

great emphasis on relationships of flow, seasonal changes, and water quality in an effort to provide this knowledge.

GEOCHEMICAL RESEARCH AS RELATED TO POLLUTION

Ground-water systems, impounded water, and estuaries are subject to unwholesome quantities directly related to a variety of biological, chemical, and geochemical processes. Some of these processes could be inhibited or counteracted if they were properly understood. The Survey has a considerable research program aimed at understanding such subjects as the solution chemistry of sediment-water interfaces in lakes, and acid-producing processes in mines. Mine acid and accompanying serious iron contamination result from reversal of a massive process of nature originally responsible for pyrite deposits, which now are primarily responsible for the mine problems. It is not known whether these processes occur in both aerobic and anaerobic environments, nor whether it is possible to inhibit or reverse the process by proper catalysis, bacterial seeding, or other encouragement. Geochemists of the Survey are working to understand such processes and to demonstrate, by pilot applications, what might be done to reduce related pollution.

REMOTE SENSING POSSIBILITIES

The massive expansion in population, industry, and urbanization, and the attendant waste disposal problems, mean that much information must be collected on a large and relatively inexpensive scale of we are to keep up with the rate of problem development. Remote sensing of pertinent environmental factors is the only answer to this situation. The Survey's Remote Sensing Hydrologic Applications Program has an extensive plan for surveillance of lakes, hydrodynamic studies of estuaries, and other subjects, which well could result in breakthroughs of understanding of environmental phenomena.

APPENDIX 2

COMMENTS ON ISSUE D(2) OF "ISSUES FOR THE CONSIDERATION OF THE CONGRESS,"
PAGES 15-17, "REPORT OF THE RESEARCH MANAGEMENT ADVISORY PANEL"

"D. The Scientific Basis for Pollution Policy.

"(2) What do we need to know about movement of ground water to permit deep well disposal of wastes? Similarly, do we know enough about oceanic circulation and marine ecology to permit deep sea disposal of wastes?"

DEEP-WELL DISPOSAL OF WASTES

Until the utopian goals of waste management are realized—complete and productive re-use of waste products or total removal of wastes from man's environment—compromises must be acceptable. This means reduction of waste volumes to the maximum practicable extent and discharge into those parts of the environment that are farthest from the biosphere. The fluid-filled void space of the geologic subsurface contains storage reservoirs for liquid wastes that have been out of direct contact with surface processes for millions of years. Injection of liquid wastes into this inner space provides the opportunity to remove noxious materials from contact with man almost indefinitely.

Deep injection of wastes is a useful alternative to disposal into surface or near-surface potable or usable waters. It is not a panacea and is presently an expensive and often uncertain alternative. Although the general methods are well known and are based on proven engineering concepts, confidence in feasibility judgments and long-term acceptability at a given site requires information in a degree of detail that is seldom readily available. This includes (1) a knowledge of the subsurface rocks and their contained fluids, (2) the dynamics of the flow system of which all subsurface fluids are a part, and (3) possible adverse geochemical interactions among waste fluids, native water, and reservoir rock, dangerous hydraulic fracturing and possible adverse effects of waste fluids on geologic processes such as movement in faulting zones.

Considerable geologic and hydrologic research is required to provide a better basis for evaluating underground waste disposal sites. Geologic and hydrologic research, data collection, and analysis activities of the Geological Survey must make major contributions to attaining the necessary information. Expansion of some activities, particularly in the areas of age dating of deep ground