# POLLUTION OF GROUND WATER

The importance of protecting ground water from pollution stems from its increasing use as a source of supply by industry, cities, and irrigators. It presently represents approximately 20 percent of the water consumed in the United States.[1] By the year 2000 ground water may be relied on to supply as much as 50 percent of the amount needed, with the total demand by this time having increased an estimated three hundred percent.[2] Thus, if usable quantities of ground water are to be available to meet this increasing demand, its pollution will have to be controlled.

Ground water pollution presents a unique set of problems. The first of these, the travel of pollution, is a consequence of the underground environment in which the water is found. Without adequate knowledge of the phenomena of pollution travel it is impossible to predict when ground water will become polluted and where and how fast the pollution will move within the ground water basin before it is eventually withdrawn. The second problem, the existing doctrines which control the use of ground water, is the consequence of archaic legal concepts of the nature and origin of ground water itself. The legal profession has in the past been criticized for its unscientific approach to ground water. Courts have often treated it as a mysterious intruder into the soil beneath the land's surface.[3] Courts and legislatures have in recent years come to a more enlightened understanding of the nature of ground water, but have failed to adapt the basic water rights doctrines to conform to this new awareness. This failure manifests itself in two important aspects of ground water pollution. First, the law still recognizes the use of ground water for disposal of wastes as a reasonable use.[4] Second, the concept that the use of ground water is a property right has inhibited the much needed development of withdrawal controls in areas threatened with sea water intrusion.[5]

The purpose of this chapter is to illustrate why the unique nature of underground pollution and the present ground water doctrines create barriers to pollution control, to explain why these barriers must be overcome before ground water pollution can be controlled or prevented, and to suggest action that could be taken either to overcome these problems or at least to lessen their inhibiting impact on ground water pollution control.

## I. TRAVEL OF POLLUTION

Before a pollution control agency can deal with the problem of how pollution travels from place to place in the ground water basin, it must first es-

[1] G. WALTON, PROTECTION OF GROUND WATER RESOURCES 6 (Robert H. Taft Sanitary Engineering Center, U.S. Public Health Service, Tech. Report W62-25, 1966).

[2] C. MCGUINESS, THE ROLE OF GROUND WATER IN THE NATIONAL SITUATION 82–83 (U.S. Geological Survey Water-Supply Paper No. 1800, 1963).

[3] Thomas & Luna, *Ground Water in North America*, 143 SCIENCE 1001, 1003 (1964).

[4] *See, e.g.*, N. M. STAT. ANN. § 75-39-11f (1953).

[5] The California situation is discussed in text accompanying notes 152–65.

tablish that usable ground water exists beneath the surface and that there are sources of pollution that threaten its quality. Both of these considerations will be dealt with here to place the travel of pollution in its environmental context.

### *A. The Existence of Usable Quantities of Ground Water*

There are six environmental conditions that must exist before ground water can be usefully exploited in a given area. For ground water to exist at all there must be sufficient amounts of precipitation or flowing surface water penetrating the surface and moving downward under the influence of gravity, rocks beneath the soil that are permeable enough to transmit the water, and a rate of downward infiltration that is high enough to form a saturated zone before the rate of lateral movement out of the area matches the rate of infiltration.[6] This water is useful only if the rocks in the zone of saturation are permeable enough to yield useful quantities of water to natural springs, streams, or manmade wells. It is also necessary that the zone of saturation exist long enough to permit practical exploitation. Finally, the rocks comprising the aquifer must not be dissolved by the water; otherwise concentrations of minerals in the water might make it unfit for its desired use.[7]

Despite the seemingly restrictive conditions under which usable quantities of ground water might be found, it is one of the world's most ubiquitous resources. Federal and state agencies in recognition of this fact have begun an intensive program to discover and document the existence of ground water in order to allow for its future development.[8] Armed with this information, a pollution control agency may focus on those areas yielding ground water that require protection from pollution.

### *B. Sources of Pollution*

There are two major sources of pollution, waste disposal and salinity. These sources differ not only in their nature but also in the problems they raise for pollution control.

#### 1. Waste Disposal

Waste disposal by industry and municipalities poses as great a threat to the purity of ground water as it poses to surface waters. The extent to which ground water is polluted by waste disposal is for the most part still unknown or at least unreported.[9] There are five major waste disposal methods that have resulted in significant ground water contamination.

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[6] C. McGuiness, *supra* note 2, at 22.

[7] *Id.*

[8] For detailed reference materials on the subject of ground water, see U. S. Geological Survey Water-Supply Paper series and California Dep't of Water Resources Bulletins.

[9] Innumerable studies have been made on the frequency of pollution, but even the authors of these studies hedge the results because state administrators have a tendency to forget and forgive when reporting for publication. *See* Kaufman, *Inorganic Chemical Contamination in Ground Water*, in Robert A. Taft Sanitary Engineering Center, U.S. Public Health Service, Proceedings of 1961 Symposium, Ground Water Contamination 113 (Tech. Report W61-5, 1961) [hereinafter cited as Ground Water Symposium].

*a. Impoundments and Lagoons*

The use of seepage ponds or evaporation pits was traditionally confined to areas in which surface water disposal of wastes was unavailable. In recent years growing restrictions on waste disposal in streams have caused an increase in the use of these methods as an inexpensive alternative to greater treatment of the wastes.[10] Ground water contamination occurs when seepage ponds are located in areas of permeable soil overlying a ground water basin. Instead of evaporating, the liquid waste seeps through the permeable soil and down to the water table below, carrying its waste substances with it.[11]

One particularly striking example of pollution from sewage lagoons occurred in Washington in 1957.[12] The city of Tieton, attempting to avoid the problems created by individual sewage disposal by septic tanks, built a municipal waste disposal pond on the outskirts of the city. The pond was designed for disposal by evaporation and filtration. Little of the waste was disposed of by either process. The soil beneath the pond was so porous that the sewage infiltrated sixty times faster than the expected rate. It reached the ground water and began appearing in downstream wells 1550 feet away within six days. It was discovered that the ground water was traveling at the rate of 100–300 feet per day, an additional indication of the high permeability of the soil. The normal rate-range for ground water travel is between five feet per day and five feet per year.[13]

Ground water contamination from evaporation pits also occurs in those states fortunate enough to have oil fields within their borders.[14] Oil often coexists with salt water brines. These brines are treated as a waste product and are either "spread" over wide areas for disposal or are placed in evaporation pits. Texas, a heavy user of ground water,[15] discovered these were not evaporation pits but were seepage pits which placed large quantities of salty water into the badly needed ground water and caused severe economic losses to irrigators and ranchers.[16]

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[10] Deutsch, *Incidents of Chromium Contamination of Ground Water in Michigan*, GROUND WATER SYMPOSIUM 98.

[11] *See* Walton, *Public Health Aspects of Contamination of Ground Water in the Vicinity of Derby, Colorado*, GROUND WATER SYMPOSIUM 121; Burttshell, Rosen & Middleton, *Two Cases of Organic Pollution of Ground Water*, GROUND WATER SYMPOSIUM 115; Willets & Gould, Ground Water—a Vulnerable Resource, Aug. 1963 (unpublished paper presented to 13th General Assembly of Int'l Union of Geodesy and Geophysics, Berkeley, Cal.)

[12] Bogan, *Problems Arising from Ground Water Contamination by Sewage Lagoons in Tieton, Washington*, GROUND WATER SYMPOSIUM 83.

[13] C. LONGWELL & R. FLINT, INTRODUCTION TO PHYSICAL GEOLOGY 201 (2d ed. 1962). The most rapid rate of movement recorded within the United States is 770 feet per day. *Id.*

[14] Incidents of oil field brine contamination of ground water have been reported in Alabama, Arkansas, Kentucky, Louisiana, Indiana, Pennsylvania, Michigan, Texas, and Oklahoma, and the problem probably exists to some degree in every state having oil fields within its boundaries.

[15] McMillion, *Hydrological Aspects of Oilfield Brine in Texas*, 3 GROUND WATER, Oct. 1965, at 36.

[16] *Id.* at 39.

Some technological answers have been developed in this field of waste disposal. Most states with an oil field brine problem now require that these disposal pits be lined with an impermeable substance to prevent seepage into the ground water and insure evaporation.[17] But some wastes do not lend themselves to evaporation as a process of disposal. The plating industry, for example, has wastes containing large amounts of chromium and cyanide.[18] Chromium is highly toxic in small amounts, and lined evaporation pits should be used to prevent it from reaching the ground water.[19] But, paradoxically, the only known safe method of disposing of poisonous cyanide wastes is to allow them to percolate down through the soil from an unlined disposal pit. The minerals in the soil react with the cyanide and render it harmless.[20] A complete solution to the dilemma faced by the plating industry has not yet been discovered and incidents of chromium contamination of ground water continue to occur.[21]

*b. Septic Tanks and Cesspools*

The post-war boom in housing development in suburban areas of America beyond the reach of municipal sewage and water systems has produced in a significant number of communities serious ground water contamination. Since neither water nor sewers were available, heavy use was made of individual water wells and septic tanks. In many areas with abundant supplies of ground water that could be withdrawn at minimum cost and soil of high permeability that was suitable for septic tank waste disposal methods, the temptation to forego the expense of creating community supply and disposal systems was too great for developers to resist.[22] Public health services were either nonexistent or unaware of the danger of such arrangements. Most of the developers were aware that using the ground water beneath a particular area for both source of supply and disposing of wastes did create some chance of contamination. But it was felt at the time that if the wells were placed at sufficient distances from the septic tanks they would be safe from contamination. Faith in the distance approach was ill-advised. Contamination was not prevented; only its discovery was postponed.[23] Researchers have

[17] *Id.*

[18] Deutsch, *supra* note 10, at 100.

[19] M. DEUTSCH, GROUND WATER CONTAMINATION AND LEGAL CONTROLS IN MICHIGAN 25 (U. S. Geological Survey Water-Supply Paper No. 1691). 0.05 parts per million constitutes grounds for rejection of the water according to quality standards set by the United States Public Health Service. One part per million may have detrimental effects on the human nervous system resulting in chronic liver ailments. *Id.*

[20] *Id.*

[21] *See* Davids, *Control of Ground Water Contamination by a County Health Department*, GROUND WATER SYMPOSIUM 155; Rainwater, *Natural Ground Water Quality Problems*, 20 J. OF SOIL & WATER CONSERVATION 254 (1965); Deutsch, *supra* note 10; Jordan, *Ground Water Contamination in Indiana*, 54 J. AM. WATERWORKS ASS'N 1217 (1962).

[22] This trend is revealed by the large number of states that had reported ABS contamination in housing developments by the late 1950's. *See* Ewing, Letke & Banerji, *Retention of ABS on Soils and Biological Slimes*, GROUND WATER SYMPOSIUM 166.

[23] *See, e.g.*, Woodward, *Ground Water Contamination in the Minneapolis-St. Paul Suburbs*, GROUND WATER SYMPOSIUM 69.

discovered that almost all of the wells in these areas contain contamination with the highest levels of contamination being detected in the older developments.[24] Complaints were not received in newer developments because the contamination levels were still generally below detection by all but laboratory methods.[25]

The most serious contaminants from the point of view of public health are the biological organisms found in sewage. An outbreak of hepatitis in epidemic proportions in a community was traced directly to contamination of the ground water beneath the town by septic tanks.[26] Sewage effluent also carries large amounts of nitrates which can be hazardous.[27]

The most objectionable contamination contained in domestic sewage is alkyl benzene sulfonate (ABS). ABS was a surface-active ingredient in many domestically used detergents.[28] Although it has no known harmful effects, at extremely low concentrations it will foam if agitated.[29] ABS is such a widespread contaminant because it cannot be significantly degraded by any known method. Thus even in communities that have sewers and sewage treatment plants, if effluents are placed in the soil ABS will appear in the ground water.

Aside from city sewage plants and private homes with septic tanks, the largest single group of contributors of ABS to the ground are launderettes. In many areas where ABS contamination has become a significant problem, these businesses have been saddled with a heavy burden of treatment and disposal costs since the normal septic tank methods are denied them.[30] Future pollution by ABS may not be a threat since the detergent industry has, under pressure,[31] developed a substitute ingredient called LAS (lateral alkyl sulfonate) which is easily degradable.[32]

Pollution from septic tank waste disposal can only be prevented by long range planning. The decision to protect local ground water supplies in areas of suburban explosion cannot be left to developers and contractors. The difficulty of the situation is increased by the knowledge that whenever the soil

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[24] *Id.*

[25] *Id.*

[26] Vogt, *Infectious Hepatitis Outbreak in Posen, Michigan,* GROUND WATER SYMPOSIUM 89–90.

[27] Keller & Smith, *Ground Water Contamination by Dissolved Nitrates,* GEOLOGICAL SOC'Y OF AMERICA, Nov. 1964, at 120.

[28] CALIFORNIA STATE WATER QUALITY CONTROL BOARD, DISPERSION AND PERSISTENCE OF SYNTHETIC DETERGENTS IN GROUND WATER 3 (Pub. No. 30, 1965) [hereinafter cited as Pub. No. 30].

[29] *Id.* Most researchers agree that 0.5 milligrams of ABS per liter of water will cause the foaming effect. *Id.*

[30] *See, e.g.*, Davids, *supra* note 21, at 156.

[31] WIS. STAT. ANN. § 144.14 (Supp. 1967).

[32] According to the detergent industry, production of ABS was discontinued entirely in July of 1965. Lockwood, *The Detergent Industry and Clean Water,* SOAP & CHEM. SPECIALTIES, Dec. 1965, at 70. In a follow-up study the Sanitary Engineering Research Laboratory at the University of California showed that LAS is degradable enough that elimination of the aesthetically undesirable frothing can confidently be predicted. UNIVERSITY OF CALIFORNIA, SANITARY ENGINEERING RESEARCH LABORATORY, EFFECTS OF LAS ON THE QUALITY OF WASTE WATER EFFLUENTS (Report No. 66-5, 1966).

in a given area is permeable enough to make septic tank disposal practical and efficient it is almost certain that exploitable quantities of ground water exist. Conversely in areas where ground water does not exist, because of unfavorable soil conditions, septic tank disposal systems do not operate efficiently. These physical facts leave no alternative; if ground water is to be protected, sewage disposal systems must be installed. An area that seeks to protect its ground water supply must prohibit the widespread use of septic tank disposal methods.

*c. Refuse Dumps and Sanitary Landfills*

Four hundred million pounds of refuse is produced in the United States every day.[33] The temptation to dispose of it into the ground has been irresistible. Proof[34] that improper disposal could cause ground water contamination has required an alteration of attitudes towards the use of refuse dumps and sanitary landfills.

Contamination of ground water occurs whenever a sufficient quantity of water flows through the landfill or dump site to permit the leaching out of impurities, and this water subsequently enters the ground water aquifer. Most of the impurities found in these sites result from the natural decomposition of waste materials. The inorganic minerals produced by decomposition, when leached out and carried to the aquifer, increase the hardness of the water. Decomposing wastes often form carbon dioxide which when dissolved in water forms carbonic acid. The acid attacks and dissolves calcium carbonate rocks found in many aquifers, and again the hardness of the water is increased. Decomposing organic compounds produce ammonia which will dissolve and extract nitrates from other material. Nitrates in sufficient quantities will make the ground water unusable for most purposes. Other deleterious substances are picked up directly from the wastes; their identity depends on the composition of the waste material.[35]

In many areas the normal rainfall is not sufficient to cause significant amounts of leaching as the rainwater passes down through the landfill or refuse dump. In those areas contamination of the ground water can be prevented if disposal sites are located above the highest historical water table mark. This precaution would prevent the ground water itself from ever flowing through the site and directly leaching out the impurities.[36] Unfortunately

[33] Weaver, *Refuse Disposal, Its Significance,* 2 GROUND WATER, Jan. 1964, at 26.

[34] CALIFORNIA STATE WATER POLLUTION CONTROL BOARD, REPORT ON THE INVESTIGATION OF LEACHING OF ASH DUMPS (Pub. No. 2, 1952). This report was the first authoritative proof that sanitary landfills are a serious source of ground water contamination.

[35] *See generally* CALIFORNIA STATE WATER QUALITY CONTROL BOARD, IN-SITU INVESTIGATION OF THE MOVEMENTS OF GASES PRODUCED FROM DECOMPOSING REFUSE (Pub. No. 35, 1967); CALIFORNIA STATE WATER QUALITY CONTROL BOARD, IN-SITU INVESTIGATION OF THE MOVEMENTS OF GASES PRODUCED FROM DECOMPOSING REFUSE (Pub. No. 31, 1965); CALIFORNIA STATE WATER POLLUTION CONTROL BOARD, EFFECTS OF REFUSE DUMPS ON THE GROUND WATER QUALITY (Pub. No. 24, 1961); CALIFORNIA STATE WATER POLLUTION CONTROL BOARD, INVESTIGATION OF LEACHING OF A SANITARY LANDFILL (Pub. No. 10, 1954) [all Reports are hereinafter cited by Pub. No.].

[36] Pub. No. 10, *supra* note 35, at 13.

in many such areas abandoned gravel pits that are below the water table have been and are being used as refuse dumps and sanitary landfills.[37]

Since sanitary landfills do serve the dual beneficial role of refuse disposal and land reclamation their use probably should not and probably will not be prohibited. Alternate solutions for controlling their effect on ground water have been proposed. In a report[38] to the California Water Quality Control Board it was recommended that such sites be located only where there existed either no danger of ground water contamination (*i.e.,* no ground water below, or insufficient rainfall to cause leaching of a site above the high ground water mark) or where the contamination would not adversely affect a subsequent user of the water. If no such location exists, the report recommended that attempts be made to control the gases and contaminant bearing waters.[39]

*d. Surface Water Waste Disposal*

It will be seen later that in the normal course of events ground water discharges into surface streams, lakes, or oceans.[40] But in two situations, one natural the other manmade, this normal flow of water is reversed and surface water enters the ground and thus the ground water. If this surface water is polluted, obviously the ground water will become contaminated.

In some regions of the United States the rainfall is so light or intermittent that the ground water table is below the level of the surface water either permanently or periodically.[41] In this situation the surface water seeps into the aquifer through the river bottom. Unfortunately the greater density of polluted water causes it to settle to the bottom of the flowing river. As a consequence, the most polluted surface water is transmitted to the ground water.[42] Natural seepage of surface water into the ground is desirable since it slows the natural runoff, by virtue of ground water's slow movement, and results in water storage.[43] Axiomatically the only way to keep the ground water unpolluted in these areas is to keep the surface water unpolluted.

The normal flow of ground water into surface streams is also reversed whenever wells adjacent to a stream are pumped at a high rate.[44] Since this pumping causes a localized lowering of the water table,[45] the hydraulic pres-

[37] Pub. No. 35 *supra* note 35, at I-1.

[38] Pub. No. 31, *supra* note 35, at 38.

[39] *Id.* Five methods are mentioned as being under study: plastic liners, asphalt-soil mixtures, gel and silicone injection processes, and ventilation of the refuse and burn-off of the gases. *Id.* Some feasibility studies have been made and are reported in Pub. No. 35, *supra* note 35, at V-3.

[40] C. McGuiness, *supra* note 2, at 28.

[41] C. Longwell & R. Flint, *supra* note 13, at 206.

[42] Ninety-five percent of waste water released from two sewage plants had percolated into the aquifer within six miles of downstream flow. Pub. No. 30, *supra* note 28, at 43.

[43] Deutsch, *Natural Control Involved in Shallow Aquifer Contamination,* 3 Ground Water, July 1965, at 37.

[44] *See, e.g.,* Norris, *Effects of Ground Water Quality and Induced Infiltration of Wastes Disposed into the Hocking River at Lancaster, Ohio,* 5 Ground Water, July 1967, at 15.

[45] For a technical approach to this phenomenon, see Lehr, *Model Analysis of Water Table Downdraw Surrounding Pumping Wells,* 18 J. Soil & Water Conservation 205 (1963).

sure gradient is reversed and the surface water moves into the aquifer, carrying its pollutants with it. Unlike the natural situation in arid regions, steps can be taken to prevent this type of ground water contamination. Either lowering withdrawal levels of the stream-adjacent wells or relocating the wells where withdrawal does not effect the pressure gradient adjacent to the stream would prevent contamination.[46]

*e. Disposal Wells*

The use of abandoned water wells or deliberately constructed disposal wells is one method of waste disposal that has been subjected to rather strict control.[47] The reason for the long history of control is a simple one. The cause and effect relationship between waste injected deliberately into the ground water and contamination appearing elsewhere has never been difficult to establish.[48] The only mystery is how soon it will appear and where.

In recent years a variation of the same method, called deep-well injection, has been developed and hailed as one answer to industrial waste disposal.[49] The well is drilled to depths of 5000 feet or more (a level below which ground water rarely exists) and through an impermeable rock layer to prevent the waste material from rising to the ground water level.[50] Great care is taken to predict the underground flow of the wastes and insure that they will not surface or reach ground water. This method has been used successfully several times and so far the results are positive.[51]

2. Salinity

In the section of this chapter on sources of pollution resulting from waste disposal it was seen how the misuse of the ground water in a particular area could result in contamination. Contrary to this, pollution by salinity usually occurs only when water or ground water is properly used but is withdrawn in such quantities that the natural balance struck by nature is upset.

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[46] Norris, *supra* note 44.

[47] TEX. REV. CIV. STAT. art. 7621b (Supp. 1967).

[48] *See, e.g.,* M. DEUTSCH, *supra* note 19, at 13.

[49] Barraclough, *Waste Injection into a Deep Limestone in Northwestern Florida,* 4 GROUND WATER, Jan. 1966, at 22; Hundley & Malulis, *Deep-Well Disposal,* 1 GROUND WATER, Apr. 1963, at 15; Brown & Spalding, *Deep-Well Disposal of Spent Hardwood Pulping Process,* 38 WATER POLLUTION CONTROL FEDERATION J. 1916 (1966).

[50] D. WARNER, DEEP-WELL INJECTION OF LIQUID WASTE 2 (Public Health Service Pub. No. 999 WP-21, 1965).

[51] Several experts in the field of waste disposal doubt that deep-well injection is the panacea that many waste disposers claim it is. In this connection see McMillion, *supra* note 15, at 40, and D. WARNER, *supra* note 50. An article in 6 WATER NEWSLETTER, May 21, 1964, at 2, illustrates the variance of opinion by citing an address to the American Institute of Chemical Engineers in which the members were told that underground disposal of industrial wastes is a "safe method of waste control and is not a hazard to potable ground water." The speaker then cited the successes of the oil and gas industries in disposing of salt water brines by the deep-well injection technique. The article goes on to state that Alabama's experience with this indicates a contrary conclusion and it cites a study conducted by the U. S. Geological Survey Office and the Alabama Oil and Gas Board indicating that every oil field in Alabama has created problems of ground water contamination.

*a. Sea Water Intrusion*

Whenever a coastal ground water aquifer is being mined, that is when withdrawals exceed natural recharge, and the aquifer is of the type that normally discharges into the ocean, seawater intrusion will occur.[52] The overdraft causes a lowering of the ground water table and a reversal of the normal flow of the water out to sea. As the sea water moves inland, wells near the coast begin pumping saline water. If the process is allowed to continue, the salinity levels will rise to the point where the water withdrawn is unfit for use.[53]

The overdraft itself need not take place immediately adjacent to the coast, but may occur several miles inland. If this is the case, a trough is formed along the point of the overdraft and the seaward fresh water reverses its direction of flow. The sea water merely follows this inward flowing fresh water into the aquifer. Local geological and hydrologic conditions are so variable that for any specific case the foregoing explanation may be somewhat oversimplified, but the principles underlying it apply generally.[54]

Sea water intrusion has occurred in several parts of the United States;[55] but nowhere is the problem more acute than in California.[56] There is evidence to show that in some areas of California inland wells began withdrawing sea water as long ago as 1906.[57] Methods to control sea water intrusion have been under study in California for a number of years. To date five alternatives have been proposed but none has been fully implemented.[58] One absolutely certain method of stopping sea water intrusion would be to reduce the pumping levels in the ground water basin to the point of recreating the natural seaward flow of the ground water. This method has not been used because of the view in California that ground water and the right to withdraw it is a form of property[59] not subject to state control without the exercise of the eminent domain power. Additionally, large quantities of imported water would be required to meet the unanswered demand resulting from the reduction in withdrawals.

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[52] CALIFORNIA DEP'T OF WATER RESOURCES, SEA-WATER INTRUSION IN CALIFORNIA 15 (Bull. No. 63, 1958).

[53] SANITARY ENGINEERING RESEARCH LABORATORY, TECHNICAL BULL. 11, REPORT ON LABORATORY AND MODEL STUDIES OF SEA-WATER INTRUSION 11 (1955).

[54] CALIFORNIA DEP'T OF WATER RESOURCES, *supra* note 52.

[55] In Florida: Sherwood & Klein, *Saline Ground Water in Southern Florida*, 1 GROUND WATER, Apr. 1963, at 4. In South Carolina and Georgia: McCollum, *Salt-Water Movement in the Principal Artesian Aquifer of the Savannah Area in Georgia and South Carolina*, 2 GROUND WATER, Oct. 1964, at 4. In Hawaii: Visher, *Fresh and Salt Water in Southern Oahu, Hawaii*, GEOLOGICAL SOC'Y OF AMERICA, Nov. 1964, at 41. In New York: U. S. Geological Survey, Salt-Water Encroachment in Southern Nassau and Southeastern Queens Counties Long Island, New York (Water-Supply Paper 1613-F, 1966).

[56] *See* CALIFORNIA DEPARTMENT OF WATER RESOURCES, *supra* note 52, at 85.

[57] *Id.* at 9.

[58] *Id.* at 41.

[59] CALIFORNIA DEP'T OF WATER RESOURCES, SANTA ANA GAP SALINITY BARRIER 84 (Bull. No. 147:1, 1965).

It is also theorized that proper rearrangement of the areas of withdrawal would slow the intrusion process. Rejection of this alternative is usually based on the fact that it is not completely effective. But even if it were coupled with a sufficient reduction in pumping to be effective, a new distribution system would be required, and the costs would be prohibitive.

Artificial recharge of the ground water basin has been suggested as another answer. This method would entail the spreading or injection of imported or supplemental water into the basin in sufficient quantities to reverse the present inland flow and to maintain the water table at somewhere near or above sea level. This method has three drawbacks. A large supplemental water supply would be required as with pumping reduction, the process of recharging by injection is very expensive, and the possibility that artificially raising the water table would prevent natural recharge is presented.

A variation of artificial recharge has been proposed. A fresh water ridge along the present point of intrusion would be created. Instead of attempting to raise the water table in the entire basin by artificial recharge, water is injected only along the present interface between the fresh water and sea water. Just as withdrawal at a particular point creates a localized lowering of the water table or cone of depression, injection creates a mound or ridge in the water table. If this ridge is maintained at a proper level, the sea water cannot pass it. This method presents two advantages over general recharge of the basin. The injection system is less extensive and thus less costly, and the amount of supplemental water required to maintain the barrier is less. Consideration has been given to using treated waste water for the injection process since only insignificant amounts of it would enter the main aquifer.[60]

Serious consideration has also been given to constructing an impermeable barrier along the coastal basin, thus holding out the sea water while continuing the high level of pumping. Material such as asphalt or silica gels have been proposed as barriers. No pumping reduction or supplemental water would be required and, as an additional byproduct, no fresh water would be lost through natural discharge into the ocean, thus enabling a full exploitation of the water entering the basin. The major drawbacks to this method are its high initial cost, the practical physical limits on its depth, and the loss of natural drainage in the basin and the consequent possibility of increasing salinity through reuse.

The final proposed control method is pumping the basin at the point where the sea water is intruding and thus not only eliminate the sea water but create a trough that would allow the fresh water in the basin to return to its normal direction of flow. This method is as costly as creating a series of recharging wells to create a barrier and would waste large amounts of fresh water drawn into the trough and pumped out.

In 1965 the California Department of Water Resources[61] recommended

[60] BIENNIAL CONF. ON GROUND WATER RECHARGE, DEVELOPMENT & MANAGEMENT, PROCEEDINGS (L. Schiff ed. 1965).

[61] CALIFORNIA DEP'T OF WATER RESOURCES, *supra* note 59, at 116.

that a combination fresh water barrier-pumping trough system be used in the Santa Ana Gap region. A fresh water ridge would be constructed and maintained at sea level, and seaward from the ridge a trough would be created by heavy extration of saline water. This combination method was proposed because of the unique geological conditions in the area.[62]

*b. Salinity in Ground Water from Irrigation*

The predominant form of pollution in the arid regions of the United States which rely extensively on irrigation is excessive salinity.[63] Most arid lands are composed of soils that are high in salt content.[64] Thus through repeated applications of irrigation water to these soils the salts are leached out and carried down to the ground water aquifers. With each additional application of this water the salt content increases. This leaching coupled with the fact that two-thirds of the water applied to a field is consumed by evaporation and transpiration causes mineral salts to become highly concentrated in the remaining water.[65]

In the San Joaquin Valley in California the problem of saline ground water has been complicated by poor drainage.[66] The natural drainage of the area is unable to handle the vast amounts of imported irrigation water and as a consequence some areas in the valley have become all but worthless as arable land.[67] Additionally, increased amounts of water are needed in order to flush the soil free of the growth-impairing salts deposited by the degraded water. This sharply increases the drainage problem. Suggestions have been made that a drainage canal be constructed to transport these saline waters out of the area, but it was found that they would carry significantly high concentrations of nitrates into the area of discharge causing a large increase in the algae and plant growth and thus impairing the fishery and recreational values of the area.[68] The nitrates originate in the large quantities of fertilizers that are used in the valley.[69] Several alternate methods of disposal have been proposed including the treatment of these waste waters to remove the nitrates before discharging them.[70]

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[62] The report recognized that the use of only a withdrawal trough along the coast might cause the large number of peat bogs in the area to subside and thus create an additional problem. *Id.* at 88–89.

[63] Maxey & Farvolden, *Hydrological Factors in Problems of Contamination in Arid Lands,* 3 GROUND WATER, Oct. 1965, at 29.

[64] UNIVERSITY OF CALIFORNIA, WATER RESOURCES CENTER, AGRICULTURAL WASTE WATER SYMPOSIUM 10 (1966).

[65] Kaufman, *Inorganic Chemical Contamination of Ground Water,* GROUND WATER SYMPOSIUM 46.

[66] CALIFORNIA DEP'T OF WATER RESOURCES, SAN JOAQUIN VALLEY DRAINAGE INVESTIGATION 1 (Bull. No. 127, 1965).

[67] *Id.*

[68] *Hearings on Water Pollution—Central and Northern California Before a Subcomm. of the House Comm. on Governmental Operations,* 90th Cong., 1st Sess. 203 (1967).

[69] *Id.* at 235.

[70] *Id.* at 203.

### C. Movement of Pollution in Ground Water

McGuiness describes the movement of ground water in the following terms:[71]

> So long as there are any interconnected openings at all in a volume of rock, even very tiny ones, and so long as water enters the rock at one pressure head and can escape at even a slightly lower head, water will move through the rock.

He thus highlights the three variables that must be determined in predicting the movement of pollution in ground water: permeability of the soil and rocks, subsurface geology, and the pressure gradient.

The first subsurface environment encountered by liquid wastes is that of the zone of aeration. The zone of aeration is the area between the land's surface and the saturated zone of the ground water aquifer itself. The movement of liquid wastes through this zone has two important aspects: speed and direction. The rate at which the wastes move is dependent upon the permeability of the soil materials. Since liquids passing through soil or rock move through the interstices between the soil particles, the larger these spaces are the faster the liquid will move. As the soil and rock particles become larger, the interstices between the particles increase and thus the permeability of the soil is improved.[72] The soil in a given area is rarely of uniform composition. Thus as the liquids percolate down they encounter layers of varying permeability. These layers change not only the total rate of percolation from the surface to the aquifer but also the general direction of percolation.[73] As the liquid passes from one layer to another less permeable layer it moves laterally along the interface between the two layers. If the change in permeability is significant, the liquids may begin building up and create a perched water table far above the main aquifer.[74] Downward percolation may cease until the waters can find an easier route to the main water table. For these reasons it is essential that the entire soil composition below the point of entry be known. It is possible that the percolation rate may be so slow beyond a certain point that the chances of polluting ground water are remote. On the other hand immediate effects may be felt as was the case in the Tieton, Washington, incident, discussed above.[75]

Once it is shown that wastes will reach a ground water aquifer, and the speed at which this process will occur is known, it becomes necessary to determine the rate at which and the direction in which the now polluted ground water will flow. As previously mentioned, these are functions of the permeability of the aquifer material,[76] the subsurface geology, and the pressure gradient within the aquifer. Water below the surface moves in the same

[71] C. McGuiness, *supra* note 2, at 23.
[72] *See* R. Kazmann, Modern Hydrology 132 (1965).
[73] C. McGuiness, *supra* note 2, at 26.
[74] *Id.*
[75] *See* text accompanying notes 12–13 *supra*.
[76] Aquifer material may vary from coarse gravel to solid granite. For an analysis of the water producing properties of the more common aquifer material, see R. Kazmann, *supra* note 72, at 138.

manner as surface water.[77] It flows along the path of least resistance as determined by the permeability of the subsurface rock and subsurface geological formations. Ground water flows "downhill" or down gradient. Under normal conditions ground water flows toward and discharges into surface water streams and lakes, since the ground water table is normally above the level of the surface water courses. The rate of flow under most circumstances seldom exceeds five feet per day[78] and usually ranges between five feet per day and five feet per year, but it has been measured at 770 feet per day.[79] These variations may exist within the same basin because of geological structure and differences in permeability. This fact explains why subsurface movement of pollution presents a barrier to a rational program of pollution control. The lack of uniformity in the permeability of the aquifer materials and intervening geologic structures greatly inhibits the ability of scientists to predict if and when polluted ground water will appear in the wells of subsequent users. Scientists are able to measure the direction and rate of flow of the ground water at a given point,[80] but both the rate and direction could change ten feet downstream from the point of measurement.[81] These difficulties manifest themselves in two ways. First, even after a well has become polluted the subsurface complexities may prevent tracing the pollution back to its source. Second, it is difficult to set waste disposal standards at meaningful levels when there is no evidence that the waste materials will ever significantly impair a subsequent use of the water.

One peculiar aspect of the travel of polluted waters in a subsurface environment remains to be discussed. It has been mentioned that withdrawal of ground water causes a localized lowering of the water table or a cone of depression.[82] Conversely recharge of the aquifer, whether by liquid waste material or treated water injected for replenishment of a depleted basin, creates a mound directly below the point of introduction.[83] This mounding phenomenon has two important consequences. First, it increases the slope of the aquifer at this point and thus for a short space the wastes travel faster than the water in the aquifer below.[84] Second, the water may travel in the opposite direction of the normal aquifer flow for short periods.[85] Thus instead of dispersing vertically into the ground water the waste materials spread out horizontally along the top of the aquifer. One beneficial consequence of this is that once pollution is discovered in an aquifer the withdrawers may drill deeper wells with some hope of avoiding the pollution.[86]

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77 C. McGuiness, *supra* note 2, at 27.

78 R. Kazmann, *supra* note 72, at 157.

79 C. Longwell & R. Flint, *supra* note 13, at 201.

80 Tracers are often used to measure the speed of flow between two points in an aquifer. *See* Pub. No. 30, *supra* note 28, at 19.

81 Kazmann points out that measurements in an aquifer composed of consolidated rocks where the water moves through cracks and fissures in the rocks are meaningless. R. Kazmann, *supra* note 72, at 134.

82 Brown, *Hydrological Factors Pertinent to Ground Water Contamination,* 2 Ground Water, Jan. 1964, at 8–10.

83 *Id.*

84 *Id.*

85 Deutsch, *supra* note 10, at 98.

86 *See* Woodward, *supra* note 23, at 69.

1. Environmental-Chemical Factors.

Wastes are not placed in the ground in an effort to conceal or store them. Disposers hope that somehow the subsurface environment will purify them.[87] There are four processes on which waste disposers rely to accomplish this.

*a. Filtration*

If the soil beneath the waste disposal area can physically filter out the pollutants contained in the liquid waste material, the ground water below will not be contaminated. Filtration occurs only if the wastes contain solids of significant size. In some circumstances this process has the undesirable side-effect of causing the soil to become clogged and consequently unsuitable for waste disposal methods that call for rapid percolation.[88]

*b. Adsorption*

Adsorption is an electrochemical process involving the ability of certain substances to capture and retain other substances on their surface because of the electrical charge they carry.[89] The activated charcoal filter used to remove harmful substances from cigarette smoke is an example of one substance with this capacity. As in the case of filtration, if it is known in advance that a certain chemical pollutant will be adsorbed by the soil before it reaches the water table, the possibilities of contamination by waste disposal are lessened. However, because the adsorption capacity may be limited to a certain percentage of each quantity of a waste disposed of during a given period, pollution of ground water may occur.[90]

*c. Degradation*

Degradation is a biochemical process in which the biological organisms found in the soil break down the pollutants into other chemical substances.[91] Since the organisms need oxygen in order to maintain their metabolism at a high enough level to do any significant amount of degradation, this process takes place almost entirely within the zone of aeration directly beneath the surface.[92] The amount of degradation that takes place is dependent on the number of organisms available and the amount of oxygen available to them.[93]

*d. Dilution*

There is only a limited amount of mixing of liquid waste water with the waters already in the aquifer. Because of the mounding effect previously

[87] Deutsch, *supra* note 43, at 37.

[88] *See* McKee, *Research Needs in Ground Water Pollution,* GROUND WATER SYMPOSIUM 210.

[89] Ewing, Letke & Banerji, *supra* note 22, at 171.

[90] Pub. No. 30, *supra* note 28, at 31.

[91] *Id.* The term biodegradation is synonomous. *See* CALIFORNIA STATE WATER QUALITY CONTROL BOARD, DETERGENT REPORT 54 (1965).

[92] PUB. NO. 30, *supra* note 28, at 33.

[93] *Id.*

discussed and the almost total lack of turbulence in a ground water aquifer, pollutants travel as a cloud through the aquifer.[94] Waste waters do spread out horizontally on the top surface of the aquifer and thus become somewhat diluted,[95] but dilution cannot be relied on to significantly lessen the potency of polluted ground water as it can be with surface water. If a given basin is subjected to heavy withdrawal and recharge operations, the subsurface turbulence can be increased by the anomalous cones of depression and mounds created by withdrawals and recharging.[96]

It can readily be seen that the possible dilution, degradation, adsorption, or filtration of a pollutant has a direct effect on the amount a waste disposer will be allowed to place into the ground. These processes bear directly upon how deleterious an effect a particular waste will have on the ground water. Unfortunately, little factual information is available about the extent to which particular substances undergo these beneficial transformations and what types of soils promote these processes.[97] The result is that disposers of wastes place great reliance on these factors when speaking about waste disposal standards when in fact science has only identified their existence and has made no claim that they should be relied upon to protect the ground water from contamination.

### *D. The Impact of Withdrawal and Use*

Previous discussion has shown that withdrawal of ground water from an aquifer has a dual impact on ground water pollution. When withdrawals from a coastal aquifer exceed recharge it causes pollution in the form of sea water intrusion.[98] Withdrawals also create cones of depression in the aquifer and thus alter the flow of polluted waters.[99] Conversely ground water pollution has only one effect on withdrawal. It makes it a waste of time and effort.

A great amount of research has been concentrated on developing the minimum quality criteria required for the various beneficial uses of water.[100] If these criteria were uniformly met there would exist no need for reevaluation of ground water pollution control programs. Of course problems of classifying ground water as to intended use and then applying the requisite quality standards would still exist, but these issues raise questions of policy and economics, not of science, law, and administration. In the present state of the art, ground water quality criteria represent an unrealized ideal. The problem is not lack of criteria, but how to insure that these criteria are met. Until this problem is solved the withdrawal of ground water for a particular use and the concommitant quality standards have an impact only on whether the water should be withdrawn at all. The only question being asked when

[94] *Id.* at 34.

[95] *Id.*

[96] *See* Brown, *supra* note 82; Lehr, *An Empirical Model Study of Cones of Depression Produced by Pumping Wells*, 2 GROUND WATER, July 1964, at 10–15.

[97] Deutsch, *supra* note 43, at 37.

[98] *See* discussion of seawater intrusion in text accompanying notes 52–62 *supra.*

[99] *See* discussion in text accompanying note 60 *supra.*

[100] See generally J. MCKEE & H. WOLF, WATER QUALITY CRITERIA (State Water Quality Control Board, Pub. No. 3–A, 1963).

ground water is to be withdrawn is whether, in light of available quality, there is any point in withdrawing it.

## II. Ground Water Law

The common-law doctrines controlling the use of ground water are founded on the assumption that ground water is an immobile, renewable, naturally replenished resource that will be available in perpetuity, like the overlying land.[101] This fallacy results in doctrines that are useful only in fairly distributing this "inexhaustable" resource among its "owners." When applied to the problems of maintaining both an adequate future supply and acceptable quality, the doctrines, instead of being useful vehicles for finding solutions, become the major problem.

### *A. The Common-Law Doctrines*

The absolute dominion rule, or the English doctrine, is the progenitor of all modern ground water doctrines.[102] This rule was developed in an age when ground water was considered a "furtive invader"[103] into the soil beneath an owner's land. The courts theorized that, if the landowner could trap this water and use it, he was entitled to do so absolutely, without regard to whether anyone else was injured.[104] Many courts began phrasing this right in terms of a property right of the owner of the overlying land.[105] This rule is still applied with only slight modification in some humid eastern states. The modification consists of insisting that the use be neither malicious nor constitute an unnecessarily wasteful use.[106] Other areas found this rule unsatisfactory. In such jurisdictions, the law, while recognizing the landowner's right to capture and use the ground water, limits him to using the quantity of water necessary for some useful purpose in connection with the overlying land.[107] The only real impact of this reasonable use doctrine is that waste or exportation of ground water for distant use are not reasonable if the result is to deprive other overlying landowners of the opportunity of making reasonable use of the common supply on their land.[108]

The most complete implementation of these doctrines has occurred in California under its correlative rights doctrine. This doctrine arose out of

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[101] R. KAZMANN, *supra* note 72, at 200.

[102] Acton v. Blundell, 12 Mees & W. 324, 152 Eng. Rep. 1223 (Ex. 1843), is considered by most legal writers to have been the first statement of the rule. Texas reaffirmed its adherence to the rule in City of Corpus Christi v. City of Pleasanton, 154 Tex. 289, 293, 276 S.W.2d 798, 800 (1955).

[103] Thomas & Luna, *supra* note 3, at 1003.

[104] In Vineland Irrigation Dist. v. Azuza Irrigating Co. 126 Cal. 486, 494, 58 P. 1057, 1059 (1899), a case antedating adoption of the correlative rights rule, the California court stated, "percolating waters are a part of the soil, and belong to the owner of the soil. He may impound them at will, and the proprietor of lower lands injuriously affected cannot be heard to complain." *See also* 2 S. WIEL, WATER RIGHTS IN WESTERN STATES § 1039 (3d ed. 1911).

[105] *See* Stanislaus Water Co. v. Backman, 152 Cal. 716, 726, 93 P. 858, 862 (1908).

[106] W. HUTCHINS, THE CALIFORNIA LAW OF WATER RIGHTS 430 (1956).

[107] Hutchins, *Background and Modern Developments in State Water-Rights Law,* 1 WATER AND WATER RIGHTS 57, 73 (R. Clark ed. 1967).

[108] Hutchins, *Ground Water Legislation,* 30 ROCKY MT. L. REV. 418 (1958).

the *Katz v. Walkinshaw*[109] case decided in 1902 and has been fully developed by subsequent decisions. Each owner of land overlying a common water supply has a right to the reasonable beneficial use of the water from that supply on or in connection with his overlying land.[110] The term "reasonable use" in California ground water cases does not mean that one of two or more persons having correlative rights in a common supply of water may take all that is reasonably beneficial to his land, regardless of the needs of others. He may take only his reasonable share thereof, if there is not enough to supply the needs of all.[111] In effect the doctrine is one of public ownership of the ground water by all overlying land owners.[112] Appropriation is allowed only of that amount in excess of the reasonable need of overlying landowners.[113] Appropriation means nonoverlying use and includes use by public water suppliers, whether or not the lands receiving such public service are overlying lands.[114] Appropriative rights may be vested if they have existed for the prescriptive period.[115] These rules in practice are best exemplified by the Raymond Basin[116] case.

The basin was being severely overdrawn and as a consequence was threatened by sea water intrusion. Suit was brought to abate pumping. The court ruled that each pumper had obtained withdrawal rights equal to his average withdrawals for the previous five years. But since the total of these rights exceeded the safe yield of the basin, the court apportioned the safe yield among those having rights in accordance with the ratio of each individual's rights to the total rights in the basin. Although this decision did protect the basin at issue from further sea water intrusion, its effect on other basins was not as salutary.[117]

### *B. Appropriation Statutes*

Fourteen western states, realizing that the common-law rules governing ground water rights were incompatible with the proper exploitation of ground water, have adopted by statute the doctrine of prior appropriation.[118] These statutes recognize both the public ownership of ground water, as opposed to ownership by the overlying landowner, and the increasing need for control of the withdrawal of ground water.

Professor Clark,[119] in an examination of recent developments in ground water legislation, indicates that these statutes have the following provisions:

1. That percolating waters, or all waters in the state, are public and subject to appropriation for beneficial use.

[109] 141 Cal. 116, 70 P. 663 (1902).
[110] W. HUTCHINS, *supra* note 106, at 431.
[111] Eckel v. Springfield Tunnel & Dev. Co., 87 Cal. App. 617, 262 P. 425 (1927).
[112] W. HUTCHINS, *supra* note 106, at 450.
[113] *Id.* at 455.
[114] Burr v. Maclay Rancho Water Co., 154 Cal. 428, 98 P. 260 (1908).
[115] H. ROGERS & A. NICHOLS, 1 WATER FOR CALIFORNIA 328 (1967).
[116] City of Pasadena v. City of Alhambra, 33 Cal. 2d 908, 207 P.2d 17 (1949).
[117] *See* text accompanying note 155 *infra*.
[118] Clark, *Ground Water Legislation in the Light of Experience in the Western States*, 22 MONT. L. REV. 49 (1960).
[119] *Id.* at 53–54.

2. That all existing rights or beneficial uses are preserved or can be preserved under certain procedures.

3. A control board or commission is established.

4. Permits for the drilling of new wells are required.

5. The applicant must carry the burden of establishing a beneficial use before the license or permit can be issued and upon issuance the licensee's date of priority is fixed.

6. Data on drilling conditions must be reported.

7. Periodic reports on the actual use of the water must be filed.

8. Certain uses, such as domestic use, are exempt from the requirements.

9. Rights are terminated after the lapse of a prescribed period of nonuse.

10. Provisions are adopted for adjudication of claims.

11. Penal sanctions for violations are prescribed.

12. Appeals from board decisions to the courts are permitted.

It can be seen that the major impact of these statutes is to abrogate the common-law concept that the overlying landowner "owns" the ground water beneath his land in favor of a concept that the state under its police power may control and regulate the use of this valuable resource.[120] Two states, Washington and Hawaii, with a view towards preservation and conservation of ground water, have passed statutes allowing limitation of withdrawals when it is determined that the basin is being overdrawn.[121] This is particularly important in Hawaii where the threat of sea water intrusion exists.[122] Eight of these states allow the board to determine "critical basins" and refuse to issue new permits or limit withdrawals on the basis of that determination.[123]

These statutes represent a legislative determination that ground water needs protection from the private abuse so prevalent under the "rights in perpetuity" concepts developed by the courts.

## III. Impact of Pollution Travel and Water Rights Doctrines on Pollution Control

Programs for control of ground water pollution are at present in varying degrees of development. Many states have only recently passed control statutes.[124] But even those in which control statutes have been in existence for some time have begun to realize that proper statutory form and full powers are only the beginning steps in preventing ground water pollution. Without adequate knowledge of the travel of pollution and without a change

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[120] *Id.* at 55.

[121] Wash. Rev. Code Ann. § 90.44.070 (1961); Hawaii Rev. Stat. § 177–33 (1968).

[122] Hawaii Rev. Stat. § 177–5(5c) (1968) specifically mentions using the powers granted in cases involving an increase in the chloride content of the water.

[123] Ariz. Rev. Stat. Ann. § 45-301(1) (1967); Colo. Rev. Stat. Ann. § 148-18-3 (1963); Idaho Code Ann. § 42-233a (Supp. 1963); Mont. Rev. Codes Ann. § 89-2915 (1961); Nev. Rev. Stat. § 534.030 (1959); Okla. Stat. Ann. tit. 82, § 1007 (1951); Ore. Rev. Stat. §§ 537.620, 537.720 (1963); Wyo. Stat. § 41.129 (1959).

[124] *See generally* Hines, *Nor Any Drop To Drink: Public Regulation of Water Quality*, 52 Iowa L. Rev. 186 (1966).

in ground water rights doctrines, the full implementation of these laws cannot be realized.

### *A. Pollution Control and Disposal Standards*

It is essential to prevent, rather than merely control, ground water pollution. Control is a corrective procedure. Once it has been determined that waste discharges are polluting the ground water, the control boards take steps to halt the discharges through informal agreements, cease and desist orders, or injunctions. This approach when applied to surface water pollution works reasonably well because the impairment of the quality of the surface water is only temporary. Its rapid flow and high dilution capacity quickly disperse pollutants. Ground water dilutes wastes only slightly. Its slow, languid movement causes the pollution to persist for indefinite periods of time.[125] Knowing this, pollution control boards should pursue a vigorous campaign of prevention. At present, however, they do not.

#### 1. The Disparity Between Power and Ability

Modern pollution control statutes are often adequate vehicles for pollution control. A reading of the more recently enacted statutes in Illinois, Arizona, New Mexico, Washington, Utah, Texas, and Minnesota indicates that some legislatures are prepared to accept that control boards require full powers to deal with pollution effectively. All of the statutes expressly include ground water within their coverage.[126] Each grants the board or commission the power to adopt quality criteria[127] and designate uses for waters.[128] But the statutes vary on the crucial power to set waste disposal standards for dischargers. Illinois, Arizona, Texas, Washington, and Utah have adopted a permit system in which every discharger of waste within the state must obtain a permit, and the board may designate in the permit the strength and volume of waste that may be discharged.[129] Minnesota grants only the power to forbid discharges that cause pollution.[130] New Mexico grants an ambigu-

[125] *See, e.g.,* Pub. No. 30, *supra* note 28, at 33; Pub No. 24, *supra* note 35, at 95; Middleton & Walton, *Organic Chemical Contamination of Ground Water,* GROUND WATER SYMPOSIUM 54.

[126] ILL. ANN. STAT. ch. 19, § 145.2 (Smith-Hurd 1965); ARIZ. REV. STAT. § 36-1851 (1967); N.M. STAT. ANN. § 75-39-2 (1967); WASH. REV. CODE ANN. § 90-48-020 (1963); UTAH CODE ANN. § 73-14-2 (1953); TEXAS REV. CIV. STAT. ANN. art. 7621d (Supp. 1967); MINN. STAT. ANN. § 115.01 (1964); WIS. STAT. § 144.01 (Supp. 1967).

[127] ILL. ANN. STAT. ch. 19, § 145.6 (Smith-Hurd 1965); ARIZ. REV. STAT. § 36-1857 (1967); N.M. STAT. ANN. § 75-39-4 (1967); WASH. REV. CODE ANN. § 90-48-070 (1963); UTAH CODE ANN. § 73-14-4 (1953); TEXAS REV. CIV. STAT. ANN. art. 7621d (Supp. 1967); MINN. STAT. ANN. § 115.03 (1964); WIS. STAT. ANN. § 144.02 (Supp. 1967).

[128] ILL. ANN. STAT. ch. 19, § 145.6 (Smith-Hurd 1965); ARIZ. REV. STAT. § 36-1854 (1967); N.M. STAT. ANN. § 75-39-4 (1967); WASH. REV. CODE ANN. § 90-48-070 (1963); UTAH CODE ANN. § 73-14-4 (1953); TEXAS REV. CIV. STAT. ANN. art. 7621d (Supp. 1967); MINN. STAT. ANN. § 115.03 (1964); WIS. STAT. ANN. § 144.02 (Supp. 1967).

[129] ILL. ANN. STAT. ch 19, § 145.11 (Smith-Hurd 1965); ARIZ. REV. STAT. § 36–1856 (1967); TEXAS REV. CIV. STAT. ANN. art. 7621d (Supp. 1967); WASH. REV. CODE ANN. §§ 90-48-160—180 (1963); UTAH CODE ANN. § 73-14-5 (1953).

[130] MINN. STAT. § 115.03 (1964).

ous power to "regulate pollution,"[131] and Wisconsin allows its control boards to force the adoption of treatment methods.[132] The latter grants of authority may be euphemistic substitutes for the setting of standards or compromise provisions. However, the power to set disposal standards is crucial for ground water pollution prevention and those states that do not permit it have little chance of achieving full protection for either surface or subsurface waters. Unfortunately even those boards that have the power cannot set standards at meaningful levels. The reasons are amply illustrated by the efforts of the California Regional Water Pollution Control Boards.

The California Water Quality Control Act divides the state into nine geographical areas.[133] These were chosen on the basis of surface watershed areas which coincide, for the most part, with the major ground water basins. The State Water Resources Control Board has final authority, but each region is given enough autonomy to enable it to pursue statewide goals in the light of the differences between regions.[134] The California method of controlling pollution is similar to the approach of most of the recent legislation. All waste discharges must be reported to the regional board.[135] Failure to report enables the regional board to seek prosecution through the local District Attorney's office.[136] The board may then set the maximum quantity and potency of the waste materials,[137] but it may not dictate the treatment methods for conforming to these standards.[138] If the discharger is found to be exceeding the standards, the board may issue a cease and desist order.[139] If the discharger still fails to comply with the requirements the board may request the Attorney General to seek an injunction.[140] Only in cases involving the periodic waste disposal can the board get summary abatement, since a cease and desist order would be ineffective.[141] One expert maintains that these provisions are too cumbersome and too reliant on action by local district attorneys,[142] and as a consequence parties seeking action to prevent pollution are still forced into the courts. But even if the powers given to the regional boards were strengthened, their ability to set meaningful waste disposal standards to protect ground water would not be improved.

[131] N.M. STAT. ANN. § 73-39-4 (1967).

[132] WIS. STAT. ANN. § 144.03 (Supp. 1967).

[133] CAL. WATER CODE § 13040 (West Supp. 1968).

[134] CAL. WATER CODE § 13052(e) (West Supp. 1968).

[135] CAL. WATER CODE § 13054 (West Supp. 1968).

[136] CAL. WATER CODE § 13054.5 (West Supp. 1968).

[137] CAL. WATER CODE § 13054 (West Supp. 1968).

[138] CAL. WATER CODE § 13054 (West Supp. 1968) has been interpreted as not authorizing the state boards, regional boards, or the courts to dictate the method the discharger must adopt in treating wastes to meet the standards set. People v. City of Los Angeles, 60 Cal. App. 2d 494, 509, 325 P.2d 639 (1958).

[139] CAL. WATER CODE § 13060 (West Supp. 1968).

[140] CAL. WATER CODE § 13063 (West Supp. 1968).

[141] CAL. WATER CODE § 13080 (West Supp. 1968).

[142] Kreiger, *Law of the Underground*, 34 CIVIL ENGINEERING, Mar. 1964, at 52. In support of his argument the author cites an instance in Southern California where a city water district sued to enjoin the use of a million dollar sewage pipeline facility rather than wait for action by the local pollution board.

The regional boards use three techniques in establishing their waste disposal standards.[143] The first is based on the known deleterious effects of particular substances found in wastes. Relying on this knowledge the regional boards either prohibit the disposers from disposing of the wastes or limit the amount of disposal. This approach is greatly restricted by the lack of knowledge about most wastes and is generally used only for highly toxic substances. The second technique is called the receiving waters method. Allowed maximum amounts of specific substances present in the water are set for a particular location along the direction of flow, usually at the exit point from a sub-basin. If monitoring wells detect an excess of the substances over the maximum amounts allowed, the waste disposal standards previously established are made more strict for the entire basin. This method is essentially guesswork. Both the initial standard and any subsequent adjustments because of pollution require a knowledge of the relationship between the amount placed into the ground and the amount detected by the monitoring well. The information needed to make rational judgments is simply not presently available. The third technique for setting disposal standard uses an incremental base as the standard. Municipalities disposing of domestically used water through their sewage system are unable to remove all undesirable substances with present treatment methods. The amount remaining in municipal discharges has been applied as a standard to other disposers. The rationale appears to be that domestic use is a reasonable use and other users of the water should be entitled to pollute to the same degree.[144] This approach seems to overlook any possible distinctions based on the greater necessity or utility of domestic consumption as compared with other uses.

The inevitable conclusion is that the methods of setting standards for subsurface waste disposal in California are arbitrary and ineffective. Rational standards must await more complete knowledge about the travel of ground water pollution.

2. The Disparity Between Power and Its Exercise

The legacy of the common law and the gap in scientific knowledge of the subsurface movement of pollution have placed state pollution control boards in an unenviable position. They are granted power to set waste disposal standards but they are not given adequate scientific information on which these standards may be formulated. Moreover, they are constantly bombarded expressly[145] and impliedly[146] with the concept that subsurface waste disposal is a reasonable use of the ground water. The administrative reluctance created is reflected both in the standards that are actually set and in the permissive attitude of administrators when discussing the setting of standards. The use of municipal sewage effluent as a basis for determining allow-

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[143] Stone, *The Way We Do It?*, GROUND WATER SYMPOSIUM 161–62.

[144] *Id.* at 162

[145] N.M. REV. STAT. § 75-39-11 (1967).

[146] LeGrand, *Environmental Framework of Ground Water Contamination*, 3 GROUND WATER, Apr. 1965, at 11–15.

able discharges because it is a "reasonable" use[147] reflects the first, and a statement by a member of a California regional pollution control board the second:

> A critical review of the way we control ground water pollution reveals loopholes and shortcomings. Arbitrary limits based on our presently inadequate knowledge of the underground phenomena can have a serious effect on a community. Very strict limits would so restrain a community that its normal growth would be materially altered, or operating costs of an industry might be so increased that its product could not compete with those from another area. On the other hand, liberal limits would not afford protection to the ground water basin. It is the middle ground, somewhere between liberal and strict limits, that will allow community growth and fair industrial competition, without creating the threat of pollution, a threat difficult to determine.[148]

The real issue to most "go-slow" advocates is that waste disposal in ground water is a right which cannot fairly be denied or abridged without proper justification and that no standards, or the least strict standards, should be set until justification is available.[149] To those who consider subsurface waste disposal a reasonable use of the ground water this argument has great appeal. To those who may be considering the possible long-term effects of such an approach it has no appeal.

### *B. Controlling the Supply To Prevent Pollution*

The power and ability to set waste disposal standards would solve only one-half of the pollution problems faced by many states. A challenge to the purity of ground water that in many states exceeds the threat of pollution from waste disposal is pollution or degradation by salinity. Sea water intrusion and salinity from reuse for irrigation are the most serious contamination problems facing California,[150] which uses more ground water than any other state.[151]

Southern California is a water resources nightmare. The annual rainfall is of desert proportions and even that seems to run in ten-year drought cycles.[152] Although the area lacks significant sources of surface water, it overlies several large ground water basins which for some levels of population would be entirely adequate. But the demands on these ground water basins have for years exceeded the natural recharge. Consequently sea water intrusion has occurred. It was first detected in the 1920's[153] and has been

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[147] This, of course, is in line with CAL. WATER CODE § 13005 (West 1956), which defines pollution as an adverse and unreasonable impairment of quality. Thus the boards are forced into the position of using the old concepts of what is reasonable.

[148] Stone, *supra* note 143.

[149] LeGrand, *supra* note 146, at 14–15.

[150] WATER RESOURCES CENTER, *supra* note 64, at 1.

[151] *See* Price, *The Porter-Dolwig Law—Four Years Old*, 1965 BIENNIAL CONF. ON GROUND WATER RECHARGE, PROCEEDINGS (L. Schiff ed. 1965).

[152] CALIFORNIA DEP'T OF WATER RESOURCES, *supra* note 52, at 8.

[153] CALIFORNIA DEP'T OF WATER RESOURCES, *supra* note 59, at 8.

increasing in magnitude and severity since that time.[154] By the late 1940's the problem had finally become obvious enough to cause the initiation of legal action. The Raymond Basin[155] case ensued, unfortunately creating more problems than it solved. Pumpers of the basin were granted proportional rights in the safe yield based on their average level of withdrawals for the previous five years.[156] At the time, this answer appeared to be a just solution to a rather difficult problem, but as a direct consequence no informal agreements to lower withdrawals in other basins could be obtained because the pumpers feared that in the event of later adjudication their voluntarily lowered levels would be used as a basis for determining their rights.[157] Thus, pumpers began increasing their withdrawals as a hedge against a court determination. This caused greater sea water intrusion.[158] In an action for adjudication of rights in ground water, the court may refer the case to the State Water Resources Control Board which, upon discovery of sea water intrusion in a basin, may seek a restraining order to abate or lower pumping.[159] If the injunction is granted and the court, in its final decree, sets a pumper's rights at a higher level than that allowed by the temporary injunction, the state must compensate the pumper from another source of water until the two levels are equal.[160]

This is the present state of the law in California. No single agency has the authority to reduce or abate pumping. Withdrawals may be lowered only by voluntary agreement between the pumpers or through a cumbersome court action.[161] The only additional legislative step taken was the passage of the Porter-Dolwig Ground Water Basin Protection Act[162] which operates only to authorize the Department of Water Resources to study measures for the protection of ground water within the state. The Department in a study conducted under that statute[163] has plainly said that the most effective method of halting sea water intrusion would be to lower withdrawal levels.[164] Rather than face directly the difficulty presented by this solution because of the Cali-

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[154] *Id.*

[155] City of Pasadena v. City of Alhambra, 33 Cal. 2d 908, 207 P.2d 17 (1949).

[156] *Id.*

[157] Kreiger & Banks, *Ground Water Basin Management*, 50 CALIF. L. REV. 61–62 (1962).

[158] *Id.* at 62.

[159] CAL. WATER CODE § 2021 (West 1956).

[160] CAL. WATER CODE § 2021 (West 1956). In 1955 California amended the act which had created the Orange County Water District in 1933 to authorize the district to levy, in any year in which an overdraft occurred, a replenishment assessment against all persons who produce water in the ensuing year. If water rights are adjudicated, the assessment applies only to the amount of water withdrawn over adjudicated rights. The funds are raised for the purpose of purchasing "outside" water in order to replenish the district. *See* CAL. WATER CODE APP. §§ 40-23—34 (West Supp. 1968).

[161] Kreiger & Banks, *supra* note 157, at 66. The court procedure referred to is the reference of cases to the State Water Resources Board for an investigation that may take years to conclude and the results of which are not binding on the parties. *See* note 158 *supra*.

[162] Porter-Dolwig Ground Water Basin Protection Act, CAL. WATER CODE §§ 12920-23 (West Supp. 1968).

[163] CALIFORNIA DEP'T OF WATER RESOURCES, *supra* note 59.

[164] CALIFORNIA DEP'T OF WATER RESOURCES, *supra* note 52, at 41.

fornia water rights doctrine of correlative rights, which views water as property, the taking of which must be compensated, the state has launched a series of experiments and studies to consider scientific-engineering solutions to the problem.[165]

Degradation of ground water from salinity caused by repeated reuse of water for irrigation in an arid region has already been discussed as a serious problem in California's San Joaquin Valley.[166] Here, as with sea water intrusion, the only alternative solutions under consideration are engineering solutions. But if social and economic problems at present seem an insurmountable obstacle to control of degradation by irrigation, the following opinion may spur some action:

> I submit the proposition that the use of irrigation in the arid land of the 20th century is not an appropriate use of this valuable resource, water . . . actually from the standpoint of water use, agriculture is a marginal use of water. In the United States the water that will support one worker in arid land agriculture will support about sixty workers in manufacturing.[167]

## IV. Conclusion

If ground water pollution is to be prevented four steps must be taken. First, an intensive program of research on the travel of pollution is needed. Second, this new knowledge must be applied to setting disposal standards. Third, a reevaluation of the current water rights doctrines is required in light of the recent developments in scientific knowledge and the modern need for protection and allocation of ground water. Fourth, states must develop a means by which the quantity of ground water withdrawn can be controlled both for the purpose of preventing sea water intrusion and to allow for long-range management of ground water basins.

Research on the travel of pollution is required to allow pollution control boards to determine the relationship between waste disposal and quality of the ground water at the point of use. At present there is insufficient knowledge about whether waste disposed of in a particular way will reach the ground water and if so how fast this will occur. The impact of the various soils and aquifer materials on the waste's potency and chemical composition must be documented. Information on the dilution and dispersion of wastes by its movement in and with the ground water is incomplete. The speed and direction of pollution travel needs to be determined and, as a prerequisite to this, the geology and hydrology of the basin must be examined. Research is being done in all of these areas but the incomplete information that is available has not been assembled in a form that could aid in the administration of pollution control. Raw scientific data needs to be interpreted and compiled. Each state that seeks to advance its program of pollution control and prevention should assure that all available information is gathered and evaluated with an eye towards its rapid application.

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165 *See* text accompanying notes 59–60 *supra.*

166 *See* text accompanying notes 65–67 *supra.*

167 Koenig, *The Economics of Water Resources,* in AM. ASSOC. FOR THE ADVANCEMENT OF SCIENCE, THE FUTURE OF ARID LANDS 328 (Pub. No. 43, 1956).

The second step, the setting of meaningful disposal standards, is an absolute prerequisite to preventing the pollution of ground water. Ground water pollution must be prevented to avoid the almost irreparable injury that results to a source of supply that is increasingly relied on by consumers. As an interim step before full knowledge of the travel of pollution is obtained, the outdated concept that waste disposal is a reasonable use of ground water should be abandoned. Disposers should be required to assume the burden of proving that no pollution will occur. Allowing disposers to degrade ground water with wastes and taking the chance that the ground water will not be polluted would seem to be gambling with a valuable public resource. Disposers should be required to prove conclusively that the wastes they place into the ground will not lower the quality of the water to the point of pollution. This step would both protect ground water from the present threat of pollution and cause disposers to devote time to researching the impact of wastes on ground water quality and remove some of this burden from public agencies. Ultimately, sufficient information would be available to relieve disposers of this burden of proof. Meaningful standards could then be set.

The third step calls for a reevaluation of the basis for ground water rights doctrines referred to by courts and legislatures in deciding upon the allocation of ground water among users. The conceptualization of ground water rights in terms of property neither squares with the scientific reality nor aids in solving allocation problems in a modern society. The newer appropriation statutes are beginning to recognize that ground water is not a perpetually replenished resource to be taken at will, without regard to others, as a mere adjunct of property ownership. The statutes with control features have recognized that water must be used in light of needs greater than those of the individual user.

The third step is a prerequisite to the fourth. Recognition of the true nature of ground water and its place in future needs leads inevitably to passage of a statute granting administrative control over withdrawals in basins threatened with sea water intrusion or an overdraft that threatens the usefulness of the basin as source of supply. These powers need not be vested in the control board itself, so long as a procedure is created whereby a finding of a control board that overdraft is impairing the quality of the water can result in immediate lowering of withdrawals to protect the ground water basin until steps can be taken to preserve it.

Ground water pollution can be controlled in the same manner as surface water pollution, but to prevent ground water pollution an approach is required that is commensurate with the unique problems it presents. Answers must be found to new questions, new techniques must be adopted, and old concepts must be abandoned if efforts to save ground water from contamination are to be successful.

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