logic environment and environmental safety; (2) specific areas where better knowledge of waste—hydrogeologic interrelations may be needed; and (3) recommendations concerning present practices, or as necessary, for acquiring the information required to evaluate present practices.

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DECISION MAPPING—TOOL FOR UNDERGROUND WASTE MANAGEMENT

Deep-well disposal is one possible method for disposing of waste liquids. Serious concern must be given to the degrading effects on the subsurface environment that such a practice may involve. Yet probably there are geohydrologic basins suitable for injection of waste. At the same time, need for the detailed, and probably very costly, investigations of such basins that must precede injection should not be minimized.

The attractiveness of deep-well disposal usually is related to the favorable costs for injection compared with other disposal methods, such as high-temperature incineration, encapsulization, or others. Presuming that a given sedimentary unit has been evaluated thoroughly and found quantitatively and qualitatively suitable for waste injection, one still must evaluate whether it is more economically desirable to have each operator drill his own disposal-well facility, or whether it is more advantageous to collect the waste of several operators for disposal in a common well or wells. The economic scale advantages of centralized processing must be balanced against the costs of transporting the waste to the centralized facility. The optimal configuration of a centralized disposal system depends on the relative level of these costs. An additional advantage of centralized waste disposal is the greater effectiveness with which local, state, and federal development and operating regulations may be enforced.

We have developed a general mathematical model which allows rough optimization of a multisource, variably distributed system based on limited data. The model is expressed in terms of a decision map which indicates the optimal configuration to serve distributed sources of waste and illustrates the sensitivity of the configuration to important parameters, such as mean-source separation and waste load, which characterize the source population. Application of this economic model provides additional input to the waste-management authority who must integrate these data with environmental factors to produce a final recommendation.

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FEASIBILITY STUDY OF LIQUID-WASTE INJECTION INTO AQUIFERS CONTAINING SALT WATER, WILMINGTON, NORTH CAROLINA

An experimental system to inject liquid industrial waste into deeper sedimentary aquifers containing salt water was installed by Hercules, Inc., at Wilmington, North Carolina, in the spring of 1968, under a permit issued by the State Board of Water and Air Resources. The initial experimental system consisted of 1 injection well and 3 observation wells completed between depths of 850 and 1,050 ft, and 1 observation well completed in the next higher aquifer at a depth of about 700 ft.

The injection zone is an aquifer consisting of sand layers and some thin beds of limestone interbedded with silty sand and sandy silt. The aquifer has low permeability and productivity. The water in the aquifer is salty, with a natural artesian head of about 65 ft above land surface.

The system was placed in operation in May 1968, injecting the by-product from the manufacture of dimethyl terephthalate (DMT).The liquid, deaerated and filtered through 200-μ mesh screen, consisted of water containing acetic and formic acids with some methanol and having a pH of about 4. The maximum injection rate was about 200 gal/minute.

The pressure in the injection and observation wells rose sharply during the first few months of operation. By September 1968, the waste had passed the observation wells which were only 150 ft from the injection well, making the system obsolete for observing the rate and direction of waste movement through the aquifer. By June 1969, the injection well had become plugged with sand, and a new system was designed.

A new injection well and a part of the new observation-well system were completed and placed in operation in January 1971. One of the initial observation wells also was used for injection of part of the waste. Additional observation wells were added, and in 1972 the monitor system consisted of 6 wells completed in the injection zone at distances of 1,500–2,000 ft from the points of injection, 3 wells completed in the 700-ft zone, and 1 well completed in the 300-ft zone. The monitor system and data-collection program have provided much useful information on injection of this type of waste in relatively shallow sedimentary rocks.

The long-term feasibility of such a system appears doubtful, as the aquifer does not appear to be sufficiently permeable to accept the waste at a continuing rate of 200 gpm. Considerable difficulty also has been encountered in maintaining the injection and observation wells.

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HYDROGEOLOGY OF LIQUID-WASTE STORAGE IN FLORIDA

Restrictions on surface-waste disposal practices have caused many to look to subsurface storage of liquid waste in deep saline aquifers as a most practicable and economical alternative. Also, temporary subsurface storage of excess storm runoff and treated sewage as potential sources of fresh water to augment supplies in water-short areas is being investigated. Liquid wastes are being injected into deep, saline, carbonate aquifers at sites in the western panhandle and the southern peninsula of Florida. Additional sites are being considered in the central peninsula. The wastes, including acidic, high-oxygen-demand industrial plant effluents and variable temperature and density, secondary sewage plant effluents, and oil-field brines, are injected into permeable saline zones separated from shallower freshwater aquifers by one or more confining layers which have very little or practically no permeability. There are distinctive differences in stratigraphy between the panhandle and the peninsula of Florida. Hence, the geologic and hydrologic environments for subsurface waste storage also are different.

At a site near Pensacola, in western Florida, acidic liquid waste has, for nearly 10 years, been injected into a 1,400–1,700-ft deep, moderately permeable, carbonate zone of late Eocene age, separated from shallower freshwater aquifers by a widespread, 200-ft thick, nonpermeable, confining, plastic clay layer of middle Oligocene age. The calculated pressure effects of this injection now extend outward more than 30 mi. The