range of climatic and oceanographic conditions which prevail in our vast estuarine systems reaching from the arctic seas of Alaska to the tropic seas of Hawaii and Puerto Rico.

The demands of this task far outrun the availability of scientific knowledge although considerable progress has been made in many areas in recent years. There are many recent examples in which the research programs of the Department of the Interior have contributed to the understanding of the estuarine ecological systems and in which the expertise of Interior's scientists has been applied in programs for pollution prevention and water quality enhancement. These examples have ranged through such diverse fields as 1) oceanographic engineering studies which permitted the accurate forecasting of the rate of salt water movement up the Delaware River during the recent period of great drought in the Northeast and which pinpointed the scheduling of upstream reservoir releases thereby protecting the Philadelphia water supply while minimizing water loss to other upstream users; 2) documentation of the toxic effects of sulfite mill wastes on shellfish and fish in Puget Sound; 3) contributions to the understanding of problems resulting from the discharges of warm water into estuarine systems to assist in powerplant site selection; 4) the development of methods for the detection of pesticides at "parts per billion" levels and establishment of the cause—effect relationship of these minute levels to the recent extensive destruction of fish life in the Mississippi River; 5) the determination by the Bureau of Commercial Fisheries of the growth-inhibiting effects of pesticides on oysters; and 6) the determination by the Geological Survey of minute quantities of metals such as zinc or copper in streams which discharge into estuaries. However, the knowledge bank which is available to the engineer and scientist is as yet inadequate for real understanding of the ecological systems in estuaries necessary for effective water pollution control and water quality enhancement.

The technical problems associated with the protection of estuarine resources are vastly different from those which are encountered in the study of fresh water streams and lakes. Whereas a river consistently flows in one direction, the estuary presents a dynamic situation constantly reacting to the forces of wind and tide. Flow is sometimes in one direction, sometimes in another, and sometimes not at all. This complex situation is made even worse by the difference in weights of fresh and salt water which permits the lighter fresh water to ride over the salt water below. Thus, an estuary frequently has dissimilar top and bottom flow patterns which is reflected in differences in water quality in the top and bottom layers of water. Consequently, almost any major study of dispersion, retention, or distribution of a pollutant in an estuary presents problems which tax the abilities of the most skilled mathematicians, and the capabilities of space age computers. Mathematical models have, however, been applied to complex estuarine situations by Interior specialists to determine ecological impacts of proposed water resource development. Two outstanding examples are the San Joaquin Master Drain Study in California and the Delaware Estuary Study in New Jersey, Pennsylvania, and Delaware. Similar models are currently being applied to the Potomac River-Chesapeake Bay system to develop methodology which will upgrade water quality in the most effective manner.

The variations in water masses within a given estuary also present many problems in the collection and examination of water samples for pollution. In general, many more samples are required; the cost of collection is higher; and, the difficulties of laboratory examination are magnified. To meet these challenges the technician must find ways to obtain adequate data at reasonable cost and to develop methods for identification of pollutants in water in which ocean salts are present in varying degree. Progress is being made, and more progress is likely. Automatic devices are being developed for the sensing of pollutants and for transmission of flow and quality data to a central point; such a system has already been installed in the Potomac River below Washington. The Federal Water Pollution Control Administration is now developing a research project for use of infrared imagery for the rapid aerial mapping of thermal pollution sources (fig. 30). The atomic absorption spectrophotometer has been adapted for the detection of minute quantities of metallic contaminants.