rials, toxic metals or substances, nuisance-stimulating nutrients, and waste heat. Treatment and control processes are now available for most industrial wastes. Some pollutants including complex chemicals, however, present difficult abatement problems.

The magnitude of the national industrial waste problem has remained relatively unknown. There has not been until the past few weeks a detailed inventory of industrial wastes. The Environmental Protection Agency within the past year embarked upon a three-pronged program to inventory, study, and regulate this vast waste complex.

Following a test mailing to refine the questionnaire and the instructions, a voluntary national industrial wastes inventory was begun in early August 1971. A comprehensive questionnaire has been mailed to 10,000 of the major water-using industries in the United States. The inventory questionnaire was designed to collect information on quantity and quality of wastewater constituents and discharge methods. Data from the inventory will be computerized to facilitate their use. These data will be extremely valuable in all governmental activities connected with the control of industrial wastes.

The Environmental Protection Agency is in partnership with the Corps of Engineers in the administration of the River and Harbor Act of 1899. Under the provision of this Act, each industrial waste discharge to the nation's waters will be regulated by a permit issued by the Corps of Engineers. The EPA will review, evaluate compliance with water quality standards, and recommend actions on the permit requests.

Comprehensive studies on 20 major industrial categories have recently been completed. These studies defined a feasible effluent level based upon production units for an industrial category. They present the best and most comprehensive compilation of data now available on wastewater management from these industrial categories.

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Disposal-Well Dimensions, Injection Rates, and Cost Responses

Deep-well injection as a means of liquid waste disposal is, at best, a costly and tricky operation. Nevertheless, despite the inevitable difficulties which occur, it has proven itself to be reliable, environmentally sound, and economically feasible for disposing of *certain* wastes in *certain* areas.

A mathematical simulation model has been developed for predicting the operational response of a disposal-well system. From the initial design parameters and the physical operating characteristics it is possible to estimate the cost of such an operation. Additionally, sensitivity analysis experiments can be performed to assess which design parameters, operational characteristics, or formation properties have the most significant impact on the overall system response.

Application of the model to date indicates that for favorable geologic conditions the cost of injection may range upward from \$0.25–\$0.40 per 1,000 gal; this figure includes O&M plus capital amortization, with the initial outlay ranging upward from about \$150,000. Even a ball-park cost estimate for a given injection system cannot be done until the key parameters (waste volume, well diameter, porosity, permeability, reservoir pressure, *etc.*) are known for that specific site.

Sufficient data are available from secondary sources to synthesize the basic characteristics of a "typical" injection well. (For this study, approximately 75 industrial disposal wells were considered.) Typical features include: (a) 90% of all wells in the U.S. are less than 6,000 ft deep with half between 2,600 and 4,200 ft, (b) only 10% operate with casinghead pressures greater than 1,050 psi, but 50% operate between 175 and 550 psi. These and other statistical characteristics were combined to create a set of fictitious—but representative—wells. It was upon this set of "standard" or "typical" wells that the following sensitivity experiments were performed. For our "typical well" designed to operate at 1,000 psi, an increase in wellhead pressure of 50% can be expected to raise the total unit cost from \$0.24 to \$0.32 per 1,000 gal. For a given flow rate, friction losses decrease rapidly as well diameter increases. For our well, an increase in diameter from 4 to 5 in., reduces the ratio of the pressure drop to driving pressure by 57%, thus substantially reducing energy requirements as a trade-off for a more expensive well. Responses to flow rate can be evaluated. For one of our "standard" wells, an increase in the flow rate from 400 to 600 gal/day increases the initial cost of \$224,000 by 53.5%, but lowered the unit cost by 21.2% from \$38.2 to \$30.1 per 1,000 gal. Formation impact can likewise be assessed. For our example, an unexpected drop in permeability from 60 to 40 md would increase the unit cost by 12.3%.

The above only begins to expose the type of information that simulation modeling can reveal. The modeling procedures and certain relations describing the basic processes are well understood. The weak link is data. The geologic—and other—uncertainties with which one must cope provide the real test. Only as more and better data become available will this approach reveal its true utility; hopefully it can be extended to include such things as probabilistic aspects of component failure, statistical reservoir analysis, *etc.*

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Large Saltwater Disposal Systems at East Texas and Hastings Oil Fields, Texas

The disposal of salt water produced with oil from the East Texas field has been successful in minimizing pollution of land areas and freshwater sources, and has been effective in maintaining bottomhole pressure. To date, 4.5 billion bbl of salt water have been returned to the producing reservoirs at a cost to the operators of approximately 2.5¢/bbl.

At Hastings field in Brazoria and Galveston Counties, Texas, Amoco is successfully disposing of 50,000–60,000 b/d of salt water by injection into saltwater-bearing formations below freshwater sandstones and above the oil-producing zones. The project is a "closed system," whereby the salt water produced is allowed no contact with air, thereby reducing corrosion attack on disposal facilities. To date, Amoco has injected approximately 500 million bbl of salt water.

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Deep-Well Acid Disposal—Planning and Completion

Because of the magnitude of damage wrought to our natural resources, pollution control and environmental