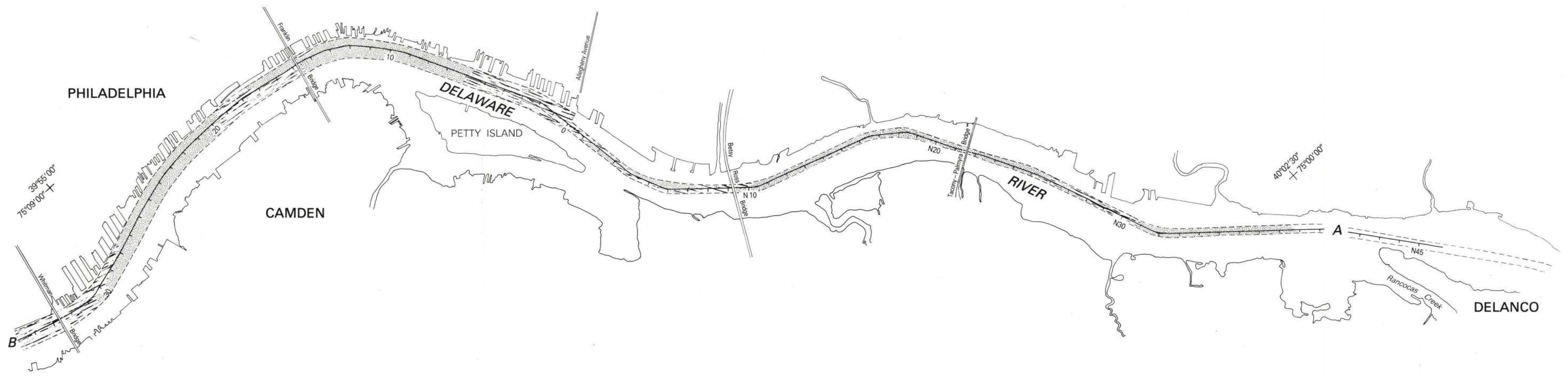
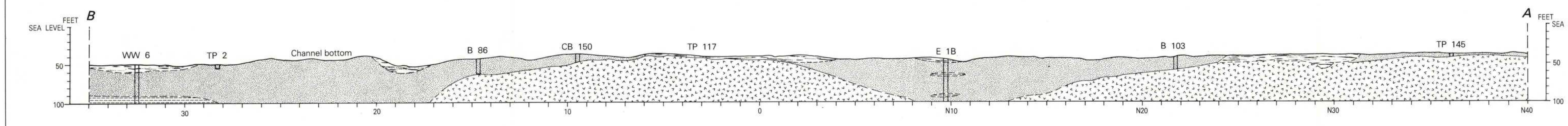
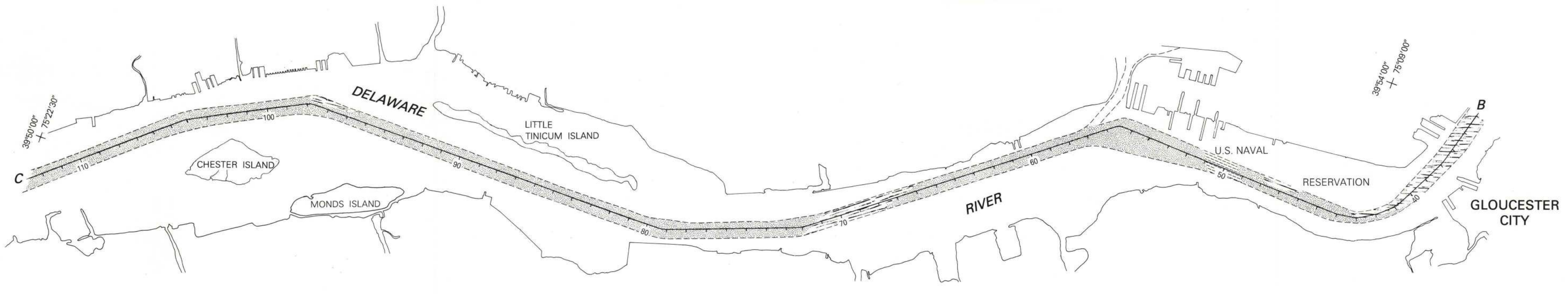
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

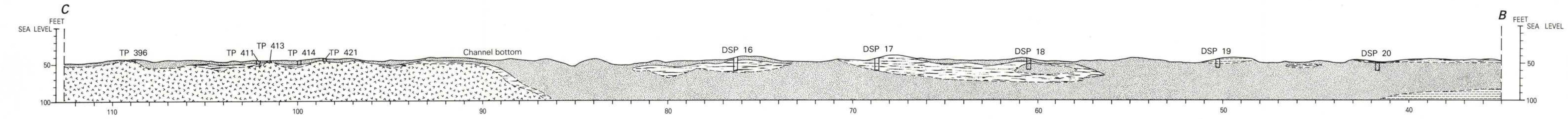
PREPARED IN COOPERATION WITH THE
UNITED STATES ARMY CORPS OF ENGINEERS

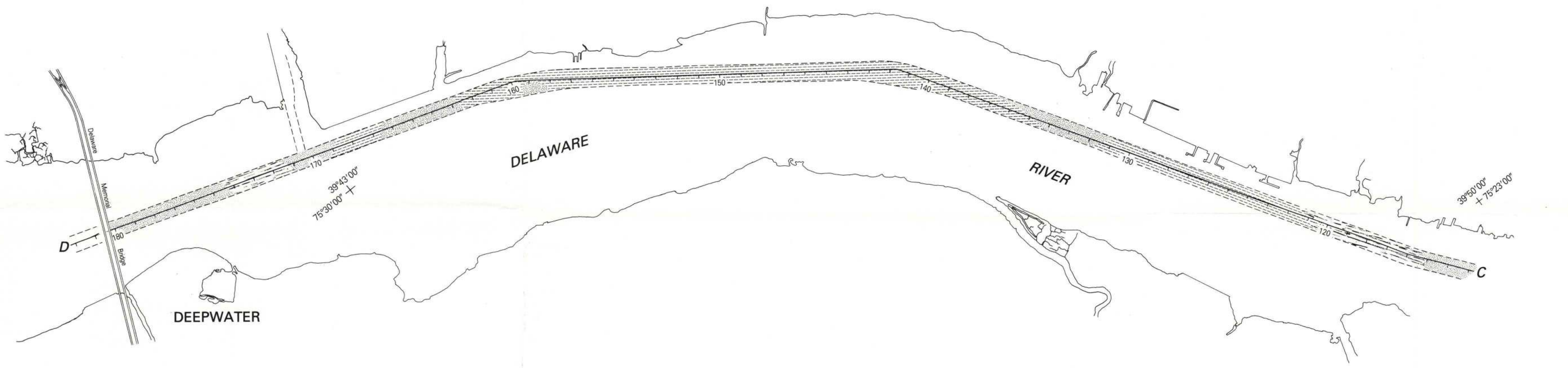
HYDROLOGIC INVESTIGATIONS
ATLAS HA–697

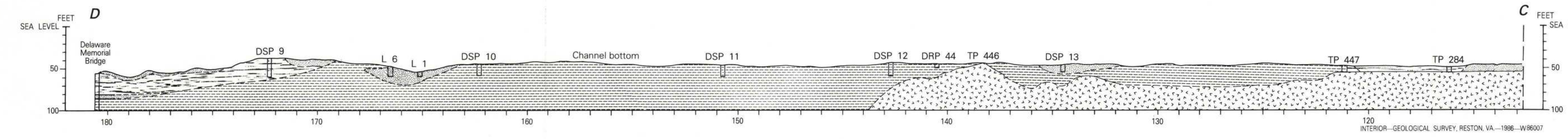












INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1986—W86007

SCALE 1:48 000

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

VERTICAL EXAGGERATION × 40

EXPLANATION

LITHOLOGIC UNITS

▤	Clay
▤	Silt
▨	Sand
▨	Bedrock

DSP 13 LOCATION OF BOREHOLE OR TEST PIT—Identification number is from U.S. Army Corps of Engineers

120 TRACE OF SECTIONS AND STATION NUMBERING SYSTEM—Station numbers begin at Allegheny Avenue and run north and south. Distance between stations is 1000 feet. Numbers to the north are preceded by the prefix "N"

— — LITHOLOGIC CONTACT—Dashed where location is uncertain

– – – EDGE OF SHIPPING CHANNEL

INTRODUCTION

The Delaware River drains an area of 12,765 square miles in New York, New Jersey, Delaware, Pennsylvania, and Maryland. The lower reach of the river, from Trenton, N. J., to the Delaware Bay is an estuary because it is influenced by tides. South of Trenton, the Delaware estuary is used by ocean-going vessels and is dredged by the U.S. Army Corps of Engineers to maintain navigability. The hydrologic effects of this dredging, however, are not well understood. This is cause for concern because extensive ground-water withdrawals in the vicinity of Camden, N. J., have reversed ground-water flow directions and induced recharge to the aquifer system from the river (Parker and others, 1964, p. 38).

Proposed dredging may increase the hydraulic connection between the estuary and contiguous aquifers where bottom sediments of low permeability are removed. This could increase recharge to the aquifers, and may cause changes in the chemical and physical quality of water in the aquifers. Evaluation of these effects requires detailed information on the distribution and hydraulic properties of the bottom sediments.

From March through July, 1984, the U.S. Geological Survey, in cooperation with the Army Corps of Engineers, collected information on the lateral and vertical distribution of sediments along the most heavily travelled part of the Delaware River ship channel. This part of the channel—shown in three sections on the small inset map—constitutes the study area. Data for the study were collected using the geophysical techniques of seismic reflection and electromagnetic conductivity, as well as by using available borehole logs, test-pit data, and results from previous geophysical studies (Moody, D.W., and Van Reenan, E. D., 1967) Seismic reflection is a geophysical technique which makes use of the fact that different lithologies often have different densities and transmit sound at different velocities. This causes sound waves to reflect off of the lithologic boundaries. The graphical record of these reflections thus serves as a guide to the geologic structure below the seismic instruments. The electromagnetic conductivity method makes use of the fact that the earth acts like an electrical conductor. When an electromagnetic field is created near the earths surface, an electrical current is induced within the earth. This current then produces an electromagnetic field that is proportional to the degree of electrical conductivity of the ground. Since saturated sand or bedrock is usually a poor electrical conductor, and saturated clay is a relatively good conductor, electromagnetic conductivity was used to help locate clay deposits below the channel bottom.

HYDROGEOLOGY

The sediments below the Delaware River estuary in the study area consist of an upper layer of Holocene sand, silt, clay and gravel that overlies a thicker sequence of Cretaceous sediments. The Holocene sediments generally are less than 30 feet thick. The Cretaceous sediments, which in ascending order consist of the Potomac, Raritan, and Magothy formations, range in thickness from zero to several hundred feet. The Cretaceous sediments consist of layers of gravel, sand, silt, and clay, and form the basal part of a gently seaward-dipping sequence of unconsolidated sediments of the coastal plain (Gill and Farlekas, 1976). Beds of the Potomac-Raritan-Magothy aquifer system crop out in several parts of the study area. The Cretaceous sediments compose an aquifer system that is the principal source of ground water for communities and industries adjoining the Delaware estuary.

Consolidated bedrock underlies the Holocene and Cretaceous sediments. The irregular surface of the bedrock ranges from 40 ft to more than 200 ft below sea level and dips gently to the southeast with a slope of 10 to 60 feet per mile (ft/mi). The bedrock consists primarily of gneiss and schist of Precambrian and Paleozoic ages.

Under natural conditions, ground water would tend to flow from the aquifer system, which is confined, to the estuary. In the vicinity of Camden and Gloucester City, N. J., however, heavy pumpage has created a large cone of depression in the water table (Walker, 1978, p. 12). The cone has reversed the natural ground-water gradient and caused water to flow from the estuary into the aquifer system.

Powell and others (1954) collected cores from the Delaware River estuary and conducted aquifer tests along the river north of Philadelphia, Pa., that indicate that the dredged ship channel increases the hydraulic connection between the estuary and the underlying aquifer. Previous studies have shown that saline water has been found within the Delaware River as far north as Philadelphia, Pa. during periods of extreme low flow (Keighton, 1969, sheet 2). No evidence of saline water was detected, however, in continuous specific-conductance data collected for this study.

DESCRIPTION AND DISTRIBUTION OF CHANNEL-BOTTOM SEDIMENTS

Because of the unstable nature of channel-bottom silt and sand, many of the Cretaceous sediments underlying the Delaware River estuary are locally overlain by a layer of Holocene silt or sand. Electromagnetic and seismic data cannot be used to determine the age of the unconsolidated sediments. Therefore, no attempt is made within this report to differentiate between Holocene and Cretaceous sediments. Location information in the text is keyed to the station numbers established by the Army Corps of Engineers along the Delaware River for construction and study purposes. The numbering system for the stations begins at Allegheny Avenue, in Philadelphia, Pa., and runs north and south; the distance between stations is 1000 feet. Stations north of Allegheny Avenue are identified by the prefix **N**: no prefix is used for stations to the south.

From station **N45** to **N24**, river borings show that depth to bedrock averages less than 10 feet below the channel bottom. Downstream from station **N24**, the altitude of the bedrock surface decreases by at least 50 ft. Seismic and electromagnetic data indicate that the channel bottom consists mostly of sand. The bedrock surface is within 10 feet of the channel bottom between station **N1** and station **9**. Except for a small deposit of silt near station **18**, the channel between stations **9** and **29** is underlain mostly by sand.

Seismic and borehole data indicate the presence of a thin, continuous layer of silt over sand between stations **29** and **43**. Smaller, less continuous layers of silt occur above and within the channel-bottom sands between stations **43** and **51**, but sand predominates between stations **43** and 56. Between stations **56** and **71**, surface geophysical and test-boring data indicate the presence of interbedded silt and sand. Sand predominates in the channel bottom between stations **71** and **73**. Between stations **73** and **82**, the electromagnetic conductivity and seismic-reflection data indicate the presence of silt below the channel. Sand predominates from station **82** to **90**, at which point the bedrock surface again rises to within 10 ft. of the channel bottom. Between stations **90** and **121** , seismic and borehole data indicate that bedrock, overlain by sand and silt, remains within 10 feet of the channel bottom. At station **121**, electromagnetic conductivity and seismic reflection data indicate the presence of clay beneath the channel bottom. Clay is the predominant lithology beneath the channel to station **132**, where seismic data indicate that the bedrock surface is within 15 feet of the channel bottom. Seismic and borehole data also indicate the presence of a sand lens directly beneath the channel bottom between stations **132** and **134**. Downstream from station **134** the channel-bottom clay thickens, and then lenses out against bedrock between stations **137** and **139**. Except for two small sand lenses near station **165** and **170**, clay is the major type of sediment in the subsurface between stations **140** and **176**. At station **176**, borehole data obtained for the Delaware Memorial Bridge construction indicate at least 20 feet of silt below the channel-bottom sand.

EFFECTS OF PROPOSED DREDGING ON GROUND-WATER HYDROLOGY

By removing layers of clay and silt, dredging can decrease the confining ability of these layers and expose aquifer sands to estuarine water. Dredging also will increase the area available for infiltration of recharging water. Thus, in the areas where large ground-water withdrawals are inducing recharge from the estuary to the aquifer, dredging can increase the rate of this recharge. Increased recharge could affect water quality, depending on the relative quality of water in the estuary and aquifers. Available information suggest that water quality in the Delaware River estuary has been affected by industrial chemicals (Hochreiter, 1982, p. 1). Trace levels of organic compounds were found in approximately 60 percent of 34 water samples collected along the Delaware River in 1980, and DDT, DDD, DDE, PCB, and Chlordane were found in most of the channel-bottom material that was analyzed. Municipal wastes and industrial contaminants were also detected in the Delaware River by other investigators (Sheldon and Hites, 1978, p. 1188). The presence of these contaminants in the estuary suggests that water quality in the aquifer could be degraded if low-permeability sediments overlying the aquifer are removed in areas where recharge to the aquifer is occuring from the estuary. Aquifer water could also be degraded if contaminants that are currently bound in the sediments are remobilized in the dredging process.

Between Army Corps of Engineers stations **30** and **43** fine-grained sediments overlie sand or gravel. This reach lies between densely populated and heavily industrialized parts of Philadelphia and Camden. Because it is an area where water from the estuary recharges the aquifer (Walker, 1978), the removal of these fine-grained sediments would probably increase the rate of recharge to the aquifer.

Other areas where low-permeability sediments overlie sand are shown in geologic section *B–C*. Two of these low-permeability layers, centered of USCE stations **46** and **50** are too thin to serve as a significant hydrologic barrier between the estuary and the aquifer. Each of the two low-permeability layers indicated on geologic section *B–C* (centered on stations **64** and **77**) is more than 9,000 ft long, and thicker than the two deposits mentioned above. The Army Corps of Engineers dredging program calls for a maximum channel depth of 55 ft below sea level, which is at least 10 ft above the lower boundary of the low-permeability zones in this area. Therefore, dredging in this channel reach is not likely to cause significant increases in the volume of recharge to the aquifer from the estuary .

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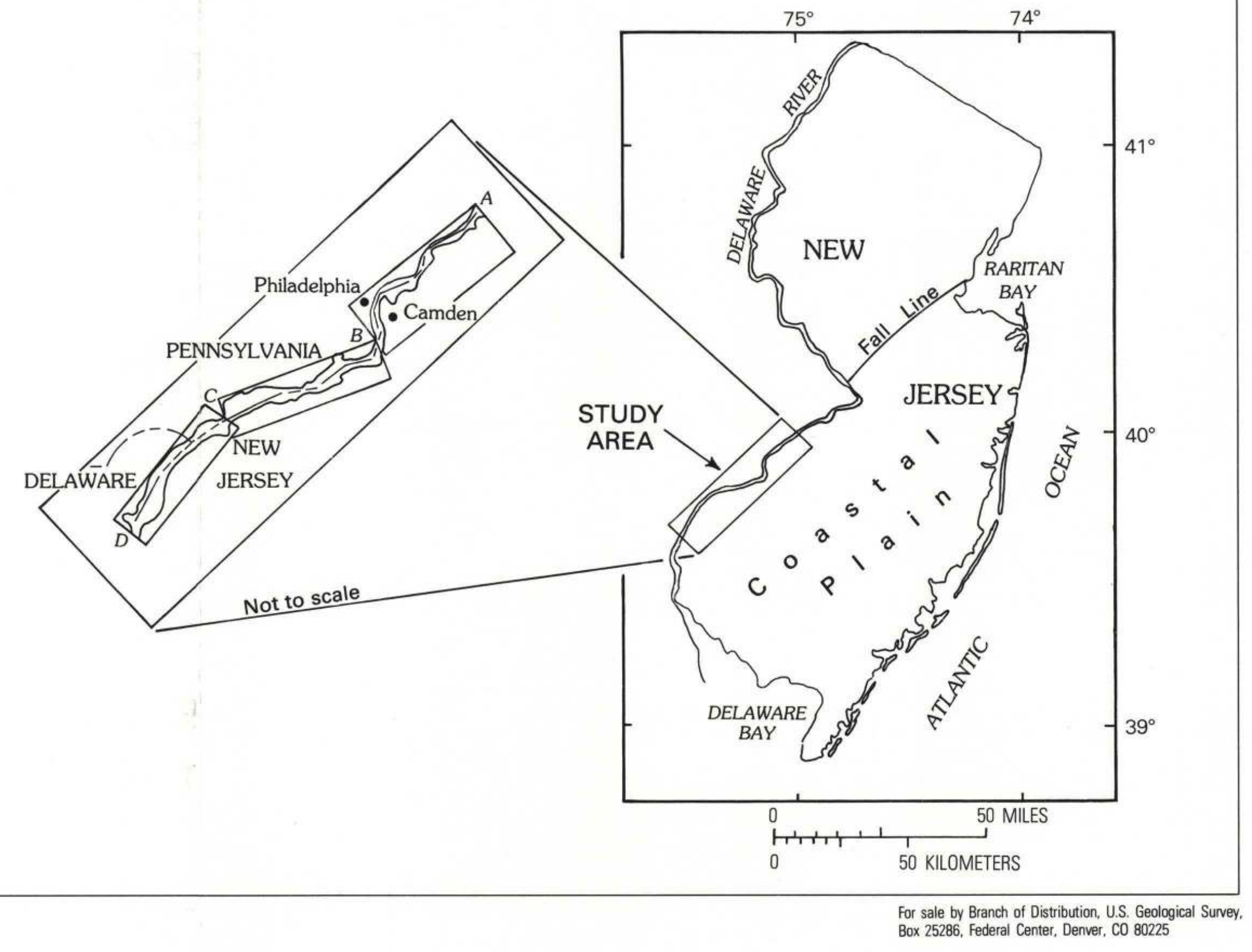
CONVERSION FACTORS AND ABBREVIATIONS

For readers who prefer to use metric (International System) units, the conversion factors for the inch-pound terms used in this report are listed below:

Multiply inch-pound unit	by	To obtain metric unit
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)



DISTRIBUTION OF BOTTOM SEDIMENTS AND EFFECTS OF PROPOSED DREDGING IN THE SHIP CHANNEL OF THE DELAWARE RIVER BETWEEN NORTHEAST PHILADELPHIA, PENNSYLVANIA AND WILMINGTON, DELAWARE, 1984

By Philip B. Duran
1986

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