1928 constitutional amendment. In the absence of any controlling California authority, the Court had to resolve that issue by its own prediction about the effect of that amendment. It construed the California law to mean that since the 1928 constitutional amendment, this unreasonable and wasteful exercise of a riparian right remained compensable although no longer enforceable by injunction.[135]

In other words, the 1928 amendment barred not the right but only the equitable remedy, the injunction, by which the riparian could previously have required the water to run down to his property. The remedy of compensation for taking or other deprivation of that right therefore remained.[136]

This holding in *Gerlach* seemed good law in California until 1967 when the California Supreme Court decided *Joslin v. Marin Municipal Water District.*[137] Plaintiff sued in inverse condemnation for compensation for damages caused when defendant's dam prevented the flow of the stream depositing sand and gravel upon plaintiff's riparian land. The court stated that the use of the stream to carry rock and gravel is as a matter of law unreasonable under the 1928 amendment: there are no property rights in an unreasonable use, there can be no taking or damaging of property by deprivation of such use, and that therefore the deprivation of such use is not compensable.[138]

The quarrel with *Joslin* is not with its result, but rather with its reasoning—namely in its attempt to distinguish *Gerlach.*

In *Joslin,* the court purported to distinguish *Gerlach* upon the ground that in *Gerlach* "[t] here was no question but that the use of water for irrigating riparian lands was a *reasonable* use, within the meaning of the [1928] constitutional amendment."[139] This purported distinction ignores both the facts and the holding of *Gerlach,* which we have discussed above.[140]

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135. *Id.* at 753-55.

136. *Id.* at 752.

137. 67 Cal. 2d 132, 429 P.2d 889, 60 Cal. Rptr. 377 (1967). *See* Malakoff, *Erosion of a Water Right or Just a Pile of Sand,* 5 Cal. Western L. Rev. 44 (1969).

138. *Id.* at 141, 429 P.2d at 895, 898, 60 Cal. Rptr. at 383, 386.

139. *Id.* at 145, 429 P.2d at 898, 60 Cal. Rptr. at 386 (emphasis added).

140. In attempting to distinguish *Gerlach,* the court in *Joslin* quoted language from

There is, however, one possible basis for distinguishing *Gerlach* and *Joslin*. *Gerlach* clearly dealt with a right that was both enforceable by injunction and compensable before the 1928 amendment. The effect of the 1928 amendment was to bar enforcement by injunction while leaving unaffected the rights to just compensation for a taking.

Although the court in *Joslin* discussed the issue of reasonableness and waste in terms of the 1928 amendment, it is entirely possible that the right claimed there was not a valid riparian right before the 1928 amendment. This interpretation is borne out by the California supreme court's reliance in *Joslin* on its decision in *Peabody v. City of Vallejo*,[141] where it had held, *inter alia*, that the use of river waters to wash silt down upon riparian lands was not a proper riparian use at common law.[142] This factual situation in *Peabody* is comparable to the factual situation in *Joslin*, where plaintiff claimed a riparian right to have the natural flow of the river waters wash sand and gravel onto his riparian lands. If the claimed riparian right in *Joslin* was not enforceable or compensable before the 1928 amendment, it was a fortiori not enforceable or compensable thereafter. The 1928 amendment did not make compensable any unreasonable or wasteful use of water that was not based on an enforceable, compensable right before 1928.

If *Gerlach* and *Joslin* cannot be thus distinguished, one might speculate that since *Joslin*, an overflow irrigation use such as that present in *Gerlach*, which wasted almost the entire flow of the stream to provide the riparian claimants with an overflow of its crest,[143] is now to be considered as a "reasonable use, within the meaning of the

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Gerlach that since the 1928 amendment, riparian "'claimants can *enforce* no use of wasteful or unreasonable character' (339 U.S. at 752)". Id. at 145, 146, 429 P.2d at 898, 60 Cal. Rptr. at 386 (emphasis added). As our emphasis shows, *Gerlach* said only that the unreasonable use could not be "enforced", *i.e.*, by requiring delivery of water. Immediately thereafter, the Court said that the unreasonable use was still compensable. *See supra* note 133, at 752-55. *Cf.* Malakoff note 137 *supra* at 66-68.

141. 2 Cal. 2d 351, 40 P.2d 486 (1935).

142. Joslin v. Marin Municipal Water Dist., 67 Cal. 2d 132, 139, 429 P.2d 889, 894, 60 Cal. Rptr. 377, 382 (1967): "In *Peabody*, several lower riparian owners sought to enjoin the City of Vallejo, as an appropriator, from storing the waters of a creek by the construction of a dam and thereafter diverting them to municipal uses. Peabody, one of the plaintiffs, asserted a right to have all the waters flow without interruption since by normally overflowing his land they not only *deposited silt thereon* but also washed out salt deposits on portions of the land. *Held*, '*(t)his asserted right does not inhere in the riparian right at common law*, and as a natural right cannot be asserted against the police power of the state in the conservation of its waters. This asserted right involves an unreasonable use or an unreasonable method of use or an unreasonable method of diversion of water as contemplated by the Constitution.' *Peabody v. City of Vallejo*, supra, 2 Cal. 2d 351, 369." (Emphasis [other than for citation] supplied).

143. United States v. Gerlach Live Stock Co., *supra* note 133, at 730.

[1928] constitutional amendment."[144] More likely, however, the California court will avoid such an unhappy result if it is ever squarely faced with that problem.

(3) *Effect of navigation power*

Any activity of the state or federal government that would interfere with the water supply for vested rights in the delta would involve diversion and regulation of waters of the navigable Sacramento and San Joaquin rivers. The protection to be accorded vested water rights in the delta valid under state law should not be impaired because navigable rivers are involved.

Congress can exercise the navigation power so as to take water rights vested under state law without payment of compensation.[145] However, it has not elected to do so in the current legislation authorizing the Central Valley Project. Under section 8 of the Reclamation Act of 1902, vested rights compensable under state law are compensable when taken by the federal government in the operation of that project.[146]

The probable effect of *Joslin* upon *Gerlach* becomes critical here. If the two decisions can be reconciled, *Gerlach* remains good law concerning the water rights which under state law are compensable when taken by the federal government in the operation of its Central Valley Project. This may give rise to litigation on the anomalous issue of how one ascertains whether a particular use of water is a noncompensable *Joslin*-type water right or a compensable *Gerlach*-type water right.

If *Joslin* and *Gerlach* cannot be reconciled, the continuing validity of the *Gerlach* holding in the operation of the Central Valley Project is put in question. If the Court in *Gerlach* simply construed Congress' interpretation of the meaning of California water law, then the holding in *Gerlach* would still be good federal law binding in the operation of the Central Valley Project. In other words, if Congress made the mistake about California water law, its mistake would still be validly incorporated in the operative federal statutes relating to the Central Valley Project.

144. Joslin v. Marin Municipal Water Dist., 67 Cal. 2d 132, 145, 429 P.2d 889, 898, 60 Cal. Rptr. 377, 386 (1967).

145. *See* Morreale, *Federal-State Rights and Relations*, 2 Waters and Water Rights 15-46 (R. Clark ed. 1967).

146. United States v. Gerlach Live Stock Co., *supra* note 133; Reclamation Act of 1902 § 8, 32 Stat. 390, 43 U.S.C. §§ 372, 383 (1964).

Even though "navigation" is listed in the Central Valley Project legislation as one purpose of the project, the Court concluded that the congressional intent was to create a reclamation project and to compensate holders of water rights taken by operation of that project under federal reclamation law.

However, if the Court in *Gerlach* was presenting, pursuant to congressional command, the Court's interpretation of the meaning of California water law, then it may be argued that cases subsequent to *Joslin* (perhaps limited to water rights taken after *Joslin*) need not provide compensation for any water rights not compensable under *Joslin*, even though they might have been compensable under the prior but erroneous *Gerlach* holding. However, the Court might still adhere to the *Gerlach* holding upon the ground that Congress had implicitly approved that practice.[147]

Under California law, the state may exercise its powers over navigable waters without payment of compensation to the owner of riparian property for limiting his access through those navigable waters to his riparian property, where the damage does not involve the actual taking of the property.[148] This does not necessarily mean that the state may exercise that power without payment of compensation for the taking of a right to the use of the water. The water right does not involve navigation, and there is a physical taking of the water that would otherwise be available for diversion to the holder of the water right. This most certainly should not mean that the state may develop state waters for diversion and use unrelated to navigation and thereby take without payment of compensation a right to the use of water that is also unrelated to navigation.

The intent of the state not to seek to destroy valid delta water rights under any real or fictitious navigation power seems clear. The statutory authorization for the California Water Plan does not expressly mention navigation as a project purpose;[149] and, as we shall see next,[150] the California Water Code contains express statutory commands for prevention of salinity intrusion into the delta and protection of the delta as an area of origin.

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147. *Cf.* Alaska Steamship Co. v. United States, 290 U.S. 256, 262 (1933), holding that the Court would not disturb a settled administrative construction that "has received Congressional approval, implicit in the annual appropriations over a period of thirty-five years, the expenditure of which was effected by resort to the administrative practice, and in amendments by Congress to the statutes. . . ."

148. *See* Colberg, Inc. v. State *ex rel.* Dep't of Public Works, 67 Cal. 2d 408, 432 P.2d 3, 62 Cal. Rptr. 401 (1967), *cert. denied,* 390 U.S. 949 (1968). [Where freeway bridge over navigable channel substantially limits the size of ships that have access to plaintiff's shipyard, the state is not required to pay compensation for that impairment.]

149. *See* Cal. Water Code §§ 10004-05 (West 1956) [purpose of California Water Plan to provide for "orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state]. *See also* Cal. Water Code § 12931 (West 1956) [enactment of chapter regarding bonds to finance state water facilities as first part of California Water Plan shall not "affect or be construed as affecting vested water rights"].

150. Text accompanying notes 151-172.

c. Statutory provisions

(1) *Salinity control for delta*

A 1945 California law authorizing studies of water development projects for the state requires that "full consideration shall be given to all beneficial uses of the State's water resources, including . . . repulsion of salt water. . . ."[151] In 1959 the California legislature enacted the Burns-Porter Act,[152] to be approved by vote of the people.[153] It provides for issuance and payment of a 1.75 billion-dollar bond issue to help to finance the State Water Facilities of the California Water Plan.[154] As used in that act, the term "State Water Facilities" is defined to include facilities "in the Sacramento-San Joaquin Delta for . . . salinity control. . . ."[155]

Section 11271, which was added to the California Water Code in 1957,[156] provided a more specific measure of protection against salinity intrusion in the delta. It requires that in the operation of the North Bay aqueduct (a new project that will divert from the delta),[157] or any joint use facilities of such a project, by the United States or the state,[158] diversions from the delta sources of water shall not be made except when the residual outflow will repel ocean salinity at Collinsville; and no water which has been stored in any facilities other than those operated by the United States as of the effective date of this section shall be required to be released to prevent such intrusion at any time that diversions are being made from the delta for the North Bay aqueduct. It further provides that the

151. Cal. Water Code § 12581 (West 1956).

152. Initially, the act was to be known as the "California Water Resources Development Bond Act." Cal. Water Code § 12930 (West Supp. 1968).

153. Cal. Stats. 1959, ch. 1762, §§ 2-4. The act was approved and became effective on November 8, 1960.

154. Cal. Water Code, div. 6, pt. 6 (West 1956).

155. Cal. Water Code § 12934(d)(3) (West supp. 1968).

Cf. § 11207. Enacted in 1933 as part of the authorization for a proposed state Central Valley Project (Cal. Stats. 1943, ch. 368), it provides that Shasta Dam shall be used primarily for the purpose, *inter alia,* of "salinity control in the Sacramento-San Joaquin Delta". § 11207(c). Section 12931 of the California Water Resources Development Bond Act provides that the facilities to be funded thereunder shall be subject to the provisions of the California Water Code governing a state Central Valley Project. Cal. Stats. 1959, ch. 1762, § 1.

156. Cal. Stats. 1957, ch. 2252, § 2.

157. The North Bay aqueduct, which is under construction, will divert water from Lindsey Slough (tributary to the Sacramento River) in the eastern delta and convey the water across Solano and Napa counties to the City of Napa. *See, e.g.,* Cal. Dep't of Water Resources, Bull. No. 132-68, The California State Water Project in 1968, at 328 (1968). *See also* note 200 *infra.*

158. Of course, state law cannot compel compliance by the United States without its consent. *See* Arizona v. California, 283 U.S. 423 (1931).

Director of Water Resources is required to continue to maintain records of the source, extent, and occurrences of salinity throughout the delta. But the section expressly negates any modification or repeal of certain area-of-origin protective statutes.

However, section 12202, which was added to the California Water Code in 1959,[159] contains a different approach to this problem. It requires that the State Water Facilities of the California Water Plan, in coordination with the United States' operation of its federal Central Valley Project, shall be used to provide salinity control and an adequate water supply for delta water users. However, the section recognizes that this objective can be accomplished, where it is in the public interest, by the state's providing a substitute water supply to delta users in lieu of the in-channel supply that would have been available to delta users by its repelling saline intrusion. The section further provides that no added financial burden can be placed upon delta water users solely by virtue of such substitution.[160] In addition, delivery of any substitute supply is subject to certain county-of-origin and area-of-origin protective statutes.

Section 12204 of the California Water Code, also enacted in 1959, implements the provisions of section 12202 by prohibiting the export of any water from the delta that is needed to meet the requirements of section 12202.

The state has in fact elected to proceed in part under section 12202. For users in the extreme western delta, it intends to provide a substitute water supply by overland facilities in lieu of the in-channel supply that would have been available if the state had chosen to repel saline intrusion in that area. To the extent that this procedure is inconsistent with section 11271, which prohibits diversions from the delta for the North Bay aqueduct when ocean salinity is not repelled at Collinsville, the provisions of section 12202 control. When two laws on the same subject are passed at different times and are inconsistent, the last expression of the legislature prevails.[161] As noted above, section 12202 was enacted in 1959 and section 11271 in 1957. In enacting section 12202, the legislature could hardly have

159. Cal. Stats. 1959, ch. 1766, § 1, adding part 4.5, "Sacramento-San Joaquin Delta" (sometimes referred to in California as the "Delta Protection Act"), consisting of §§ 12200-05 and 12220, to the California Water Code.

160. *See, e.g.*, W. R. Gianelli, The Delta Myth 5 (1968), an unpublished paper delivered by the Director of the California Department of Water Resources to the Commonwealth Club of California, Water Problems Section, in San Francisco, California, on January 11, 1968. The reason for providing a substitute supply by overland facilities: "To provide a dependable freshwater supply in the western Delta through natural river channels would require vast quantities of stored water, most of which would waste to the Pacific Ocean."

161. Spreckels v. Graham, 194 Cal. 516, 228 P. 1040 (1924).

intended to assure a double water supply to any delta water users by providing simultaneously (i) an in-channel supply by repelling salinity intrusion and (ii) a substitute supply in lieu of the in-channel supply.

Of course, the substitute supply must provide substantially the same protection that in-channel salinity repulsion would provide for reasonable beneficial uses.[162] This requirement involves consideration of benefits that may be derived from fresh water flowing in the river channels other than its utility for irrigation, municipal, and industrial uses. For example, it is claimed that in-channel salinity repulsion would prevent the intrusion of the marine bore, which attacks piers in areas of high saltwater concentration. In the absence of such in-channel protection, it is argued that docks, piers, and launching facilities would be damaged by the marine bore and would have to be replaced.[163] However, the use of freshwater releases for the purpose of repelling the marine bore from western delta channels may not be a reasonable beneficial use.[164] For such purposes, the remedy, if any, may properly be a condemnation suit by the state or, more likely, suit by the injured party to recover any damages to which he may be legally entitled[165] rather than any obligation upon the state to provide freshwater releases for in-channel salinity repulsion.

(2) *County and area of origin protection*

Delta water users may also find some comfort in the California statutes providing protection for counties of origin and areas of origin.[166]

The county-of-origin law, which was first enacted in 1931,[167] is

162. Under California water law, a physical solution, such as providing a substitute supply to satisfy a prior or senior right, may not impose any substantial expense incidental thereto upon the prior or senior right. Lodi v. East Bay Municipal Util. Dist., 7 Cal. 2d 316, 339, 60 P.2d 439 (1936). *See also* Gindler, *supra* note 24, at § 218.4.

163. Metcalf & Eddy, Report to the Contra Costa County Water Agency: An Economic Evaluation of the Water Quality Aspects of Contra Costa County's Offshore Water Supply (1965).

164. Repelling the marine bore may not be a "beneficial" use of fresh water. *Cf.* Tulare Irrigation Dist. v. Lindsay-Strathmore Irrigation Dist., 3 Cal. 2d 489, 568, 45 P.2d 972, 1007 (1935) [water used to flood land and thereby exterminate pests such as gophers and squirrels "was not devoted to a beneficial use"]. Even if it were a beneficial use, it may be an "unreasonable" use precluded under the 1928 amendment (*supra* note 131) because it would require the waste of large quantities of fresh water into the bay (*supra* note 160).

165. An "unreasonable" though beneficial use may not be compensable under California law. *See* discussion *supra* at notes 137-38.

166. For analysis, interpretation, and validity of these laws, see 25 Op. Cal. Att'y Gen. 8 (1955).

167. Cal. Stats. 1931, ch. 720.

probably of little value to delta water users. Section 10500 of the California Water Code in effect authorizes the Department of Water Resources to file applications for appropriations of water needed for the California Water Plan.[168] Substantial filings have in fact been made under this section. Section 10504 requires that all applications made pursuant to section 10500 be transferred to and held by the State Water Resources Control Board; and the Board is authorized to release the priority of the application or to assign any portion of the application to state or federal agencies or other persons.

Section 10505 requires that no priority shall be released or assigned if, in the Board's judgment, it will "deprive the county in which the water covered by the application originates of any such water necessary for the development of the county." The protection thereby afforded to delta water users is limited for two reasons. First, the county-of-origin protection relates solely to the release or assignment of state applications. It does not apply to applications by others. Second, protection is limited to the county "in which the water covered by the application originates." Little usable water originates in the delta counties. Most of the water reaching the delta originates high on the Sacramento and San Joaquin river systems.

The area-of-origin law, which was first enacted in the state's Central Valley Project legislation of 1933,[169] seems more hospitable for the delta water users. Section 12931 of the California Water Code, a part of the Burns-Porter Act,[170] provides that the California Water Plan facilities are subject to the water code provisions governing the proposed state Central Valley Project. It further specifies that for the purposes of the Burns-Porter Act "the Sacramento-San Joaquin Delta shall be deemed to be within the watershed of the Sacramento River."

Sections 11128, 11460, and 11463 of the California Water Code, which are part of the state Central Valley Project authorization, thus contain the teeth of the area-of-origin protection. Section 11128

168. The purpose of this section is to enable the state to establish early priority dates for water rights required by the state in the operation of the California Water Plan. The latter portion of section 10500 relieves the state in substantial part from the requirements of due diligence in perfecting these applications. Thus the California Department of Water Resources can now plan, construct, and operate facilities of the California Water Plan using water rights with priority dates going back a generation.

169. Cal. Stats. 1933, ch. 1042. In the early 1930's the state planned to build the Central Valley Project as part of the state's water plan. Because of the state's inability to finance it, however, the project was authorized and developed by the federal government. *See* C. Engle, Central Valley Project Documents, Pt. 1, Authorizing Documents, H.R. Doc. No. 416, 84th Cong., 2d Sess. 8-9 (1956).

170. *See* text at notes 152-54 *supra*.

provides that sections 11460 and 11463 apply to any agency of the state or federal government undertaking construction or operation of the project. Section 11460 provides that in the construction and operation of facilities by the Department of Water Resources, the watershed or area where the water originates, or an area immediately adjacent thereto which can be conveniently supplied with water therefrom, shall not be deprived by the department of "the prior right to all water reasonably required to adequately supply the beneficial needs of the watershed area, or any of the inhabitants or property owners therein." Section 11463 similarly provides that the department may not make any exchange of water unless all water requirements of the watershed or area of origin are fully satisfied as though there had been no exchange.

The county of origin and area of origin protective statutes are clearly binding upon California.[171] But are they binding upon the federal government in the operation of its Central Valley Project? The state says that they are.[172] In practice, the United States has complied with these protective provisions.[173] But there is still doubt whether the United States is obligated by the authorizing legislation for the Central Valley Project, including section 8 of the Reclamation Act of 1902, to comply with these protective statutes.[174] Perhaps new federal legislation authorizing additional federal developments above the delta may spell this out more carefully.[175]

d. Current situation

The prevailing view today seems to be that delta water users will be protected against salinity intrusion. However, a number of subsidiary but vexing questions remain relating to the extent and manner of that protection. What facilities should be constructed to provide salinity control? Where freshwater releases are involved, how much water should be released and when? When may a substitute supply be provided in lieu of an in-channel supply; *i.e.*, is the substitute supply the substantial equivalent of an in-channel supply?

The final but perhaps most important question is who will pay for how much of the cost of the facilities and the water required to provide salinity control in the delta. To the extent that delta water users hold valid and compensable water rights, salinity control should be

171. 25 Op. Cal. Att'y Gen. 8 (1955).
172. *Id.* at 27-29.
173. *Id.* at 29.
174. *See* Sax, *Federal Reclamation Law* in 2 Waters and Water Rights § 117.2 (R. Clark ed. 1967). *Cf.* United States v. Grand River Dam Authority, 363 U.S. 229 (1960).
175. *Cf.* Colorado River Basin Project Act, 43 U.S.C.A. § 1513 (1968), providing state- and area-of-origin protection in an interstate context.

provided to them without any additional cost over and above the costs they would have incurred in the absence of federal and state development (*i.e.*, pre-Shasta conditions). This principle is recognized by section 12202 of the California Water Code,[176] which specifies that "no added financial burden" may be placed upon delta water users for whom salinity protection is provided by means of a substitute supply.

The other side of the coin is that the state and the federal government would be justified in requiring repayment for the costs of salinity control that provides better protection than would have resulted in the absence of their projects. For example, section 11462 of the California Water Code specifies that the area-of-origin law does not compel the Department of Water Resources to furnish state project water to any person without adequate compensation therefor.

3. Methods of Achieving Desirable Salinity Levels

The only feasible methods of improving salinity levels in the delta are those designed to prevent excessive salinity in the water from occurring in the first place. The Interagency Delta Committee studied four concepts to protect the quality of water to be delivered south as well as water quality in the delta. These concepts were:[177]

a. The hydraulic barrier. Freshwater outflows would be used to control salinity. This approach was recommended in the early studies for a State Water Plan in 1930 and 1931.[178]

b. The physical barrier. A physical barrier would be constructed to prevent tidal waters from entering the delta. This approach had been rejected in the State Water Plan studies of the early 1930's.[179]

c. The delta waterway. Water to be exported south would be transferred through the delta by a physical structure that would separate the export water from the delta water. This approach—the Biemond Plan[180]—was included in the original version of the California Water Plan in 1957.[181]

176. Part of the "Delta Protection Act", *supra* note 159.

177. Interagency Delta Report 6-7.

178. Cal. Div. of Water Resources, Bull. No. 25, Report to the Legislature of 1931 on State Water Plan 76-80, 117-23 (1930) and Bull. No. 27, Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay 40-45 (1931).

179. *Id. See also* Cal. Div. of Water Resources, Bull. No. 28, Economic Aspects of a Salt Water Barrier Below Confluence of Sacramento and San Joaquin Rivers 41-44 (1931).

180. Named after the engineer who, as consultant to the Department of Water Resources, developed this approach.

181. Cal. Dep't of Water Resources, Bull. No. 3, The California Water Plan 185-86 (1957) and Bull. No. 60, Salinity Control Barrier Investigation (1957).

d. The peripheral canal. A canal separated from the delta channels would be constructed as a joint state-federal facility to carry water around the eastern edge of the delta and to pumping plants at the southern end of the delta. The facilities would permit the controlled release of water from the peripheral canal into the delta channels.

What benefits would be provided by the peripheral canal? Because state project water would be bypassed around the delta to pumps south of the delta, increased pumping in the delta, which would cause further saltwater intrusion, would be avoided. Good quality water could be released into delta channels during peroids of low flows to combat saltwater intrusion, and better quality water could be delivered to users in the western part of the delta to replace the current supply that is affected by saltwater intrusion. Fish and wildlife, recreation, and (to a minor measure) flood control benefits would also be provided.[182]

The Interagency Delta Committee recommended the peripheral canal as having the greatest net economic advantage of the four concepts studied.[183] On March 16, 1966, it was officially designated as a State Water Project facility.[184] Bills to authorize construction of the peripheral canal as a joint state-federal project have already been introduced in Congress.[185]

4. INSTITUTIONAL ARRANGEMENTS

a. Litigation

With respect to litigation, we have already examined the *Antioch* suit, an action by a senior lower user to enjoin junior upper users so that a sufficient flow of fresh water will be maintained to prevent intrusion of saltwater tides at the lower user's point of diversion. In that instance, plaintiff was unsuccessful.[186]

Another form of litigation, arising from administrative proceedings for the appropriation of water, is now before a California trial court. In a decision issued May 31, 1967 (modified slightly on November 30, 1967),[187] the State Water Rights Board of California,[188]

182. Interagency Delta Report 7, 10. *See also* Cal. Dep't of Water Resources, The Peripheral Canal of the Sacramento-San Joaquin Delta—A Summary of This Proposed Joint Use Feature of the California State Water Project and the Federal Central Valley Project 2-4 (1966).

183. *Id.* at 6-8, 18-19.

184. Cal. Dep't of Water Resources, Bull. No. 132-66: The California State Water Project in 1966, at 21-22, 356-57 (1966).

185. *E.g.,* S. 3312, 90th Cong., 2d Sess. (1968).

186. *See* discussion in text accompanying notes 117-128 *supra.*

187. California State Water Rights Board, Decision D 1275 (May 31, 1967) [hereinafter cited as Decision D 1275], modified slightly by Decision D 1291 (Nov. 30, 1967).

188. Now the State Water Resources Control Board; *see* note 93 *supra.*

after hearing, issued to the California Department of Water Resources permits for the appropriation of water[189] for use in the California water Project. With reference to the issue of water quality requirements for the delta, the Board found that sufficient information was not yet available to determine finally the terms and conditions regarding delta water quality that would reasonably protect vested rights there without wasting water. It reserved jurisdiction over the permits to make such a determination at a later date.[190] In order to provide interim delta water quality protection, the Board required that the minimum water quality in the delta should be maintained at a quality equal to or better than that "agreed upon" by the Department of Water Resources and the Sacramento River and Delta Water Association and which the department "has contracted to maintain. . . ."[191]

On December 29, 1967, two petitions for review of that administrative decision were filed in the California Superior Court for Contra Costa County by water agencies in the western delta.[192] Petitioners contend that for various reasons the Board's decision does

189. The proceedings were initiated by the Department to seek permits for applications filed under Cal. Water Code § 10500, discussed *supra* note 168.

190. Decision D 1275, at 17-18. The State Board reserved jurisdiction for this purpose for at least 3 years (*id.* at 18), but it has recently decided to hold such hearings in 1969 (Cal. State Water Resources Control Bd., Res. No. 68-17: Adopting Supplemental Water Quality Control Policy for Sacramento-San Joaquin Delta).

191. Decision D 1275 at 18-20.

The document entitled "Delta Water Quality Criteria," dated November 19, 1965, cannot be accurately characterized as an "agreement" or a "contract." Representatives of the Sacramento River and Delta Water Association, the San Joaquin Water Rights Committee, the California Department of Water Resources, and the United States Bureau of Reclamation signed it on this basis: "Although the negotiating teams are not authorized to commit the groups and agencies that they respectively represent, they do approve the attached Delta Water Quality Criteria dated November 19, 1965, as an appropriate basis for further negotiations leading to agreements between Delta interests and the operators of Federal and State projects affecting water supplies in the Delta which will assure the Delta area represented of a dependable supply of water of suitable quality sufficient to meet its present and future needs."

192. Jersey Island Reclamation District No. 830 v. State Water Resources Control Board; State of California acting by and through the Resources Agency, Department of Water Resources (Real Party in Interest), No. 108289 (Cal. Super. Ct., Contra Costa County, filed Dec. 29, 1967) [hereinafter cited as the Jersey Island District Case]; Contra Costa County Water Agency v. State Water Resources Control Board; State of California acting by and through the Resources Agency, Department of Water Resources (Real Party in Interest), No. 108299 (Cal. Super. Ct., Contra Costa County, filed Dec. 29, 1967) [hereinafter cited as the Contra Costa District Case]. (In California, a petition for writ of mandate is used for judicial review of decisions of the State Water Resources Control Board. Cal. Water Code § 1360 and Cal. Civ. Proc. Code § 1094.5.)

As indicated following note 160 *supra,* the state has elected to provide a substitute supply by overland facilities to users in the western delta in lieu of in-channel salinity repulsion.

not provide adequate protection against intrusion by saltwater tides as required by law. Petitioners seem to rely upon three general types of arguments in support of this challenge to the administrative decision:

(1) *Evidence-and-findings arguments.* Petitioners assert in substance that findings to support the water quality aspects of the decision are not supported by the evidence,[193] and that the decision is not supported by and contradicts one of the findings.[194]

(2) *Financing arguments.* Petitioners assert that California is financially unable to complete the State Water Facilities as now proposed and is therefore unable to construct facilities necessary to maintain the water quality in the delta required by the administrative decision.[195]

(3) *Statutory arguments.* Petitioners assert that the administrative decision is in violation of certain provisions of the California Water Code which require higher standards for delta water quality than those set by the administrative decision. In particular they argue:

(a) Section 10000 of the Water Code adopts the State Water Plan of the early 1930's as set forth in California Division of Water Resources Bulletins numbered 25 through 36. The plan of development described in those bulletins specified a flow of 3300 cubic feet per second at Antioch in order to maintain 1000 ppm of chloride ion at a point 0.6 of a mile west of Antioch. Section 1256 of the California Water Code[196] requires the Board to "give consideration" to that State Water Plan in determining the public interest of a project.

193. Jersey Island District Case, Petition paras. IX-XII, XVIII; Contra Costa District Case, Petition paras. VIII, XI, XIII.

194. Jersey Island District Case, Petition para. XIII; Contra Costa District Case, Petition para. VIII-4.

195. Jersey Island District Case, Petition para. XIX; Contra Costa District Case, Petition para. XII.

196. Cal. Water Code § 1256 (added 1956) (Stats. Ex. Sess. ch. 52, § 14), provides:

> In determining public interest under sections 1253 and 1255 [of the California Water Code], the State Water Resources Control board shall give consideration to any general or co-ordinated plan looking toward the control, protection, development, utilization, and conservation of water resources of the State, including The California Water Plan, prepared and published by the Department of Water Resources *or any predecessor thereof* and any modification thereto as may be adopted by the department or as may be adopted by the Legislature by concurrent resolution or by law. (Emphasis added.)

Section 1253 requires the Board to allow appropriation of water under such terms and conditions as will develop, conserve, and utilize the water in the public interest. Section 1255 requires the Board to reject an application to appropriate water when it would not best serve the public interest.

The argument concludes that the Board has not provided this required protection against salinity in the delta.[197]

This argument overstates the effect of section 1256. That section simply requires the Board to give consideration to the water plan, not to follow it exactly.[198] In addition, to the extent that it is inconsistent, section 12202, permitting the state to provide a substitute supply in lieu of in-channel protection against salinity intrusion, would control as the later as well as the more specific expression of the legislative will.[199]

(b) The permits relate in part to water for the North Bay aqueduct.[200] Section 11271 of the California Water Code requires that salinity be repelled at the city of Collinsville as a condition precedent to diversion of any water into the North Bay aqueduct. It is pointed out that the Board did not include such protection in the permits.[201]

However, as shown earlier,[202] such protection is not required where the state has elected, under section 12202, to provide a substitute supply by overland facilities in lieu of in-channel protection against salinity intrusion.

(c) Section 12934(d)(3) of the California Water Code provides that the "State Water Facilities" shall mean, among other things, "master levees, control structures, 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, flood and salinity control, and related functions." According

197. Jersey Island District Case, Petition para. XIV; Contra Costa County District Case, Petition para. IX.

198. Johnson Rancho County Water Dist. v. State Water Rights Board, 235 Cal. App. 2d 863, 45 Cal. Rptr. 589 (1965). The Board granted a permit for a project proposed by the Yuba County Water Agency. The project to be constructed under that permit would preclude a component of a competing project proposed by Johnson Rancho County Water District, a facility listed in Cal. Dep't of Water Resources, Bull. No. 3, The California Water Plan (1957). In a well-reasoned opinion, the court held that the permit for the Yuba agency's project was not in violation of § 1256 of the California Water Code. The California Water Plan is general, tentative, flexible, and subject to modification. Under § 1256, the Board need only "give consideration" to the plan, not follow it exactly. In any event, after the Board's decision and before the suit was filed, the Department filed a report eliminating from the State Water Plan the facility relied upon by the Johnson Rancho district.

199. *See* discussion at notes 159-62 *supra*.

200. See Decision D 1275 at 2. "Feather River water reaching the Delta, both as natural flow and as released stored water from Oroville (Dam), will be diverted, together with surplus water in the Delta, . . . from Lindsey Slough through the North Bay Aqueduct to serve the North Bay area. . . ." *See also* note 157 *supra*.

201. Jersey Island District Case, Petition para. XV; Contra Costa District Case, Petition para. X.

202. *See* text at notes 159-82 *supra*.

to the evidence presented by the department at the Board hearing, the department had not planned to construct any of these facilities as part of the California Water Plan for which it was seeking the permits. In addition, section 12934(d)(4) provides that "State Water Facilities" shall mean, among other things, "facilities for removal of drainage water from the San Joaquin Valley." The Board refused to permit protestant (petitioner here) to cross-examine the department's witnesses regarding such facilities or to offer evidence on their effect on delta water. For those reasons, petitioner alleges that the Board decision violates section 12934.[203]

However, nothing in section 12934 restricts salinity control in the delta solely to in-channel protection or specifies the nature of or timing for salinity control facilities.

On February 2, 1968, the Department of Water Resources, as real party in interest in these two administrative review cases, filed its returns, denying the contentions of petitioners discussed above. So far as we are advised, neither case is now being actively pursued by any party, apparently in the hopes that the controversy can be resolved by a mutually satisfactory agreement.

b. Other than litigation

There are a number of current factors that should help to promote a nonlitigious resolution of the delta salinity controversy:

(1) *Bay-delta study*

The California legislature enacted the Water Pollution Control Act of 1965, providing for a study of a comprehensive master plan for control of water pollution in San Francisco Bay and the Sacramento-San Joaquin Delta.[204] A preliminary report on this study recognizes salinity intrusion into the delta as one of the problems that require consideration.[205] A report by Kaiser engineers on the results of this complex study is now under review by the State Water Resources Board.

(2) *Federal-water-quality-standards proceedings*

Federal water quality standards for the delta may provide for higher salinity objectives than the State Board's decision. Section

203. Jersey Island District Case, Petition paras. XVI-XVII. This allegation is not included in the petition in the Contra Costa District Case.

Section 12934 is discussed at notes 152-55 *supra*.

204. Cal. Stats. 1965, ch. 1351, *as amended*, Cal. Stats. 1967, ch. 284, §§ 155-63.

205. Cal. State Water Quality Control Board, Preliminary Report and Prospectus: San Francisco Bay-Delta Water Quality Control Program—Detailed Edition 51, 58-59 (1966). For further discussion of events that led up to this study, see California Resources Agency, Final Report of the State Water Quality Control Board: Useful Waters for California 37-39 (1967).

10(c) of the Federal Water Pollution Control Act provides for the establishment of water quality standards by the states for interstate waters. If a state fails to submit standards acceptable to the Secretary, he may promulgate proper standards himself. These standards are enforceable by the United States.[206]

At the threshold, however, we must consider whether the federal-water-quality-standards provisions are even applicable to the delta salinity problem. This jurisdictional issue requires consideration of two questions.

The first question is whether the delta waters are "interstate waters" for which water quality standards must be set under the federal act. The term "interstate waters" is defined in the federal act to mean "all rivers, lakes, and other waters that flow across or form a part of State boundaries, *including coastal waters*" (emphasis added).[207] Since the delta waters and the rivers supplying them do not "flow across or form a part of State boundaries," the question is whether the delta waters are "coastal waters."[208]

Early in 1966, the California Attorney General issued an opinion that "coastal waters" do not include inland waters in estuaries and bays. This construction was based in part upon an interpretation to that effect by the Acting Commissioner of the Federal Water Pollution Control Administration in January 1966, when the Administration was still located in the Department of Health, Education and Welfare.[209]

Since the Administration has been in his department, the Secretary of the Interior has taken the broader view that delta waters are "coastal waters" subject to the water quality standards provisions of the federal act.[210] In guidelines issued in May 1966 to assist the states in establishment of federal standards, the Secretary explained that "coastal waters" include "the waters along indented coasts which are subject to the ebb and flow of the tides. . . ."[211] In June 1966, the

206. 33 U.S.C. § 466g(c) (1965). For a discussion of the operation of these provisions see Gindler, *supra* note 24, at 377-79, 394-403.

207. FWPC Act, 33 U.S.C. § 466j(e) (1965).

208. For analysis that they are not, see Bermingham, *The Federal Government and Air and Water Pollution,* 23 Bus. Lawyer 467, 473-75 (1968).

209. 47 Op. Cal. Att'y Gen. 135, 138-40 (1966).

Reorganization Plan No. 2 of 1966, 80 Stat. 1608, effective May 10, 1966, transferred the FWPC Administration and almost all functions under the FWPC Act from the Department of Health, Education, and Welfare to the Department of the Interior.

210. Bonderson & Gribkoff, California's Accomplishments and Problems in the Development of Standards Under the Federal Water Quality Act of 1965, at 4 (1967) (an unpublished paper presented by Mr. Bonderson, Executive Officer, State Water Quality Control Board of California, to the Western States Water Council, Helena, Montana, Sept. 29, 1967).

211. FWPC Administration, U.S. Dep't of Interior, Guidelines for Establishing

Interior Solicitor opined that coastal waters include "inland waters subject to the ebb and flow of the tide."[212]

The second jurisdictional question is whether repulsion of salinity intrusion is a proper subject for federal water quality standards. Salinity in the delta is a function of flow; it is not caused by waste discharges. If the federal standards are limited to criteria that can be achieved through abatement of waste discharges, then they are not applicable to repulsion of salinity intrusion.

Section 10(c)(5)[213] of the federal act describes the enforcement machinery for violations of water quality standards. It provides that the "discharge of matter" into interstate waters that reduced their quality below that established in the standards "whether the matter causing or contributing to such reduction is discharged directly into such waters or reaches such waters after discharge into tributaries of such waters" is subject to abatement by court action. If enforcement is limited to discharge abatement, it would seem logical that the standards were not intended to cover any broader scope.[214]

As a corollary, two other sections of the act deal with low flow augmentation. Section 3(b)[215] authorizes consideration to be given to low flow augmentation in the planning for any federal reservoir and provides that the costs of that feature may be made nonreimbursable. Section 5(d)(C)[216] authorizes the Secretary of the Interior to conduct research, studies, and experiments regarding the use of augmented stream flows to control pollution not susceptible to other means of abatement.

Nevertheless, the Secretary of the Interior has continued to insist upon establishment of water quality standards relating to delta salinity; and California has therefore submitted water quality standards for the delta area to the Secretary.

Water Quality Standards for Interstate Waters 10-11 (May 1966); Gindler, *supra* note 24, at 505.

212. Memorandum M-36690, dated June 13, 1966, from Solicitor of the Department of the Interior to Commissioner of FWPC Administration.

213. 33 U.S.C. § 466g(c)(5) (1965). *See also* 33 U.S.C. § 466e(b)(7) (Supp III, 1968) authorizing increases in federal construction grants where, *inter alia, "enforceable* water quality standards have been established for the waters into which the project *discharges* in accordance with section 10(c) . . . in the case of interstate waters" (emphasis added).

214. *See* 16 Op. Cal. Att'y Gen. 200 (1950). Section 13064 of the California Water Code provides that no cease and desist order to enforce "requirements" (*i.e.*, the receiving-water and effluent standards) imposed upon a waste discharger may specify the design, type of construction, or particular manner in which a violation is to be corrected. The California Attorney General stated that this limitation upon an enforcement order also applied to the waste discharge requirements that would be enforced by such orders.

215. 33 U.S.C. § 466a(b) (1965).

216. 33 U.S.C. § 466c(d)(C) (1965).

The delta water quality standards were initially formulated by the Central Valley Regional Water Quality Control Board,[217] which includes the delta within its jurisdiction.[218] The standards were then transmitted to the State Water Quality Control Board[219] for its consideration.[220]

At the hearing before the State Board, the Department of Water Resources, among others, took the position that certain of the water quality objectives relating to control of salinity in the western delta should be deleted from the standards proposed by the Regional Board.[221] Local interests supported retention of the Regional Board's salinity objectives for the western delta area. The State Board agreed with the Department's position and excised the provisions for salinity standards in the western delta area.[222]

On June 23, 1967, the state submitted its water quality standards to the Secretary without any salinity objectives for the western delta. The Secretary and his Federal Water Pollution Control Administration responded that salinity objectives for the western delta should be set.[223]

217. Cal. State Water Quality Control Bd., Central Valley Regional Water Quality Control Bd., Water Quality Control Policy for Sacramento-San Joaquin Delta G-1 through G-3, H-8 through H-13, I-8 & I-9 (1967). In California, the term "water quality control policy," defined in Cal. Water Code § 13001, has the same meaning as the term "water quality standards" as used in § 10 of the federal act.

218. Under California's Water Quality Act (Cal. Water Code Div. 7), the state is divided into nine regions, with a regional board established to deal with problems in its region. Cal. Water Code §§ 13040-41 (West Supp. 1968). The Central Valley region "comprises all basins including Goose Lake Basin draining into the Sacramento and San Joaquin Rivers to the easterly boundary of the San Francisco Bay region near Collinsville." Cal. Water Code § 13040(g) (West Supp. 1968).

219. Now the State Water Resources Control Board; *see* note 93 *supra*.

220. Required by Cal. Water Code §§ 13022.4, 13052.2 (West Supp. 1968).

221. J. Teerink, Statement of Department of Water Resources to State Water Quality Control Policy, Sacramento-San Joaquin Delta (1967).

222. *See* Water Quality Control Policy for Sacramento-San Joaquin Delta, *supra* note 214, at G-2, G-3, H-8, H-12. The State Board amended the policy to indicate that in lieu of the release of fresh water to repel salinity in the western delta, substitute supplies could be provided. *Id.* at H-13. The State Board expressly amended the policy by noting that as to the western delta "negotiations are under way between the water users and the [Department] of Water Resources concerning the details of substitute supplies elected to be furnished by [the Department] in lieu of salinity control as provided in the California Water Code." (Cal. Water Code § 12202 provides in part: "If it is determined to be in the public interest to provide a substitute water supply to the users in said Delta in lieu of that which would be provided as a result of salinity control no added financial burden shall be placed upon said Delta water users solely by virtue of such substitution.")

223. The status was described in California's Accomplishments and Problems in the Development of Standards under the Federal Water Quality Act of 1965, *supra* note 210 at 6-7:

> The State Board standards on the Sacramento-San Joaquin Delta and the Tidal Waters Inland from the Golden Gate within the San Francisco Bay

On July 19, 1968, the Southwest Regional Office of the Federal Water Pollution Control Administration submitted "Proposed Supplemental Delta Water Quality Standards for Chloride and Total Dissolved Solids Concentration" to the State Water Resources Control Board.[224] These supplemental standards are a somewhat stronger version of the Delta Water Quality Criteria of November 19, 1965.[225]

Following hearings on this proposal, the State Board, on October 24, 1968 refused to adopt the supplemental standards for the delta proposed by the federal authorities. Instead, the State Board did two things: First, it amended its water quality control policy for the delta by adding some provisions of the Delta Water Quality Criteria of November 19, 1965. Second, it put off until July 1969 any further consideration of additional water quality objectives for the delta.[226] However, under section 10(c)(2) of the Federal Water Pollution Control Act, the Secretary of the Interior can still initiate proceedings to prepare standards in areas in which he has found the

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Region state that for the time being there shall be no salinity standards in the western part of the Delta. Disagreement has arisen between local interests in the Western Delta and others concerned with water exports from the Delta. The only feasible method of limiting salinity intrusion into the Delta is by means of controlled releases of valuable water from upstream reservoirs. Since it has been established that such releases might be as much as 2.7 million acre-feet during a dry year, we need to evaluate the benefits and costs involved in such protection. The Board feels that the data now being developed by the San Francisco Bay Delta Study will assist in making this evaluation; and, pending the completion of this study, the adoption of salinity standards on the western part of the Delta would be premature. The Regional Office of the FWPC Administration, on the other hand, recommends that salinity standards be set at this time. We feel that setting salinity standards now is not pollution control but a water quantity-quality management problem.

224. Letter from Paul DeFalco, Jr., Director Southwest Region, FWPC Administration to Kerry Mulligan, Executive Officer of the State Water Resources Control Board, July 19, 1968.

225. The Delta Water Quality Criteria of November 19, 1965, are discussed *supra* note 191.

226. Cal. State Water Resources Control Bd., Res. No. 68-17: Adopting Supplemental Water Quality Control Policy for Sacramento-San Joaquin Delta.

The Board seemed to base waiting until 1969 on these reasons: (1) Quality and water rights are inseparably woven together in the delta. Hence, additional water quality objectives for the delta should not be considered until the Board has conducted further water rights hearings on permits issued to the California Department of Water Resources and the United States Bureau of Reclamation for appropriation of water from the delta. (Such hearings are scheduled to begin on July 22, 1969, and it is hoped that water quality objectives for the delta can be established by July of 1970.); (2) In March 1969, the special study authorized in 1965 for a comprehensive master plan for water quality control in the bay and delta (*supra* notes 204-05) was submitted for review. Public hearings have been held on the report and the final edition is expected in September 1969.

state-proposed standards do not meet the requirements of the federal act.[227]

(3) *Delta water agency for eastern delta*

An important factor in promoting a peaceful solution of part of the delta salinity controversy is enactment and implementation of the Delta Water Agency Act of 1968.[228] That act provides a vehicle for eastern delta interests[229] to enter into agreements for prevention of saltwater intrusion into the delta and for making any payments that may be required for such protection.

The act declares that its purpose is to create an agency representing that portion of the delta to enter into agreements with the United States and California to protect those delta lands from intrusion of ocean salinity and to assure those delta lands of a dependable supply of water of suitable quality for present and future uses.[230] Such agreements shall be validated in judicial proceedings[231] and must be approved by a majority of voters.[232] (However, if no such agreement is entered into by December 31, 1973, the agency is automatically dissolved.[233]) To meet its obligations under these agreements, the agency may borrow money and incur indebtedness,[234] and it may levy a tax upon all taxable lands within the exterior boundaries of the agency.[235] The agency has already been formed and is presently negotiating for an appropriate agreement.

(4) *Substitute supply contracts for western delta*

Pursuant to the decision to provide western delta users with a substitute supply by overland facilities in lieu of in-channel salinity repulsion,[236] the state through its Department of Water Resources has entered into contracts with the city of Antioch and the Contra Costa County Water District, two of the western delta water users.[237] The department does not provide the substitute supply di-

227. 33 U.S.C. § 466g(c)(2) (1965). Query, whether the Secretary has time to promulgate delta standards under the federal act before the State Board reconsiders additional delta standards?

228. Cal. Water Code App. §§ 108.1.1 et seq. (West Supp. 1968).

229. Most of Contra Costa County in the western delta is not included within the agency boundaries. *Id.* § 108.10.1, 10.2.

230. *Id.* § 108.4.1.

231. *Id.* § 108.6.1.

232. *Id.* § 108.7.1.

233 *Id.* art. 8.

234. *Id.* § 108.4.2(e).

235. *Id.* arts. 5 & 9.

236. *See* text, *supra* following note 160.

237. Contract dated April 11, 1967, between State of California and City of Antioch; contract dated April 21, 1967, between State of California and Contra Costa Water Agency.

rectly. Rather, it provides financial assistance to the district and the city to obtain the substitute supply by increased deliveries from units of the federal Central Valley Project. In essence, these contracts require the department to reimburse the city and the district for the additional cost of the substitute supply to replace water in the channel that is rendered unusable by excessive salinity as a result of the operation of the state project.

c. Conclusion

It appears that in the eastern delta, which is furthest upstream from the salt water in Suisun and San Francisco bays, salinity control will be obtained primarily by in-channel salinity repulsion. The implementation of this concept is being worked out without litigation and in an orderly manner.

In parts of the western delta, which is closest to the salt waters (primarily portions of Contra Costa County), the California Department of Water Resources intends to provide an equivalent substitute supply by overland facilities in lieu of in-channel salinity repulsion—something it is specifically authorized to do. Although contracts for this purpose have been concluded with two agencies in the western delta, other agencies in the area strongly deny that the department has complied with applicable law or that a substitute supply is any equivalent of in-channel salinity protection. As a result, litigation is now pending over the department's appropriative rights to water for the California Water Plan. Hopefully, however, an approach to peaceable resolution of all salinity problems of the western delta can be developed in time.

C. INCREASED SALINITY IN A HIGHLY DEVELOPED RIVER BASIN IN AN ARID AREA: COLORADO RIVER BASIN, WITH DETAILED ANALYSES OF PROBLEMS OF SALTON SEA, IMPERIAL AND RIVERSIDE COUNTIES, CALIFORNIA

1. SALINITY PROBLEMS ON THE COLORADO RIVER SYSTEM

a. History and background

The Colorado River rises in the high peaks of Colorado and is joined by the Green and San Juan rivers before it flows through the Grand Canyon. The main river, together with its tributaries, drains portions of seven southwestern states (Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming) and flows through the Republic of Mexico to its mouth in the Gulf of California. Nine major dams and reservoirs with an aggregate usable capacity of over 60 million acre-feet control the flow of the river and its tributaries. The Colorado River Basin is shown in Fig. 3.[238]

COLORADO RIVER BASIN

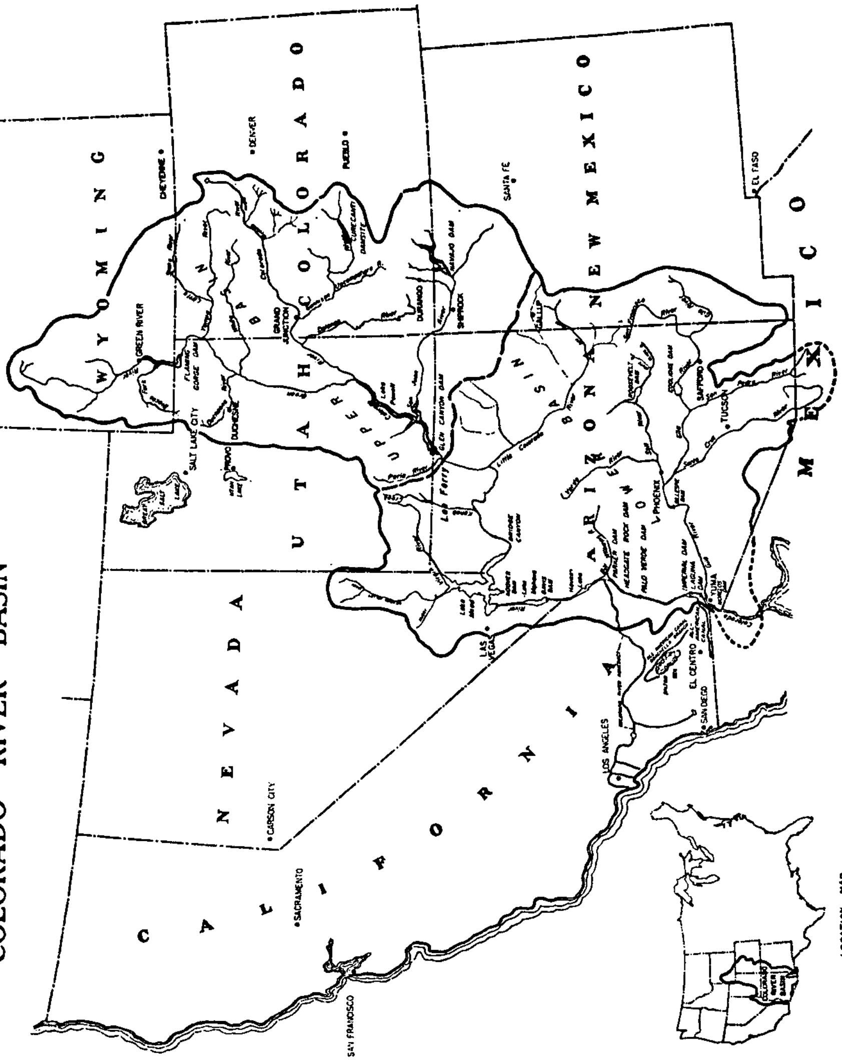

Figure 3

The lower Colorado River area, including the Salton Sea, which is the primary subject of this article, is shown in more detail in Fig. 4.[239]

238. The map was provided by Colorado River Board of California.
239. *Id.*

LOWER COLORADO RIVER AREA

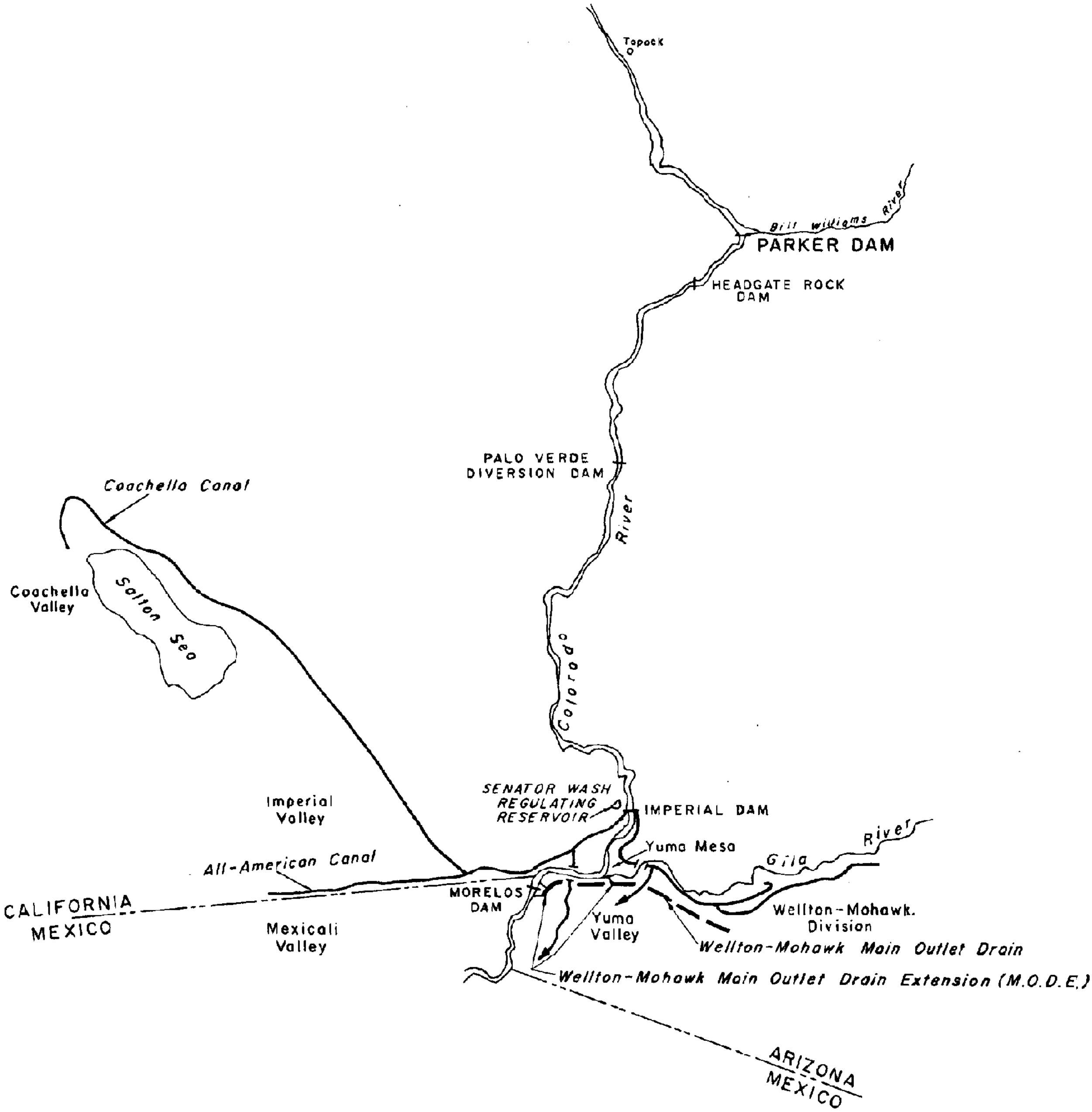

Figure 4

In 1928, when Congress was considering the bills enacted that year as the Boulder Canyon Project Act,[240] there was only a single criticism of the project with reference to salinity. Exposed salt deposits in the reservoir area of Lake Mead behind Hoover Dam would make the mineralized Colorado River water too salty for use.[241]

The Sibert Board, which in 1928 had been directed by Congress to investigate and report on the engineering and financing feasibility of the project,[242] refuted that criticism.[243] The Board asserted that, although Colorado River water was normally high in dissolved solids,[244] the water was usable for irrigation and domestic purposes. The Board concluded that salt deposits in the reservoir area would not increase the salinity of the water to an injurious level when water storage began and that, in a short time, incoming silt would effectively blanket the salt deposits so that the water salinity would reduce to about then current (1928) amounts.

b. Extent of salinity problem

Today, excessive salinity is the major water quality problem on the Colorado River.[245] Its waters continually degrade on their way

240. 43 U.S.C. §§ 617-17t (1964), authorizing Hoover Dam and the All-American Canal.

241. The major water quality problem on the Colorado River in 1928 was its silt burden, estimated at 113,000 acre-feet annually at Yuma, Arizona. Lake Mead behind Hoover Dam largely solved this problem by storing the silt. Problems of Imperial Valley and Vicinity, S. Doc. No. 142, 67th Cong., 2d Sess. 3, 4, 20 (1922); Arizona v. California, 373 U.S. 546, 553 (1963); Lake Powell, behind Glen Canyon Dam in northern Arizona and southern Utah, will trap and store about 80% of the sediment that formerly flowed into Lake Mead. U.S. Dep't of Interior, Quality of Water, Colorado River Basin: Progress Rep. No. 4, at 57 (1967).

242. 45 Stat. 1011 (1928).

243. H.R. Doc. No. 446, 70th Cong., 2d Sess. (1928).

244. Salinity on the lower river at Grand Canyon averaged about 523 ppm for the 1926 water year (Oct. 1, 1925—Sept. 30, 1926). This is the salinity of the water that would theoretically result from the impoundment of all of the flow of the river for the water year in a reservoir after thorough mixing. At that point, the salinity of the river varied during the 1926 water year from a high of 1135 ppm when the discharge of the river was 19,400 cfs to a low of 237 ppm when the flow was 69,800 cfs. At Topock, Arizona (just above Parker Dam), during the same year, the salinity ranged from a high of 1135 ppm when the flow was 24,300 cfs to a low of 253 ppm when the flow was 75,100 cfs. Geological Survey, U.S. Dep't of Interior, Water Supply Paper 596-B: Quality of Water of Colorado River in 1925-1926, at 36, 39-42 (1927).

In recent years, the mixing and regulation now provided by major reservoirs on the Colorado River have reduced such extreme variations in Colorado River water quality.

245. It was probably not until establishment of the U.S. Regional Salinity Laboratory of the Department of Agriculture in Riverside, California, in 1937 (U.S. Dep't of Agriculture, Agriculture Handbook No. 60, Diagnosis and Improvement of Saline and Alkali Soils iii (1954)) that a public awareness of the salinity problem on the Colorado River slowly began to develop.

Since 1963, a "Conference in the Matter of Pollution of Interstate Waters of the Colorado River and Its Tributaries," called at the request of the Colorado River Basin downstream, with a major cause of increased salt concentrations being the reduction in the amount of water transporting the salts.[246]

Between its headwaters high in the State of Colorado and Imperial Dam, the lowest diversion point in the United States, the salt concentration of the Colorado River increases about twentyfold.[247] Within the lower Colorado River Basin (below Lee Ferry), significant salinity figures for the 1942-1961 period adjusted to 1960 conditions of development, are that the Colorado River at Hoover Dam had an average salt concentration of approximately 725 ppm and an average salt load of nearly 10.9 million tons per year.[248] Of this salt load, it has been estimated that 1 percent came from municipal and industrial sources, 67 percent from sources of natural origin, and 32 percent from irrigation.[249] By the time this Colorado River water reaches Imperial Dam, that average salinity had changed to about 800 ppm with an average salt load of nearly 10.3 million tons per year.[250]

Future deterioration in water quality at Hoover Dam will result primarily from consumptive use and depletion of the water supply in the upper basin states above Lee Ferry. Unless some corrective action is taken, salinity concentration at Hoover Dam is expected to increase from the average of 725 ppm to 825 ppm by 1980 and to almost 950 ppm by the year 2010.[251] At Imperial Dam, the salt concentration would increase from the average of 800 ppm to in excess of 1200 ppm by the year 2010.[252] This means that by the year 2010 every acre-foot of Colorado River water would carry 1.3 tons of salts at Hoover Dam and in excess of 1.6 tons of salts at Imperial Dam.

c. Federal-water-quality-standards proceedings

On January 13, 1967, representatives from the seven Colorado

states under § 10(d) of the FWPC Act, has been considering the salinity problems on the Colorado. The most recent report in connection with this conference is FWPC Administration, U.S. Dep't of Interior, General Background on the Mineral Pollution Problem in the Colorado River Basin (preliminary edition subject to revision, Jan. 1968).

246. *Cf.* FWPC Administration, U.S. Dep't of Interior, Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior 113 (1968).

247. General Background on the Mineral Pollution Problem in the Colorado River Basin, *supra* note 245 at 3.

248. *Id.* at 5.

249. *Id.* at 6.

250. *Id.* at 5. Although the total tonnage of salts at Imperial is less than at Hoover Dam, the salt concentration at Imperial is higher because there is much less water there than at Hoover.

251. *Id.* at 12.

252. *Id.* at 5.

River Basin states agreed substantially upon interstate guidelines for water quality standards being set pursuant to the Federal Water Pollution Control Act by each of those states for the Colorado River system waters within its boundaries.[253] With reference to total dissolved solids, the states agreed that sufficient information was not yet available to set such standards in quantitative terms (*e.g.*, in ppm). In effect, they agreed only to consider the subject again at a later date when more and better information is available.[254] This approach was incorporated in the water quality standards for the Colorado River in California which this state submitted to the Secretary of the Interior on June 23, 1967,[255] as required by section 10(c) of the Federal Water Pollution Control Act.[256] On August 17, 1967, the Regional Director of the Federal Water Pollution Control Administration requested California's State Water Quality Control Board[257] to limit TDS at Imperial Dam to a maximum of 1000 ppm and to initiate a two-year program for establishment of numerical criteria for significant chemical characteristics.[258] (The other six basin states were similarly advised.)

On September 20, following intrastate and interstate conferences on this request, the California State Board adhered to its original position.[259] In part, it indicated that a pending federal study on Colorado River water quality should be completed and its findings reported before TDS standards on the Colorado could be intelligently established.[260] On November 15, 1967, the other basin states joined in substantially the same position.[261]

253. State Conferees in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries, Guidelines for Formulating Water Quality Standards for the Interstate Waters of the Colorado River System (January 13, 1967), developed at a series of meetings during 1966 and 1967 in the interests of compatible state water quality standards. Interstate cooperation has been encouraged by the Secretary. U.S. Dep't of Interior, FWPC Administration, Guidelines for Establishing Water Quality Standards for Interstate Waters: Policy Guideline 10 (1966), reprinted in Gindler, *supra* note 24, at 504.

This attempt for compatibility was not completely successful. The Secretary has recently "hoped the different standards set by Arizona, Nevada, and California for Colorado River boundary waters they share could be made compatible." Arizona Water Quality Standards Approved, Dep't of Interior News Release, Sept. 27, 1968.

254. Guidelines for Formulating Water Quality Standards for the Interstate Waters of the Colorado River System, *supra* note 253, Basic Principle 1.

255. State Water Quality Control Bd., Colorado River Basin Regional Water Quality Control Bd., Water Quality Control Policy for Colorado River in California I-2, 19 (1967).

256. 33 U.S.C. § 466g(c), discussed *supra* note 206.

257. Now the State Water Resources Control Board; *see* note 93 *supra*.

258. Letter from Regional Director William B. Schreeder to Paul Bonderson, Executive Officer, Cal. State Water Quality Control Bd., August 17, 1967.

259. Cal. State Water Quality Control Bd., Res. No. 67-43 (Sept. 20, 1967).

260. California's Accomplishments and Problems in the Development of Standards

In a statement delivered on January 30, 1968, the Secretary reversed his position and agreed that for the Colorado River "salinity standards will not be established until we have sufficient information to assure that such standards will be equitable, workable, and enforceable."[262]

2. SALINITY PROBLEMS WITH MEXICO

The water quality problem on the Colorado River continues at the international boundary where a minimum of 1.5 million acre-feet of Colorado River water is delivered by the United States to Mexico under the provisions of a 1945 treaty.[263] In 1961 the TDS of water being delivered to Mexico increased about one and a half times from spring to winter—from about 1100 ppm in March to about 2700 ppm during November and December. This astounding increase in salt concentration resulted from the operation of the Wellton-Mohawk Project in Arizona, on the lower river near Yuma, Arizona. A battery of wells had been put in operation to pump out salty groundwater building up under that project in order to prevent waterlogging of lands in the project; and the highly saline effluent was discharged into the Colorado River above Morelos Dam, Mexico's diversion dam on the river at the international boundary. The increased salinity of water being delivered to Mexico resulted from a combination of the smaller monthly deliveries in the winter months and this highly saline effluent from the Wellton-Mohawk Project.

The Mexicans protested bitterly. In 1965, after several interim procedures proved unsatisfactory, the two countries agreed to a temporary settlement of the controversy.[264] Essentially, the United States agreed to construct a drainage channel ("Main Outlet Drain

under the Federal Water Quality Act, note 210 *supra*, at 7-8. The federal study was authorized in 1956 by the Colorado River Storage Project Act § 15, 70 Stat. 111, 43 U.S.C. § 620(n) (1964), in 1962 by the authorizing legislation for the San Juan-Chama Project and the Navajo Indian Irrigation Project § 15, 76 Stat. 102, 43 U.S.C. § 615(ww) (1964), and again in 1962 by the legislation authorizing the Fryingpan-Arkansas Project § 6, 76 Stat. 393, 43 U.S.C. § 616(e) (1964). The most recent progress report is U.S. Dep't of Interior, Quality of Water, Colorado River Basin: Progress Rep. No. 4 (1969).

261. July 1, 1966—Dec. 31, 1967, Colo. River Bd. of Cal. Rep. 39.

262. *Hearings on H.R. 3300 Before the Subcomm. on Irrigation and Reclamation of the House Committee on Interior and Insular Affairs*, 90th Cong., 2d Sess. 705 (1968).

263. Treaty with Mexico Respecting Utilization of Waters at the Colorado and Tijuana Rivers and of the Rio Grande, Nov. 14, 1945, 59 Stat. 1219 (1945); T.S. No. 994. This controversy, the legal problems involved, and its temporary resolution are analyzed in Gindler, *supra* note 24, at 351-53.

264. Minute 218, International Boundary and Water Commission, United States and Mexico (Mar. 22, 1965).

Extension" [M.O.D.E.]) to bypass the pumped saline effluent around Morelos Dam except when Mexico requested that the effluent be discharged in the river above Morelos Dam. The agreement runs only five years, and it disclaims any intention to modify or construe the treaty.

This temporary settlement seems to be working well to date. M.O.D.E. was completed and put into operation in November 1965. Average salinity of water in the river at the northern international boundary has reduced from about 1380 ppm during the 1964-1965 period to 1230 ppm during the comparable 1965-1966 period and to 1210 ppm during the comparable 1966-1967 period.[265]

However, during the first two years of operation under the agreement, the United States has had to release to Mexico 50,000 acre-feet of water from storage in the United States to comply with the agreement.[266] Furthermore, there has been no indication that the pumping of the saline ground waters beneath the Wellton-Mohawk Project will be completed or can be terminated in 1970, when the temporary agreement ends under its own terms.

3. SALTON SEA

a. *History and background*

The Salton Sea lies below sea level in the southern part of California, with the Colorado River to the east, Coachella Valley to the northwest, Imperial Valley to the southeast, and Mexico to the south. Its water quality problems begin where those of the Colorado River in the United States and Mexico leave off. The sea is located in the Salton Basin (the lowest point on its floor is 278 feet below sea level). The natural runoff is normally insufficient to maintain a permanent body of water in the depression now occupied by the sea. However, it was created in 1904, when a series of floods eroded the temporary diversion headgate for the Imperial Valley and turned the entire flow of the Colorado River into the Salton Basin. When complete control of the diversion was finally attained in February

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265. U.S. Section, International Boundary and Water Commission, Report on Second Year's Operations for Solution of the Colorado River Salinity Problem Under Minute No. 218 (Dec. 8, 1967).

266. July 1, 1967—Dec. 31, 1967, Colo. River Bd. Rep. 40. Under Minute 218, the bypassed water is charged to Mexico under the treaty. Nevertheless, the United States also agreed in Minute 218 that when the water is being delivered at the minimum monthly winter rate, it would maintain certain minimum deliveries at Morelos Dam without counting the bypassed water. This total of the bypassed water and the minimum deliveries at Morelos Dam under Minute 218 was about 50,000 acre-feet over and above the delivery requirements under the treaty.

1907, the Salton Sea remained. At that time, it covered 500 square miles and at some points was more than 80 feet deep.[267]

After 1907 the sea began to recede, but from 1925 to 1963, the water level was generally moving upward because of increasing drainage from irrigation. Since 1963 the level of the sea has been rising slightly.[268] The sea is sustained primarily from drainage water received from Imperial and Coachella valleys in the United States and from Mexicali Valley in Mexico.[269]

The waters of the Salton Sea now approximate ocean water in chemical composition.[270] Its mineral content has increased from 3500 ppm and 77 million tons in 1907 to 33,000 ppm and 276 million tons in 1964. Since 1945 the addition of salts to the sea has averaged about 4 million tons annually.[271] Salts are brought in by irrigation drainage water. Some water evaporates, but the salts remain.

At present, the Salton Sea supports flourishing recreational and sports-fishing activities. Without salinity control measures, the sea will become so salty that eventually the fishery will be completely destroyed, possibly between 1970 and 1980.[272] This would eliminate a major base of the recreational attractions of the sea.

b. Establishing desirable salinity levels

The desirable salinity level for the Salton Sea is one that is relatively easy to determine. It is the current salinity level or one as close to the current level as can be achieved. The current level of salinity does support the important recreational and fishery resources of the Salton Sea. There does not seem to be any substantial economic advantage in reducing salinity in the sea, even if that were feasible, which it is not.[273] Hence, the objective of any study is to determine

267. A. Hely, G. Hughes & B. Irelan, Hydrologic Regimen of Salton Sea, California C2-C4 (Geological Survey Professional Paper 486-C, 1966) [hereinafter cited as Hydrologic Regimen of Salton Sea].

268. Imperial Irrigation District, Annual Summaries of Water Diversion, Transportation, Distribution and Drainage, for years 1963-1967, item called "Elevation of Salton Sea."

269. Hydrologic Regimen of Salton Sea C6-C7.

270. Pomeroy, Johnson & Bailey, Engineers, A Reconnaissance Study and Preliminary Report on a Water Quality Control Plan for Salton Sea, Prepared for the California State Water Quality Control Board S-1 (1965) [hereinafter cited as Preliminary Salton Sea Study], which has provided most of the information presented here on the problems of the Salton Sea and the engineering and economic feasibility of remedies.

See also Hydrologic Regimen of Salton Sea C24: Salinity of the Salton Sea fluctuated between 32,000 and 37,000 ppm during 1942-1963.

271. Hydrologic Regimen of Salton Sea C22, C23.

272. Preliminary Salton Sea Study S-1, II-4 through -31, III-51 through -57.

273. Theoretically, there are two ways to reduce the salinity of the Salton Sea: One is desalination, which is both technically and economically infeasible for this purpose.

whether it is worthwhile to prevent the Salton Sea from becoming much saltier—to improve the anticipated future salinity.

The benefits from such a salinity control project for the Salton Sea will be substantial. It has been estimated that the recreational benefits for the period 1970-2010, discounted to 1970 at a 7 percent rate,[274] would total $32 million. Community fringe benefits—value of service and retail sales in fields like sporting goods, hotel and motel accommodations, and catering—have been assumed to be about $16 million. Enterprises such as fish cannery and geothermal industry might benefit, but no monetary estimate can be made of the measure of this benefit. Finally, adjacent property, which can be conservatively valued at $100 million, would suffer substantial loss of market value if the recreational resource were lost to salinity, but again it is difficult to quantify such losses.[275]

Compared with those benefits, the 1970 values for salinity control costs by way of diking off 29 square miles of the sea,[276] discounted at a 7 percent discount rate, total less than $25 million.[277]

Accordingly, it appears that benefits of preventing substantial increases in the salinity of the Salton Sea in the future exceed costs thereof.[278] The next question is whether and how this salinity control can be accomplished and who will pay the costs.

c. Methods of achieving desirable salinity levels

Desalination of the Salton Sea or its inflow does not seem feasible at this time. Nor does dilution alone appear feasible. However, if salinity concentrations in Colorado River water were reduced (such as by dilution from an importation of high quality water),[279] this improvement in the river water would in time raise the quality of

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Another is by dilution with higher quality water in addition to or in place of the highly saline inflows from irrigation activities. However, no source of such water is available; and if the water were available, it would be a waste to run the water into the Salton Sea without using it in this arid water-short area for other beneficial uses first. *Id.* at IV-5. Dilution by way of *adding* the higher quality water to the present inflow suffers from this further disability: The level of the sea would have to be raised about four inches each year to keep the salinity at its present concentration, and this would substantially damage the value of fronting property. *Id.* Or the excess waters would have to be pumped out, at some expense.

274. Since the choice of a discount rate was considered debatable, comparisons were made at 4%, 7% and 10%. *Id.* at IV-53 to -54. The benefits exceed the costs under all three comparisons. For simplicity, we have chosen the middle figure.

275. *Id.* at IV-54 to -60.

276. The diking program, which is considered the best method to prevent harmful increases in salinity, is explained at 397-98 *infra*.

277. Preliminary Salton Sea Study IV-54.

278. *Id.* at IV-61. "The project is economically sound by any reasonable standards."

279. U.S. Dep't of Interior, Quality of Water, Colorado River Basin: Progress Rep. No. 3, at 80 (concl. 6) (1967).

the drainage water from the Imperial, Coachella, and Mexicali valleys into the Salton Sea. Thus, an importation would at least slow down the danger to the Salton Sea.

A recreational attraction of the Salton Sea is the orange mouth corvina, a game fish that the California Department of Fish and Game imported into the sea from its natural habitat in the Gulf of California.[280] The corvina thrives in the Salton Sea, which now approximates ocean water in salinity. There is no proven source of game fish that will tolerate substantially higher salinity.[281]

Therefore, the solution, if any, is to eliminate or reduce the sources of increased salt load and concentration in the Salton Sea. The search for this solution is limited by two important facts:

In the first place, the major sources of salination cannot be controlled.[282] For example, chloride ion, which is added to the sea at the rate of 4850 tons each day, comes from four sources:[283] (1) diffusion from bottom of the sea, 16 percent; (2) Mexicali Valley in Mexico, 14 percent; (3) water supply of Imperial and Coachella valleys, 30 percent; and (4) accumulated salts leached from Imperial and Coachella valleys, 40 percent.[284] Control of the first source is not physically feasible. The third and fourth sources are not practically susceptible of reduction as they are the necessary result of irrigated agriculture, which is the major economic base of the entire area.[285] Control of the second source, which is a major economic base for a part of a foreign country, is probably politically infeasible as well.

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280. Preliminary Salton Sea Study II-4, 6, III-43 to -44.

281. *Id.* at III-51 to -55.

282. Some minor sources of additional salts can be and have been controlled. For example, the Colorado River Basin Regional Water Quality Control Board has prohibited the discharge of geothermal brines into the Salton Sea, either directly or indirectly. *Id.* at IV-2.

283. During the Mexican Treaty salinity incident (*supra* at 392-93), one counterattack from the United States water users was that the Mexican farmers needed a better drainage system to maintain salt balance in the Mexicali Valley. Construction of an extensive drainage system in Mexicali Valley would tend to increase the mineral inflow to the sea from Mexico. Preliminary Salton Sea Study III-22; Hydrologic Regimen of Salton Sea C30.

284. The amount of accumulated salts being leached from these soils may decrease in the future, although it will be a large amount for a long time. Preliminary Salton Sea Study IV-22.

285. *Id.* at IV-2. The storage of waste and seepage water from irrigated land in Imperial and Coachella Valleys and of natural drainage waters from the combined watershed has been declared to be the primary beneficial use of the Salton Sea. Protection of aquatic resources and of fishing is declared to be a secondary major beneficial use. The state's water quality control policy for the Salton Sea exempts natural drainage and agricultural drainage and seepage waters from water quality objectives. California Colorado River Basin Regional Water Quality Control Bd., Res. No. 62-5: Policy Statement Regarding Disposal of Sewage and Other Wastes into Salton Sea and Adjacent Areas (March 22, 1962).

Second, the salts that are in the sea become more concentrated as water evaporates from its surface. That is one reason why the Salton Sea's waters have become ten times more saline than the irrigation drainage waters that are its principal source of supply.[286]

Hence, to prevent further undue salination of the sea, salts must be removed in solution from the Salton Sea at a rate equal to their inflow.[287] The methods that have been considered are:[288]

(1) *Removal and pumping of water to disposal site.* Water would be removed from the sea at a rate that will remove the salts as fast as they flow in, and this water would then be pumped to a secure disposal site. The estimated annual costs range from $1.8 to $3.4 million, depending upon what disposal site is selected.[289]

(2) *Removal of water to adjacent area, such as diked-off area, and pumping concentrate to disposal site.* Water would be removed from the sea to an evaporation area adjacent to the sea or to a diked-off part of the sea itself, and the resulting concentrate would be pumped to a secure disposal site. The estimated annual costs are $1,370,000.

(3) *Removal of water to diked-off area.* Water would be removed from the sea to a diked-off area of sufficient size to retain the salts for a long period of time. The estimated annual costs are $1,410,000.

The most feasible method from an economic point of view seems to be a variation of the third method—diking off a portion of the sea to serve as the final collecting place for the salts as the water evaporates.[290] The monetary difference between the estimate for

286. *E.g.*, the flows of the Alamo and New rivers, which are substantially (98% and 70%, respectively) irrigation drainage waters from Imperial Valley, averaged 2700 ppm and 3900 ppm, respectively, during the 1962-1966 period. California State Water Quality Control Bd., Colorado River Basin Regional Water Quality Control Bd., Water Quality Control Policy for Alamo River in California 2, 4 (1967) and Water Quality Control Policy for New River in California 2, 4 (1967).

287. Preliminary Salton Sea Study IV-5. The theory, oversimplified, is that a certain number of acre-feet of Salton Sea water with a salinity of about 33,000 ppm would be removed and replaced by a larger number of acre-feet or irrigation drainage water with a salinity of less than 3,000 ppm. Thus, the same amount of salts can be removed as are being added but in a much smaller quality of water. Perhaps this might be considered a combination salt-reduction and water-dilution method.

288. *Id.* at IV-5 to -29. *See also* Hydrologic Regimen of Salton Sea C30-C31.

289. Two of the most likely disposal areas, the Gulf of California and Laguna Salada (a dry, below-sea-level playa in Mexico, just south of the Salton Basin), would require an international agreement. *See* Hydrologic Regimen of Salton Sea C31; Preliminary Salton Sea Study IV-28.

290. Preliminary Salton Sea Study S-1. The diking procedure would operate in the following manner (*Id.* at IV-28):

> There will be large pipes with butterfly values to admit either river water or water out of Salton Sea into the evaporation area. There will be no pumping, and the water level in the evaporation area will never be higher than in the

removal of the concentrate to a disposal site as in the second method and the estimate for leaving the salts in a diked-off evaporation area as in the third method is less than the uncertainties inherent in the computation of those estimates. Dike costs under the third method are more likely to be lower than higher when they are revised in future studies. But a disposal site in Mexico under the second method might incur additional costs.[291]

In addition to providing salinity control, diking under the third method can also be used to maintain the water level of the Salton Sea. A sufficient area could be diked off so that the evaporation losses from the remaining area of the sea would equal the minimum inflow to the sea.[292]

d. Institutional arrangements

California's Colorado River Basin Regional Water Quality Control Board has declared the storage of natural drainage and of waste and seepage water from irrigated lands in the Imperial and Coachella valleys to be the primary beneficial uses of the Salton Sea. The water quality objectives for discharges into the sea do not restrict salinity of natural and agricultural drainage and seepage waters.[293]

Consequently, a public agency, which might be known as the Salton Sea Authority, will be required to raise the moneys for a salinity control project, construct it, and maintain and operate it.[294]

Finances could be supplied from various governmental agencies in the area, from fees paid by recreational users, from royalties for commercial fishing (if commercial fishery should prove beneficial or at least not detrimental to sport fishery), and from property taxes on properties adjacent to the Salton Sea that will benefit from a salinity control program.[295]

California has created a Salton Sea Advisory Committee,[296] whose membership is intended to represent a broad base of the interests in the Salton Sea area.[297] However, its only authority is to receive in-

Sea. Thus, there will be no problem of seepage of salt back into the Sea. The amount of water flowing from the sea into the evaporation area will control the salt concentration of the Sea. River water would be added to make use of the surplus evaporation capacity of the area.

291. *Id.* at IV-28.

292. *Id.* at IV-40; Hydrologic Regimen of Salton Sea C30.

293. California Colorado River Basin Regional Water Pollution Control Bd., Res. No. 62-5: Policy Statement Regarding Disposal of Sewage and other Wastes into Salton Sea and Adjacent Areas (Mar. 22, 1962).

294. Preliminary Salton Sea Study S-2, V-6 to -7.

295. *Id.* at V-1 to -5.

296. Cal. Stat. 1968, ch. 392.

297. *Id.* §§ 5-6.

formation from the Resources Agency on all matters pertaining to the Salton Sea and to advise the Resources Agency on such matters.[298]

Publication is expected shortly of a report on a reconnaissance study of the Salton Sea problems, by a joint federal-state study group composed of nine federal agencies and six state agencies, under the lead of the Bureau of Reclamation. Following this reconnaissance study, a more detailed three-year study will be conducted. These studies will seek to find means to stabilize the sea's surface elevation and to resolve its nutrient-related problems as well as to control its salinity levels. Undoubtedly, future action to control Salton Sea salinity will be based upon the results of these studies.

CONCLUSIONS

From this brief survey, we can draw certain conclusions about the proper approaches to the control of increased salinity caused by man's use of water.

The determination of a desirable salinity level for any body of water is by no means a simple task. Prevention of increased salinity and maintenance of the lowest possible salinity count are obvious, but not always the most desirable objectives. Each case requires consideration of a myriad of legal rights and complex studies of costs and benefits, both tangible and intangible.

Generally, the costs properly allocable to salinity control can be expressed in monetary terms. These costs should recognize valid water rights vested under state or federal law, by providing to their holders either the water in a quality and quantity to which they are entitled or just compensation for the part taken. Whether or not navigability permits the taking of such rights without compensation, there is no good reason in law or policy to heap all of those costs upon the owner of a water right that happens to be in the way of a public project. The project costs should include the cost of any property rights taken, whether those are rights to land or rights to water.

On the other hand, the benefits properly allocable to salinity control may have to be expressed partly in monetary terms and partly in qualitative terms as to benefits that are extremely difficult to quantify under present methodology.

The final decision is judgmental and may often depend upon the most practical considerations. For example, the necessary capital outlay may be hard to budget and raise where benefits seem only to approximate the costs and taxes already seem too high.

298. *Id.* § 9.

The benefit-cost ratio of salinity control facilities can also be affected substantially by changes in techniques for reducing or preventing salinity, or by full and detailed consideration of all alternatives. Improved techniques could lower the cost of achieving a given salinity level; or they could enable a greater reduction in salinity levels either at a lower cost per salinity unit eliminated or at an increased benefit per unit.

This continuing search for a better way to deal with salinity is exemplified by the water plan of California. As we have seen, the State Water Plan of the early 1930's would have prevented salinity intrusion into the delta by releasing sufficient water from storage to hold the saltwater tides out of the area. By 1957, when the California Water Plan was unveiled, the Biemond Plan for a waterway across the delta was proposed instead of a hydrologic barrier. But the most recent studies have concluded that the peripheral canal, combining a hydrologic barrier for some parts of the delta and substitution of supplies for other parts, has the greatest advantage among the salinity control facilities proposed for the delta.

Most forms of salinity control require the creation of a regional agency to administer them. Although litigation alone will not solve most salinity problems, it can serve some important purposes in conjunction with other institutional arrangements. For example, litigation initiated by the regional agency is one means by which the extent of water rights can be resolved among the parties to a salinity problem.

In California, the procedures currently being followed for salinity control seem substantially in line with these evaluations.